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The Effect of Bandwidth Modeling on the Learning of Movement Components

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Abstract

Background: The authors assessed the effect of bandwidth modeling in learning relative timing and absolute timing. **Method:** Participants were 10 male high school students who volunteered to participate in the experiment (M age = 16 years, SD = 0.942 years). None of the participants had prior experience with the task or was informed about the purpose of the experiment. They had to learn soccer chip shot under either a bandwidth (model delivered when participant's performance was outside a predefined bandwidth or rang) or yoked (same number of model provided as bandwidth group) modeling procedure. **Results:** The results show that the bandwidth group was more effective in learning relative timing than the yoked group. **Conclusions:** It indicated that benefits of feedback frequency reduction is generalizable to observational learning context. The authors propose that this method may be an appropriate method for relative timing learning.

Keywords: Bandwidth modeling, Observational learning, Soccer chip shot

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INTRODUCTION

In the motor control and learning domain, theoretical models suggest that two distinct and independent mechanisms are involved in action production (Badets & Blandin, 2010). One mechanism deifnes the relationship between elements in the movement sequence, and another responsible for the activities is required for the scaling of the individual elements. The relationship between elements in the motor sequence relfects a coordination structure (Kelso, 1997), which is stored in a abstract representation (Schmidt, 1975; Vogt, 1995). However, the scaling representation emphasizes the control of action execution (Schmidt, 1975; Mattar & Gribble, 2005) and implies mechanisms of detection and correction of errors are independent of the abstract representation (Blandin & Proteau, 2000; Shea & Wulf, 2005).

Physical practice is not the only way to acquire new motor skill and observation of a model can facilitate learning a wide range of behavior (Bandura, 1986; Blandin & Proteau, 2000; Mattar & Gribble, 2005). Numerous experimental manipulations have been shown to impact observational learning in a manner very similar to that for physical practice, and hence reinforce the seminal suggestion that similar cognitive processes are involved between the two practice conditions (Adams, 1986).

Scully and Newell (1985) proposed that when individuals observe a moving demonstration, the visual system perceives and automatically minimizes relative motion. When the learner attempts to reenact the observed movement, the relative motion pattern acts to constrain the emergence of coordination through its informational or instructional properties. The observation enhances in a wide part the abstract coordination learning of a task such as relative timing (Buchanan, Ryu, Zihlman & Wright, 2008; Shea, Wright, Wulf, & Whitacre 2000).

As suggested by Shea et al. (2000), for physical practice, the absolute timing for motor constraints and relative timing for coordination are both primary goals for the task, and during over action, these goals are principally governed by motor processes (Dominey, Lelekov, Ventre-Dominey, & Jeannerod, 1998; Schmidt, 1975).

Among the different variables known to improve learning of the abstract structure, feedback (knowledge of results [KR]) is one of the most important (Schmidt & Lee, 2005; Shea & Wulf, 2005).

According to Challenge Point Torey, learning loses in the presence of excessive or very low information and reduces the amount of provided information via model must be according to the skill level of the learner and difficulty of task (Guadagnali & Lee, 2004), and a person can learn temporal-spatial complex acts when movement pattern was determined by task constraints (Hays, Ashford & Benet, 2008).

Observation with a low KR frequency might have enhanced the capacity of participants to extract important information about relative characteristics of movement such as relative timing, because it is accepted that a low KR frequency enhances the sensory and perceptual process during skill acquisition (Winstein & Schmidt, 1990; Badets, Blandin, Wright, & Shea, 2006; Blandin, Toussaint & Shea, 2008).

Bandwidth KR appears to be a particularly fruitful schedule for relative timing learning (Lai & Shea, 1999). Bandwidth KR schedule during both observational and physical practice was beneficial to the participant’s relative timing goal learning (Badet & Blandin; 2010). But in the field of observational learning, the impact of feedback reduction has been less studied in the form of bandwidth modeling (re-presentation of model in case of departure from the specified range). In this regard, only Bahrampoor (2010) has investigated the impact of bandwidth modeling on relative and absolute timing learning of a sequential timing task and showed that this method has influence on absolute timing learning. However, Bahrampoor’s results contradict previous findings concerning the impact of observational learning on learning movement components (Buchanan et al. 2008; Shea et al., 2000).

According to our knowledge, the effect of bandwidth modeling has never been examined on sport skills within the field of observational learning. Therefore, in this research, we study the effect of bandwidth modeling together with physical practice on learning movement components in a soccer chip shot. Based on the literature, we expect that the bandwidth group show further progress in terms of relative timing learning compared with the yoked group.

METHOD

Participants were 10 male high school students who volunteered to participate in the experiment (M age = 16 years, SD = 0.942 years). None of the participants had prior experience with the task or was informed about the purpose of the experiment. Each participant was requested to read and sign a consent form prior to participation. They were randomly divided to bandwidth and yoked groups. All participants were self-declared right-footed individuals, and they had normal vision.

The students' task was to chip a soccer ball over a barrier 0.50 m in height at a distance of 4.0 m. We selected that movement to increase the novelty of the task. Whereas kicking might be considered a fundamental motor pattern, chipping is a context-specific skill (Clark, 1994). That means that without soccer experience, the participants were not likely to adapt the basic kicking pattern into a chipping action (Horn, Williams, Scott, & Hodges, 2005). Also, this type of multi-articular task involves multiple biomechanical degrees of freedom. Therefore, it offered the opportunity to investigate not only performance outcomes but also changes to movement form as a consequence of practice (Chow, Davids, Button, & Koh, 2007).

We constructed a target area of a circle 80 cm in diameter; a red cross indicated the target center. The center of the target was 8 m away from the ball starting position. An Astroturf mat was placed on the start position of the shots to minimize friction between the sole of the kicking foot and the floor (Uehara, Button, & Davids, 2008).

The model was a college-level male soccer player (age = 17 years). After a period of practice, we filmed the model in the sagittal plane using a video camera (Canon Powers hot G9) during the performance of a successful chip for demonstration of participant. The viewing time of the videotape recording was approximately 30 seconds. The view of the demonstrations in this videotape recording contained the model's whole body movement, the target, and the trajectory of the ball (Al-Abood, Davids, Bennett, Ashford, & Marin, 2001).

Movement kinematics were collected using a motion analysis system (Digital Camera, Casio Exilim, and 12 X Optical 200 m) at a capture rate of 300 Hz for all markers. Four reflective markers were placed on the participants' right side at the distal head of the fifth metatarsal (toe), the lateral malleolus (ankle), the lateral condyle of the femur (knee), and middle of the thighbone. The motion analysis calculations were performed using motion analysis software of Tak Arsh (see and compare the output with Winanalyze software in www.sportseng.com).

A summary of the experimental design is provided in Table 1. The participants were assigned at random to one of two experimental treatment groups (n = 5): Bandwidth and yoked group. All participants followed the same experimental procedures but differed in the reason of observation of model (KR) during acquisition and practice phases. All participants observed the model performance for six times before physical practice trials. The bandwidth group received a video of the model again, only when his performance fell outside the circle area, but the yoked group received the model on the same trial as the bandwidth group, whereas they did not know its reason. The participants were allowed a 1 min rest after every block (Al-Abood et al., 2001). Each trial was initiated by a ready command given by the experimenter approximately 2 s before the `go’ command to start the movement.

Other phases, called retention, were performed approximately 24 hours after the end of the acquisition. 2 and 10 minutes after retention was performed, the transfer test with distance reduction to 630 cm was taken.

Dependent Measures and Data Analysis

Movement coordination (relative timing): To examine the effect of bandwidth modeling on movement coordination, we computed the participants’ relative timing pattern to those of the model. The task was segmented into three steps: First or before kicking (start of knee flexion to end of knee flexion), second or during kicking (start of knee extension to first contact with the ball), and third step or after kicking (start of kicking the ball to the end of hip flexion). Due to variation in the time it took participants to begin the movement, the start and end points of the movement were normalized across trials. We used the following formula:

$$\text{Relative timing error (AE prop)} = |R1-T_1|+|R2-T_2|+|R3-T_3|$$

Movement control (absolute timing): Absolute movement time was used as a measure of control (see Newell, 1985). This measure was operationally deifned as the d.fference in time it took each participant to complete the action in comparison to the model. The start point was when the knee started to flex, and the end point was when the hip fully flexed after ball shot and follow-through.

Statistical Analysis

All control and coordination variables were analyzed by using separate factorial analyses of variance (ANOVA) in both groups. For all analyses, means and standard deviations were computed for each participant for the first six Acquisition 1 trials, the last six Acquisition 2 trials, and the first six retention and transfer trials. We used the Bonferroni test to follow up significant effects as appropriate (alpha = $p < .05$). When we observed violations of the assumption of sphericity for repeated measures ANOVA, we adjusted data with a Greenhouse-Geisser correction.

RESULTS

Table 1: Experimental Phases Performed by the Two Groups

Day 1					24 hours past	
	Observation	**Acquisition 1**	**Practice**	**Acquisition 2**	**Retention**	**Transfer**
Bandwidth	6 observations	10 physical practice trials + KR	4 blocks of 10 trials + KR	10 physical practice trials + KR	10 physical practice trials (no KR)	10 physical practice trials (no KR)
Yoked	6 observations	10 physical practice trials + KR	4 blocks of 10 trials + KR	10 physical practice trials + KR	10 physical practice trials (no KR)	10 physical practice trials (no KR)

Note: KR = Knowledge of results via re-observation

Table 2: Mean (M) and Standard Deviation (SD) of Relative Timing Error

Test Period								
	Acquisition 1		**Acquisition 2**		**Retention**		**Transfer**	
Group	*M*	*S*	*M*	*S*	*M*	*S*	*M*	*S*
Bandwidth	23.38	11.78	22.39	11.06	25.11	16.30	24.85	15.81
Yoked	31.83	13.08	32.87	18.36	38.16	13.83	35.87	15.82

Table 3: Mean (M) and Standard Deviation (SD) of Absolute Timing Error

Test Period								
	Acquisition 1		**Acquisition 2**		**Retention**		**Transfer**	
Group	*M*	*S*	*M*	*S*	*M*	*S*	*M*	*S*
Bandwidth	.10	.07	.14	.17	.15	.19	.14	.26
Yoked	.12	.08	.08	.06	.09	.07	.13	.07

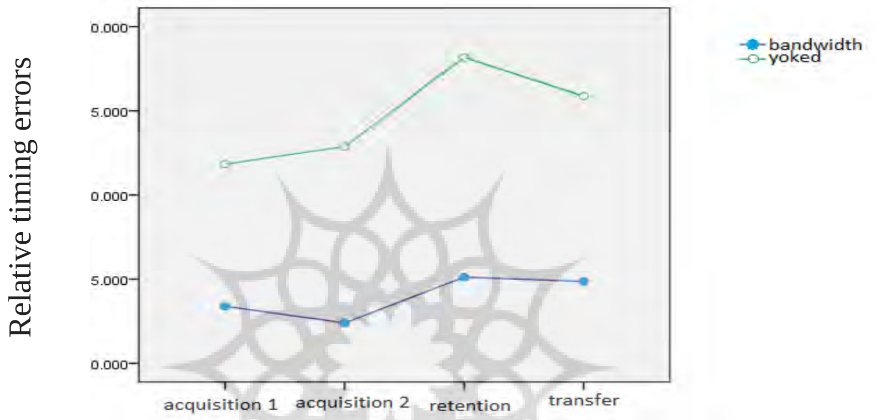

Figure 1: Mean relative timing error for all test blocks as a function of display for the two groups

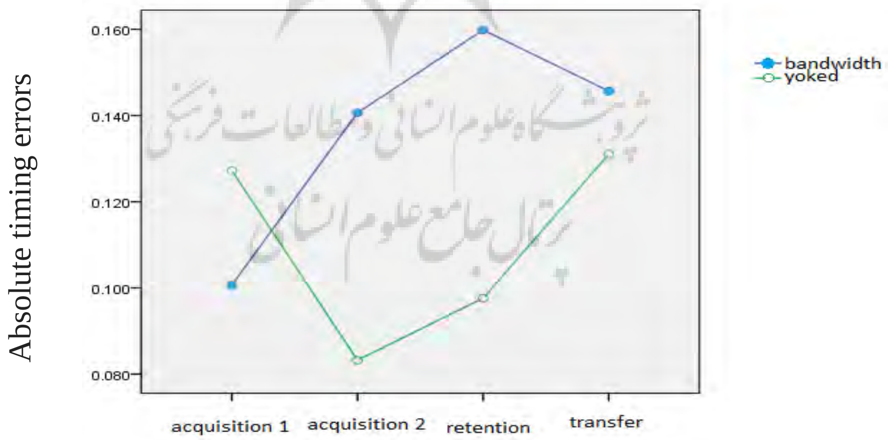

Figure 2: Mean absolute timing error for all test blocks as a function of display for the two groups

Movement coordination (relative timing): We analyzed the mean data for between and within group differences. No signiifcant main . ffect was observed for trial blocks, F (2.631, 152.579) = 2.330, p = .085 and groups × trial blocks Interactions F (2.631, 152.579) = 0.511, p = 0.651. However, there was a significant main effect for groups F (3.56, 103.3) = 7.097, p = 0.001. Follow-up Bonferroni tests revealed significant differences between the two groups in Acquisition 1 (p = 0.031) and Acquisition 2 (p = 0.014). Also, there were significant differences between the two groups in retention block (p = 0.0004) and transfer block (p = 0.005), as shown in Table 2 and Figure 1.

Movement control (absolute timing): The ANOVA on mean absolute timing scores showed no significant effect for groups F(3.057, 88.64) = 1.354, P = 0.262 or groups × trial blocks Interactions F(2.512, 145.691) = 2.139, p = 0.109. Moreover, there was no significant main effect for trial blocks F (2.512, 145.691) = 2.139, p = 0.109. The results are shown in Table 3 and Figure 2.

DISCUSSION

The aim of the present study was to investigate the effect of bandwidth modeling on learning the soccer chip task via the comparison of a bandwidth group with a yoked group. We expected to see further advance of relative timing learning in the bandwidth group in comparison with the yoked group. As expected, we observed less relative timing error in the bandwidth group for the stages of acquisition, retention and transfer relative to the yoked group, while there was no difference between these two groups regarding absolute timing error. The results indicated that, in case of departure from the specified range, providing bandwidth feedback information in the form of re-demonstration of a skilled model and then having physical practice again to acquire soccer chip shot skill had a positive impact on relative timing learning of the movement. Thus, bandwidth learning is introduced as an effective method to increase relative timing learning within the field of observational learning (Buchanan et al., 2008; Shea et al. 2000).

Consistent with previous findings, our results show that the decrease of KR and bandwidth KR is effective in achieving relative timing of movement during observational learning (Winstein & Schmidt, 1990; Badets et al., 2006; Blandin et al., 2008; Badet & Blandin, 2010). A possible explanation for the useful effect of bandwidth modeling could be provided based on challenge point theory (Guadagnoli & Lee, 2004) which let the subject have more effective performance in the absence of a model by an optimal use of information proportional to the conditions of the practice and the experience level of the learner. One possible reason for the lower-level learning of relative timing in the yoked group in comparison with the bandwidth group could be attributed to the determination of a specific limit for the landing point of ball and re-demonstration of a skilled model upon departure from that specified limit. This is so because according to exploratory learning theory (Hayes, Ashford & Bennett, 2008), complex temporal-spatial motor actions are faster acquired if movement pattern is restricted. Our results are in agreement with the views of Scully and Newell (1985).

They stated that information acquired from observation is an aspect of coordination. On the other side, our results are inconsistent with those of Bahrampoor's (2010). The study of the effect of bandwidth modeling in his work indicates the influence of this method on absolute timing, for which the reason could be the type of the task (sequential timing task). Since the ultimate goal of the task was set as the total time based on goal-directed imitation theory of Wohlschläger, Gattis, and Bekkering (2003), the ultimate goal of the task is the main restrictor that reduces the attention of the performer to other aspects.

However, in the present study, by selecting the task of soccer chip, putting emphasis on a specific component of movement was prevented. Furthermore, the circumstances made the test closer to the real sports situation.

CONCLUSIONS

In summary, the results of our research indicate that in observational learning, providing bandwidth feedback in the form of bandwidth modeling would facilitate relative timing learning of movement, which is consistent with the views of Scully and Newell (1985), challenge point theory (Guadagnoli & Lee, 2004), and exploratory learning theory (Hayes et al., 2008). It is also in agreement with previous findings concerning the effect of observational learning and reduction of the frequency of bandwidth feedback (Lai & Shea, 1999; Badet & Blandin, 2010). Therefore, coaches could utilize bandwidth modeling when using video systems and even for practices without any coach. It is also recommended to conduct further studies on other relative features of movements, other sport techniques, and other types of feedback to introduce the best observational learning method.

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