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The Effects of Autonomy Support on Observational Motor Learning

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Abstract

Previous studies have shown that autonomy support (AS) can foster a person's motivation and facilitate motor learning. However, the effects of AS on observational motor learning are not well understood. The present study investigated this issue by manipulating to-be-observed-model. Forty-eight male students were assigned into autonomy, yoked, and no-demonstration control groups. Three male Baseball coaches acted as models A, B, and C. Model A was instructor of students of AU group and acted as a model with high social status for AU group. Models B and C were not familiar for all participants and acted as low social status models. Participants were asked to perform a Baseball-pitch into a target during pretest (10 trials), acquisition phase (5 blocks of 10 trials), and retention test (10 trials). Prior to each acquisition block, the participants of AU and YO groups observed a model three times. Participants of AU group were free to choose model A, B, or C for any single observation. Participants in YO group were matched with those in AU group. Movement outcome, movement form, self-efficacy (SE), perceived learning effect (PLE), and perceived model attractiveness (PMA) were measured as dependent variables. Results showed that AS, relative to yoked and control conditions, led to better movement outcome during acquisition and retention. Action observation enhanced movement form during acquisition and retention. AS increased SE, PLE, and PMA compared with yoked and control conditions. Results provide support for the OPTIMAL theory and indicate that AS facilitates observational motor learning.

Keywords: Autonomy, model observation, OPTIMAL theory, self-efficacy

Introduction#

Autonomy support (AS) is considered as a key factor in the OPTIMAL (Optimizing Performance through Intrinsic Motivation and Attention for Learning) theory of motor learning (Wulf & Lewthwaite, 2016). AS refers to situations in which a person is allowed to control or choose some aspects of practice or performance conditions (Simpson, Ellison, Carnegie, & Marchant, 2020; Wulf & Lewthwaite, 2016; Wulf, Lewthwaite, Cardozo, & Chiviacowsky, 2017). In previous studies, AS has been studied in various ways such as self-controlled augmented feedback (Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Chiviacowsky, 2014, Ghorbani, 2019), choosing the color (Lewthwaite, Chiviacowsky, Drews, & Wulf, 2015; McKay & Ste-Marie, 2020 a, b; Wulf, Iwatsuki, Machin, Kellogg, Copeland, & Lewthwaite, 2017) or controlling order of practice (Wulf, Freitas, & Tandy, 2014). A general finding in these studies was that AS in comparison to a yoked condition results in superior motor performance and learning in children and adults (for a review see Wulf & Lewthwaite, 2016). Additionally, some studies found that AS in comparison to a yoked condition increases self-efficacy (SE) and intrinsic motivation (Bund & Wiemeyer, 2004; Chiviacowsky, 2014; Ghorbani, 2019; Hooyman, Wulf, & Lewthwaite, 2014; Lemos, Wulf, Lewthwaite, Chiviacowsky, 2017; Wulf, Chiviacowsky, Drews, 2015; Wulf, Chiviacowsky, &

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Cardozo, 2014). As a result, the OPTIMAL theory proposed that AS would increase performer's expectations and subsequently facilitate motor performance and learning (Wulf & Lewthwaite, 2016).

AS can be explored in many components related to motor learning. One of the most important factors that can affect motor learning is action observation. Observational motor learning is a common way for facilitating acquisition of new motor skills in children and adults (Ashford, Bennett, & Davids, 2006, 2007; Ghorbani & Bund, 2016; Hodges, 2017; Hodges & Franks, 2002; Hodges, Williams, Hayes, & Breslin, 2007; Maslovat, Hayes, Horn, & Hodges, 2010; Wulf, Shea, & Lewthwaite, 2010). However, AS has been rarely investigated in observational motor learning context. For instance, Wulf, Raupach, and Pfeiffer (2005) examined the effects of self-controlled observational practice on motor learning. The motor task was a jump shot from a free-throw line. The participants in self-control group were informed that they could watch freely the video model at any time as often as they want during practice phase. Those in yoked-control group were told that the video model would be demonstrated from time to time during practice phase. The results showed that although there were no significant differences between groups in practice phase, self-control group outperformed the yoked group in retention test in terms of both form and accuracy scores. Motivational state was not measured in this study.

In addition, Ste-Marie, Vertes, Law, and Rymal (2013) examined this issue further by a self-observation instead of expert model. Children were asked to train a progression of trampoline skills during 2 days. Learner-controlled group had control on when and how much they want to watch their performances (self-observation), whereas yoked group had no control over self-observations. Physical performance, SE, intrinsic interest, perceived choice, and perceived success were measured as dependent variables. Results showed that SE in learner-controlled group increased during practice days, while no improvements were observed for yoked group. On the retention test, learner-controlled group had higher scores in terms of intrinsic motivation, perceived choice, and performance in comparison to yoked group. Finally, Kok, Komen, van Capelleveen and van der Kamp (2020) investigated the effects of self-control video feedback on motor learning and SE in a physical education setting. Children from first grade in school asked to practice a shot-put during four practice sessions organized during physical education lessons. One class trained with self-controlled video feedback and a second class trained as a yoked fashion. A third group trained in a traditional way, in which teacher guided children with demonstrations, verbal instructions and feedback. Shot-put distance, shot-put technique and SE were measured as dependent variables. Results showed that self-control video feedback training did not lead to superior motor learning compared with other conditions, but it had positive effects on SE.

The above-mentioned studies, which mostly used self-observation feedback, show that AS increased motivation in observational learning process. However, there are some other factors related to observational model learning that can be investigated. One of important factors related to observational motor learning is model type. Model type (i.e., who to observe) has been extensively studied in observational motor learning literature. For instance, it has been shown that observing expert vs. novice (Andrieux & Proteau, 2013; Rohbanfard & Porteau, 2011), high social status vs. low social status (McCullagh, 1986), and similar vs. dissimilar (Meany et al. 2005) models result in superior motor learning. However, AS by giving the learners to choose the to-be-observed model has not been investigated yet. The present study was designed to extend existing knowledge and further examine the role of AS on observational motor learning. This study posed the question whether giving a choice to the observers to choose who to observe (from models with different levels of social status) would benefit observational motor learning in comparison to a yoked group? Therefore, the purpose of the present study was to investigate the effects of AS through giving choice to the learners to choose who to observe on motor learning and motivational state. In the present study, it was hypothesized that AS would result in better motor learning and motivational state in comparison to yoked and no-demonstration control conditions.

Method

The current study utilized an experimental approach in which the participants were randomly allocated to experimental and control groups who performed a pretest and a retention test.

Participants

Forty-eight undergraduate male university students from general physical education courses (mean age = 21.31 years; SD = 1.81) participated in this study for course credit. Participants had no previous experience of Baseball-pitch. All were right-handed and had normal or corrected-to-normal vision. The participants were equally assigned into autonomy (AU), yoked (YO), and no-demonstration control (C) groups. The protocol was performed in accordance with the Declaration of Helsinki and was approved by the university's ethical board. The students gave written informed consents.

Motor Task

Motor task was a very complex and dynamic throwing action with high coordinative demands, i.e., Baseball-pitch. Dillman, Fleisig, and Andrews (1993) divided the pitch into six phases including wind-up, stride, arm cocking, arm acceleration, arm deceleration, and follow-through. In the present study, the task was to stand within an area of 3 m × 3 m and throw a baseball towards a square target with 1 m side that was drawn on the wall and was positioned 8 m away. Participants of observation groups were asked to try to hit the target while exactly replicating the model's form or style. Control group was only asked to try to hit the target, because they received no model.

Model

Three right-handed male Baseball coaches with several years of experiences were chosen to act as models A, B, and C. Age of models A, B, and C were 37, 39, 30 years-old. Model A was a university instructor who worked as the instructor of participants of AU group. The aim of choosing this instructor was that the students of AU group were familiar with him and they might feel a model with high social status. It should be noted that the experiment was done in the second half of university semester and it was assumed that the students in AS group got familiar with their instructor. However, the students of YO and C groups had neither course with model A nor models B and C. So, it can be assumed that they have no previous familiarity with models and these models can act as low social status models. To make sure, students were shown a picture of models and asked whether they know them. Results confirmed that all students of AU group knew model A but not models B and C; and all students of YO and C groups did not know any models. Video models were generated by using a digital camera from a sagittal plane. In each video, the model demonstrated the Baseball-pitch as well as explained in detail standard instructions including how to stand, hold the baseball, move the body, and release the baseball toward the target.

Instruments

Movement outcome: On each trial a score of one was awarded if the baseball hit target.

Movement form: Two male experienced Baseball coaches evaluated performances of participants. Evaluation was performed by using an evaluation form which designed especially for this research. Totally, twenty-one criteria on a four-point scale from 0 (criterion is not met) to 3 (criterion is perfectly met) were considered for the evaluation form. Therefore, score of a pitch performance varied between 0 to 63 points. Because of large number of trials during the experiment, a selection of trials was chosen and filmed by a digital camera for later evaluation. For each participant, a total of 21 trials (including first three trials of the pretest, each acquisition block, and the retention test) were selected for later analysis. Both raters evaluated all selected trials. Correlation between the two raters was good to very good (mostly over 0.70). Evaluation scores of the first rater were used for statistical analysis.

Self-efficacy: Two forms of SE, namely movement outcome SE and movement form SE, were measured. In previous research in which the effects of AS on observational motor learning was investigated, only one dimension of SE was assessed while action observation has positive effects on movement outcome as well as movement form (Ashford et al. 2006). Therefore, in this study both dimension of SE including movement outcome and movement form were assessed to highlight a better picture of the effects of AS on SE during the process of observational motor learning. To assess movement outcome SE, participants were asked to rate how confident they were, on a scale from 0 (not confident) to 100 (absolutely confident), to hit the baseball into target at least on half of following trials (5 of 10 trials). Half of the trials in each throwing part was selected because the Baseball-pitch is a very unusual sport skill in country where this study was done as well as participants were novices with no prior experiences in Baseball-pitch. Therefore, it was assumed that half of the trials in each throwing part would be a logical goal for a good level of throwing accuracy. To assess movement form SE, participants were asked to rate how confident they were, on a scale from 0 (not confident) to 100 (absolutely confident), to replicate a standard Baseball-pitch style.

Perceived learning effect: In order to assess perceived learning effect (PLE) during the acquisition phase, participants rated "I learned to improve my Baseball-pitch during the practice sessions" on a scale from 0 (highly disagree) to 100 (completely agree).

Perceived model attractiveness: Perceived model attractiveness (PMA) in participants of AU and YO groups was rated on a scale from 0 (not attractive) to 100 (absolutely attractive).

Procedure

Participants were tested individually in two days. Prior to data collection, participants were given general information of experimental process and then completed a questionnaire to provide information such as age, laterality, and previous experiences of motor task. To familiarize with experimental setting, participants performed two throws. Then, they performed a pretest including 10 trials while no model-observation or other instructional information were provided. During the acquisition phase, participants performed five blocks of 10 trials, and one day later they performed the retention test consisting of 10 trials without any model-observation. Prior to each acquisition block, participants of AU and YO groups observed a model three times. To provide sense of autonomy, participants of AU group were shown a photo of each model and told that they can choose to watch the model A, B, or C. They were free to choose any model they wanted for a single observation. For instance, a participant could choose models A, C, A prior to an acquisition block. Participants in YO group, who were matched with those of AU group on the basis of model observation, were told that they will observe model demonstrations for three times prior to each acquisition block, but they had no choice to select the model. Participants in C group received neither model observation nor instruction throughout the acquisition phase. Participants were allowed to freely look at landing points, however, no knowledge of results was provided to them. Movement outcomes were recorded for further analysis. Additionally, first three throws in each experimental part (inducing pretest, each acquisition phase, and retention test) were recorded by using a digital camera for further analysis. Participants completed SE scale prior to the pretest, each acquisition block, and the retention test. Perceived learning effect and perceived model attractiveness were assessed after the acquisition phase.

Data Analysis

Mean and standard deviation were used to descriptively report the data. Movement outcomes, movement form, and SE scores on the pretest (baseline) were analyzed by a one-way analysis of variance (ANOVA). Movement outcome, movement form, and SE scores on the acquisition phase were analyzed by a 3 (GROUP: AU, YO, C) × 5 (BLOCK: five acquisition blocks) ANOVA with repeated measured on the last factor. Movement outcomes, movement form, and SE scores on the retention test were analyzed by a one-way ANOVA. PLE scores were analyzed by a one-way ANOVA. When there were significant group differences, partial eta squared (η^2) was calculated as the effect size. Independent-Samples *t* test was used to compare PMA scores of AU and YO groups. Furthermore, simple linear regression analyses were used to determine possible associations between movement outcome and movement form SEs on the pretest, the acquisition phase, and the retention test with movement outcome and movement form scores, respectively. To perform regression analyses on the acquisition phase, scores on the five blocks were averaged. Tukey test was used as Post-hoc test. For all analyses, significance level was set at $p < .05$.

Findings

Frequency of Model Selection

Results showed that participants of AU group have chosen Model A 13.12±1.5 of 15 times.

Movement Outcomes

Means of movement outcome scores of experimental groups across the pretest, the acquisition phase, and the retention test are presented in Figure 1. Analysis of movement outcome scores on the pretest showed no significant main effect for GROUP, $F_{(2, 45)} = 1.16$, $p = .32$, indicating that experimental groups had identical movement outcome performance at baseline. During the acquisition phase, there was a significant main effect for GROUP, $F_{(2, 45)} = 14.38$, $p < .001$, $\eta^2 = .39$, but main effect for BLOCK, $F_{(4, 180)} = 1.69$, $p = .15$, and GROUP × BLOCK interaction, $F_{(8, 180)} = .81$, $p = .59$, were not significant. Post-hoc tests revealed that during the acquisition phase AU group performed significantly better than YO and C groups, however, no significant differences were observed between YO and C groups. On the retention test, there was a significant main effect for GROUP, $F_{(2, 45)} = 5.04$, $p = .011$, $\eta^2 = .18$. Post-hoc test showed that AU group performed significantly better than C group, however, there was no significant difference between YO and C groups.

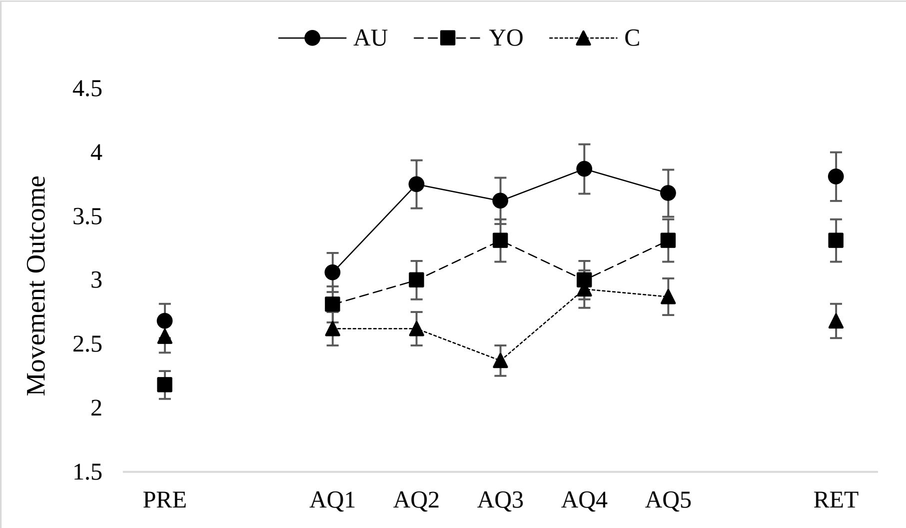

Figure 1.
Means and Standard Deviations of Movement Outcome Scores of Experimental Groups Across the Pretest, the Acquisition Phase, and the Retention Test.

Movement Form

Means of movement form of experimental groups across the pretest, the acquisition phase, and the retention test are presented in Figure 2. Results of ANOVA on the pretest showed that experimental groups had identical movement form scores at baseline, $F_{(2, 45)} = 2.41$, $p = .10$. During the acquisition phase, a significant main effect was observed for GROUP, $F_{(2, 45)} = 17.08$, $p < .001$, $\eta^2 = .43$, but main effect for BLOCK, $F_{(4, 180)} = .57$, $p = .68$, and GROUP × BLOCK interaction, $F_{(8, 180)} = 1.78$, $p = .08$, were not significant. Post-hoc tests revealed that during the acquisition phase AU and YO groups performed significantly better than C group, however, no significant differences were observed between AU and YO groups. On the retention test, there was a significant main effect for GROUP, $F_{(2, 45)} = 12.31$, $p < .001$, $\eta^2 = .35$. Here, AU and YO groups performed significantly better than C group. No significant differences were observed between the AU and YO groups.

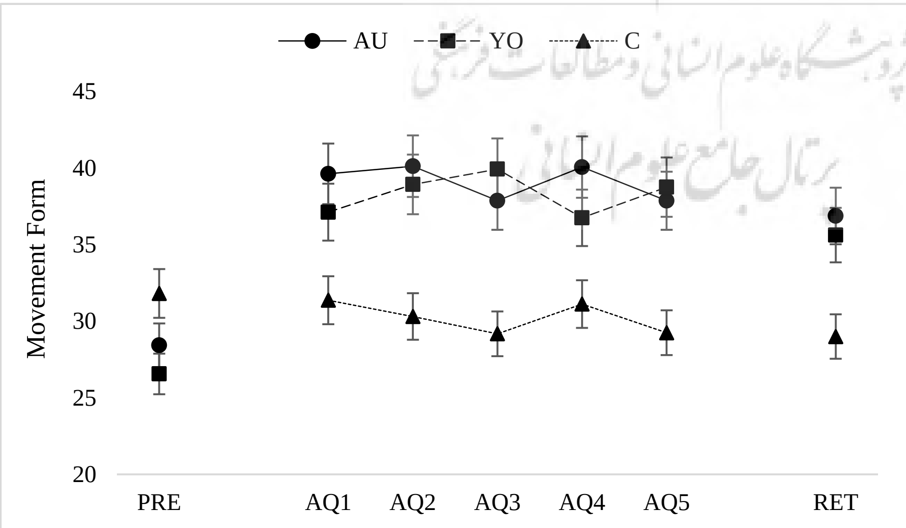

Figure 2.
Means and Standard Deviations of Movement Form Scores of Experimental Groups Across the Pretest, the Acquisition Phase, and the Retention Test.

Movement Outcome Self-Efficacy

Means of movement outcome self-efficacy of experimental groups across the pretest, the acquisition phase, and the retention test are presented in Figure 3. On the pretest, there was no significant main effect for GROUP, $F_{(2, 45)} = .66$, $p = .52$, for movement outcome SE indicating that experimental groups reported identical SE scores at baseline. During the acquisition phase, there was no significant main effect for GROUP, $F_{(2, 45)} = .58$, $p = .56$, but main effect for BLOCK, $F_{(4, 180)} = 3.02$, $p = .01$, $\eta^2 = .06$, was significant. GROUP × BLOCK interaction was not significant, $F_{(8, 180)} = .36$, $p = .93$. These results indicate that movement outcome SE scores were improved across the acquisition phase, regardless of group conditions. On the retention test, there was no significant main effect for GROUP, $F_{(2, 45)} = 1.03$, $p = .36$.

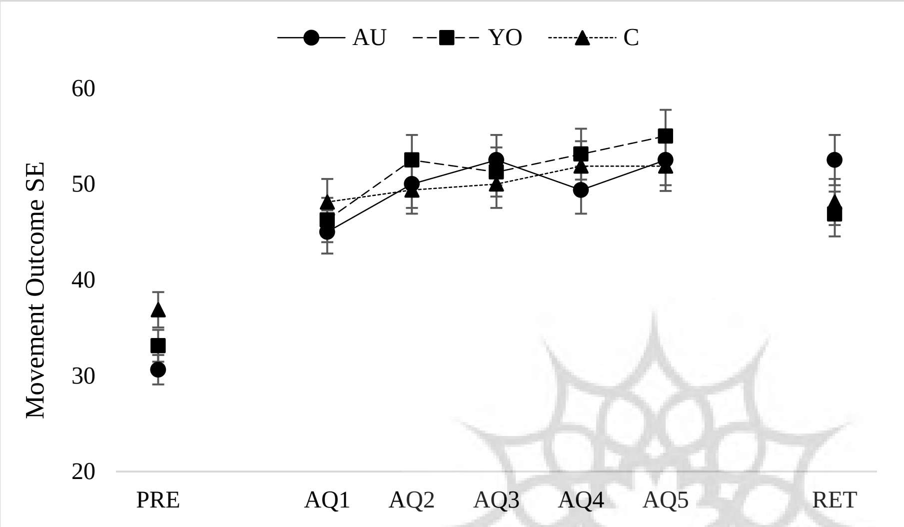

Figure 3.
Means and Standard Deviations of Movement Outcome SE Scores of Experimental Groups Across the Pretest, the Acquisition Phase, and the Retention Test.

Movement Form Self-Efficacy

Means of movement form self-efficacy of experimental groups across the pretest, the acquisition phase, and the retention test are presented in Figure 4. Results of ANOVA revealed identical movement form SE performance at baseline, $F_{(2, 45)} = .61$, $p = .54$. During the acquisition phase, a significant main effect was observed for GROUP, $F_{(2, 45)} = 12.82$, $p < .001$, $\eta^2 = .36$, BLOCK, $F_{(4, 180)} = 12.17$, $p < .001$, $\eta^2 = .21$, and GROUP × BLOCK interaction, $F_{(8, 180)} = 3.68$, $p = .001$, $\eta^2 = .14$. Post-hoc tests revealed that AU group significantly reported higher scores than YO and C groups. Additionally, YO group significantly reported higher scores than C group. Significant main effects for BLOCK and GROUP × BLOCK interaction indicate that AU and YO groups significantly improved their SE scores during the acquisition phase but C group showed no improvement (Figure 4). On the retention test, a significant main effect was observed for GROUP, $F_{(2, 45)} = 39.97$, $p < .001$, $\eta^2 = .64$. Here, AU group significantly reported higher scores than YO and C group. Moreover, YO group significantly reported higher scores than C group.

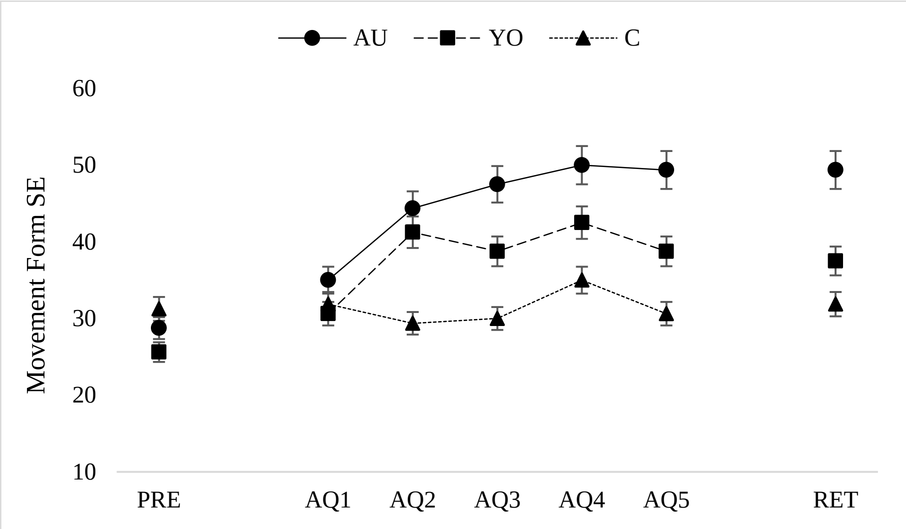

Figure 4.
Means and Standard Deviations of Movement Form SE Scores of Experimental Groups Across the Pretest, the Acquisition Phase, and the Retention Test.

Perceived Learning Effect

Means of perceived learning effect scores of experimental groups are presented in Figure 5. Results of ANOVA showed a significant main effect for GROUP, $F_{(2, 45)} = 31.04$, $p < .001$, $\eta^2 = .58$. Post-hoc tests revealed that AU group significantly reported higher PLE scores than YO and C groups. Moreover, YO group significantly reported higher PLE scores than C group.

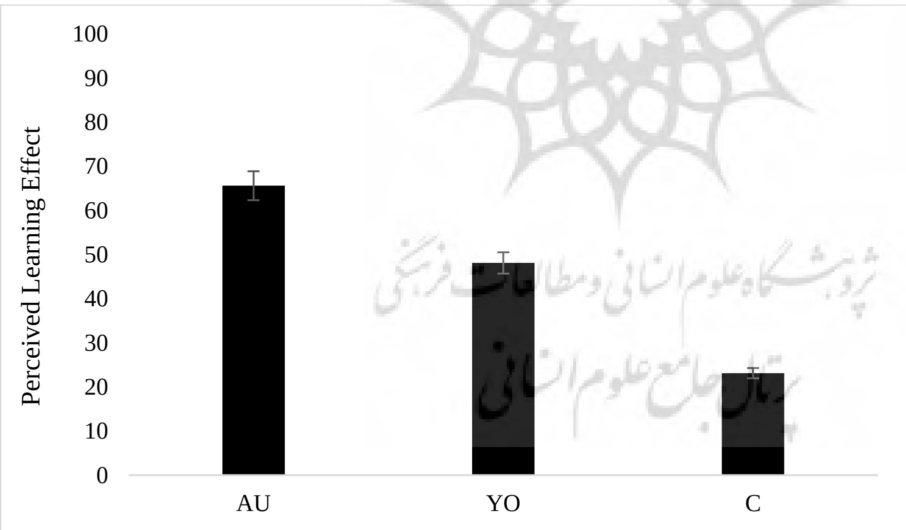

Figure 5.
Means and Standard Deviations of Perceived Learning Effect Scores of Experimental Groups.

Perceived Model Attractiveness

Means of perceived model attractiveness scores of AU and YO groups are presented in Figure 6. Results of Independent-Samples *t* test showed that AU group significantly reported higher PMA scores in comparison to YO group.

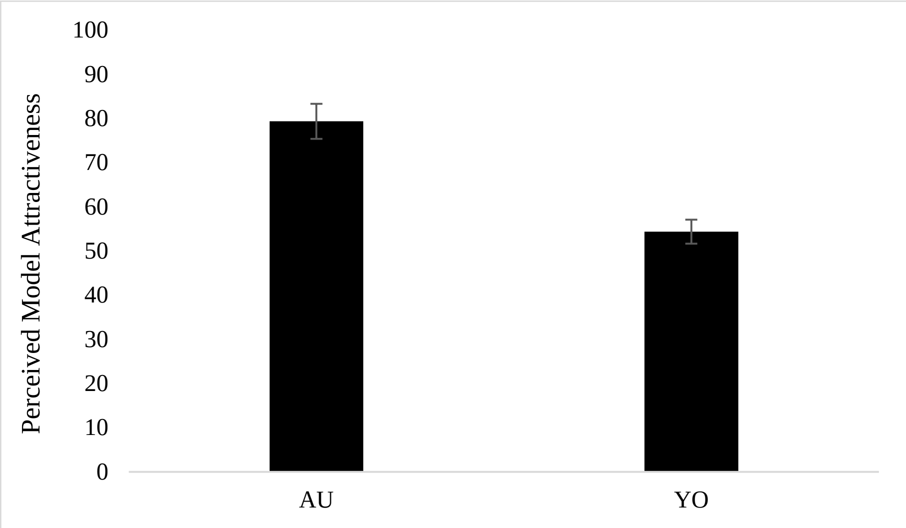

Figure 6.
Means and Standard Deviations of Perceived Model Attractiveness Scores of Observation Groups.

Regression Analyses

Movement outcome SE did not predict movement outcomes on the pretest, F (1, 46) = 3.61, p = .064, *Adjusted* R^2 = .053, β = .270, the acquisition phase, F (1, 46) = .01, p = .901, *Adjusted* R^2 = -.021, β = .018, and the retention test, F (1, 46) = .11, p = .740, *Adjusted* R^2 = -.019, β = -.049. Movement form SE did not predict movement form on the pretest, F (1, 46) = 1.01, p = .319, *Adjusted* R^2 = .000, β = .147. However, movement form SE did predict movement form on the acquisition phase, F (1, 46) = 6.22, p = .016, *Adjusted* R^2 = .100, β = .345, and the retention test, F (1, 46) = 8.14, p = .006, *Adjusted* R^2 = .132, β = .388.

Discussion and Conclusion

Previous research has clearly demonstrated that action observation enhances motor learning in novice performers (Ashford et al. 2006, 2007; Ghorbani & Bund, 2016; Hodges, 2017; Hodges & Franks, 2002; Hodges et al. 2007; Maslovat et al. 2010; Wulf et al. 2010). However, effects of AS, which is considered as an important factor in the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016), on observational motor learning has been rarely investigated. The present study was designed to investigate effects of AS by giving choice to novice observers to choose who to observe on SE and learning of a Baseball-pitch. It was predicted that AS would result in better motor learning and motivational state in comparison to yoked and no-demonstration control conditions.

Regarding to performance in Baseball-pitch, the results of movement outcomes revealed that AS condition compared with yoked and no-demonstration control conditions resulted in significantly better performance outcome on the acquisition phase and the retention test. However, observation itself (yoked condition) did not led to significantly higher movement outcome scores in comparison to no-observation condition. These results are in line with previous studies in which AS on action observation benefitted movement outcome (Ste-Marie et al. 2013; Wulf et al. 2005). As no superiority of action observation itself over no-observation was found, these results might indicate that effects of action observation on movement outcome would increase by AS. Moreover, results showed that action observation condition in comparison to no-observation condition, regardless of AS, resulted in improving movement form on the acquisition phase and the retention test. These results are in accordance with a large body of research indicating that action observation compared with no-observation condition leads to superior motor learning (for a review see Ashford et al. 2006, 2007; Wulf et al. 2010). Based on the above-mentioned results, it seems that action observation has positive effects on movement form than movement outcome. Additionally, providing AS to action observation would improve acquiring movement outcomes during the process of observational motor learning. Ashford, et al. (2006) conducted a meta-analysis of observational motor learning literature and found a moderate to strong effect size (0.77) on movement form and a small effect size (0.17) on movement outcome. Results of this study are in accordance with results of this meta-analysis and indicate that action observation affects movement form more than movement outcome. Based on results of this study, it can be suggested that AS can act as an influential factor on the process of observational motor learning by improving movement outcome.

Regarding to SE, two types of SE were measured in this study including movement outcome SE and movement form SE. The results of this study demonstrated that movement outcome SE scores were enhanced across the acquisition phase, however, regardless of group conditions. On the retention test, no significant differences were observed between groups. Nevertheless, the results showed that AU group in comparison to YO and C groups significantly reported higher movement form SE on the acquisition phase and the retention test. Furthermore, YO group compared with C group significantly reported higher movement form SE scores. These results are in line with those of previous studies showing improvements in movement form SE following AS on the process of observational motor learning (Kok et al. 2020; Ste-Marie et al. 2013). These results indicate that action observation itself can increase movement form SE, while AS can duplicate it (Figure 4). Regarding to PLE, results of this study indicated that participants in AU group significantly perceived higher learning effects as a result of observing their selected model in comparison to those in YO and C groups. Moreover, participants in YO group significantly perceived higher learning effect than those in C group. Finally, PMA was significantly higher in AU group in comparison to YO group. These results along with the results showing that on average 13.50 from 15 video observations in AU group were chosen Model A (which represents their instructor) indicating that giving choice to observers to select who to observe will result in higher motivation and PLE on the process of observational motor learning and it may be affected by perceptions of the observes towards their model attractiveness.

According to the regression analysis, there were reciprocal effects between participants' performance and SE. Results showed that movement outcome SE did not predict movement outcomes; however, movement form SE did predict movement form. These results are in accordance with those of previous studies (Kok et al. 2020; Ste-Marie et al. 2013) and provide further support for predictions from the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016) showing that enhanced expectancies in the form of AS mediated observational motor learning.

Based on these results, it should be stated that the results confirm hypothesis of this study and provide support for the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016), positing that AS leads to enhancements on motivational state that might partially explain better motor learning. OPTIMAL theorists assume that enhanced expectancies in the form of AS facilitate motor learning by making dopamine available for memory consolidation and neural pathway development, thus contributing to efficient goal-action coupling by preparing the motor system for task execution (Wulf & Lewthwaite, 2016). In this way, the enhanced expectations of participants in AU group may have led to extracting main spatiotemporal features of the action and subsequently more effective observational motor learning.

Among this study's limitations, only SE was measured as a psychological dependent variable (to measure effects of AS on motivational state in the process of observational motor learning). Nevertheless, future studies might operationalize participants' motivational state not only by SE but also by using other cognitive-motivational variables such as expectancies, goal-orientation and self-concept. Such an approach would provide additional information about other learner traits. Second, motor performance and learning was qualitatively measured, while future research might be improved by measuring motor performance and learning by using quantitative methods such as kinematic and kinetic analysis.

In conclusion, this study replicated prior findings that AS facilitated observational motor learning. It was further demonstrated that AS was associated with particularly enhanced motivational states and PLE of observers. These results support the OPTIMAL theory of motor learning, positing that enhanced expectancies in the form of AS can facilitate motor learning (Wulf & Lewthwaite, 2016). Practical implications of these results are the particular benefits of AS for novices in the process of observational motor learning. Accordingly, it can be suggesting that coaches, physical educators, and physical therapist may apply AS into action observation while teach novel motor skills.

Acknowledgments

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Conflict of Interest

No conflict.

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