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Enhancing Motor Learning Through Dyad Practice: Contributions of Observation and Dialogue

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It has been shown that practice in dyads, as compared to individual practice, can enhance motor learning and increase the efficiency of practice (as two participants can be trained at the same time; Shea, Wulf, & Whitacre, 1999). The dyad practice protocol used by Shea et al. included both observation and dialogue between partners. Thus, it was not clear whether the learning benefits of dyad practice were due to observation, dialogue, or both. The present study examined the individual and interactive effects of observation and dialogue. The task used was speed cup stacking. Participants practiced under one of four conditions: observation/dialogue, observation/no dialogue, no observation/dialogue, and no observation/no dialogue. The two conditions that included observational practice were more effective (i.e., produced faster movement times) than the two conditions without it, both during practice and on a retention test performed under individual performance conditions. This suggests that the learning advantages of dyad practice are primarily due to the opportunity to observe another learner.

Key words: effectiveness, efficiency, observational learning, training

Motor learning studies are generally concerned with factors that enhance motor skills learning, such as the type of instructions or feedback, practice order of different tasks, learner-controlled practice, and observational or mental practice. That is, research has primarily focused on variables that can promote motor skill retention. How to enhance practice effectiveness is interesting not only for scientists trying to understand the learning process, but it is also vital for practitioners in physical therapy, sports, or music, for example, who are teaching motor skills to enhance long-term retention and facilitate transfer to novel situations. Aside from training effectiveness, another important consideration from a practical perspective is training efficiency. The efficiency of a training method is reflected in the costs associated with it, such as time and money spent on personnel, equipment, or other resources. Ideally, training methods should be effective and efficient.

Shea, Wulf, and Whitacre (1999) examined a training protocol that seemed to have the potential to facilitate learning *and* minimize costs, namely, practice in dyads. Their study was inspired by the work of Shebilske and colleagues (e.g., Shebilske, Regian, Arthur, & Jordan, 1992; see also Arthur, Day, Bennett, McNelly, & Jordan, 1997), who showed that having participants practice a video game ("Space Fortress") in dyads, such that each partner controlled half of the complex task (i.e., keyboard or joystick), was not detrimental to learning, compared to having participants practice the whole task individually. Thus, although dyad practice did not enhance learning in that study, it was more efficient than individual practice, as two people were trained in the same amount of time usually required to train one person. Another study by Arthur et al. (1997) showed that reacquisition of the same task after an 8-week nonpractice interval was similar for dyad and individual groups. Again, while dyad training was not more effective, it was more efficient than individual practice.

Shea and colleagues (1999) followed up on these findings by using a modified dyad protocol. They argued

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that many tasks do not lend themselves to dual control as did the video game used by Shebilske and colleagues. Shea et al. (1999) used a dynamic balance task to compare the effectiveness of dyad versus individual practice. They found that participants who practiced with a partner learned the task more effectively and were subsequently superior to an individual practice group when tested 1 day later. Thus, in addition to being efficient, the dyad protocol resulted in enhanced learning. These findings are noteworthy given the extent to which individual practice is advocated. For example, considerable amounts of money are spent on individual tennis, skiing, or golf lessons, or physical therapy sessions.

A question that has not received much attention in the research literature is: What are the reasons for the learning benefits of dyad practice? The Shea et al. (1999) study did not provide a clear answer to this question. In that study, dyad protocol included not only the opportunity to observe another person but also undirected dialogue between participants during the rest interval. That is, participants were encouraged to exchange ideas or strategies they might have used to improve performance. Thus, the learning advantages of practice in dyads, relative to individual practice, could have been due to observation, dialogue, or both. Observing another performer has been shown to be beneficial for learning (for a review, see McCullagh & Weiss, 2001; Wulf & Shea, 2002), especially for relatively complex skills (Bird, Osman, Saggerson, & Heyes, 2005; Landers & Landers, 1973; Martens, Burwitz, & Zuckerman, 1976; Whiting, 1988). Although observational practice might not be as effective as physical practice, because some aspects of learning are unique to physical practice and cannot be experienced during observation, observational practice is viewed as an effective method to teach general task characteristics. Yet, some have argued that observational practice offers unique opportunities for information processing activities that would otherwise not be possible early in practice, when most of the cognitive resources are required to physically perform the task (Shea, Wright, Wulf, & Whitacre, 2000). Thus, the observer might be able to gain insight into specific aspects of the coordination pattern or evaluate the effectiveness of different strategies, which might be difficult or impossible to do while trying to execute a new skill. It is also interesting to note that the benefits of observational practice seem to be independent of whether or not that performer is an expert or another learner (e.g., Hebert & Landin, 1994; McCullagh & Meyer, 1997; Pollock & Lee, 1992). Whereas observation of a skilled model might facilitate the development of a correct movement representation, observing another learner might help performers identify and correct errors.

Dyad practice participants in the Shea et al. (1999) study might also have benefited from the dialogue in which they engaged between trials. During rest intervals, participants were encouraged to exchange observations, movement strategies, and other things they found effective or ineffective. A dialogue with their partner might have caused them to invest more cognitive effort (Lee, Swinnen, & Serrien, 1994) and may have promoted processing activities they would not have engaged in otherwise. Furthermore, as Shea et al. (1999) pointed out, practicing and sharing strategies with a partner might have increased participants' feeling of responsibility for and involvement in the learning process, which, in turn, might have enhanced the learning process (McCombs, 1989; Watkins, 1984). In fact, a study by Prislin, Jordan, Worchel, Semmer, and Shebilske (1996) showed that unstructured group discussion between practice sessions enhanced performance of a complex perceptual motor skill (although no retention test was used to assess learning effects). Furthermore, Chi (1997; see also Jeong & Chi, 1997) found that, in solving physics problems, engaging in dialogue facilitated learning.

Because it was unclear from the Shea et al. (1999) study whether the learning benefits of dyad practice were primarily due to the effects of observational practice, dialogue, or both, Shea et al. called for future studies to "determine the additive and/or interactive influences of observation and dialog [sic]" (p. 124). They suggested that learning might have been enhanced differentially through observation and dialogue or "that dialog [sic] would not be as effective if not coupled with observation" (pg. 124). The purpose of the present study was to examine the effects of observation and dialogue separately and any interactive effect of those two factors. We compared the effectiveness of four conditions for learning a novel task (cup stacking). In one dyad condition, participants observed each other and engaged in a dialogue between trials (observation/dialogue). In another, participants observed each other, but no dialogue was allowed (observation/no dialogue). In a third condition, participants were not allowed to observe each other but were asked to engage in a dialogue between trials (no observation/dialogue). Finally, in the fourth, participants practiced individually (no observation/no dialogue). Thus, this design allowed us to determine any main or interaction effects of those two factors. If both contributed to the learning benefits of dyad practice, for example, the observation/dialogue group should show superior (retention) performance compared to all other groups. In contrast, if observation (dialogue) was the main contributing factor, the two groups whose practice conditions included observation (dialogue) would be expected to demonstrate more effective learning than those without it. All groups received a practice phase under the respective treatment conditions on the first day. Learning was assessed in a retention test, which participants performed individually, on Day 2.

Method

Participants

Forty-eight volunteers between the ages of 18 and 60 years (M = 23 years; SD = 5.4) were recruited to participate in the study. Participants did not have any previous experience in any form of cup stacking. All were naive as to the purpose of the experiment, and all gave their informed consent. All participants were aware their services would be needed for 2 consecutive days. Participants did not receive any form of payment or extra credit compensation for their participation.

Apparatus and Task

The task in the present study was speed cup stacking (Hetzner, 2004; Udermann, Murray, Mayer, & Sagendorf, 2004), based on the instructions developed by the *World Sport Stacking Association.* This task has recently been introduced in many elementary school physical education classes as a motor skill that requires hand-eye coordination (Udermann et al. 2004). Participants used 12 specialized cups for speed stacking (Speed Stacks, Inc., Castle Rock, CO). These cups are smoother than normal plastic cups, thus creating less friction, and have three holes at the top to allow air to escape quickly during movement. The task consisted of two phases. At the beginning of each trial, the cups were placed in front of the participant, with a three-cup tower (i.e., cups stacked together upside down inside each other as one tower) on the participant's left, a six-cup tower in the middle, and a three-cup tower on the right (see Figure 1, top). When told to "go," the participant used two hands to build a 3 x 6 x 3 cup stack (i.e., the participant built a three-cup pyramid on the left using the three-cup tower on the left, then built a six-cup pyramid in the middle using the six-cup tower, and then built a three-cup pyramid on the right using the three-cup tower from the right side; see Figure 1, bottom). Participants were instructed to hold the cups loosely in their hands and spread the cups apart with their fingers to create quicker movements. This first phase of the task is called "up-stacking." Participants were also instructed to alternate their hand movements while up-stacking the six-cup pyramid (e.g., take three cups in the right hand, two cups in the left, and release them one at a time). Then the participant began the "down-stacking" phase of the task by reversing the procedures used for up-stacking and putting the three pyramid stacks into their original three towers (see Figure 1, top). As with the up-stacking, the participants were required to begin with the left pyramid stack, then move to the middle, and finish with the right stack. Participants were instructed to slide the cups down one another for quicker movements. The amount of time (i.e., movement time) to up- and down-stack the three cup stacks was measured using a stopwatch. If errors occurred during the trial, the participant was told to correct them and continue until the cups were put into the proper arrangements for the two phases of the trial.

Procedure

Participants received general instructions regarding the task. Specifically, the experimenter demonstrated how to up-stack and down-stack the cups and gave instructions as to the order and direction of stacking. The experimenter instructed participants of the procedures to follow while up-stacking and down-stacking the cups. That is, they were told to use two hands and hold the cups lightly, alternate their hand movements for efficiency, and correct any mistakes before continuing. For the six-cup stack, they were to take three cups in their right hand and two in their left and alternate hands by placing one cup down at a time until the pyramid was formed. Participants were to perform these movements as quickly as possible. They received these instructions before practice began. During the practice phase, they got occasional reminders to move from left to right while up-stacking and down-stacking and to correct mistakes before moving on.

Participants were randomly assigned to one of four groups. In the observation/dialogue group, 2 participants practiced in alternating dyad format. Specifically, while Partner 1 performed one trial, Partner 2 observed. This was followed by a dialogue period of 10 s, in which both participants were asked to discuss the trial, by sharing observations or tips, such as possible strategies they might have used (to remember the correct sequence, for example). (A duration of 10 s was chosen, because pilot

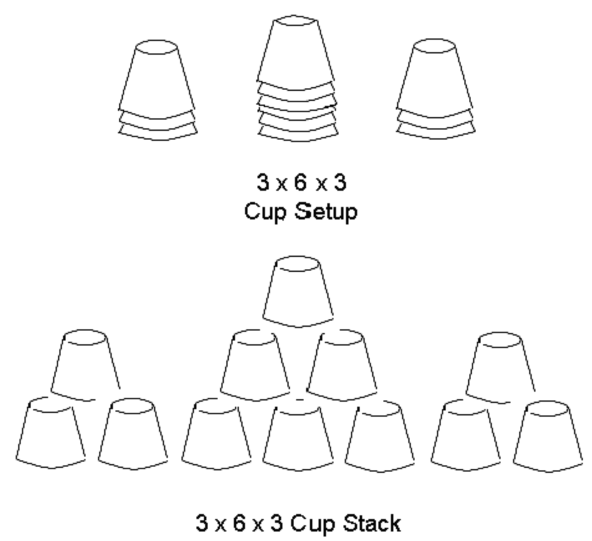

Figure 1. Schematic of the cup setup and cup stack.

testing had shown this was the approximate duration required for up- and down-stacking the cups and, thus, the duration of observational practice.) Then Partner 2 practiced, while Partner 1 observed. This sequence of physical practice, observational practice, and dialogue continued until both partners had completed 20 practice trials. The observation/no dialogue condition was similar to the first in that 2 participants practiced physically and observationally in an alternating format. However, in this group, no dialogue was allowed during the break between trials. In the no observation/dialogue condition, participants also practiced in dyads; however, they were not allowed to observe each other perform. When Partner 1 practiced, Partner 2 was instructed to turn around, and vice versa. During the breaks, participants were instructed to engage in a dialogue, similar to the observation/dialogue group. Finally, a fourth group served as a control condition. In this no observation/no dialogue group, participants practiced individually. The breaks between trials were identical to those used in the other conditions. The experimenter took the time for each physical practice trial. However, participants did not receive augmented feedback about the movement time (MT). All participants performed a 20 practice trials on Day 1. One day later, they performed a retention test that consisted of five trials performed individually in the same manner the practice trials were performed, including correcting mistakes, moving from left to right, and alternating the use of their hands.

Data Analysis

Average MT across blocks of five trials was analyzed in a 2 (observation: yes, no) x 2 (dialogue: yes, no) x 4 (five-trial blocks) analysis of variance (ANOVA) with repeated measures on the last factor. MTs on the retention test were analyzed in a 2 (observation: yes, no) x 2 (dialogue: yes, no) ANOVA. The Huynh-Feldt epsilon was applied to degrees of freedom to account for violation of sphericity assumption.

Results

Practice

All groups reduced their MT across practice blocks (see Figure 2, left panel). Yet, the two conditions that included observing a partner (observation/dialogue, observation/ no dialogue) showed generally faster MTs than the two conditions that did not (no observation/ dialogue, no observation/ no dialogue). The main effect of block was significant, $F(2.84, 125.07) = 96.31$, $p < .001$, $\eta^2 = .69$. The main effect of observation was significant, with $F(1, 44) = 4.60$, $p < .05$, $\eta^2 = .10$. None of the other main or interaction effects were significant.

Retention

One day later, the two observation groups (observation/dialogue, observation/ no dialogue) demonstrated more effective performance than the groups without observation (no observation/dialogue, no observation/ no dialogue), whereas dialogue had no apparent main effect (see Figure 2, right panel). The observation main effect was significant, with $F(1, 44) = 8.30$, $p < .01$, $\eta^2 = .16$. The main of dialogue and the interaction of observation and dialogue, $F(1, 44) < 1$, were not significant. We also conducted an ANOVA that included trial as a factor. This analysis showed that all groups consistently reduced their MTs across the five retention trials, $F(2.98, 130.98) = 7.14$, $p < .001$, $\eta^2 = .14$. There were no interactions with trial blocks. Thus, in contrast to dialogue, being able to observe another learner during practice had a beneficial effect on learning, as demonstrated in a test situation under individual-performance conditions.

Discussion

The purpose of the present study was to examine the relative contributions of observational practice and dialogue between partners in a dyad practice protocol. While dyad practice has previously been shown to be an effective and efficient method for learning motor skills (Shea et al., 1999; Shebilske et al., 1992), it was unclear to what extent each factor (i.e., observation, dialogue) contributed to the learning benefit. Therefore, in the present study we used a design that allowed us to examine the individual as well as the interactive effects of ob-

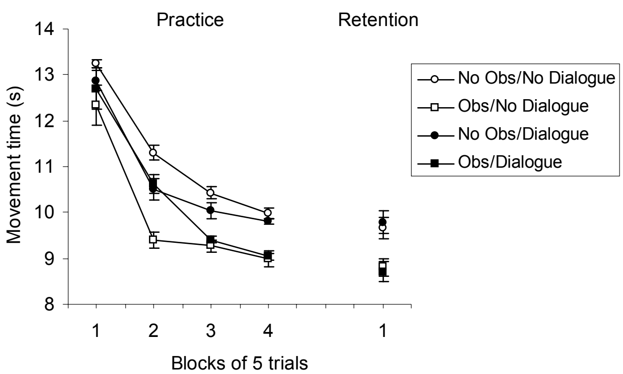

Figure 2. Average movement times for the no observation/no dialogue, observation/no dialogue, no observation/dialogue, and observation/dialogue groups in practice and retention.

servation and dialogue. Specifically, we compared practice conditions that included either, both, or none of the factors and assessed the learning effects in a test requiring individual performance (i.e., without a partner). The results clearly showed that participants practicing with a partner benefited most from observing their partners, rather than engaging in a dialogue with them. The two groups that included observing a partner, with or without dialogue (observation/dialogue, observation/no dialogue), performed more effectively than those who did not observe another person (no observation/dialogue, no observation/no dialogue). In contrast, dialogue with a partner provided no additional benefit, compared to no dialogue. This was the case for both the practice phase and retention test. Thus, the advantages of observing a partner during practice transferred to a situation in which the partner was no longer present (i.e., in retention) and, therefore, represented learning effects.

These findings raise the question: What are the reasons for the beneficial effects of observational practice and lack of interspersed dialogue? Because the task required a series of specified, two-handed coordinated movements to be executed as fast as possible, the ability to observe another performer between physical practice trials might have served as a potent reminder of the correct movement sequence. That is, observational practice allowed learners to rehearse the up-stacking and down-stacking sequence. In essence, participants in the observation conditions received twice as many practice trials (half of which were physical, and half observational) as those in the no-observation conditions. As a consequence, the opportunity to observe visual demonstrations, in addition to physical practice, resulted in performance gains during practice and eventually in enhanced learning. An additional benefit of observational practice might have been that it allowed the individual to direct most of his or her attentional resources to observing the sequence and thereby rehearsing it at the same time. This is presumably not possible to the same degree when the task has to be performed physically, because many of the information processing activities need to be dedicated to actual task execution (Shea et al., 2000). Rehearsal is probably also not possible to the same degree during rest and/or dialogue, where no visual model is available to facilitate this process.

There might be other advantages of observational practice as well. Observing another learner (as opposed to a skilled model) is an advantage in that performers are able to observe—and subsequently avoid—mistakes performed by the learning model (e.g., Pollock & Lee, 1992). In the present study, participants were asked to correct mistakes (in the same trial) if they occurred, thus giving observers the opportunity to vicariously participate in the error-detection-and-correction process. In fact, it has been shown that observational practice facilitates error recognition (Black & Wright, 2000). Thus, this factor might also have facilitated acquisition of the correct sequence, and ultimately enhanced learning.

The lack of opportunity to observe errors and their correction might be one reason why dialogue between learners had no benefit for learning. Nevertheless, given that some studies have found benefits of group discussion, albeit for tasks that were more cognitive in nature (e.g., Chi, 1997; Prislin et al., 1996), it might seem somewhat surprising that the verbal interactions with a partner did not facilitate learning. Although dialogues in the present study were not recorded or formally analyzed, informal observations indicated that participants' interactions mainly involved reminders of the instructions the experimenter had given them prior to starting practice. In particular, a number of participants seemed to have forgotten the instruction to alternate hands to facilitate up-stacking the six-cup stack. In those cases, their partners would remind them, sometimes using cues such as "right, left, right, left." Many dyads also found faster ways on their own to down-stack the cups. They noticed that it was faster to use their right hand to place the three-cup stack on the right on top of the six-cup stack, grab the middle cup on the six-cup stack with their left hand, and slide all the cups down at the same time with both hands, than to take the six-cup stack down one cup at a time and setting it down. If one partner discovered this, he or she would discuss this strategy with the other, which typically resulted in a decrease in MT.

While one might have expected the exchange of reminders and strategies to enhance learning, this was not the case. A possible explanation is that verbal reminders presumably require a "translation" process, whereby the verbal information is translated into an image of the act that then guides skill execution. This is different from observation, in which the image is already available and can presumably be translated into action relatively easily (e.g., Gibson, 1979). Although there is some controversy as to whether or not translation processes are necessary to turn observation into action (e.g., Bandura, 1986; Carroll, & Bandura, 1987; Scully & Newell, 1985), the fact that observation was advantageous compared to dialogue seems to suggest it was "easier" to use.

Overall, the present findings suggest learning advantages of dyad training that incorporate observation and dialogue with a partner, compared to individual practice (Shea et al., 1999), are primarily due to observing another learner. Engaging in a dialogue with the partner had no effect on learning, at least for the task in the present study. Future studies should examine whether other tasks, for example, those more cognitively demanding or requiring problem solving, such as complex (video) games, might benefit from interspersed dialogue. That is, dialogue may provide useful information for learning certain tasks. Alternatively, observation may not be beneficial for all tasks. For example, tasks that involve complex behavior and/or interactions with environmental stimuli, which are not easily grasped, may (at least initially) benefit more from dialogue than observation. The issue of whether and how the type of task interacts with dialogue and observational practice should be examined in future studies.

Furthermore, given the benefits of observation in the present study, another interesting issue for future research is the relative effectiveness of a live model, rather than a video model, for example. It is conceivable that practicing together with another learner has beneficial learning effects that go beyond those related to observation per se. One factor that might also have an impact on learning in group situations is competition (Deutsch, 1949; Marten, 1975). While one might argue this competitive interaction between learners could be detrimental and might result in increased anxiety during performance (Arthur, Young, Jordan, & Shebilske, 1996; Brooks, Ebner, Manning, & Balson, 1985), results of dyad training studies thus far have shown the opposite (e.g., Dossett & Hulvershorn, 1983). Furthermore, goal setting (e.g., Locke & Latham, 1985; Locke, Shaw, Saari, & Latham, 1981) might be enhanced in dyad training situations. That is, the direct interaction with another learner might cause individuals to set higher goals than they normally would, such as outperforming the other person. Goal setting has been found to benefit performance and motor skill learning (Boyce, 1992; Burton, 1994; Kyllo & Landers, 1995; Weinberg, 1994). Future studies should examine to what extent factors such as competition and goal setting play a role in dyad practice situations. At any rate, the present results confirm the effectiveness of dyad practice for motor learning. Aside from its learning advantages, practice in groups also increases training efficiency, as two (or more) participants can be trained at the same time. This aspect of group practice might be particularly relevant for physically or cognitively demanding skills that require rest intervals between trials. In addition to allowing "recovery" from task demands, the intervals between physical practice trials give the learner the opportunity to engage in other forms of information processing activities that can promote learning (Shea et al., 1999). As Shea et al. (1999) pointed out, an optimal training protocol maximizes training effectiveness while minimizing costs. The present results suggest that dyad practice can achieve both these training goals.

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