Journal of Personality and Social Psychology
1973, Vol. 26, No. 1, 122–130

ROLE OF SYMBOLIC CODING AND REHEARSAL PROCESSES IN OBSERVATIONAL LEARNING [1]

ALBERT BANDURA [2] AND ROBERT W. JEFFERY

Stanford University

The present experiment investigated the effects of symbolic coding and different types of rehearsal on retention of observationally learned responses over varying temporal intervals. Subjects who coded the model's actions verbally or numerically at input and immediately rehearsed the memory codes from which the behavior could be reconstructed attained the highest level of response retention. Physical practice, on the other hand, did not independently aid retention of modeled responses. Both coding and symbolic rehearsal emerged as critical determinants of delayed imitative performance. Neither rehearsal without coding nor coding without rehearsal of the codes in immediate memory improved retention of modeled behavior. In further tests conducted a week later, symbolic coding remained as a significant determinant of matching performance, with the facilitative effects being largely attributable to codes that previously existed in permanent memory. These results were interpreted as supporting a social learning view of observational learning that emphasizes central processing of response information in the acquisition phase and motor reproduction and incentive processes in the overt enactment of what has been learned.

Traditional conceptions of modeling phenomena rely heavily on nonmediated associative mechanisms. In such theories observational learning is depicted as a process in which the behavior of models elicits similar responses in others, and as a result of repeated reinforcement, the modeled actions become cues for imitative responses. This type of theory has limited explanatory power when applied to observational learning under conditions where observers perform no responses at the time of exposure, neither the model nor the observers are reinforced during this period, and the first appearance of the acquired responses may not only be delayed for weeks or months but typically occurs in situations where the model is not present to serve as a cuing influence. In the latter case, which represents one of the most prevalent forms of social learning, modeled actions are acquired observationally before they have been performed or reinforced.

[1] This research was supported by Public Health Research Grant M-5162 from the National Institute of Mental Health. The authors are indebted to Philip Satre for his generous assistance in scoring the response records.

[2] Requests for reprints should be sent to Albert Bandura, Department of Psychology, Stanford University, Stanford, California 94305.

The social learning analysis of observational learning (Bandura, 1971) assumes that modeling influences operate principally through their informative function, and that observers acquire mainly symbolic representations of modeled events rather than specific stimulus–response associations. In this formulation, which is summarized schematically in Figure 1, modeling phenomena are governed by four component subprocesses. They include attentional functions that regulate sensory registration of modeled actions; retention processes whereby transitory influences are converted to enduring internal guides for memory representation; motor reproduction processes that govern the integration of component actions into the patterns and sequences required to enact modeled behavior; and incentive or motivational processes that determine whether or not acquired responses will be activated into overt performance. Within this framework acquisition of modeled patterns is primarily controlled by attention and retention processes, whereas performance of observationally learned responses is regulated by motor reproduction and incentive processes.

If an observer is to reproduce a model's behavior when it is no longer present to serve

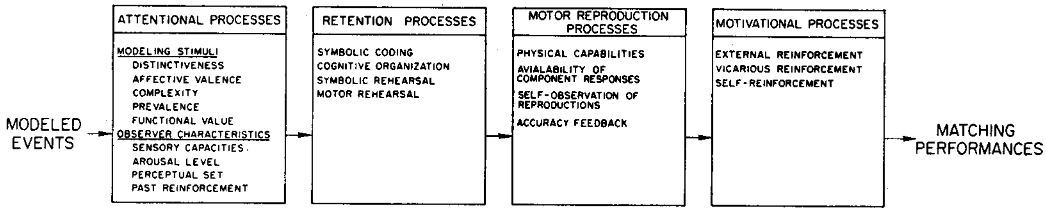

FIG. 1. Component subprocesses in the social learning analysis of observational learning.

as a guide, the response patterns must be represented in memory in symbolic form. After modeled activities have been transformed into images and readily utilizable verbal symbols, these memory codes can function as guides for subsequent reproduction of matching responses. Acquisition and retention of modeled performances are facilitated by such codes because they carry a great deal of information in an easily stored form.

Cognitive representation may differ on a variety of dimensions, depending on whether the modality is primarily verbal or imaginal and on whether the code is reductive or includes elaborate linguistic or imaginal constructions. Moreover, coded representations may be structurally isomorphic with the modeled responses or bear little resemblance to them. Research conducted with both children (Bandura, Grusec, & Menlove, 1966; Coates & Hartup, 1969) and adults (Gerst, 1971) demonstrates that observers who transform modeled actions into either descriptive words, linguistic constructions resembling familiar activities, or visual imagery achieve a higher level of observational learning than noncoders.

In the foregoing studies, the modeled performances, though novel, contained a limited number of response elements so that they were readily amenable to visual or linguistic transformations. However, there are many modeled activities that, due to the large number and complexity of constituent responses, can neither be conveniently stored in visual form nor easily preserved in linguistic elaborations without creating a taxing memory load. Observational learning is best achieved in such instances by reductive transformations that incorporate the essential response information in a few distinctive symbols. One of the purposes of this experiment was to evaluate the relative efficacy of different reductive codes for preserving motor responses not stored as such.

Memory codes are of little value if they are forgotten. Retention of response information can be strengthened in permanent memory through rehearsal. There is probably more than one mechanism responsible for the performance gains accompanying rehearsal activities (Bower, 1967). During the period of rehearsal, action patterns may be subjectively organized or recoded into linguistic and imaginal mnemonic aids designed to facilitate recall. In addition, repetition itself may enhance retention by increasing the strength or number of memory traces. Since the social learning analysis of observational learning places greater emphasis on central processing of response information than on physical responding, the present study examined the effects of two types of rehearsal on retention of modeled performances. Physical practice of the modeled actions was compared with rehearsal of the memory codes from which the responses could be reconstructed when needed.

In the present experiment, subjects observed a model perform complex movement configurations. Noncoders were left to their own devices in learning the modeled performances. Coders, on the other hand, assigned letter or number associates to each component response as it was demonstrated and stored the patterns in memory as aggregate letter or numerical codes. Immediately after a test for observational learning, subjects in each condition either overtly practiced the modeled responses, rehearsed the codes symbolizing the actions, or were provided with no opportunities to practice what they had seen. In addition, half the subjects in each subgroup again rehearsed the responses after a delayed interval, or they engaged in no deferred rehearsal activities. Retention of modeled responses was then measured at the end of the experimental session and again 1 week later.

It was predicted, for reasons given earlier, that symbolic coding would significantly enhance both observational acquisition and retention of modeled performances. It was further hypothesized that immedate rehearsal would strengthen response retention, with symbolic rehearsal producing the better results. This difference was predicated on the assumptions that symbolic codes can be repeated more often than responses can be reenacted during a given time and that too early preoccupation with behavioral reproduction can jeopardize retention of memory codes at the critical period when they are least stable.

Observed responses are likely to be lost rapidly unless rehearsed in some form. Few benefits were therefore expected to accrue from delayed rehearsal under conditions where rehearsal was prevented after input. This variable was included, however, to assess whether further rehearsal of retained responses or their codes might aid their maintenance over a long period of time. Since the complex response configurations were performed rapidly by the model without leaving a perceptible trace, they did not lend themselves easily to subjective organization or spontaneous coding. Consequently, response retention was not expected to be much improved by rehearsal without the benefit of symbolic coding at modeling input.

Retention of the model's actions was additionally examined as a function of code familiarity. Some of the response configurations constituted familiar words or number sequences while others represented meaningless ensembles. It was predicted that modeled responses forming codes that already exist in permanent memory would be retained at a higher level than those embodying unfamiliar codes.

METHOD

Subjects

The subjects were 44 males and 44 females drawn from an introductory psychology course and paid volunteers. They were randomly assigned from these categories to nine experimental and two control groups of 8 subjects each. The groups were equally balanced for sex and source of subjects, though separate analyses revealed that these factors were unrelated to observational learning.

Procedure

Subjects were told that they were participating in an experiment investigating visual perception. All experimental subjects were first shown on film the six component actions that appeared in varying combinations in the more complex modeled performances. Each component response consisted of a lateral movement covering either one, two, or three interval distances followed by a downward and lateral movement of one interval; each of these three movement patterns could be made to the right or to the left, thus creating a total of six component moves.

For subjects in the coding conditions, each component move was assigned a distinctive letter or numerical associate. In the case of the numerical codes, the odd numbers 1, 3, and 5 designated the three movements to the left of progressively longer length, while the even numbers 2, 4, and 6 represented the corresponding movement intervals to the right. The verbal code utilized the same principle, with letters progressively higher in the alphabet representing increasing movement intervals. Movements to the left of one, two, and three intervals were designated B, C, and D, respectively, while the analogous movements to the right were labeled A, E, and I.

After subjects studied the component moves and their associated codes for a period of 1½ minutes, they were asked to reproduce them to ensure that all had learned the component responses, which they did. Subjects were then given three practice trials to familiarize them with the modeling and coding activities.

Modeling Stimuli

Each of the modeled response configurations used in the practice and test series was formed by connecting sequentially six component moves of varying distances and directions. The responses were performed on a green panel containing a field of equidistant dots to clarify whether the model was moving one, two, or three intervals at any given time.

Eight novel response configurations were devised to measure observational learning. In order to assess the effects of code meaningfulness on observational learning and retention, four of the modeled configurations were constructed to form familiar number sequences for numerical coders but meaningless letter aggregates for verbal coders (e.g., 123456, BACEDI). The remaining four response configurations represented familiar words in the verbal code but a less organizable collection of numbers in the corresponding numerical code (e.g., DECADE, 543254). All modeled performances were presented to subjects individually on color film.

Coding Operations

Subjects in the *noncoding condition* were shown the modeled performances with the instruction that they could best learn the overall patterns by subdividing them into their component parts. Those assigned to the coding conditions were given the same instructions except they were told to code the model's actions as they were being performed into the appropriate letters or numbers. Subjects in the coding conditions thus learned each modeled response configuration by assigning letter or number associates to each component as it was performed and storing the entire pattern in memory as an ensemble letter or numerical code. Subsequent response reproduction was achieved by translating sequentially each of the code elements into its corresponding action.

In the three practice trials, which all subjects received, the modeled performances left a visible trace to convey some idea of what a total response configuration might look like. For subjects in the coding conditions, the appropriate number or letter associates appeared beside the response components as they were performed on the first trial. In the remaining two practice trials, subjects in the coding conditions were asked to code aloud the component actions as they were performed rather than have the symbolic associates supplied for them on the film.

Test for Observational Learning

Following the practice session, the model twice performed each of the eight response configurations one at a time with a metal stylus leaving no visible trace. Thus subjects were provided with no external response cues except those supplied by the transitory actions of the model. Noncoders were left to their own means in learning the modeled performances, whereas coders silently transformed the sequence of actions into corresponding letter or numerical associates.

Immediately after a response pattern was twice demonstrated, subjects were given a response sheet containing a field of equidistant dots and were instructed to reproduce the modeled performance as rapidly and as accurately as possible. They were given no feedback concerning the accuracy of their reproductions. One minute was allowed for the task, which was established in pretest to be more than ample time. After finishing a given test, subjects engaged in one of three rehearsal activities for 1½ minutes, whereupon they were administered the next modeled item. This sequence of demonstration, test for observational learning, and rehearsal was repeated with each item until all eight were completed.

Rehearsal Operations

One third of the subjects in each of the three coding conditions performed one of three forms of rehearsal. In one of the treatments, designated *motor rehearsal,* subjects practiced performing overtly the modeled patterns as often as they could during the allotted time. A second group, assigned to *symbolic rehearsal*, repeated aloud the symbolic code throughout the same period, and their verbalizations were tape recorded. The third group of subjects, who were provided with *no opportunities to rehearse* what they had seen, performed an interpolated task. They viewed a film in which a faint yellow dot flashed rapidly and unpredictably in different quadrants of a square, and they pressed one of two telegraph keys depending on the dot location. This task was selected because it was sufficiently absorbing to prevent subjects from rehearsing the modeled performances symbolically, but it differed markedly in content so as not to interfere with either numerical or letter codes.

At the conclusion of the entire series of modeled performances, half the subjects in each of the subgroups performed the rehearsal-impeding interpolated task for approximately 4 minutes, while the remaining subjects continued to rehearse the modeled patterns in the manner they had immediately after each individual test for observational learning. This additional feature was included to compare the response-consolidating effects of immediate and delayed rehearsal.

Delayed and Follow-Up Response Reproduction

In the final phase of the experiment, subjects were asked to reproduce as accurately as possible all of the modeled configurations that they could still recall. This measure of long-term retention was supplemented with a further reproduction test conducted 1 week later. Subjects were mailed the response forms with instructions to reproduce the modeled patterns. They were not informed beforehand that they would be tested for retention either at the end of the session or at a later time, in order to deter spontaneous rehearsal during the intervening periods. Although there was little reason to expect that these intricate response sequences would be retained beyond the period of the experiment, it was of interest to determine whether any of the behavioral patterns could be enduringly sustained in meaningful symbolic codes.

Control Conditions

The experimental design also included two control groups to provide base lines against which to assess the effects of modeling alone and component familiarization. One group was shown the component moves and the practice patterns and was then instructed to guess how the model may have combined the components to create eight additional response configurations without having observed the modeled test performances. The second group observed the practice and test performances modeled under nonrehearsal conditions without having previously learned the component moves.

Response Measures

Observational learning and retention were measured using the stringent criterion of perfect reproduction of the modeled response configurations. The performance records were scored by comparing subjects' responses against appropriate templates of the model's action patterns. Interscorer agreement, based on independent ratings of half the records, was virtually perfect ($r = .99$). In addition, measures were obtained of the frequency with which subjects in rehearsal conditions accurately repeated the modeled responses in symbolic code or overt practice and the percentage of their rehearsals that were correct.

Results

Subjects in the experimental conditions who observed the modeled performances demonstrated substantial observational learning (65% correct reproductions), whereas those shown the component routes and practice patterns without the benefit of modeling failed to reproduce a single novel response configuration. Comparison of subjects who observed the modeled performances, either with or without prior exposure to the component moves, disclosed no differences. These results show that accurate reproductions represent modeling effects rather than chance performances or the influence of extraneous nonsocial factors, such as familiarity with the constituent responses.

Immediate Response Reproduction

Table 1 shows the percentage of modeled items accurately reproduced as a function of modeling, coding, rehearsal, and retention interval. Analysis of variance of the immediate reproduction scores reveals that observational learning is significantly improved by symbolic coding of the modeling stimuli ($F = 6.23$, $p < .01$). In individual comparisons between groups numerically coded and verbally coded, modeling did not differ significantly. Numerical coders achieved a substantially higher level of observational learning (80%) than subjects who observed the same modeled performances without being given a convenient way of coding them for memory representation (46%), a difference that is highly significant ($F = 12.45$, $p < .001$). Although verbal coders (65%) also surpassed the group without a preassigned coding system, the difference fell short of conventional significance levels.

TABLE 1

Percentage of Modeled Response Configurations Accurately Reproduced as a Function of Modeling, Coding, Rehearsal, and Retention Interval

Treatment conditions	Retention interval		
	Immediate	Delayed	One week
Numerically coded modeling			
Symbolic rehearsal	81	44	21
Motor rehearsal	70	17	8
No rehearsal	88	13	4
Verbally coded modeling			
Symbolic rehearsal	83	36	17
Motor rehearsal	58	27	20
No rehearsal	55	11	16
Modeling without a preassigned code			
Symbolic rehearsal	53	5	2
Motor rehearsal	33	9	4
No rehearsal	63	3	4
Modeling without component familiarity	41	2	0
No modeling	0	0	0

Since rehearsal followed the test of immediate reproduction, it could not affect observational learning of the preceding items. However, it could conceivably influence learning indirectly by altering attentiveness to succeeding modeled responses. Analysis of variance reveals that the rehearsal activities had no significant effect on observational learning, either overall or in the different coding conditions.

Subjects assigned to noncoding conditions were free to develop memory aids of their own choosing, which many of them did, according to their reports in a postexperiment questionnaire of the schemes they used to help them remember the movement patterns. Two judges independently categorized the subjects, with 92% agreement, into spontaneous coders and noncoders. Of the 24 subjects, 16 created their own coding strategy using direction and length of movement as the means of representing the model's actions, while 8 of them failed to produce any symbolic device for retaining what they had observed. Subjects who spontaneously generated memory aids achieved substantially better observational learning (66%) than those who did not (19%). These subgroup differences were highly significant ($t = 3.48$, $p < .005$). Although the informal coding systems enhanced immediate reproduction of individual performances, they were too unwieldy and indistinguishable to sustain retention of many varied responses. By the time of the delayed and follow-up assessments, both groups had lost virtually everything they had learned and no longer differed from each other.

Delayed Response Reproduction

Analysis of variance applied to the delayed reproduction scores reveals that retention of observationally learned responses is substantially aided by symbolic coding ($F = 12.35$, $p < .001$), by immediate rehearsal ($F = 9.04$, $p < .001$), and by the interactive effects of these two factors ($F = 2.93$, $p < .05$). Repeated delayed rehearsal of symbolic codes or actual responses, however, had no effect on subsequent response reproduction. Evidently the deferred rehearsal merely revealed rather than consolidated what had already been retained.

Unlike the findings of the immediate reproduction test where only numerically coded modeling proved superior, at the delayed interval both numerical ($F = 17.09$, $p < .001$) and verbal coders ($F = 17.09$, $p < .001$) retained significantly more modeled responses than subjects in the noncoding conditions. The two coding treatments, in fact, produced identical mean scores. In addition, subjects who rehearsed the modeled responses symbolically retained them better than those who practiced them motorically ($F = 5.27$, $p < .05$). Contrary to expectation, physical rehearsers did not differ significantly from nonrehearsers.

The two-way interaction indicates that rehearsal had differential effects depending on

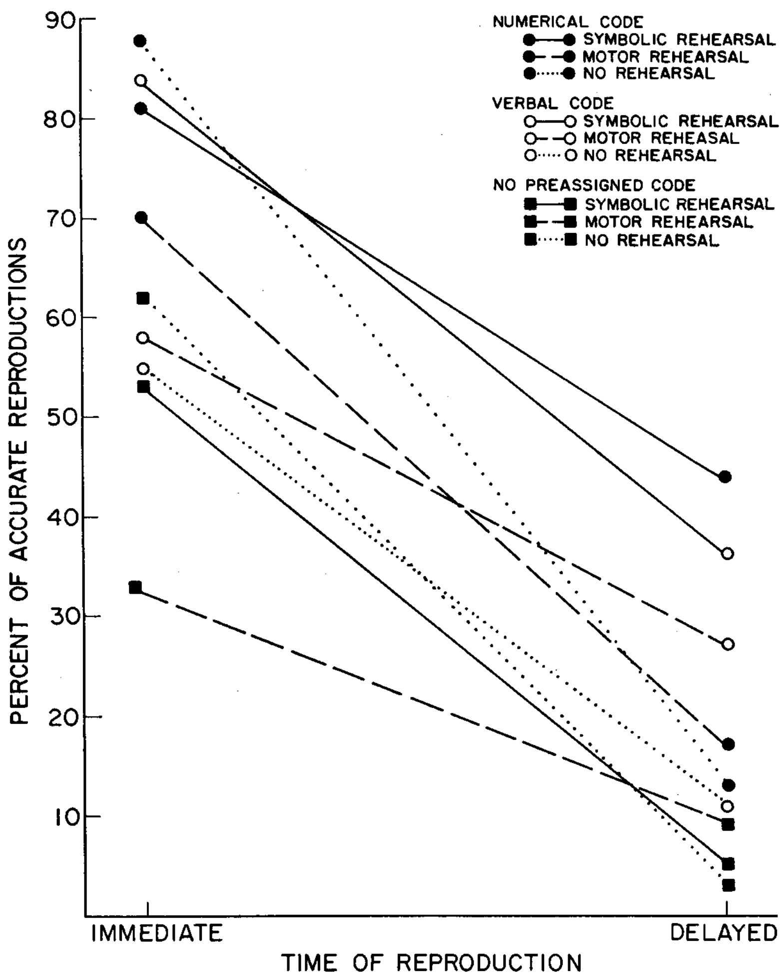

FIG. 2. Percentage of modeled performances accurately reproduced as a function of symbolic coding, rehearsal, and retention interval.

whether and how the modeled performances had been coded during acquisition. This is shown graphically in Figure 2. The different modes of rehearsal did not aid response retention in subjects who failed to code the modeled events for storage and retrieval. Numerical coders, on the other hand, achieved better retention when they rehearsed the modeled responses symbolically than behaviorally ($F = 11.43$, $p < .01$) or not at all ($F = 15.82$, $p < .01$), but they did not benefit significantly from motor rehearsal. Similarly, only symbolic rehearsal improved retention for the verbal coders ($F = 10.13$, $p < .01$).

An analysis of covariance was also performed on these data to examine how coding and rehearsal of memory aids affected retention of modeled responses when scores were adjusted for variation in initial level of observational learning. As in the previous analysis, coding ($F = 6.85$, $p < .01$) and rehearsal ($F = 10.86$, $p < .001$), as well as their interactive effect ($F = 3.78$, $p < .025$), were significant determinants of response retention. Intergroup comparisons also yielded the same pattern of differences, except that motor rehearsal aided retention under conditions where coding apparently played a lesser role. Subjects who used the slightly weaker verbal code ($F = 4.22$, $p < .05$) and those given no formal coding system ($F = 4.15$, $p < .05$) later achieved higher reproduction scores if initially they practiced manually what they had seen than if they had no opportunities for motor rehearsal.

Long-Term Retention

The follow-up measurement yielded approximately the same high return rate (85%) in all subgroups. Table 1 summarizes the percentage of perfect reproductions achieved by subjects receiving the various treatments. Since a substantial decline in performance in some of the conditions produced highly skewed distributions, the treatment effects were analyzed by nonparametric techniques.

Results of the Kruskal-Wallis analysis of variance revealed that long-term retention of modeled responses was significantly influenced by coding ($H = 9.74$, $p < .01$) but was unaffected by either immediate or delayed rehearsal. Individual comparisons between the different coding conditions with the Mann-Whitney U test showed numerically ($z = 2.57$, $p < .01$) and verbally ($z = 2.50$, $p < .01$) coded modeling to be superior to noncoded modeling but not significantly different from each other.

Acquisition and Retention of Modeled Responses as a Function of Code Meaningfulness

The number of perfect reproductions achieved by subjects at each retention interval was compared by the Wilcoxon test for modeled configurations representing familiar letter or number ensembles with those forming meaningless sequences. In accord with prediction, modeled responses were learned and maintained better in familiar memory codes than in symbolic transformations devoid of meaning. The advantage of code familiarity was evident in the test of observational learning (6% gain), and it became progressively larger in the delayed (9%) and follow-up (18%) periods. The corresponding significance levels of the differences similarly increased from immediate ($z = 1.66$, $p < .05$), to delayed ($z = 2.86$, $p < .01$), to follow-up ($z = 4.04$, $p < .001$) performances.

Relationship between Code Retention and Response Reproduction

Subjects in the symbolic rehearsal condition repeated their codes aloud to make observable cognitive activities that are ordinarily covert. These data were obtained to provide additional evidence on the functional role of memory codes in retention of modeled behavior. The findings supported the hypothesized relationship between availability of symbolic codes and accuracy of response reproduction.

At immediate reproduction, subjects coded accurately 86% of the modeled responses and achieved a comparably high level of response learning, whereas it was rare (3.8%) for them to reproduce a modeled response that had not been coded. During delayed rehearsal they retained 55% of the codes they originally rehearsed, and 86% of these were subsequently enacted behaviorally. In marked contrast, subjects reproduced only 1% of the responses for which they lacked the code in delayed rehearsal.

The results also substantiated the major hypothesis that immediate rehearsal facilitates code retention. Subjects who engaged in symbolic rehearsal shortly after observing the model's actions produced 48% of the codes during the delayed period, while nonrehearsers were able to retain only 17% of the codes, a difference that was highly significant ($t = 2.99$, $p < .01$). Consistent with theoretical expectation, the delayed response reproduction levels for immediate rehearsers (40%) and nonrehearsers (12%) closely matched code availability.

Discussion

The results of this experiment demonstrate the importance of symbolic processes in determining both the level of observational learning and retention of modeled responses over time. It was the observers who symbolically coded the modeling stimuli at input and rehearsed the memory code from which the behavior could be reconstructed who achieved the superior performances. On the other hand, those who failed to code the modeling stimuli for memory representation rapidly lost what they had learned even when given ample opportunities to practice the demonstrated actions. However, unless the codes are rehearsed when available in immediate memory, the response information is forgotten, resulting in subsequent deficits in imitative performances. The importance of immediate stabilization of modeling inputs through symbolic reinstatement is further shown in the finding that delayed rehearsal, in any form, had no effect on retention loss, whereas immediate rehearsal substantially improved delayed response reproduction.

Data from the recorded rehearsal provided further confirmatory evidence for the functional relationship between immediate rehearsal, code retention, and response reproduction. Symbolic rehearsal following exposure to modeled actions greatly aided code retention. The modeled responses that were reproducible on later occasions were essentially confined to those for which memory codes existed, and it was rare to find imitative performances that were not cognitively represented in memory. When modeled inputs are not symbolized and then stabilized through immediate rehearsal, neither the memory codes nor the responses are later retrievable. Immediate imitation of simple responses does not require much in the way of cognitive aids because the enactments are externally guided by the modeling stimuli. Cognitive representational functions play an influential role in delayed reproductions of complex performances when models are no longer present.

It is noteworthy that the short-term advantages gained through immediate symbolic rehearsal were no longer evident after a long time interval. This is not an entirely surprising finding considering that many of the code aggregates for the response configurations lacked meaningfulness and were therefore vulnerable to loss. With the passage of time, it was mainly the responses represented in easily remembered codes that endured. Had subjects applied a mnemonic device to the unfamiliar codes and then rehearsed them periodically, they probably could have retained the modeled performances over long periods. The effectiveness of a two-stage coding process clearly warrants exploration.

For purposes of studying observational learning, it is necessary to select novel modeled activities that are unfamiliar and do not exist in integrated form as a result of prior learning. Responses that are devoid of meaning and functional value are not easily retained. By contrast, observational learning in everyday life includes a number of retention-enhancing factors. As a rule, modeled behavior is repeatedly exhibited, thus providing many opportunities to master features that originally were either inadequately learned or lost from memory. The patterns of social behavior usually involve novel configurations of familiar component activities that exist in memory. Moreover, individuals are inclined to rehearse spontaneously adopted modes of response until established in permanent memory because they have utilitarian value for them.

One of the unexpected results of the present study is that physical practice had little effect on response retention, and then only under conditions where subjects either did not code the model's actions or used one of intermediate effectiveness. This finding may be interpreted in several ways. As noted earlier, some of the performance gains accompanying behavior rehearsal result not from sheer response repetition but from the formation of mnemonic aids that enhance recall. Engrossment in motor activities reduces the opportunity to code responses into easily remembered words or images. It seems unlikely, however, that the findings are entirely explainable in terms of deployment of attention, because the modeled patterns were not readily codable in terms of idiosyncratic imagery or verbal mediators that could incorporate the vast amount of information needed for perfect reproduction.

An alternative interpretation is in terms of the detrimental effects of interference processes. Representational mediators play an especially influential role in early phases of response acquisition. After a given patterned response has been repeatedly performed, it eventually becomes routinized to the point where it is enacted smoothly and automatically without requiring representational guidance. In the present experiment, however, subjects practiced only briefly a variety of responses, each formed by combining essentially the same component movements. Under conditions of massed practice of numerous responses containing similar elements, the resultant interference can offset the potential benefits of motor rehearsal. Following this line of thought, overt rehearsal would most likely enhance retention, given distributed practice of responses having low component similarity.

A third possibility is that failures encountered in response reproduction during practice elicit disruptive emotional arousal which is conducive to the loss of vulnerable memory codes. Although subjects rarely showed visible distress over difficulties in reproducing the model's actions, they often manifested discouragement over evident failures. Any of the above factors, singly or in combination, might explain why motor rehearsal failed to aid either short- or long-term retention of matching responses. Differences between symbolic and physical rehearsal can arise from variations in repetition rate as well as from their qualitative properties. During immediate rehearsal, each code was repeated approximately 12 times, but in the same time interval the corresponding responses were physically enacted on the average only 3 times.

Of the four subsystems included in the social learning analysis of observational learning, cognitive representational functions and motivational influences have received the most experimental attention. Another important, though largely ignored, subprocess is concerned with the mechanisms of motor reproduction. Some of the subjects' performance errors resulted from reproduction rather than representational deficiencies. Evidence from the recorded rehearsal groups disclosed that, in 14% of the instances, subjects learned and retained the codes, but they had difficulty coordinating the various actions into the required patterns and sequences. This factor largely accounts for the small consistent discrepancy between code availability and response reproduction.

The problems of behavior enactment become even more critical in intricate motor skills where performers cannot observe all the responses they are making; hence, they must rely on ill-defined proprioceptive cues or verbal reports of onlookers. It is exceedingly difficult to guide actions that are not easily observed or to identify the corrective adjustments needed to achieve a close match of symbolic model and overt performance. The mechanisms governing response reproduction also merit detailed examination.

REFERENCES

BANDURA, A. (Ed.) *Psychological modeling: Conflicting theories.* Chicago: Aldine-Atherton, 1971.

BANDURA, A., GRUSEC, J. E., & MENLOVE, F. L. Observational learning as a function of symbolization and incentive set. *Child Development,* 1966, 37, 499–506.

BOWER, G. A multicomponent theory of the memory trace. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation.* New York: Academic Press, 1967.

COATES, B., & HARTUP, W. W. Age and verbalization in observational learning. *Developmental Psychology,* 1969, **1**, 556–562.

GERST, M. S. Symbolic coding processes in observational learning. *Journal of Personality and Social Psychology,* 1971, **19**, 7–17.

(Received November 2, 1971)