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The Role of Visual Monitoring in Observational Learning of Action Patterns: Making the Unobservable Observable

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ABSTRACT. The present experiment tested the hypothesis that concurrent visual feedback enhances observational learning of a novel action pattern that normally would be unobservable. Subjects repeatedly enacted a modeled action pattern with visual monitoring of their reproductions throughout enactments, during only early or late phases of enactment, or not at all. At periodic intervals, the adequacy of their conception of the modeled pattern was also measured. Visual feedback during ongoing performance enhanced accurate reproduction of the modeled pattern; the facilitative effect was most pronounced for reproduction of complex response components. The superiority of subjects who had enacted these difficult response components with visual feedback was maintained even when both the model and feedback were withdrawn. Visual feedback did not facilitate accurate enactment of the modeled pattern before development of an adequate cognitive representation of it. The results support the social learning view that observationally-learned behaviors are cognitively represented and that visual monitoring serves to decrease discrepancies between conception and action.

DEMONSTRATION IS WIDELY used in the development of motor skills, and it has been argued that visual presentation is preferred over verbal instruction because language is unable to specify with precision critical aspects of human movement (Martens, 1975). It is, thus, paradoxical that the role of modeling in the acquisition of action patterns has received relatively little attention by investigators in the area of motor learning (Martens, Burwitz, & Zuckerman, 1976). Holding (1965) at-

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tributes this inattention to the fact that usually performers have partially mastered through prior observation the activities they are to perfect by formal training; consequently, the contribution of modeling may be seriously underestimated. An additional, and possibly more important, reason for the neglect of observational learning is the implicit assumption of many current theories of motor learning that overt practice and outcome feedback are necessary for improvement in performance to occur, although this kind of feedback may be unnecessary later in learning (Adams, 1971; Schmidt, 1975). Furthermore, most commonly-used laboratory tasks emphasize attaining a goal, such as accuracy, by a rudimentary action, rather than acquisition of novel action patterns. This emphasis has led to the neglect of the issue of how complex movement patterns are acquired (Adams, 1978). It is in the acquisition of more intricate behavior patterns that observational learning plays an especially important role.

According to social learning theory (Bandura, Note 1), acquisition and performance of complex action patterns are mediated by a common conception-matching process. Viewed from this perspective, the principal constituent processes include conception induction from modeled information; centrally-guided enactment; monitoring of response enactments; and matching action to conception through corrective performance adjustments. This approach posits that motor learning involves the construction of a conceptual representation which provides the internal model for response production, and which serves as the standard for response correction from feedback accompanying response execution. The conceptual representation is constructed by transforming observed sequences of behavior into symbolic codes which are cognitively rehearsed to increase the probability of their retention. During the course of rehearsal, these codes may be further modified by meaningful elaboration and/or conversion into more concise codes which, in turn, further reduce memory load and maximize retrievability.

Initially, response patterns are organized at the cognitive level and the cognitive representation of the behavior enables learners to produce from the outset at least a rough approximation of the activity. If the response components of the modeled actions are already in the behavioral repertoire of observers, an adequate conceptual representation can be readily formed to guide performance without requiring much in the way of enactments and accompanying feedback. However, in the case of novel and complex activities, and especially those involv-

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ing subtle combinations of spatial and/or temporal features, overt performance is usually necessary to detect mismatches between the conceptual representation and performance feedback and to make appropriate corrections in response execution.

Recent studies of observational learning of complex action patterns provide support for the view of motor learning espoused by social learning theory. Bandura and Jeffery (1973) found that if observers transformed modeled actions into symbolic codes and rehearsed them cognitively, reproduction was markedly more accurate than if they did not symbolically code what they saw. If coding was not employed and mentally rehearsed, observers were rarely able to reproduce what was modeled. Observational learning is best achieved by coding operations combining reductive symbolic codes to facilitate retrieval and elaborative linguistic codes to facilitate retention (Bandura, Jeffery, & Bachica, 1974). Failure of code retrieval almost invariably results in failure to reproduce the action patterns.

Imaginal coding (i.e., visualizing oneself performing the modeled actions) has also received attention. Gerst (1971) found that imaginal coding enhanced observational learning of compound motoric responses used in the language of the deaf. The more vivid the imaginal coding, the more accurate were the reproductions of response configurations which were difficult to encode verbally. Using assembly tasks, Jeffery (1976) found that imaginal coding facilitated observational learning and that the effect was most pronounced on intricate constructions. The combination of imaginal coding followed by motor rehearsal led to a higher level of reproduction on both simple and intricate activities than did the exclusive reliance on imaginal coding.

The studies just described provide substantial evidence for the paramount role played by cognitive transformations in the development of the cognitive representation of modeled actions. If observers do not transform modeled actions into cognitive representations, or if these cognitive guides are not retained, attempts at overt performance are significantly flawed.

A persistent problem in the learning of many activities arises because performers cannot observe during enactment aspects of their performance which lie outside their field of vision (Bandura, 1977). For example, this problem occurs in the learning of sports skills, such as golf and tennis, and is most pronounced in the acquisition of skills for which none of the movement pattern is directly observable, as in singing. Given the importance of vision in the learning and regulation of complex motor behavior (e.g., Posner, Nissen, & Klein, 1976; West, 1967), the learner is at a serious disadvantage in attempting to enact accurately what cannot be visually monitored. Mismatches between the conceptual representation and performance are not only difficult to detect, but performers may erroneously assume that they are performing correctly. To the extent that discrepancies between the symbolic model and what is enacted go undetected, it is difficult to make corrective adjustments in performance that match the conceptual representation.

The present experiment was designed to address the problem of unobservability in the enactment of observationally-learned action patterns. All subjects observed a model perform a novel action pattern that would normally lie outside their field of vision. After each modeling trial, they were tested for their ability to reproduce what they had seen either with or without concurrent visual feedback for some or all enactments. Visual feedback was provided by allowing subjects to observe themselves in a video monitor while they were performing. It was predicted, for reasons given earlier, that the provision of visual feedback for all enactments would result in superior reproduction of the modeled action pattern than would the absence of such feedback.

It was further hypothesized that visual feedback presented prior to the development of an adequate conceptual representation of the action pattern would have little or no effect on performance since subjects would not have developed an accurate standard for using feedback correctively. To test this hypothesis, a group of subjects was given visual feedback on early reproduction trials, but had it withdrawn subsequently. If visual feedback cannot be utilized effectively without formation of an adequate conception, one would expect this group not to differ in reproduction accuracy from a group which did not receive visual feedback on any trial. Additionally, one would expect a group of subjects who performed without visual feedback on early trials, but had it introduced subsequently, to produce a level of performance comparable to that of a group that had received visual feedback on all trials.

To determine whether performance could be guided by the conceptual representation without additional presentations of the model, and whether the predicted facilitative effect of visual feedback was transitory or more enduring, all subjects enacted the action pattern on a final series of trials without the aid of modeling or visual feedback.

Method

Subjects. The subjects were 20 male and 20 female right-handed, paid volunteers who were undergraduate students at Stanford University. They were randomly assigned to four treatment conditions as they arrived at the laboratory, with the restriction that an equal number of subjects of each sex were assigned to each condition.

Modeling Stimuli and Apparatus. A male model employing a light-weight paddle (28.3 g) enacted on a video monitor a sequence of nine different response components which varied as to the spatial attributes of the paddle, arm, and wrist (see Figure 1). A light-weight paddle was chosen to minimize any heightened proprioceptive feedback that would have arisen from gains in inertia if a heavy paddle had been used. A round handle was used to eliminate orienting guides regarding the face of the paddle. The paddle consisted of a square (10.2 × 10.2 cm), white polyethylene head with a depth of 1.3 cm. The handle of the paddle, made of light pine, was 17.8 cm in length with a diameter of 1.3 cm. Each face of the paddle was painted black with the exception of an un-

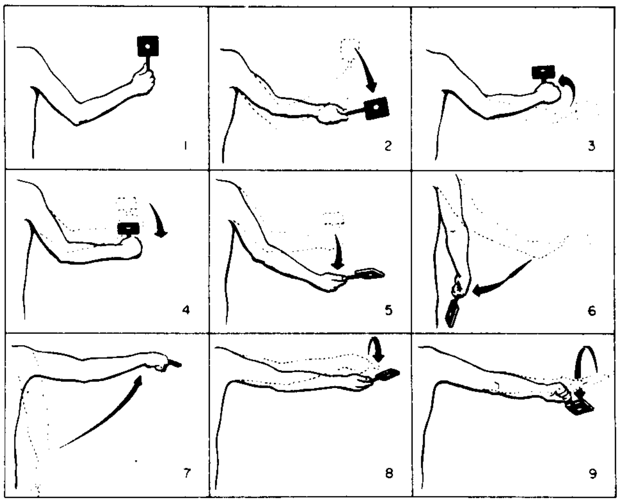

Fig. 1—Response components of the action pattern. (Arabic numerals refer to the order in which components were enacted; 1 = starting position.)

painted and centered white circle whose diameter was 2.5 cm. The sides of the head were also unpainted and, therefore, appeared white. The combination of white and black areas served to increase visual contrast and, thus, to increase visibility of the paddle.

The modeled performance began with a 5-sec demonstration of the first response component or starting position. Each of the subsequent eight response components were modeled for 2 sec, with a 2-sec transitional movement from one response component to another. The aggregate of pauses at the various positions and transitions from one position to another resulted in an overall movement sequence of 32-sec duration.

The modeled performance was recorded and played back by means of a video recorder connected to a 21-in (53.3 cm) video monitor. A video camera equipped with a wide-angle lens was located behind the model and scanned only the extreme right portion of his body. The model's performance was recorded in such a way that the visual stimuli resulting from playback would closely approximate those that subjects themselves would receive when attempting to reproduce the modeled movement pattern. A second video recorder, shielded by a large screen and connected to the same video monitor, was used to record unobtrusively subjects' enactments of the modeled movement pattern and also to play back their performance for subsequent scoring. A manual switching device connected to the two video recorders permitted subjects to observe themselves in the video monitor while they were performing. When subjects were not scheduled to receive visual feedback, the switch was placed in a position which produced a neutral gray, imageless raster on the video monitor. An additional 14-in (35.8 cm) monitor was located near the video recorders so that the operator could observe subjects' performance when no image was visible in the large monitor.

Procedure. Subjects were seated facing the video monitor. The video camera was located behind them, with the camera angle adjusted so as to make visual feedback from each subject's performance as similar as possible to visual feedback from the modeled performance.

The male experimenter told subjects that the study in which they were about to participate dealt with the effect of different types of training on the learning of movement patterns. They were then told to roll up their right sleeve, and to put on a pair of plastic safety goggles whose lenses had been removed, and whose translucent areas had been covered with black, plastic tape. They were also instructed to keep their eyes focused on the video monitor while they were performing. Although subjects in pilot research reported being unable to see their movements even when not wearing the goggles, the latter were used to further ensure the unobservability of the movement pattern.

After the standard grip for holding the paddle handle was demonstrated by the experimenter, the subject's arm was passively moved and adjusted to match the correct starting position. Subjects were then given two trials in which they practiced the correct grip and the designated starting position. They were informed that they should indicate when they had completed enactment of the modeled pattern by saying "finished." Furthermore, subjects were instructed to attend to the arm, wrist, and paddle position of the model, and to try to match their movements as closely as possible to the demonstrated movement. In the conditions providing visual feedback, subjects were informed that they would be able to see their actions in the video monitor as they performed them.

The movement pattern was modeled six times, and subjects were verbally cued to enact it after each demonstration. Immediately after each enactment, subjects were asked to rate the perceived similarity between their performance and the modeled pattern on a 7-point scale. After Trials 3, 6, and 9, subjects were shown nine photographs which depicted, in a scrambled order, each of the various positions at which the model had paused briefly. They were instructed to arrange these photos in the order which accurately depicted the sequence of component responses exhibited by the model. A maximum of two minutes was allowed for this task. The pictorial-arrangement and perceived-similarity ratings provided measures of the development of conceptual representation of the modeled pattern.

After completing the similarity-rating and pictorial-arrangement tasks on Trial 6, all subjects were informed that they would no longer see the demonstration before performing, but that they would continue the enactments of the action pattern. Subjects who were provided visual feedback were also informed that they would no longer be able to view their enactments.

Experimental Conditions. Subjects were randomly assigned to four treatment conditions; trial blocks (blocks of three trials) constituted the within-subjects factor of the 4 × 3 mixed-design ANOVA. The *vision condition* received six trials of visual feedback. The *vision–non-vision condition* received three trials of visual feedback, followed by three trials in which visual feedback was omitted. The *non-vision–vision condition* was not provided visual feedback during the first three trials, but received it on the subsequent three trials. The *non-vision condition* was not given visual feedback during any of the six trials. All subjects performed the final three trials without either the provision of a model or visual feedback.

The visual feedback provided to subjects in the present experiment should not be confused with knowledge of results. Knowledge of results is an external source of error information. In the case of visual feedback, subjects derive error information from it by comparing what they see themselves doing with their internal conception of the activity.

Response Scoring. A measure of reproduction accuracy was specified for each response component and the transition movement which preceded it. To facilitate scoring, each of the response components was played back and viewed separately by stopping the movement of the tape. Two points were awarded for each match to the model's performance that was essentially perfect. If there was a discernible, but minor, difference between the model and subjects' performance on paddle, wrist, arm position, or transition, one point was awarded. If there was a major discrepancy between the model and subjects' reproduction on one or more dimensions, or if a response component was omitted, no points were awarded. If subjects produced a response component out of sequence which would otherwise receive two points, a score of one point was awarded to reflect the error in sequencing. The maximum score possible was thus 16 points for each trial.

Two judges independently rated the reproductions of half the sample of subjects, with an equal number of performances being randomly drawn from the four experimental conditions. The overall reliability for the sum of scores achieved on the three trial blocks was $r = .98$. Reliability coefficients computed for each trial block were, in order, $r = .97$; $r = .97$; $r = .94$.

The pictorial-arrangement measure was scored by awarding one point for any two response components which were arranged in the correct sequence, excluding the starting position. A maximum score of 7 was achieved if all photos were placed in the correct sequence on a particular trial. As discussed earlier, perceived similarity between enactments and the modeled pattern was determined by subjects' ratings. The maximum score for each trial block was 21.

Results

Data for males and females were pooled since the sex factor did not approach significance on any of the three response measures ($Fs < 1$).

Reproduction Accuracy. A 4 (conditions) × 3 (trial blocks) ANOVA revealed significant main effects for conditions, F (3, 36) = 6.50,

$p < .005$, and trial blocks, $F(2, 72) = 210.24$, $p < .001$. The Condition × Blocks interaction was also significant, $F(6, 72) = 6.65$, $p < .001$. Planned orthogonal comparisons on the main treatment effect revealed that the pooled vision and non-vision–vision conditions produced significantly higher mean reproduction scores than did the pooled vision–non-vision and non-vision conditions, $F(1, 36) = 17.06$, $p < .001$. The vision–non-vision condition was not significantly different from the non-vision condition, $F(1, 36) = 1.83$, $p > .05$, nor was there a significant difference between the vision and non-vision–vision conditions ($F < 1$). Further analysis of the treatment source of variance revealed that the vision and non-vision–vision conditions were each significantly superior to the non-vision condition in reproduction accuracy, $F(1, 36) = 15.89$, $p < .001$, and $F(1, 36) = 10.30$, $p < .005$, respectively. As may be seen in Table 1, no condition showed a decrement in reproduction accuracy on the last trial block during which subjects performed without the model and without visual feedback.

Table 1
Mean Reproduction Accuracy for Treatment Conditions on Each Trial Block

	Trial Block		
Conditions[a]	1	2	3
Vision	23.30	38.40	39.40
Vision–Non-Vision	20.50	30.50	32.80
Non-Vision–Vision	20.50	37.40	38.10
Non-Vision	20.10	25.90	28.90

Note. Maximum score = 48
[a]$n = 10$

In order to facilitate interpretation of the Conditions × Blocks interaction, separate ANOVAs were conducted on each trial block. No significant difference was found on the first trial block, $F(3, 36) = 1.06$, $p > .05$. Significant difference among conditions, however, emerged on the second, $F(3, 36) = 10.84$, $p < .001$, and third, $F(3, 36) = 5.88$, $p < .005$, block of trials. Comparisons between conditions for Blocks 2 and 3 precisely mirror results obtained from the same comparisons based on the overall analysis of the main treatment effect. Subjects who had the benefit of visual feedback surpassed the performance of those who did not in both the second block of trials, $F(1, 36) = 24.16$, $p < .001$, and the final set of trials during which they performed without observing their actions, $F(1, 36) = 11.24$, $p < .005$. Visual feedback only during the initial trial block did not facilitate reproduction of the modeled action pattern, and visual feedback only during the second trial block produced equivalent gains in reproduction accuracy on the second and third trial blocks to those subjects who had visual feedback throughout both sets of trials.

Inspection of the data suggested that the learning of response components which were complex benefited more from the provision of visual feedback than did those which were relatively simple. In order to test this notion, five judges were instructed to rank independently the modeled response components according to level of complexity. Complexity was defined as the degree of perceived difficulty in determining and coordinating the joints at which movement should take place in order to make the transition to a particular component from the one immediately preceding it. Kendall's coefficient of concordance (Siegel, 1956) yielded excellent agreement among the raters ($W = .92$, $p < .001$). The sum of the ranks for each response component was then used to define operationally the three simplest and the three most complex components. Component 9 in Figure 1 was rated most complex. In addition to positioning of the paddle, enactment of this component requires a combination of flexion at the shoulder joint and pronation of the wrist.

Examination of the relationship between component complexity and visual feedback by means of a 4(conditions) × 3(blocks) × 2(component complexity) ANOVA revealed significant main effects for conditions, $F(3, 36) = 7.15$, $p < .001$, for trial blocks, $F(2, 72) = 50.30$, $p < .001$, and for component complexity, $F(1, 36) = 364.33$, $p < .001$. The latter finding reflects the superior reproduction accuracy produced by simple components as compared to those that were judged to be complex. The significant effect of conditions yielded the same pattern of significant differences previously reported for analysis on all eight response components.

A significant interaction was found between trial blocks and component complexity, $F(2, 72) = 22.62$, $p < .001$, which reflects substantial gains in reproduction accuracy on complex components, but relatively small gains on simple ones. A significant interaction was also found between component complexity and conditions, $F(3, 36) = 4.44$, $p < .01$. This interaction resulted from the lack of a treatment effect on simple components, $F(3, 36) = 1.72$, $p > .05$, and a pronounced impact on complex ones, $F(3, 36) = 9.05$, $p < .001$. Comparisons between conditions on complex components revealed the same pattern of significant results as previously reported for comparisons based on the analysis of all response components. Similarly, analysis of the significant interaction between conditions and trial blocks, $F(2, 72) = 4.77$, $p < .025$, disclosed the same pattern of significant results as those previously reported.

The triple interaction between treatments, trial blocks, and component complexity was also found to be significant, $F(6, 72) = 2.75$, $p < .025$. To clarify the meaning of this interaction, separate ANOVAs were performed on each trial block for simple and complex components. On the first block of trials, there was no difference among conditions for either simple or complex components ($Fs < 1$). On the sec-

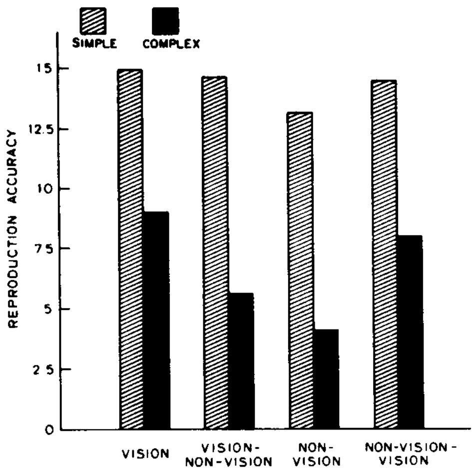

Fig. 2—Mean reproduction accuracy as a function of treatment conditions and component complexity.

ond block, significant treatment effects were found for both simple, $F(3, 36) = 4.11, p < .025$, and complex, $F(3, 36) = 8.18, p < .001$, components. On the third block of trials, significant treatment effects were found for complex components, $F(3, 36) = 8.41, p < .001$, but not for simple ones ($F < 1$).

On simple components, both the vision and non-vision-vision conditions were superior in reproduction accuracy to the non-vision condi-

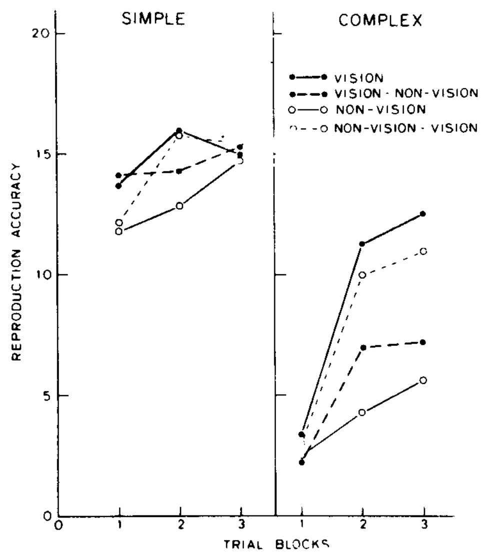

Fig. 3—Mean reproduction accuracy as a function of treatment conditions, component complexity, and trial blocks.

tion on the second trial block, $F(1, 36) = 9.11$, $p < .005$, and $F(1, 36) = 8.53$, $p < .01$, respectively. These two conditions were not significantly different, nor did the difference between the vision–non-vision and non-vision conditions approach significance. None of the conditions provided with visual feedback were significantly superior to the non-vision condition on the third or final block of trials. On complex components, in contrast, the vision and non-vision–vision conditions were superior in reproduction accuracy to the non-vision condition on both the second trial block, $F(1, 36) = 20.23$, $p < .001$, and $F(1, 36) = 13.80$, $p < .001$, and on the third trial block, $F(1, 36) = 20.29$, $p < .001$, and $F(1, 36) = 11.97$, $p < .005$. The vision and non-vision–vision conditions did not differ significantly from each other, nor was there a significant difference between the vision–non-vision and non-vision conditions on either trial block.

Development of the Conceptual Representation. A 4(conditions) × 3(blocks) ANOVA revealed that the main effect of conditions was not significant for either the perceived-similarity, $F(3, 36) = 2.42$, $p > .05$, or the pictorial-arrangement measure, $F < 1.00$. A significant main effect of trial blocks was found, however, for both the perceived-similarity, $F(2, 72) = 189.67$, $p < .001$, and pictorial-arrangement measure, $F(2, 72) = 18.23$, $p < .001$, reflecting a progressively better conception of the modeled pattern over trials. The mean scores for perceived similarity on trial blocks 1 through 3 were, in order, 8.95, 14.98, and 16.83; for the pictorial-arrangement measure, they were 3.40, 5.20, and 5.33.

Discussion

The results of the present experiment demonstrate that observational learning of a novel action pattern that normally lies outside an individual's visual field can be markedly accelerated by the provision of concurrent visual feedback. The failure to find differences in reproduction accuracy between those performing with and without visual feedback on the first trial block is consistent with the proposition that action patterns are first organized cognitively before being successfully enacted. If an adequate conceptual representation has not been developed, visual feedback provides little basis for error detection or correction, and is, therefore, ineffective in improving performance for which external reference points are lacking. The finding that independent measures of conceptual-representation development parallel increases in reproduction accuracy across trials also lends support to the necessity of developing a conceptual representation of action patterns in order for visual feedback to facilitate learning.

The conceptual representation developed as a function of exposure to modeled displays, but was not directly affected by the addition of visual feedback. Conceptions of action patterns can be extracted through repeated observation alone when constituent elements are limited and highly salient. In extended sequences of activities, observing one's enactments can help to identify those aspects that were missed or only partially learned. On subsequent observations of the same behavior, observers are apt to focus their attention on troublesome segments to fill in the missing components in the conception.

Although the present experiment was not designed specifically to determine whether visual feedback would differentially affect acquisition of simple and complex components, the results of post hoc analyses clearly indicate that visual feedback has a more pronounced effect on complex subunits of action patterns. Even when the model and visual feedback were withdrawn, subjects who enacted complex components with visual feedback on both trial blocks, or who had the benefit of it on the second trial block, continued to be superior to those who had enacted the same components without the aid of visual feedback.

Despite the fact that separate analyses of the development of conceptual representation for simple and complex components is not possible in the present study, it is likely that modeling of simple components would produce a more adequate conceptual representation since the spatio-temporal features of these components, being more familiar and less intricate, would be easier to represent cognitively. Moreover, on simple components, the coordination between kinesthetic and visual feedback arising from performance should be firmly established by past learning. One would, therefore, not expect provision of visual feedback to play a major role in the guidance of response reproduction. In contrast, cognitive representation of complex response components, consisting of subtle combinations of spatial and/or temporal features, should be less adequate. Moreover, because of less experience in coordinating visual and kinesthetic feedback arising from the performance of complex response components, one would expect provision of visual feedback to markedly facilitate accurate reproduction of what was modeled.

In contrast to the positive effect of modeling with visual monitoring of enactments, many studies employing film or videotape techniques have failed to facilitate the acquisition of complex motor skills (Keele & Summers, 1976; Singer, 1980). Keele and Summers attribute the failure of many of these studies to reliance solely on either a model or video feedback rather than on both sources of information. They argue that a model aids development of a template, but provides inadequate performance feedback for comparison with it. Video feedback without an adequate template is ineffective because there is no standard of correctness against which to evaluate such feedback. These investigators also argue that neglect of the issue of closeness of match between modeling stimuli and stimuli received from response enactment may have contributed to failures to achieve observational learning. For example, Greenwald and Albert (1968) found that observational learning of a discrete motor task is better if both the model and subject maintain the same spatial orientation. Roshal (1961) found superior observational learning of an intricate task if the camera angle used to film the modeled activity was identical to the visual feedback received by performers attempting to reproduce what they had seen.

According to Bandura (Note 1), the causes of modeling deficits must be considered within the context of the four component processes that govern observational learning (i.e., attentional, representational, motor production, and motivational processes). If observers do not selectively attend to the critical features of the modeled display, they will not extract the necessary information to construct an adequate representation of what they have seen. Narration which accompanies visual presentation has been found to enhance observational learning by directing the observer's attention to the relevant aspects of the model's performance (McGuire, 1961; Sheffield & Maccoby, 1961). The subdivision of complex actions into natural segments and emphasis of constituent skills have also been found to enhance response enactment (Sheffield & Maccoby, 1961). A further problem involving attentional processes occurs in the observational learning of response patterns that comprise subtle neuromuscular adjustments without salient, accompanying visual features. To the extent that the visual information conveyed is inadequate, failures to reproduce the modeled performance will occur (Martens et al., 1976).

In addition to attentional processes, we have seen earlier that effective observational learning requires cognitive representation of modeled events. Both symbolic coding and rehearsal of codes are critical to the formation and retention of conceptual representations which guide performance. Failure to transform modeled input into enduring symbolic codes will result in performance which is markedly flawed.

Motor production processes come into play when performers attempt to use their conceptual representation to guide behavioral enactments. Discrepancies between cognitive representation and response execution serve as cues for identifying and correcting errors. However, if visual feedback is impoverished, or unavailable to monitor performance, the detection and correction of deficits in performance will be severely hampered. In the studies reviewed by Keele and Summers, subjects do not observe their performance in real time. Instead, their performances are viewed sometime after their completion. Providing delayed visual feedback has the disadvantage of not allowing for immediate detection of mismatches between performance and cognitive representation. Subsequent attempts to reproduce the modeled behavior will then require memory of errors and their appropriate correction. Even if persons are able to effectively retain this information, they may not be able to translate it into action because the lack of visual feedback while performing may result in their erroneously assuming they are performing correctly. As suggested by the present study, this problem is apt to be most serious when enactments which require precise spatial and temporal adjustments are not fully observable.

In addition to the processes already discussed, motivational processes influence observational learning by affecting selective attention and symbolic coding and rehearsal. Insufficient incentives will also have a more direct effect on performance itself. The focus of this study centered on the acquisition and accurate enactment of a behavioral pattern. In everyday life, of course, the behavioral skills that are learned are used to secure desired outcomes. However, questions about how certain skills are best learned and the purpose they might serve address different issues. That is, knowledge about the ends does not explain how the means are best acquired. As noted, likely outcomes can augment observational learning by providing incentives for cognitive processing of modeling and feedback information.

The preceding analysis of observational learning leads to the conclusion that merely providing a model is not usually sufficient to produce mastery of modeled activities. One must consider the effect of the various processes of observational learning. Attempts can then be made to create modeling displays and informative feedback that will optimize the operation of these processes. Since visual feedback does not preclude failure to detect small differences between enactments and modeled patterns, corrective modeling (Vasta, 1976) can be used in which troublesome segments are identified and the correct ways of performing them are modeled, coded, and rehearsed.

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