

# Effectiveness of the Use of a Learning Model and Concentrated Schedule in Observational Learning of a New Bimanual Coordination Pattern

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The present research examined the interaction between the skill level of a model (an expert or learning model) and a learning schedule (alternating observation and practice; or concentrated observation and practice, respectively) on acquiring a new bimanual pattern of 90 degrees relative phase. Five groups were compared: alternating-expert, alternating-learning, concentrated-expert, concentrated-learning and physical practice only. The concentrated-learning group performed better than alternating-expert, alternating-learning, as well as physical practice only learning schedule groups in retention tests. This seemed to arise from the effectiveness of concentrated observation throughout the improvement processes exhibited by the learning model.

**Keywords:** observational learning, learning model, concentrated observation schedule, bimanual coordination

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## 1. Introduction

Observational learning relates to learning where an observer's behavior changes after viewing or witnessing the display of behavior of a model. The functional role of observation is that through this learners can understand what they should do for a certain task and how it should be done. Information obtained by observational learning includes series of movements in a continuous flow of motion [Whiting, Bijlard, & den Brinker, (1987)], timing information [Zelaznik, Shapiro, & Newell, (1978)] and strategies used by a model [Martens, Burwitz, and Zuckerman, (1976)]. Many researchers of observational learning use expert models [Carroll & Bandura, (1990); Weeks, Hall, & Anderson, (1996)], and observing an expert

model can provide learners with information on goals and objectives of learning. However, some research suggests that learning models, which shows a process where the novice develop skills, can be effective for observational learning [McCullagh & Caird, (1990); McCullagh & Meyer, (1997); Pollock & Lee, (1992)]. Observing a learning model allows learners to watch early learning stages that a model may experience and provides learners with information regarding what to do and how that should be done in each learning stage.

Although Twitmyer (1931) originally used a learning model in his early research, Adams (1986) was the first to suggest the use of a learning model, showing that an observer, who observed a learning model and shared the knowledge of result with a learning model, had an improvement in performance.

However, learners who only observed a learning model, but were not told the knowledge of results did not improve their performance. Therefore, observers can gain a great deal of information from observing the performance of a model, sharing knowledge of the result with a model, and also observing how the performance is to be improved in the following attempt using knowledge of the result [Schmidt & Lee,(1999)]. Thus, observers may have much to learn from witnessing a problem-solving process that a model is engaged in. Some research compared a learning model with an expert model to verify this hypothesis with McCullagh and Meyer (1997) finding no difference in the learning effect between an expert model and a learning model. However, McCullagh and Caird (1990) showed that a learning model including the use of knowledge of result was seen to be more effective than an expert model. Therefore, no definitive answer has been given as to which of the two models, expert or learning, provides a more effective means of learning.

Recently some researchers [Newell & McDonald, (1992)] argue that the knowledge acquired in the research where the task is parameter learning (coordination between the body and the limbs is already developed, and the objective of learning is attaining optimal parameter conditions) may produce different results from targeting coordination learning (where coordination between the body and the limbs is yet to be developed).

Further, Schmidt and Lee (1999) suggest that guided instructions may not be effective in parameter learning, but could be effective in coordination learning. One possible reason why previous research (e.g., McCullagh and Meyer, 1997) found no difference in learning effects between an expert model and a learning model is that these research experiments did not use coordination learning, which is intended to develop new coordination patterns, but parameter learning, which is designed to adjust parameters such as speed and energy force in order to determine details of an already developed coordination pattern. Through coordination learning, learners will, on occasion, need to develop new coordination patterns that require compensatory relationships among parameters, in addition to adjusting and assigning parameter values. In this case, it is expected that a learning model where a goal is to be achieved

through a trial and error process, may be more effective in comparison with an expert model, which provides an example of perfect technique. In order to adapt the knowledge of observational learning to the practical and educational activities in sports or gymnastics, it may be necessary that research selects a task developing new coordination patterns so as to examine the issues of an expert model and a learning model in observational learning.

Also of importance is the role of the schedule in observational learning. In previous research carried out to verify a skill level of a model in observational learning, the model's schedule was not rigorously controlled. For example, in the research conducted by McCullagh and Caird (1990), participants in an observational learning group attempted 6 blocks, with each block consisting of 5 physical practice trials performed after 5 observation trials. In a different study, McCullagh and Meyer (1997) used learning schedules where participants in an observational learning group were instructed to perform a physical practice trial after an observation trial, repeated over 5 cycles. This type of schedule requiring participants to repeat a physical practice trial and an observation trial in turn, is known as an alternating style of observational learning. There is also a schedule where participants perform all physical practice trials only after they have completed all observation trials. This type of schedule, used by Adams (1986), and Lee and White (1990), is a concentrated style of observational learning. In alternating schedules, as observers improve their performance gradually through learning, it is likely that skill levels of observers are close to those of learning models, and observers acquire information from models as required. Therefore, it is expected that an alternating schedule using a learning model is to be more effective than a concentrated observation schedule with the use of a learning model, or either of two schedules using an expert model. However, no comparison of these two types of observation schedule has been conducted.

The purpose of this study is to examine the interaction between the skill level of a model (an expert or learning model) and learning schedule (alternating observation and practice; or concentrated observation and practice, respectively) on acquiring a new bimanual pattern. The other purpose is to examine the effect of observational learning not

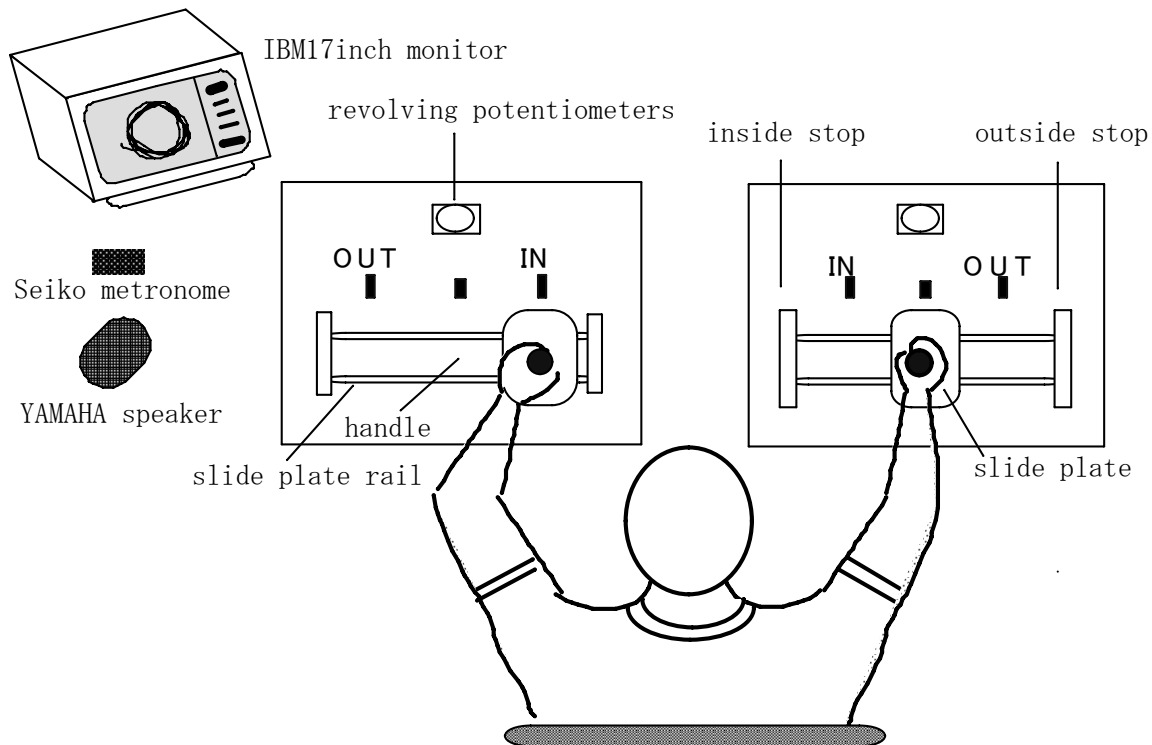


Figure 1 Movement apparatus.

by using a parameter adjustment task but a new coordinating learning task.

## 2. Methods

### 2.1. Participants

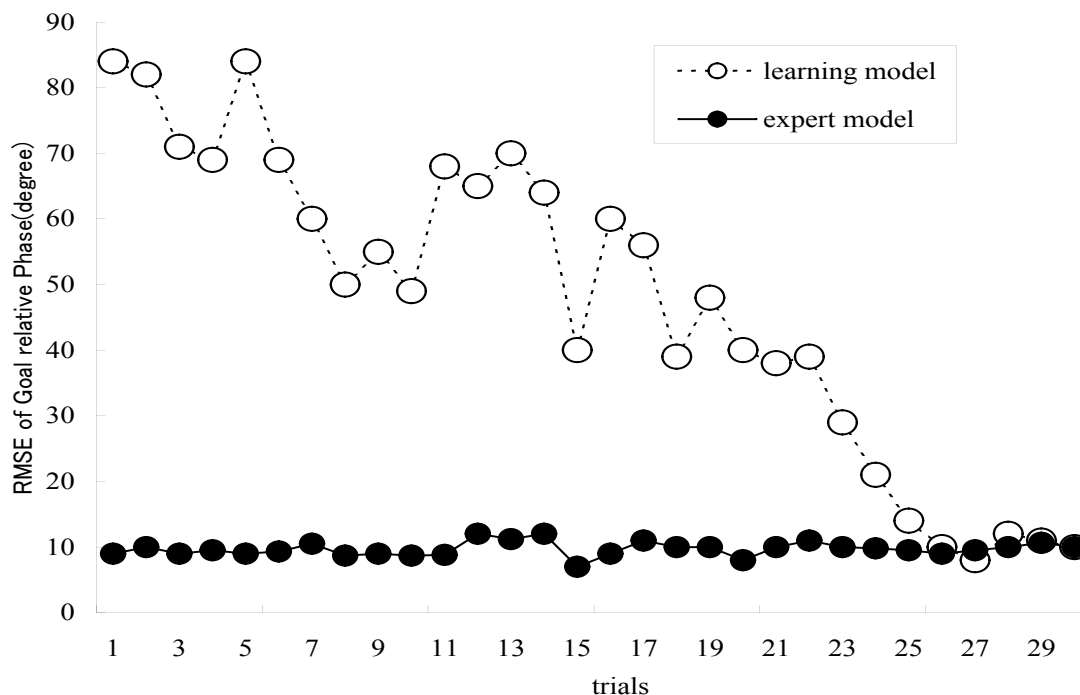
The participants were 45 students (20 males, 25 females) who volunteered their time. They were all right-handers aged between 18 and 23 with no previous experience of performing such a learning task. An explanation was given prior to the experiment and consent was obtained from the participants. Participants were divided into 5 groups so that there were 4 males and 5 females in each group. Five groups, consisting of a control group (with no observational learning), a concentrated-expert group (concentrated observation schedule of an expert model), an alternating-expert group (alternating observation schedule of an expert model), a concentrated-learning group (concentrated observation schedule of a learning model), and an alternating-learning group (alternating observation schedule of a learning model) were formed.

### 2.2. Assignment

The task was to create a new bimanual coordination pattern through moving both hands in side to side motion (Figure 1). The participants held a handle running parallel to a rail located on a table. The participants were required to perform bimanual coordination patterns in which they continuously moved both arms from side to side, while maintaining the timing of the phase of arms  $1/4$  cycle out of synchronization (relative phase of 90 degrees).

### 2.3. Experimental instrument

The participants were instructed to sit on a chair with an adjustable height so that the sagittal plane of the head will be located in the center of experimental instrument. A sliding plate was placed on four sets of ball bearings, allowing two handles that are fixed on the sliding plate to move freely on the four parallel steel rods. The participants were instructed to hold and move the handle which a researcher had previously placed 15cm off the center of the experimental instrument. Participants moved the palms of their



**Figure 2** The root mean square error (in degrees of relative phase) relative to goal ( $90^\circ$  relative phase) for the model while learning and then as an expert.

hands in a parallel motion, while bending an elbow comfortably and holding the handle. In order to show the target width (9cm) of the movement, paper was placed beneath the experimental instrument to indicate both ends. A rotary potentiometer (CPP-45 manufactured by MIDORI PRECISIONS) was installed parallel to the slide to convert the position of the handle into digitized data through using an AD converter. Digitized data was digitally converted at 200Hz and was sent to an IBM Aptiva H7G computer.

The participants were instructed to perform an oscillating motion moving the handle at the frequency of 1.25Hz to the sound of a digital metronome (SMP-20 by SEIKO CORP.), which can be heard through a speaker (ms101-2 by YAMAHA CORP.). Program software LabWindows/CVI made by National Instruments controlled the flow of each trial, recorded the digitized data of a handle position and provided additional visual feedback. A video monitor (KV-29 HX1 by Sony Corp.) connected to a videotape player (WV-BS1 by Sony Corp.) was installed two meters in front of the participants on the left during acquisition trials.

#### 2.4. The Model

A female graduate school student acted both as a learning and an expert model. She had not previously undertaken this particular task. She received instructions on the motor task, and performed 100 trials so in three days she mastered the assigned task. The movements of her arms during the 100 trials as well as the terminal visual feedback shown on the computer screen were recorded by a video camera (CCD-TRV95K by Sony Corp.) placed in front of her. The videotape, which recorded 100 trials from the beginning stage to expert stage, was edited into a series of 30 trials, so that typical performance errors and their correction processes would be clearly demonstrated. This videotape was used as observation material of a learning model. Subsequently, she practiced for another week and was finally able to demonstrate consistently expert performance. 30 trials of this outstanding performance were videotaped as an observation material of an expert model. RMSE relative to goal (relative phase of 90 degrees), which she presented both as a learning model and an expert model, is shown in **Figure 2**.

## 2.5. Procedures

Procedures used in previous research [Tsutsui et al., (1998), Tsukamoto et al., (1999)] and for learning bimanual coordination patterns of 90 degrees relative phase were used. Participants were informed of the purpose of the experiment and instructions were given on how to develop the goal motor pattern (relative phase of 90 degrees). While the experimenter was giving verbal instructions on experimental procedures, participants were allowed to touch the experimental instrument.

The participants were able to observe the movements of their arms during each trial. After each trial, the participants received from the computer a terminal visual feedback on their motions. A summary of the real-time displacement-displacement plot of the right hand against left hand (a Lissajous figure) was shown on the monitor screen. One Lissajous figure is drawn per cycle. Therefore, one trial of 10 seconds generates 12.5 plots, and the more stable reciprocating movements are the more overlapped those plots are. If the coordination patterns are precisely executed, Lissajous figures of relative phase of 90 degrees will create round circles rather than ellipses. All participants were informed that successful patterns would form contiguous circles, which would appear on a monitor as feedback.

## 2.6. Experiment design

5 pretest trials were performed by all the participants to evaluate their initial performance level but terminal visual feedback was not provided. Subsequently, learning trials were carried out over two continuous days. The participants of the control group carried out 30 trials of physical practice without observational learning on the first day, followed by 60 trials of physical practice on the second day. The participants of four observational learning groups carried out 30 trials of observational learning and 30 trials of physical practice on the first day, and then 60 trials of physical practice on the second day. The participants of both concentrated-expert group and concentrated-learning group intensively observed 30 trials for each model and they performed 30 trials of

physical practice on the first day. The participants of both alternating-expert group and alternating-learning group observed 1 trial of physical practice for each model, and then performed 1 trial of physical practice. This was repeated in 30 cycles on the first day.

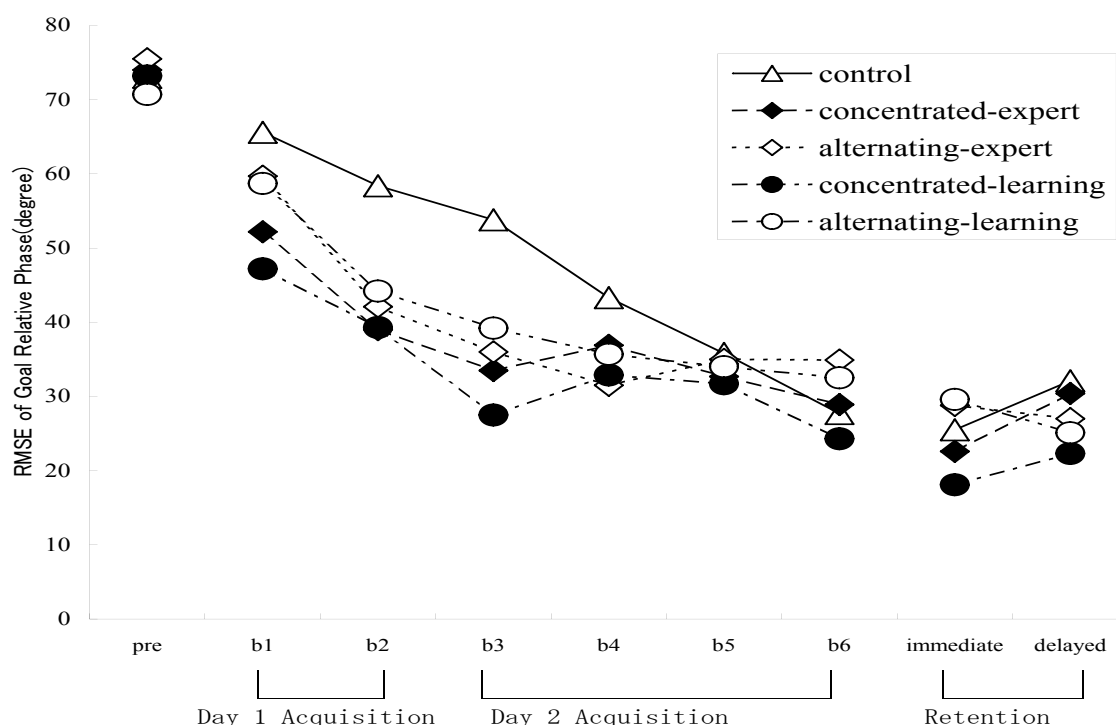
An immediate retention test consisting of 5 trials without terminal visual feedback was given immediately after the learning trials were completed on the second day. Another delay retention test of 5 trials was given without terminal visual feedback one week after acquisition trials were completed.

## 2.7. Analysis

The positional data of both arms was re-calculated as a relative phase for one cycle of reciprocating motion ( $2\pi$ ). Point values of a relative phase (this means the difference in the phase angles made by both arms) were the difference in the relative phase between the preceding arm and the trailing arm when the preceding arm was at its maximum extension and flexion. The phase angle was calculated using the method described by Scholz and Kelso (1989, p.129). The main performance criterion was the root mean square error (RMSE) against goal coordination (relative phase of 90 degrees). This RMSE is criterion that ensures accuracy and stability of timing performance. Acquisition trials were divided into 6 blocks, each consisting of 15 trials. The pretest data of 5 groups were analyzed using one-way analysis of variance. Acquisition trials of 5 groups multiplied by 6 blocks were analyzed using two-way analysis of variance (block factor is a repetition factor). The retention test data of 5 groups multiplied by 2 timings (timing factor is a repetition factor) were analyzed using two-way analysis of variance (timing factor is a repetition factor). The Ryan method was used for post hoc comparisons of mean values. The 5% (0.05) level of statistical significance was utilized throughout the tests.

## 3. Results

RMSE relative to goal (relative phase of 90 degrees) obtained in the pretest, the 6 practice blocks and two retention tests, which had been given to the



**Figure 3** The root mean square error (in degrees of relative phase) relative to goal (90°relative phase) for participants in the five strategy groups. Performance means in a pretest, each of six practice blocks and two retention test (immediate and delayed) have been plotted.

participants in five groups, is shown in **Figure 3**.

### 3.1. Pretest

Analysis of Variance for the pretest has shown no significant difference between groups in RMSE,  $F(4, 40) < 1.0$ .

### 3.2. Acquisition trial

Post hoc comparisons between group means, whose main effect was significant;  $F(4, 40) = 53.015, p < .001$  found significantly lower RMSE in concentrated-learning group compared with a control group. No other significant differences were observed between groups. However, post hoc comparisons between block means, whose main effect was significant;  $F(5, 200) = 14.500, p < .05$ , found significantly higher RMSE in Block 1 compared to the other blocks. Likewise Block 2 was higher compared to Blocks 4-6, and Block 3 in comparison to Block 6. No other significant difference was found between blocks. These results indicate that the RMSE values

drops as the number of physical practice trials are increased. Interactions between groups and blocks were found to be not significant;  $F(20, 200) < 1.0$ .

### 3.3. Retention test

The main effect of the groups was significant;  $F(4, 40) = 4.468, p < .01$ . Post hoc comparisons between individual group means found significantly lower RMSE in a concentrated-learning group compared with the control group, alternating-expert group, and the alternating-learning group. No other significant difference was found between groups. The main effect of timing;  $F(1, 40) < 1.0$ , or interaction between group and timing;  $F(4, 40) < 1.0$ , was not significant.

## 4. Discussion

Concentrated observation of a learning model is seen to be a faster and more effective way of improving performance in acquisition trials compared with only performing physical practice (without observational learning). This indicates the possibility

of concentrated observation of a learning model reducing the amount of physical practice required and that this effect may be sustained for a week or more.

Seen from a practical viewpoint, such accelerated learning raise skill levels in sports and aid rehabilitation and may help motivate learners. It could also benefit elderly people enabling them to easily and quickly acquire new skills such as operating computers. It may be that elderly people tend to discontinue motor skill learning if their skills do not show improvement at the initial stage of learning.

In the retention test, the concentrated-learning group demonstrated better performance compared with the control group or two alternating observation groups. This seems to show the benefits of the interaction between a learning model and a concentrated observation schedule. The concentrated observation schedule of a learning model will allow observers to watch the entire flow of learning processes, involving them in problem solving processes that a learning model experiences. It is presumed that in an alternating observation schedule, the overall flow of learning process is interrupted by each physical trial even if the same learning model is observed. It may be that observing a model developing her skills from beginner to expert will motivate learners who observe such a learning model.

Our research on coordination learning has found that the two groups who observed an expert model did not exhibit better performance in either acquisition trials or retention tests when compared with the control group. Previous research on parameter learning [McCullagh & Meyer, (1997)] reported a significant difference in learning effects between conditions of an expert model observation and physical practice, however the current research has found no such difference. The cause may be by the difference in the types of tasks used (coordination learning and parameter learning). In the present experiment, observers who learn a new coordination movement learning need to gain optimal parameters, such as the timing of the power output and amount of kinetic energy, as well as new coordination pattern, in order to achieve a smooth coordination movement. In previous research by McCullagh & Meyer (1997), learners of parameter learning of a weightlifting task

needed to learn only the optimal parameters for the already gained coordination pattern.

In order to learn new coordination, learners may need to understand cognitive factors such as what to do in addition to parameter learning. It can be inferred that a continuous observation of the overall learning process flow, provided by the concentrated observation schedule of a learning model will help understand necessary cognitive factors.

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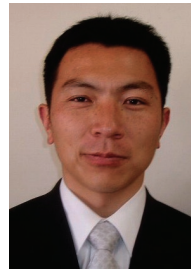
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