The Role of Scheduling in Learning Through Observation

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ABSTRACT. In the 2 experiments reported in the present article, participants (N = 40, Experiment 1; N = 60, Experiment 2) learned to solve complex puzzles under different schedules of physical practice, observation, or a combination of the two. The results of both studies indicated that observation, in the absence of any physical practice, allows the development of an accurate but relatively nonfunctional cognitive representation. The data suggest that, even when the motor demands are minimal, the functional significance of the cognitive representation is not maximally realized until physical interaction with the task is possible. Thus, providing the participant with an interspersed practice schedule during acquisition enables that interaction to occur, thereby allowing the absolute number of physical practice trials to be reduced and replaced by observation trials, but leading to equivalent learning.

Key words: calibration, cognitive representation, observational learning

Visual demonstration has long been acknowledged as one of the most powerful means of transmitting patterns of thought and behavior (Bandura, 1986). It has been postulated that learning occurs through observation because observers are engaged in cognitive activity similar to that of the model during their exposure to the model's performance. Sheffield (1961) proposed that observers symbolically represent a model's performance through the development of a perceptual blueprint of the task to be learned. He contended that development of the perceptual code is enhanced through repeated demonstrations, and it serves as a referent against which comparisons are made between the model's performance and that of the observer. Bandura (1969, 1977, 1986) and Bandura, Jeffery, and Bachicha (1974) have proposed that when observers are exposed to a model they extract generalities or rules relating to performance of the task, rather than specific stimulus–response associations. They combine those rules to form a cognitive representation that influences their performance in two ways. First, the representation provides an approximation of the task that is used to guide their initial attempts. Second, continued exposure to the model results in the development of error detection and correction mechanisms that the observers can use to evaluate the adequacy of their own performance. Adams (1971) and Schmidt (1975) have suggested similar mechanisms in their attempts to describe the learning of motor skills through physical practice.

The functional relationship between physical practice and observational learning has received little attention in the literature. However, evidence has been provided that suggests observational learning and learning through physical practice do share commonalities for the acquisition of a timing task. Specifically, the contextual interference (CI) effect, which is found in the learning of skills through physical practice, has been replicated within the observational learning paradigm (Blandin, Proteau, & Alain, 1993, 1994; Wright, Li, & Coady, 1994). To more completely understand the roles of physical practice and observation in the learning of a novel skill, one must assess both the isolated and the combined effects of those two variables. If learning through observation and physical practice are mediated by similar underlying processes, the use of an interspersed schedule of observation and physical practice trials during acquisition will not allow one to dissociate the effect of both variables on the learning of a novel skill.

Few researchers have used a learning paradigm in which all observation trials occur prior to any physical practice on the task. Carroll and Bandura (1990) had two groups of observers watch a videotape of a model who was complet-

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ing a serial spatiotemporal pattern. They reported that the group who observed the video eight times prior to their own attempt at reproduction performed significantly better on the task than did those observers who observed the model perform only two trials. Although no physical practice group was included, Carroll and Bandura's work illustrated that performance is enhanced by the opportunity to observe and that the number of observation trials has an incremental effect on performance: More was better.

Blandin, Lhuisset, and Proteau (in press) evaluated the effect of observational learning on the learning of a specified timing sequence for a four-segment barrier-knockdown task (Shea & Morgan, 1979). The authors reported a significant but modest advantage for their observation group over physical practice groups, which was enhanced following subsequent physical practice with the experimental task and knowledge of results (KR).

Blandin and Proteau (in press, in Experiment 1) reported a similar pattern of results in an experiment in which the development of an error detection mechanism through observation was evaluated. Participants either physically practiced a three-segment barrier-knockdown task in a criterion movement time of 900 ms or they observed either a perfect or a learning model performing the task. Following 18 trials of practice or observation with KR, all participants performed 12 immediate retention trials. The results indicated that the observation groups did not perform as well as the physical practice group. However, the observation groups did achieve equivalent performance on the barrier-knockdown task with subsequent physical practice.

Collectively, those findings suggest that learning through observation is mediated by processes very similar to, but not as well developed as, those underlying learning through physical practice. Nonetheless, Blandin and his colleagues have shown that following very few physical practice trials with KR, observers can attain performance levels similar to participants who have had physical practice on the task. That finding provides support for previous work by Ross, Bird, Doody, and Zoeller (1985), who reported that an interspersed schedule of observation and physical practice is an effective means of learning a new task.

**EXPERIMENT 1**

In the first experiment of the present study, we tested the hypothesis that the effects of observational learning are not fully accessible until participants have the opportunity to physically interact with the task. To provide a strict test of the hypothesis, and to reduce possible confounds with motor production demands, a task with minimal physical demands was employed.

Assessment of the first physical practice trials performed by all participants is one method for determining what observation provides for the initial motor production attempts of the observer. The first physical practice trials would represent the first exposure to the task for the 100% physical practice group, whereas the observation groups will have had varying numbers of observation trials prior to their first attempt at the task. Equivalent performance on the first physical practice trials between a physical practice group and observation groups would suggest a very limited role for observation in the development of a functional cognitive representation that is capable of guiding initial performance on a task. However, if the cognitive representation does develop but remains latent until the participant interacts with the task, one would expect similar performance across groups following very few physical practice trials for the observation groups.

**Method**

**Participants**

Forty undergraduate students from the Département de kinesiologie at the Université de Montréal participated in this experiment. All participants were naive as to our goals in the experiment.

**Tasks**

We conducted the experiment by using the puzzle task from the TRAIL program (Deakin, 1992); participants completed the experiment on a laboratory computer. The participants used the arrow keys on a computer keyboard to move a set of "boxes" through a maze-like puzzle to specified endpoint locations. Movement of the boxes via the cursor was constrained by two rules: First, boxes could only be pushed, and second, they could be pushed only one at a time. Within those rules, the program afforded flexibility in both puzzle construction and completion alternatives. With the program, we recorded the pattern being executed and obtained outcome information on the number of moves, the number of pushes, the number of boxes successfully placed, and the total time on the task. The program also kept a separate record of all keyboard activity made by the participants.

Each of the three puzzles used required the movement of eight boxes to specified endpoint locations. The presentation of puzzles was randomized within each block of three trials. An example of one of the test puzzles is illustrated in Figure 1.

**Experimental Groups and Procedure**

All participants had to learn how to solve each of the three test puzzles. They were instructed to exit the puzzle as soon as they realized that they had made a move that precluded completion of the puzzle. Participants took part in three experimental sessions: two sessions of acquisition and retention (Day 1 and Day 2), and one session each of long-term retention (LTR) and transfer (Day 3). On Day 1 they were randomly assigned to one of five groups (n = 8). The groups differed in the schedule of acquisition trials they were exposed to. The five groups included an only physical practice group (100% pp), a 100% observation group (100% obs), a 50% observation–50% physical practice group (50% obs), a 75% observation–25% physical practice...
group (75% obs), and a control group. Although the number of exposures to each puzzle was held constant across the four experimental groups, the amount of physical practice each group had with the task during the acquisition phase was different.

The 100% pp group completed 36 acquisition trials per day for 2 days. The 100% obs group watched the computer generate solutions over the 36 acquisition trials per day for 2 days. The 75% obs group watched the computer solutions for Trials 1–9, 13–21, and 25–33 and performed Trials 10–12, 22–24, and 34–36 each day, whereas the 50% obs group watched the computer generate the solutions for Acquisition Trials 1–6, 13–18, and 25–30 and performed Trials 7–12, 19–24, and 31–36 each day. Finally, the control group participated in only the retention and transfer tests. Therefore, the amount of physical practice with the task during acquisition decreased from 36 trials for the 100% pp group, to 18 trials for the 50% obs group, to 9 trials for the 75% obs group, and to 0 trials for the 100% obs group.

Each acquisition trial was followed by summary feedback in the form of the number of moves made, number of boxes placed, and total time on task. That information was displayed on the screen. Participants were informed that the object of the task was to solve the puzzle and therefore that time to completion and number of moves were not relevant in the absence of a complete solution. Participants in the 100% pp group received feedback on their performance, whereas the 100% obs group received the model’s (i.e., the computer’s) summary feedback. Participants in the two interspersed schedule groups received the model’s summary feedback on their observation trials and feedback on their own performance during their physical practice trials. Because the computer generated a complete solution on each trial, the information provided was the time to completion and the number of moves the computer made to complete the puzzle. Following acquisition on each of Day 1 and Day 2, all participants performed six retention trials.

They consisted of two blocks of three trials presented in random order. On Day 3, they performed two trials of a transfer puzzle and an LTR test on the original puzzles. The transfer puzzle adhered to the identical rule structure as the original puzzles. Participants attempted to move a total of 14 boxes to endpoint locations. No feedback was provided during the retention, LTR, or transfer trials.

**Results and Discussion**

Separate analyses were conducted on total time on task and the number of boxes placed for each of the retention, LTR, and transfer tests. Additional analyses were conducted on the acquisition trials of the relevant experimental groups. Because the pattern of results did not differ across dependent measures, we report only the data concerning the number of boxes placed. In addition, because the participant’s first mistake was identified in the analysis program, the number of boxes placed was partitioned into two subsets: the number of boxes placed before and those placed after the first mistake. Preliminary comparisons of analyses on the total number of boxes placed with the number of boxes placed prior to the first mistake provided a similar pattern of results. Therefore, we report only the results of the analyses computed on the proportion of boxes correctly placed. All significant effects are reported at $p < .05$, and we computed post hoc comparisons of the means by using the Tukey least significant difference technique. Because the epsilon values for all analyses equaled 1, original degrees of freedom are reported.

**Performance in Acquisition**

First, we wanted to determine the influence of the type of practice on acquisition of the task. To reach our goal, we contrasted the performance of the 100% pp, 50% obs, and 75% obs groups for Trials 10–12, 21–24, and 33–36 for each of the two acquisition sessions. The data were submitted to a 3 (group) $\times$ 2 (day) $\times$ 3 (block) mixed analysis of variance (ANOVA) with repeated measures on the last two variables. The data of interest are illustrated in the acquisition panels of Figure 2.

The results of the ANOVA revealed a significant effect of group, $F(2, 21) = 8.53$, indicating that the 100% pp and the 50% obs groups placed a higher proportion of the boxes (79% and 76%, respectively) than did the 75% obs group (61%). Those results indicate that observation had a positive influence on performance, in that the 50% obs group performed as well as the 100% pp group, although they had had only half the number of physical practice trials. However, the poorer performance that was noted for the 75% obs group suggests that optimal performance might only be achieved through sufficient physical interaction with the task. In addition, the ANOVA revealed a significant interaction of Day $\times$ Block, $F(2, 42) = 4.76$, which confirmed that participants placed fewer boxes on the first block of Day 1 (51%), than on the subsequent blocks on Days 1 and 2 (mean of 75%).

**FIGURE 1.** Puzzle task from TRAIL program.
The Effects of Different Schedules of Practice on Learning

In this section, we evaluated how learning of the task was influenced by the different schedules of practice when the total number of exposures to the task was equated. To reach our goal, we submitted the data on the proportion of boxes placed in retention to a 5 (group: 100% pp, 100% obs, 50% obs, 75% obs, control) x 2 (day) x 2 (block) x 3 (puzzle) mixed ANOVA with repeated measures on the last three variables. The ANOVA revealed a significant main effect of day, F(1, 35) = 8.26, indicating that participants improved from a placement proportion of 71% on Day 1 to 81% on Day 2. Furthermore, the ANOVA revealed a significant Group x Puzzle interaction, indicating that although performance was similar across groups on Puzzles 2 (83%) and 3 (81%), the 100% obs and the control groups placed a lower proportion of boxes on Puzzle 1 than did the remaining three groups (36% versus 73%). That finding suggests that Puzzle 1 was somewhat more difficult to learn than the other two puzzles.\(^1\)

Finally, and perhaps more important, the ANOVA indicated a significant Group x Block interaction, F(4, 35) = 2.62. For the first block in retention, the groups who had physical practice during acquisition outperformed the 100% obs and the control groups. On the second block, however, the 100% obs group became significantly better than the control group and equivalent to the three groups who had at least some physical practice during acquisition. The high interparticipant variability may have masked some potentially important effects. For example, as illustrated in Figure 2, for Day 1, Block 1, the groups who had physical practice during acquisition (100% pp, 50% obs, and 75% obs) outperformed the 100% obs and the control groups (means of 83% and 57%, respectively). However, by the 2nd block of Day 1, the 100% obs group became significantly better than the control group and became equivalent to the three groups who had at least some physical practice during acquisition. The control group was able to achieve and maintain a performance level equivalent to those of the experimental groups by Block 1 of Day 2.

The relatively poor performance of the 100% obs group in the first block of retention is consistent with much of the research discussed earlier and indicates that observation per se does not immediately lead to good performance. However, because three trials of physical practice were sufficient to enable this group to perform as well as the 100% pp group, it appears that observation provided the "shell" or structure for successful performance of the task. Access to that structure could be refined only after the participants had the opportunity to interact directly with the task. Given that the only physical interaction necessary in the present study was simple key pressing, possibly the number of trials of physical practice necessary for this fine-tuning to take place increases as a function of the complexity of the motor task.\(^2\)

LTR Trials

The results of the LTR analysis corroborated the preceding findings. Specifically, the Group (100% pp, 100% obs, 50% obs, 75% obs, and control) x Puzzle (1–3) mixed ANOVA revealed a significant interaction between those two factors, F(8, 70) = 2.02, p = .05. That interaction indicates that the control group placed a lower proportion of boxes (62%) than the remaining four groups for Puzzle 1 (mean of 96%) and that there were no group differences on

![Figure 2](chart.png)

**FIGURE 2.** Experiment 1. Group x Day x Block interaction for acquisition, retention, and long-term retention trials. During acquisition, the 100% pp, 100% obs, 50% obs, 75% obs, and control groups received, respectively, only physical practice (pp), only observation, equal proportions of observation and physical practice, 75% observation and 25% physical practice, or neither physical practice nor observation.
Puzzles 2 and 3 (means of 95% and 93%, respectively). As alluded to earlier, that finding suggests that although Puzzle 1 was somewhat more difficult to solve, its solution had been acquired through observation by the 100% obs group.

Analyses of Performance During Transfer Trials

We evaluated transfer trials to determine whether participants acquired the underlying rules of the task so that they could use those rules to solve different and more complex puzzles. The Group (100% pp, 100% obs, 50% obs, 75% obs, control) x Attempt (1–2) mixed ANOVA yielded no significant effects. The percentage of boxes placed across all groups was 68%, with a range of 57% to 76%. Given that the performance on the transfer puzzle was similar to that during retention, it is apparent that all groups were equally able to apply the basic rule structure to the solution of the new puzzle.

The results of these analyses support the proposition that when one assesses performance by means of various retention tests, the scheduling of observation and physical practice trials is found to affect performance. Analyses of performance during the acquisition phase of the experiment provided additional information regarding the performance curves of the 100% pp, 50% obs, and 75% obs groups. Furthermore, the incremental effect of a fewer number of either physical practice or observation trials can be more closely assessed.

Analyses of the First Physical Practice Trials

To test the hypothesis that the effects of observation remain latent until after a learner has had an opportunity to interact with the task, we examined the first three physical practice trials in one-way ANOVAs on all groups. Acquisition Trials 1–3 (100% pp), 7–9 (50% obs), and 10–12 (75% obs) were analyzed with retention Trials 1–3 for the 100% obs and control groups. In spite of differential exposures to the task, which favored the observation groups, no between-group differences were found. Participants placed a mean of 48% of the boxes (100% pp, 51%; 100% obs, 61%; 75% obs, 40%; 50% obs, 42%; control, 52%), $F = 0.472$. The equivalence in performance of the first three physical practice trials is consistent with earlier findings (i.e., Blandin et al., 1994; Ross et al., 1985; Weir & Leavitt, 1990). It seems clear that the effects of observation on the learning of a new task are limited and are not apparent until the individual has had the opportunity to interact with the task. The rapid improvement in performance that was seen in the second block of retention trials for the 100% obs group in the present study illustrates the positive effect of observation on learning.

Conclusions

Learning through observation, in the absence of any physical practice, seems to allow the development of a cognitive representation, which is not easily accessible in early performance trials, and requires that the participant have some interaction with the task to become as efficient as that developed through physical practice. We have found no evidence to suggest that the characteristics of that representation are different from the one developed through physical practice. In the present study, however, all participants including the control group were provided with the two basic rules that underlie success on the TRAIL puzzle task, namely, that boxes could only be pushed and they could be pushed only one at a time. If the essence of the cognitive representation developed through observation is based on the rule structure of the novel task, then explicitly providing the two rules to all participants may have masked any between-groups differences in the development of the representation. In fact, providing the rules to all participants might have masked some benefit of observation per se. Specifically, had that information not been provided, one might expect that the quality and rate of development of the representation in retention would have been better for the 100% obs group than for the control group. Those issues were addressed in Experiment 2.

EXPERIMENT 2

Method

Participants

Participants were 60 undergraduate students who had not been involved in Experiment 1. All participants were naive as to our goals in the experiment and were unfamiliar with the TRAIL task.

Tasks

The identical puzzle tasks from the TRAIL program were used in this experiment. All instructions were removed from the display screens. All participants were aware that the arrow keys controlled the movement of the cursor on the display. The presentation of puzzles was randomized within each block of three trials.

Experimental Groups and Procedure

Twelve participants were randomly assigned to each of five groups (100% pp, 100% obs, 50% obs, 75% obs, and control). Given that the second acquisition session during Experiment 1 did not result in superior performance across groups in retention, participants in Experiment 2 received only one session of acquisition trials. Following exposure to 36 acquisition trials on Day 1, all participants completed 6 no-KR retention trials and 4 transfer trials. On Day 2, they completed an additional 6 LTR and 4 transfer trials. The within-group ratios of physical practice to observation trials during acquisition were the same as in Experiment 1. Similarly, participants in the 100% pp group received feedback on their own performance during acquisition, whereas participants in the observation and interspersed groups received the computer's summary feedback on the observation trials and feedback on their own performance during their physical practice trials.
Results and Discussion

Performance in Acquisition

We undertook analyses of the acquisition data for the 100% pp, 50% obs, and 75% obs groups to examine whether different ratios of physical practice to observation trials affected performance early in acquisition. As in Experiment 1, by computing the analyses on Acquisition Trials 9–12, 21–24, and 33–36, we controlled for the total number of exposures. The Group × Block ANOVA on the proportion of boxes placed correctly resulted in a significant main effect of block, $F(2, 66) = 18.27$, and a Group × Block interaction, $F(4, 66) = 3.14$. As illustrated in the left panel of Figure 3, a post hoc comparison confirmed that the 100% pp group performed better than the 50% and 75% obs groups in the first acquisition block. There were no group differences in the second block, but both the 100% pp and the 75% obs groups placed a higher proportion of boxes than the 50% obs group in Block 3. That pattern of results suggests that both observation groups' poorer initial performance may have been caused by their limited physical interaction with the task. The usefulness of the observation trials was displayed most dramatically by the 75% obs group, who attained equivalent performance with the 100% pp group throughout acquisition, although they had performed only 25% of the total number of trials.

The Effect of Different Schedules of Practice on Learning

Group (100% pp, 100% obs, 50% obs, and 75% obs, and control) × Puzzle (1, 2, 3) × Retention Phase (retention, LTR) × Block (1, 2) ANOVAs were conducted on the proportion of boxes correctly placed data for the retention trials of each group. Significant main effects were found for group, $F(4, 55) = 9.76$, puzzle, $F(2, 110) = 30.77$, and phase, $F(1, 55) = 29.20$. The interaction of Group × Puzzle, $F(8, 110) = 2.85$, was similar to the results of Experiment 1. The control group did not perform as well as all other groups on Puzzle 2 but performed similarly to the 100% obs and 50% obs groups on Puzzle 3. The 50% obs group and the control group displayed a marginally poorer performance on Puzzle 2 than the remaining three groups did. We take that finding as evidence that when no rules are provided, the participants have difficulty determining the key factors necessary to solve the puzzles. In this case, not only was the very subtle and specific move related to Puzzle 1 not available to the control group, but they also had difficulty with the more general rules, as evidenced by their poorer performance on Puzzle 2. We do not have an explanation as to why the control group had less difficulty with Puzzle 3. Perhaps the initial configuration of the boxes in Puzzle 3 allowed for more direct access to the endpoint locations.

The interaction of Group × Block, $F(4, 55) = 3.46$, was superseded by a significant three-way interaction of Group × Phase × Block, $F(4, 55) = 4.29$. The source of the three-way interaction was revealed when separate analyses were computed for each experimental phase. The interaction is displayed in Figure 3.

In retention, (see the middle panel of Figure 3), the significant Group × Block interaction, $F(4, 55) = 7.00$, indicated that on the first block of trials both the 100% pp and the 75% obs groups outperformed the 50% obs and 100%

![Figure 3](image-url)
obs groups, who, in turn, outperformed the control group. The 50% obs group improved their performance from Block 1 to Block 2; in Block 2 they performed as well as the other groups who had some physical practice during acquisition. Thus, in the 2nd block, all groups who had some physical practice in acquisition performed better than the 100% obs group, who outperformed the control group. In LTR, all four experimental groups performed similarly but significantly better than the control group, \( F(4, 55) = 3.66 \).

Unlike the results of Experiment 1, the consistently better performance noted for the 100% obs group, in comparison with the control group, is indicative of the value of observation of the task during the acquisition phase. The fact that observation benefited the 100% obs group on Block 1 of immediate retention suggests that the effects of observation do not remain completely inaccessible prior to physical practice. That this representation does not remain totally dormant prior to physical practice may be indicative of the overriding rule-based nature of the present task, which could have diminished the need for a physical interaction with the task before the effect of observation was evident. Converging evidence from two sources supports that proposition. First, the superior performance of the 100% obs group over the controls in Experiment 2 resulted entirely from the latter group’s drop in performance during the 1st block of retention between Experiments 1 and 2. Specifically, in Experiment 1, where all participants were provided with the rules of the task, the control group attained an average accuracy of 54%. The 100% obs group averaged 62% accuracy for the same block. Conversely, in Experiment 2, in which there was no explicit knowledge of the rules provided before the 1st retention block, the control group averaged 32% accuracy, which is significantly lower than the percentage found in Experiment 1, whereas the 100% obs group averaged 60% accuracy. We take that finding as evidence that the 100% obs group was able to acquire the specific rules from observing the acquisition trials in Experiment 2 as efficiently as they did when they were provided with the rules in Experiment 1. Second, when the LTR performance of the control group in Experiment 2 was examined (60% accuracy), it was clear that the control group’s accuracy was consistent with that of the 100% obs group in immediate retention (60%) as well as with the control group performance during the retention trials of Experiment 1 (58%). We take that finding as further evidence that access to the rules of the task allows for a 50 to 60% accuracy level, whereas performers require physical interaction with the task following observation to elevate their performance to 70–90%.

Analyses of Performance During Transfer Trials

We evaluated transfer trials to determine whether the rules of the task were sufficiently developed and were useful in defining a solution path for a more detailed puzzle. We were also interested in whether the representation developed through exposure to a perfect model would be flexible enough to be useful in the solution of a novel puzzle. The Group \( \times \) Day \( \times \) Block mixed ANOVA yielded a significant main effect for day, \( F(1, 55) = 15.49 \). The mean proportion of boxes placed increased from 63% on Day 1 to 74% on Day 2. Similarly, the main effect for block, \( F(1, 55) = 11.83 \), indicated that performance improved from 64% on Block 1 to 74% on Block 2. The equivalence of performance across groups, \( F(4, 55) = 1.13, p > .35 \), suggests two things. First, six physical trials on the task for the control group were adequate for them to derive the underlying rules of the task and apply them to the transfer puzzle. Second, the 100% obs group was not disadvantaged by having been exposed to perfect solutions of the original test puzzles during their observation trials.

Generally, the results of the analyses for retention, LTR, and transfer trials corroborated the findings of Experiment 1. Performance by the 100% pp and the 75% obs groups was similar in both experiments. The transmission of rule-based information through observation alone was evident from the performance differences between the 100% obs and control groups during retention trials of Experiment 2. The fact that all four experimental groups performed better than the control group in retention but not in transfer suggests that the experimental groups gained some specific knowledge concerning each of the puzzles used in the acquisition and retention tests. The fact that that knowledge did not easily transfer to the new puzzle used in transfer suggests that what was learned was specific to the puzzles used in acquisition. The exact reason for that specificity escapes us at the present time. It might be that the number of acquisition trials was not sufficient for the participants to fully extract the basic rules of the game. Nonetheless, the similar pattern of results noted in retention and in transfer for the 100% obs and the 100% pp groups underlines the similarity of the representation of the game developed under those two types of practice.

Analyses of the retention data in Experiment 2 produced a different pattern of results from those found in Experiment 1. Although the difference between experiments can be attributed to the poorer performance of the control group in Experiment 2, it does not alter the fact that some benefit of observation was immediately available to the 100% obs group. A further test of the hypothesis can be derived from the analysis of the first physical practice trials across all groups.

Analyses of the First Block of Physical Practice Trials

An analysis of the first three physical practice trials was carried out so that we could examine whether the positive effects of observation were accessible during early attempts at performing the task. If a cognitive representation of the task, developed in the absence of any prior physical practice, could drive performance, then all observation groups should exhibit better first block performance than the 100% pp or control groups. If, however, the effects of observation remain latent until after participants have interfaced with
the task, then no group differences should be evident. The one-way ANOVA on group for the number of boxes placed did not reach significance, $F(1, 4) = 1.51, p < .20$. The absence of group differences in the first block of three trials (see Table 1 for detailed data) was consistent with the results of Experiment 1. Given strong a priori justification for a direct comparison of the 100% pp and 100% obs groups, we conducted a Student $t$ test. The $t$ value of $-2.05$ did not reach statistical significance. Those findings are supportive of our proposition regarding the latent effects of observational learning.

**GENERAL DISCUSSION**

In the present study, the impact of different acquisition schedules of observation and physical practice trials on the learning of a rule-based task was examined. The ability of learners to derive and use the knowledge of task constraints for successful completion of the task as a function of acquisition schedule was also investigated.

The results of Experiment 1 indicated that the schedule of observation versus physical practice trials during acquisition did affect performance, as measured by retention trials. Participants who received any physical practice during acquisition attained higher performance scores early in retention than participants who received only observation trials during the same period. In fact, our results demonstrated that performance equivalent to a physical practice group who received 36 trials was attained not only by a group who received 50% physical practice and 50% observation but also by a group who received physical practice on only 25% of trials with observation on the remaining 75% of the trials. Thus, it seems that observation might, in some instances, be used instead of physical practice (see also Blandin et al., in press; Blandin & Proteau, in press).

The impact of scheduling of observation and physical practice trials became more obvious when the results of the pure observation group were assessed. The comparison of the performances of the control group and the 100% observation group in Experiments 1 and 2 indicated that one of the major contributions of observation to the performance of our experimental task was that it permitted observers to learn the rules of the task. That aspect of the results supports previous propositions that it is the transmission of underlying rules related to the task that occurs through observation (Bandura, 1969, 1977; Blandin et al., in press; Blandin & Proteau, in press).

The full benefit of observation appeared only after the participants had had opportunity to interact with the task. Specifically, we have shown that, when the game’s rules were known to all participants, the initial performance of the group who received only observation trials during acquisition did not differ from the performance of the control group. After only three trials of physical practice on the task, however, the observation group was performing at a level similar to all the groups who received physical practice during acquisition, and outperformed the control group. In addition, the between-groups comparison of the first three physical practice trials across all groups once again highlighted the need for physical practice with this task in order for the full benefit of observation trials to be realized. It should be noted that following 36 trials of observation, the observation group was no more successful on its first three trials of physical practice than were any of the physical practice groups on their first three trials. If that were the only comparison made, one would have to conclude that observation played no role in the acquisition of this rule-based task.

Our results are consistent with many of the reports in the literature that observers who have not been in an interspersed acquisition schedule do not perform as well as participants who have had physical practice on the task. Furthermore, it should be remembered that in the task used in the present study participants required only simple key presses to solve the puzzles, and yet the assessment of the first physical practice block indicated that performances were similar across groups. It was only following the first block of trials that the effects of observation became apparent. We expect that the amount of physical practice necessary will vary as a function of the motor demands of the task. We are currently examining that hypothesis by using a task in which the motor demands are much higher.

The results of this study support the contention that observation can be an effective means of transmitting task-relevant information on a rule-based task. Furthermore, that information, regardless of the scheduling of acquisition trials, seems to be specific to “known” puzzles. The fact that this relative specificity occurred for both the 100% pp and the 100% obs groups suggests that what was learned under those two practice schedules was achieved through very similar processes. However, the functional significance of the cognitive representation that develops through observation remains relatively inaccessible until after the participant has interacted with the task. For motor skills, it seems clear that the interaction should be of a physical nature. Pro
viding an interspersed practice schedule during acquisition enables that calibration to occur, thereby allowing the absolute number of physical practice trials to be reduced and replaced by observation trials. Under those circumstances, one would expect that equivalent performance will occur during retention.

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NOTES
1. The critical move in Puzzle 1 required that a specific box be moved away from the endpoint location so that other boxes could be moved to the final positions. That pattern of movements amounted to creating an interim position for the box prior to moving it to a final position. The 100% obs group appeared to be unable to pick up that subtlety through their observation trials. Their performance on this puzzle was not significantly different from that of the control group; participants in the control group were unaware of any particular strategies prior to their initial physical attempts.

2. We ran a control experiment to investigate whether the differences in performance noted between the physical practice and the observation groups were caused by the fact that, although the observers could see how the computer solved the puzzle, they could not see the corresponding sequence of keystrokes. Twelve participants observed the computer solve the puzzle as in Experiment 1, whereas a second group of 12 participants observed a human model solving the puzzles. The human model was an expert who solved the puzzle while respecting the time frame used by the computer and using the same sequence of keystrokes. Thus, participants in the latter group observed both the displacement of the boxes on the computer screen as well as the keystrokes causing those displacements. The results of this experiment did not reveal any difference between the two groups in a retention test, $F(1, 22) = 1.59, p > .22$. Therefore, one could conclude that having the computer solve the puzzle without seeing the corresponding action on the computer keyboard did not, in itself, account for the difference in learning found between the two groups.

3. We wanted to determine whether the performance of the control groups in Experiments 1 and 2 was significantly different. To reach that goal, we compared the performance in retention of the control group in Experiment 1 (explicit knowledge) with the performance of the control group in Experiment 2 (no explicit knowledge). The ANOVA yielded significant main effects for Experiment 1, $F(1, 3) = 4.75$, and experimental session, $F(1, 18) = 10.12$. Therefore, the differences in performance between the control groups of the two experiments can be attributed to the explicit provision of the rules for all participants in Experiment 1.

REFERENCES


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