The Effects of Observing a Learning Model (or Two) on Motor Skill Acquisition

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Modeling, which enhances skill acquisition, is an often-used means of conveying information to learners. While models typically provide a demonstration of correct movements or successful performance, skill acquisition is also enhanced by observing a “learning model,” who practices, receives feedback, and improves. The effect is proposed to be due to the observer engaging in problem-solving, error detection, and strategy evaluation. The purpose of this experiment was to examine the effects of observing one or two learning models in combination with physical practice, and the temporal placement of model observation during physical practice, on the acquisition and retention of a motor skill. College students practiced a $3 \times 6 \times 3$ cup stacking task in groups of three, and had opportunities to observe their peers’ physical practice. Treatment groups differed in the order of observation and physical practice; some participants engaged in physical practice prior to observation, while others observed one or two learning models before practice. Data indicated observation prior to engaging in physical practice enhanced learning. In addition, participants were able to identify strategies they observed that enhanced skill performance. These results support and add to existing research on modeling, and provide insight into the types of cognition that occur during observational learning.

Keywords: information processing, motor learning, modeling, observational learning

The use of demonstrations, or modeling, is among the most commonly used instructional strategies, and the idea that one could learn a motor skill by watching another perform it has intrigued scholars for decades (for recent reviews, see [Ong & Hodges, 2012](#); [Rosen, Salas, Pavlas, Jensen, Fu, & Lampton, 2010](#); [Ste-Marie et al., 2012](#)). Research on modeling has been guided primarily by Bandura’s (1986) *Social Cognitive Theory*. This theory suggests that acquisition of modeled behavior is governed by cognitive processes including attending to, coding, and rehearsing critical features of the action. Through these, the learner forms a cognitive representation of the motor pattern that is used to guide production of

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an action, and serves as a standard of correctness to which actions are compared (Carroll & Bandura, 1982).

Most modeling research has investigated the effects of observing a correct (or expert) model, one who demonstrates the desired movement pattern. The general idea is that the model provides information about how to produce an effective movement, and learners use the information gained to organize and evaluate their own actions during subsequent physical practice. As a result of decades of research, strong evidence supports the conclusion that the opportunity to observe a skilled or expert model enhances motor learning (Ste-Marie et al., 2012). The benefit is greatest in the early stages of skill acquisition, and is enhanced when demonstrations are provided prior to and interspersed during practice (e.g., Hayes, Ashford, & Bennett, 2008; Sidaway & Hand, 1993; Whiting, Bijland, & den Brinkler, 1987).

Several researchers (e.g., Hodges, Williams, Hayes, & Breslin, 2007; Scully & Carnegie, 1998; Ste-Marie et al., 2012) have pointed out that, among the questions yet to be answered adequately, one pertains to the nature of the information conveyed and perceived during model observation. That is, what information do observers glean from models and use during their subsequent physical practice? Scully and Newell (1985) suggested that demonstrations convey characteristics of relative motion (i.e., coordination), which is the goal of the initial stage of learning. Horn, Williams, and Scott (2002) suggest the primary role of a demonstration is to convey general strategy-related features of a movement. Similarly, Horn, Williams, Hayes, Hodges, and Scott (2007) held that models convey a movement solution that observers adopt during their own physical practice, thus serving as a “rate enhancer.”

A second question that has yet to be addressed conclusively pertains to the relative effectiveness of the order of modeling with respect to physical practice (Ste-Marie et al., 2012). Observation of a model may be done prior to any physical practice, interspersed during practice, or after learners have engaged in varying amounts of practice. There is evidence that providing multiple demonstrations prior to physical practice is effective (e.g., Weeks & Anderson, 2000), as well as alternating between observing a model and physical practice (e.g., Shea, Wulf, & Whitacre, 1999; Sidaway & Hand, 1993). Few studies, however, have compared groups differing in the timing of model presentation and physical practice.

In recent years, in addition to studying the benefits of observing a correct demonstration, researchers have also explored the effects of observing alternative models, who, rather than demonstrating error-free task performance, instead show a learner engaging in practice with varying levels of success. One of these is the *learning model*. A learning model is a person shown engaging in the skill learning process, practicing the task, making errors, receiving feedback, and improving (Hebert & Landin, 1994; McCullagh & Caird, 1990). Adams (1986) initiated the contemporary learning model literature in an experiment wherein models practiced a task requiring moving a control stick to produce a pattern with specified movement speeds for each segment, and received knowledge of results (KR) feedback after each trial. The practice of each model was monitored by two observers, one who could both watch the model's actions and see the model's KR, and the other who could only watch the model's physical movements. Observers then engaged in their own physical practice and received KR after each trial.

The results showed that task performance was best among the observers who were able to watch the model's actions movements and also monitor their KR.

Adams' (1986) experiment spurred additional research exploring the potential benefits of observing a learning model. Lee and White (1990) paired learning models and observers who practiced computer-based tasks requiring coordinated key presses to maximize performance of a simulated athlete on the screen. When observers practiced the task, they outperformed their models. Others have compared the relative effects of observing learning models to and in combination with correct models, and in combination with differing forms of feedback. For example, McCullagh and Meyer (1997) conducted an experiment in which correct and learning models were filmed performing the free weight squat weight training exercise and receiving feedback. Observers were exposed to videotapes of either correct models who received feedback, learning models with feedback, or learning models without feedback. Retention data indicated that participants who observed either a correct model with feedback, or a learning model with feedback, performed the task better than the learning models themselves, or those who observed a learning model without feedback. Presently, research findings support the conclusions that observing a learning model facilitates skill acquisition particularly when the model's feedback is also observed (McCullagh & Caird, 1990; Pollock & Lee, 1992; Weir & Leavitt, 1990), and the combination of observing both correct and learning models enhances learning more than either a correct or learning model alone (Andrieux & Proteau, 2013, 2014).

Support for the benefits of observing learning models has also been derived from naturalistic field-based studies of teaching and learning motor skills (e.g., Hebert & Landin, 1994; Kalapoda, Michalopoulou, Aggelousis, & Taxildaris, 2003) and from research on *dyad practice*. In dyad practice, learners are paired, and afforded opportunities to both watch a partner practice and engage in physical practice. Multiple studies have shown that dyad practice enhances learning compared to practicing individually (e.g., Granados & Wulf, 2007; Shea et al., 1999).

In explaining the findings, Adams (1986), and others (e.g., Blandin & Proteau, 2000; Lee & White, 1990) proposed that, when watching a learning model, the observer engages in problem solving cognitions that form the basis of motor learning, including appraising/evaluating actions and considering error-correction responses. Thus, the processes underlying observing a learning model may be somewhat different from those when observing a correct model. Skill acquisition, at least in the early stages, may be conceived as a problem-solving process involving a search for better or more appropriate motor solutions among alternatives, and information gained from observing a model may guide the search (Newell, 1991). Solutions to a movement situation have been conceived of as *strategies*, as there may be more than one technique or action pattern that could be used (Taylor & Ivry, 2012). Horn and Williams (2004) suggested demonstrations may convey strategies for action, and learning models may employ different strategies as they engage in the trial-and-error practice characteristic of beginners. This idea has some support. For example, in an experiment involving learning to juggle (Meaney, Griffin, & Hart, 2005), participants who observed a learning model showed increased use of strategies during transfer to other juggling tasks, when compared to those who observed a correct model. Also, Buchanan and Dean

(2010) found that skill acquisition was enhanced in learners who observed a learning model engaged in discovery learning as compared to a model who demonstrated one specific coordination strategy. Further, the process of motor learning involves performing an action, receiving feedback, and adjusting the action on subsequent trials. Observing a learning model is suggested to allow the observer to engage in this cognitive process (Lee, Swinnen, & Serrien, 1994). Thus, observation of a learning model may facilitate considering among possible strategy options, and understanding how to adjust actions to correct errors, with this information then employed in subsequent physical practice (Blandin & Proteau, 2000; Pollock & Lee, 1992). This problem-solving perspective underlying the benefits of observing a learning model guided this experiment.

In summary, evidence suggests that observing others practice and learn a motor task enhances skill acquisition, which may result from engaging the observer in cognitive processes characteristic of the learning process. The experiment reported here continues this line of research, by comparing the relative effects of observing one versus two learning models, as well as the order of modeling and physical practice on skill acquisition, and examining reports from learners about what they believed they had learned by observing.

Methods

Participants and Task

Participants were 117 college undergraduates (79 females, 38 males) ranging in age from 19 to 36 ($M = 21.19$) years, who volunteered for the experiment and reported no prior experience with the task. Prior to data collection, the experiment was approved by the university's Institutional Review Board, and all participants provided written consent. In addition, prior to the experiment, a pilot experiment was conducted to establish and test the methodology.

The motor skill utilized in the experiment was speed cup stacking, an eye-hand coordination task involving the stacking and unstacking of cups into specified arrangements. Cups used were plastic standard-sized official sport stacking cups (www.speedstacks.com). The task used 12 cups, initially arranged into three towers with cups stacked upside down (3 cups, 6 cups, 3 cups). On a "go" signal, the performer moves the cups from the three towers into a three pyramid formation, then immediately returns the cups into the three tower arrangement (see Figure 1). The goal of the task is to move the cups from the tower formation into the pyramid formation and back to the tower formation as quickly as possible. This task has been used in previous research (e.g., Granados & Wulf, 2007), is improved quickly with practice, and may be completed using different strategies.

Procedure

Thirty-nine groups of three participants were formed, and those within each triad were randomly assigned to positional order as Learner 1, Learner 2, and Learner 3. Participants were provided a brief overview of the experiment, and informed they would practice cup stacking on one day and return in two days for a retention test. When each group of participants arrived at the laboratory, a table had been set up

Figure 1 — Diagram of cup stacking task.

with cups arranged in the starting position. They were provided verbal instructions indicating they would begin with towers, and were to move the cups into the pyramid arrangement, then return the cups back into the 3-tower arrangement as quickly as possible. Instructions included a diagram (Figure 1) of the starting, middle, and ending arrangements. They were also informed that they would each perform 20 trials of the task; who would go first, second, and third; and that they should watch their peer(s) practice.

Learner 1 then performed 20 trials of the task. Each trial was timed with a stopwatch, and initiated with a verbal “Go” signal. At the completion of each trial, KR (length of time to complete the task) was provided verbally and recorded on a large scoresheet posted near the table and visible to participants. During Learner 1’s trials, Learner 2 and Learner 3 were positioned on the opposite side of the table with a clear view of Learner 1 and the cups, therefore being able to observe Learner 1’s actions and hear and see the score of each trial.

At the completion of Learner 1’s practice, participants rotated positions. Learner 2 then performed 20 trials of the task, while Learner 1 and Learner 3 watched. This was followed by Learner 3 performing 20 trials of the task while Learner 1 and Learner 2 observed. The position of observers, and timing and recording of scores for Learner 2 and Learner 3 was similar to those of Learner 1. Therefore, all three participants in the triad observed the other two participants’ acquisition (40 observation trials), and performed 20 physical practice trials, but the order of observation and physical practice were different for each learner.

Learner 1 engaged in physical practice prior to observing their peers' practice. Learner 2 observed 20 trials, performed 20 physical practice trials, then observed 20 trials. Learner 3 observed both partners, then performed physical practice trials.

In addition to examining effects on physical performance, a purpose of the experiment was to investigate what learners believed they had learned from observing. Therefore, data was collected via a brief survey from Learner 2 and Learner 3 immediately following observation and prior to their physical practice trials. During the rotation, these participants responded in writing to the following prompt: "As specifically as possible, write down what you learned from watching your peer(s) practice this task." At the conclusion of the initial session, participants were instructed to not practice the task between sessions. Two days after acquisition, participants returned to the laboratory and performed two warm-up trials followed by five retention trials. Retention was performed individually, and KR was provided after each trial.

Results

Performance scores (length of time to complete each trial) were grouped into blocks of five trials for analysis. Acquisition data were analyzed using a 3×4 (Group by Trial Block) repeated measures ANOVA, and retention was analyzed using a one-way ANOVA. Cohen's d was calculated to provide effect size.

Acquisition

As shown in Figure 2, all three groups demonstrated a reduction in time to complete the task over acquisition. Participants assigned to the Learner 1 position performed the task slowest, and those in the Learner 3 position fastest. Analysis of

Figure 2 — Cup stacking speed of treatment groups during acquisition and retention.

acquisition data revealed a significant effect for Group [$F(2,114)=13.37$, $p<.001$], Trial Block [$F(3,342)=165.32$, $p<.001$], and Group by Trial Block interaction [$F(6,342)=3.58$, $p<.01$].

The Trial Block main effect indicated significant improvement during physical practice. Follow-up comparisons indicated significant differences between each trial block. Post-hoc analysis of the Group main effect indicated significant differences between all three groups (see Table 1). On average, Learner 1 performed the task significantly slower than Learner 2 (Cohen's $d=0.64$), and Learner 3 (Cohen's $d=1.13$). Also, Learner 2's acquisition trials were, on average, significantly slower than Learner 3 (Cohen's $d=0.56$). These effect sizes indicate moderate to large differences between groups.

The Group by Trial Block interaction indicated that groups improved at differing rates during physical practice. As seen in Figure 2, Learner 2 and Learner 3 performed the task faster than did Learner 1 throughout acquisition, having an advantage over Learner 1 at the outset of practice and retaining faster times through all acquisition trials. The performance of Learner 3 was faster than that of Learner 2, however, the size of the difference between Learner 2 and Learner 3 was gradually reduced over time. Post-hoc comparisons of groups at each time point (see Table 1) revealed that Learner 3 performed the task significantly faster than Learner 1 during all trial blocks. Learner 2 performed the task significantly faster than Learner 1 in acquisition Blocks 2 and 4. Finally, Learner 3 was significantly faster than Learner 2 in Trial Blocks 1 and 2.

Retention

Analysis of retention data (see Table 1) indicated significant Group differences [$F(2,114)=13.48$, $p<.001$]. Post-hoc comparisons indicated Learner 2 and Learner 3 performed the task significantly faster than did those assigned to the Learner 1 position. Effect size differences in retention were: Learner 1 vs 2 = 0.80; Learner 1 vs 3 = 1.08; Learner 2 vs 3 = 0.33. These values indicate a large effect of observing either one or two learning models prior to engaging in physical practice, compared to engaging in physical practice prior to observing a model.

Survey Results

Responses to the post-acquisition survey were analyzed qualitatively using procedures suggested by Bogdan and Biklen (2007). Each participant's responses

Table 1 *M* (SD) Cup Stacking Performance of Groups

	Acq1	Acq2	Acq3	Acq4	Acq <i>M</i>	Retention
Learner 1	14.50 (2.76) ^a	12.82 (2.08) ^a	11.67 (1.75) ^a	11.49 (1.75) ^a	12.62 (1.94) ^a	10.80 (1.76) ^a
Learner 2	13.55 (2.13) ^a	11.39 (1.68) ^b	10.94 (1.67) ^a	10.16 (1.65) ^b	11.51 (1.53) ^b	9.51 (1.41) ^b
Learner 3	12.03 (1.94) ^b	10.39 (1.83) ^c	10.29 (1.97) ^b	9.74 (1.54) ^b	10.61 (1.66) ^b	9.03 (1.48) ^b

^{a,b,c}Indicates groups significantly different ($p<.01$).

Abbreviation: *M* = mean; Acq, acquisition.

to the survey were typed verbatim, then read as a group by the researcher, searching for key words, phrases, and ideas. A tentative list of coding categories was developed. Notes were written onto each response indicating the category into which it fell. Some responses were coded as one category, others as more than one. Once this was completed, responses and codes were reviewed again to consider whether categories initially identified were appropriate or should be modified, and that responses fit the identified category. A second reviewer with experience analyzing qualitative data was then presented the coded responses for review to determine the accuracy of the identified categories, and independently coded responses. Finally, the two reviewers discussed the coding categories and categorized responses until agreement was reached that the categories derived were adequate to describe the data, and responses were coded appropriately.

Responses indicated that observers believed they had learned strategies by observing their peer(s) practice. Eight types or categories of strategies were identified (see Table 2). The most common strategy described related to the order of buildup (i.e., which stack to begin with, which to build next, etc.). Other strategies reflected rushing vs not rushing during stacking and unstacking, patterns of stacking individual cups within a pyramid, and determining the appropriate amount of space between cups or stacks/pyramids. Responses of the 39 participants assigned to the Learner 3 position were coded into a total of 89 ideas (an average of 2.28 per participant). Learner 2 responses were coded into 67 total ideas (averaging 1.72 per participant).

Discussion

Considerable research supports the conclusion that observing another person perform a motor task enhances skill acquisition, and both correct and learning models have been shown to be beneficial. In this experiment, participants practiced a cup-stacking motor task in groups of three, and had opportunities to observe their peers' practice session as well as engage in physical practice. The procedures allowed for a comparison between three conditions: (1) engaging in physical practice before observing two learning models; (2) observing one learning model, then engaging in physical practice, followed by observing another learning model; and (3) observing two learning models prior to physical practice. In addition, participants who observed one or two models prior to engaging in physical practice provided insight into what they believed they had learned during observation. The results of this experiment demonstrated three key findings.

First, observing a learning model enhanced early physical performance of the task. This is consistent with previous research (e.g., [Adams, 1986](#); [Lee & White, 1990](#)). When observers began physical practice they did so at a higher level than models they observed, and continued to improve during their subsequent physical practice. During acquisition, Learner 2 performed the task significantly faster than did Learner 1, and Learner 3's acquisition trials were significantly faster than both Learner 1 and Learner 2. Thus, in the initial physical performance of the task, observing one learning model enhanced acquisition, but there was a clear advantage for those who had the opportunity to observe two learning models prior to practicing the task.

Table 2 Observed Strategies and Number of Participants in Learner 2 and Learner 3 Positions Who Described Them

Strategy	Learner 2	Learner 3	Example comments
Order of build up	29	29	<p>"I learned which set up cups to start with."</p> <p>"I learned to stack the 6 cups first, then do the smaller ones."</p>
Stacking individual cups	8	16	<p>"For the stack with 3 cups, I noticed it was faster to set the top cup to the left of the stack, then pick one from the stack and put it on top of the other two."</p> <p>"I learned that you couldn't slam the cups down; you have to set them lightly or they will fall on top of each other."</p>
Speed (rushing vs not rushing)	7	15	<p>"Do not rush. Don't go so fast because that will cause cups to fall."</p> <p>"To take your time, because if you rush, you end up messing up more."</p>
Grasping whole stack vs moving individual cups	7	8	<p>"I learned not to take the cups out one-by-one. With the 6 cup pyramid, it is best to grab 3 cups in one hand and 2 in the other, then let the bottom ones drop out of your hand."</p> <p>"I observed that the cups needed to fall from your grasp into the formation. This is especially important on the middle stack."</p>
Order of take down	5	7	<p>"Take down big pyramid first, then small ones."</p> <p>"Whichever side you start on, break down from the opposite side."</p>
Spacing between stacks/pyramids	5	5	<p>"I also learned to keep my stacks a little closer together so that I could be quicker in unstacking them."</p> <p>"I learned that it is better to space out the 3 sets of cups so you don't hit another pyramid or confuse what cups go with which pyramid"</p>
Sliding take down strategy	3	6	<p>"Slide the cups down to deconstruct the pyramid."</p> <p>"Slide the cups down to the middle when you are breaking the cups down to save time."</p>
Spacing between cups	3	3	<p>"Try getting cups as tight as possible."</p> <p>"Not to place the base cups too far apart within the stack"</p>

Second, when asked what they had learned through observation, participants provided responses indicating they had learned varied strategies. On average, those who observed two models prior to physical practice identified more strategies (2.28) than individuals who observed one model (1.78). In addition, some strategies were identified more often by those who observed two learning models before practicing, specifically strategies for stacking individual cups, finding an appropriate speed, and the sliding take-down approach.

These two findings support the perspective that, when observing a learning model, the observer engages in cognitions associated with skill acquisition, which may include searching for effective solutions to the problem, appraising strategies used by the models that are more and less effective, and recognizing errors and means for correcting them. Then, during subsequent physical practice, observers used what they had learned during observation to begin at a level in advance of the model, and continued to improve. Proposals about the information provided via modeling includes the idea that demonstrations convey strategies for action (Horn & Williams, 2004; Shea, Wright, Wulf, & Whitacre, 2000; Ste-Marie et al., 2012; Taylor & Ivry, 2012), and previous research supports this suggestion (e.g., Buchanan & Dean, 2010; Meaney et al., 2005).

Participants assigned to the Learner 3 position observed two different learners engage in physical practice and therefore observed 40 modeled trials prior to engaging in their own physical practice. By comparison, Learner 2 observed one model perform 20 trials prior to practicing. The advantage for Learner 3 may be a function of both quantity of observations, and the variety of performances observed. Previous research has shown that skill acquisition is improved when observing more demonstrations, particularly prior to engaging in physical practice (Carroll & Bandura, 1990; Ong & Hodges, 2012). For example, Feltz (1982) reported that performance of a climbing task was better when participants were shown 12 demonstrations compared to four or eight. It is also likely that one model performed the task differently than another, explored different strategies, and made different types of errors and corrections. Strategies identified are presumably a result of watching models engage in trials for which different strategies were employed, resulting in different performance speeds. Observers who watched two models prior to practice were likely exposed to a wider array of approaches to the task, as compared to those who observed only one model, thus allowing them to recognize a greater number of strategies. This explanation is consistent with previous research on strategy observation and use following model observation (Buchanan & Dean, 2010; Meaney et al., 2005).

The third main point, concerns the finding that learners who observed modeling prior to engaging in physical practice performed the task significantly faster than those who practiced prior to observing. While task performance in retention was faster for participants assigned to Position 3 position than Position 2, the difference was not significant. Thus, having the opportunity to observe either one or two learning models prior to physical practice was more beneficial than engaging in physical practice prior to model observation.

The temporal placement of modeling and physical practice has been explored previously, without definitive conclusions (Ong & Hodges, 2012; Ste-Marie et al., 2012). However, there is evidence supporting the advantage of modeling prior to physical practice (e.g., Andrieux & Proteau, 2013; Landers, 1975; Weeks &

Anderson, 2000). It is possible that observing modeling prior to physical practice provides the observer the opportunity to understand general task characteristics (Scully & Newell, 1985), and observe various strategies or approaches to the task. Strategies observed to be less effective can be eliminated, and those with more promise retained. Thus, more physical practice is devoted to the exploration and development of skills using effective strategies identified during observation. However, when physical practice is completed in advance of peer observation, more of physical practice is spent on strategy exploration, and less on effectively using them to complete the task, with the resultant retention (learning) being reduced.

The results of this experiment align with, and add to, previous research on the effects of observing a learning model, and support the notion that one underlying cause of this accelerated acquisition and retention is the engagement in cognitive processes that characterize the early stages of skill learning (Adams, 1986; Blandin & Proteau, 2000; Lee & White, 1990). Specifically, observation of a learning model facilitates exploration and evaluation of possible patterns of coordination and/or strategies (Horn et al., 2002), assessing the viability of such, and identifying errors and means of remedying them. The experiment reported here adds to the literature by comparing the effects of observing one versus two learning models, and examining the effects of the placement of model observation relative to physical practice. An additional unique aspect of this experiment was the inclusion of self-reports by observers concerning what they had learned by watching their peer(s) practice. While not all cognitive activities are suspect to conscious awareness, theory suggests that cognition underlies observational learning, and an attempt was made to determine what learners believed they had learned by watching. Self-reports from the learners highlight the nature of information gleaned from the models in this task, specifically the strategies observed that were associated with improved performance of the task.

This experiment may also be couched within a larger body of literature that has examined the effects of observing models who are engaged in the process of acquiring motor skills, as opposed to those who demonstrate desired or correct actions (e.g., dyad practice). Continued examination of these types of models is warranted. This may include exploration of various modeling conditions and tasks, as well as further investigation of the factors underlying cognitions that result from watching others learn. Historically, modeling research has studied its effects on motor performance, but recent investigation has taken a more learner-centered approach (Ste-Marie et al., 2012), with this research offering new perspectives. The benefits of observing peer models may result from a variety of factors including gaining information on the task, engaging in mental practice, as well as motivation resulting from competition, and changes in self-confidence. The idea that learners gain insight into more and less effective strategies for action from model observation also needs further investigation and may require a closer examination of specific strategies used and explored by models and observers. Finally, the impact of temporal placement of model observation relative to physical practice has yet to be clearly established (Ong & Hodges, 2012; Ste-Marie et al., 2012). In this experiment, there was a clear advantage for observing a learning model (or two) prior to engaging in physical practice. Yet, modeling both before and during physical practice has been shown to enhance learning, and future research on this aspect of modeling is needed.

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