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OBSERVATIONAL LEARNING WITH EXTERNALLY IMPOSED AND SELF-CONTROLLED FREQUENCY OF MODEL DEMONSTRATION

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Abstract
Introduction. The aim of this study was to investigate the effect of learning a complex gymnastic routine with different frequencies of externally imposed and self-controlled model demonstration. ***Material and Methods.*** Thirty undergraduate physical education (PE) students were randomly assigned to 3 groups: G100 (100% frequency), GS (self-controlled frequency) and GC (control group). Each participant from groups G100 and GS performed 150 trials of a complex gymnastic routine during 10 practice sessions. The learning effect was evaluated on the basis of the mean absolute error value and measured during pre-acquisition (baseline), acquisition (practice sessions) and post-acquisition (retention and transfer tests) phases. ***Results.*** It was revealed that observational learning with self-controlled and high externally imposed frequency of model demonstration proved to be equally effective. The differences were found during the acquisition phase only. The self-controlled group achieved higher outcomes than the externally imposed group. ***Conclusions.*** This study indicates that performance during practice sessions does not always reflect the permanency and adaptability of the motor skill learning process.

Key words: motor skill learning, complex gymnastic routine, students, video-based training

Introduction

There are many factors that facilitate motor skill acquisition [1, 2, 3, 4]. One of the methods used in motor skill learning is observational learning [5]. A video-based training is extensively used by coaches as a teaching strategy to facilitate the acquisition of motor skills, especially in sport settings. The observational practice enables the observer to extract information concerning coordination patterns of the learning task to organize and evaluate their own actions during a physical practice session. The positive impact of observation on the effectiveness of motor learning has been confirmed, e.g., in gymnastics [6, 7], swimming [8] or rowing [9].

The conclusion that observational learning enhances motor skill learning is widely confirmed in the literature [10, 11].

Ste-Marie et al. [10] stated that it is possible to increase the effectiveness of observational learning by the manipulation of several model demonstration characteristics, e.g., the angle of viewing, the speed or the frequency of model demonstration. The authors emphasize that these characteristics have not yet been thoroughly studied and further scientific research needs to be conducted taking into account the factors that can complement the observation to optimize its effectiveness. One of such factors is the frequency of model demonstration. To date, the frequencies of model demonstration have been studied in conditions imposed externally (the experimenter sets the frequency of model demonstration for the learners) [12, 13] and in self-controlled conditions (the learner has an autonomous choice of the frequency to observe the model demonstration) [2, 13, 14, 15]. Sidaway and Hand [12] reported that high frequencies of observing the model demonstration during practice trials should not decrease the effectiveness of the motor learning process. The researchers compared the learning effectiveness of a golf ball hitting task through the observation of model demonstration with different frequencies. The most effective was 100% frequency of model demonstration. In contrast, Wrisberg and Pein [13] found no differences in the effectiveness of learning the long serve in badminton in groups with different frequencies of model observation. In their study, one group used 100% frequency of model demonstration, while the other group was allowed to self-control the frequency of observation when learning the long serve in badminton. For both groups, the results were significantly high and did not differ. Compared to other findings [12], these two learning situations revealed existing divergences.

Contradictions in findings may have resulted partly from differences in the task and practice conditions. Based on research analysis in the motor learning literature, it was found that giving the learner control over certain aspects of the practice conditions enhances the motor learning process [16, 17]. The findings of a large body of studies highlight the benefits of self-controlled conditions in observational learning, e.g., in basketball set shot [15], skill sequences on a double-mini trampoline [18], classical ballet positions [19] or pirouette en dehors [20]. These studies showed that groups that self-controlled the conditions during physical practice achieved better results than yoked groups. However, it is unknown what frequency of observation level is the most appropriate. The few study results which registered when the learners requested to view a movement pattern indicate high benefits of self-controlled frequency of model demonstration, i.e. only 27% [15], 48.9% [2] and even at a significantly low level – less than 10% [13] and 5.8% [14]. Sanli et al. [16] suggested that self-controlled practice conditions facilitate autonomy and competence of the learner, increase motivation and confidence in their actions, thus leading to a relatively permanent change in the function of the motor skills.

To date, knowledge about the frequency of model demonstration in the learning of complex movement skills is ambiguous [10, 11]. Moreover, no comparison has been done on the effectiveness of learning a complex gymnastic routine in conditions of self-controlled frequency and imposed frequency of model demonstration. The aim of this study was to investigate the effect of learning a complex gymnastic routine with different frequencies of externally imposed and self-controlled model demonstration.

Methods

Participants

Thirty undergraduate students (n = 30; 17 males, 13 females) selected randomly from 85 first-year physical education (PE) students participated in the study. The participants were randomly assigned to one of the three practice groups: G100 – 100% frequency (n = 10; age 20.3 ± 0.5 years; height 174.6 ± 5.8 cm; body mass 75.4 ± 4.5 kg); GS – self-controlled frequency (n = 10; age 20.9 ± 0.9 years; height 171 ± 9.5 cm; body mass 68 ± 10.3 kg); GC – control group (n = 10; age 20.4 ± 1.0 years; height 172.9 ± 9.8 cm; body mass 73.8 ± 13.8 kg). None of the participants had any locomotor system injuries. All of them took part in the study voluntarily and they were informed that they could resign at any time. The research was conducted following the principles of the Declaration of Helsinki. Ethical approval was provided by the Scientific Research Ethics Committee of Józef Piłsudski University of Physical Education in Warsaw.

Experimental task

The participants learned a complex gymnastic routine – the vertical jump with swinging the arms forwards and upwards, pulling the knees up to the chest while grabbing the shins followed by a half-squat landing with the arms extended sideways. The experimental task was unknown to all the participants. No feedback was provided to them.

Experimental design and procedures

The research consisted of three phases: pre-acquisition (baseline), acquisition, and post-acquisition (immediate retention test, delayed retention test, transfer test). Firstly, we conducted the baseline test before the first practice session (and a 15-minute break separating the test from practice). During the baseline and post-acquisition phase, the participants did a learning task after one of the model demonstrations. Ten practice sessions were conducted on non-consecutive days. The immediate retention test was performed after the final practice session (and a 15-minute break separating practice from the test). Delayed retention and transfer tests were conducted seven days after the final practice session.

The groups undertook a similar experimental design, with one difference: group G100 received the frequency of model demonstration imposed externally, whereas group GS could self-control that condition. Group G100 watched the model demonstration before each trial (15x; 100%). Group GS self-controlled the frequency of model demonstration which was registered during each practice session. Group GC took part in baseline and immediate retention tests only. From the distance of 5 meters, the participants viewed a video recording on a computer with an expert model who demonstrated the desired movement pattern. The angle of viewing of the model demonstration was objective – the participants observed the model on video in front of them (face to face). In total, in ten practice sessions, group G100 watched the demonstration 150 times, while group GS viewed it 58 times.

Baseline, immediate and delayed retention tests involved 5 trials. The transfer test also involved 5 trials and the participants did the experimental task in other conditions – they were on the platform 30 cm high. The practice comprised 150 trials in total, with 15 trials (3 sets x 5 repetitions) completed during each of the ten practice sessions. A 10-minute break was administered between each set. Prior to commencing the learning session, the participants performed a standardized warm-up (running/10 minutes, stretching exercises/10 minutes). Three professional gymnastic judges with the license of the Polish Gymnastic Federation and with experience of practice (7.7 ± 2.5 years) rated the value of the errors made by the participants during the task performance. The inter-rater reliability of the judges' scores was confirmed by the concordance correlation coefficient (=0.95). The learning effect was evaluated on the basis of the mean absolute error value (AEr).

Statistical analysis

The current study was guided by the sample sizes and analyses of similar studies (Sidaway and Hand [12] – n = 10; Winstein, Pohl and Lewthwaite [21] – n = 10; Park, Shea and Wright [22] – n = 9; Anderson and Campbell [9] – n = 8; Ghorbani and Bund [23] – n = 10, n = 11). We conducted a power analysis of the research using G*Power Version 3.1.9.4 [24]. Based on a predicted moderate effect size, it was determined that a minimum of ten participants were required in each group (Effect size f = 0.27, Power = 0.80, p = 0.05). Therefore, the recruited sample of 10 participants in each group was considered appropriate.

Normality of distribution and homogeneity of variances were tested with the Shapiro-Wilk test. To assess the differences between both groups, a repeated measures ANOVA was conducted for retention and transfer (Group x Test) and practice (Group x Practice). Partial eta squared (η_p^2) effect sizes were calculated for multiple comparisons (0.01 – small; 0.06 – moderate; 0.14 – large) and Cohen's *d* effect sizes were calculated for pairwise comparisons (0.2 – small; 0.5 – moderate; 0.8 – large) [25]. Post hoc Fisher's LSD test was used for pairwise comparison. Statistical significance was set at $p < 0.05$. Data was analysed using STATISTICA 12 (StatSoft, Inc. 1984-2014, USA).

Results

ANOVA at baseline revealed no significant differences between the three groups ($F_{2,27} = 0.129$; $p = 0.88$; $\eta_p^2 = 0.009$), allowing findings to be reasonably attributed to the effects of the independent variable manipulation. In GC group between the baseline test and immediate retention test no significant difference was observed ($p = 0.4$). Therefore, only two experimental groups were included in the analysis.

Skill learning

Mean AEr values achieved by the two groups during the two phases of the experimental design (pre-acquisition and post-acquisition) are illustrated in Figure 1.

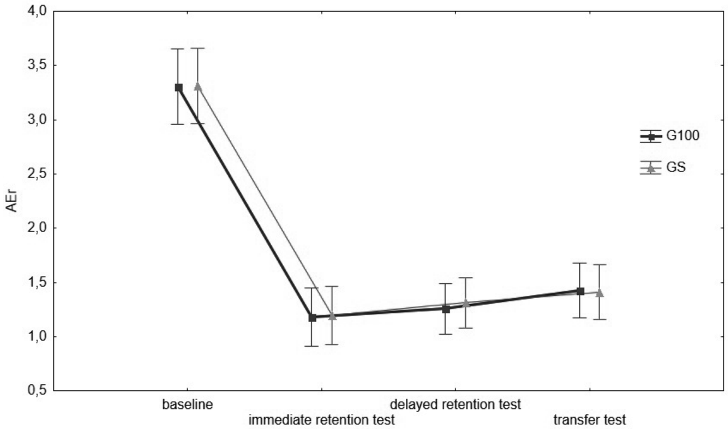

Figure 1. Mean AEr values in G100 and GS during the two phases of the experimental design (pre-acquisition and post-acquisition)

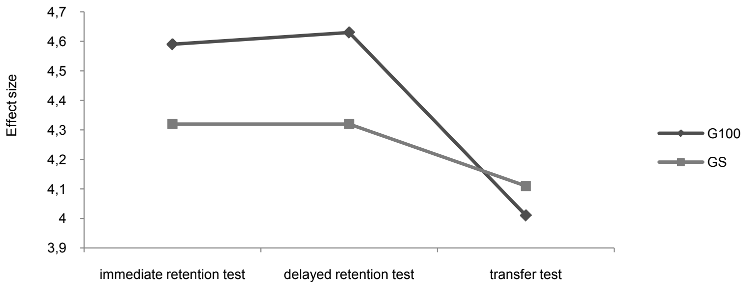

Figure 2. The values of Cohen's d effect size in comparison to baseline in G100 and GS

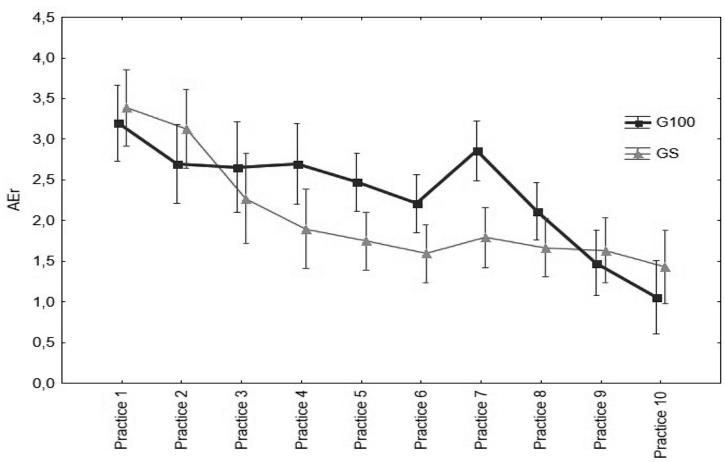

Figure 3. Mean AEr values in G100 and GS during the acquisition phase

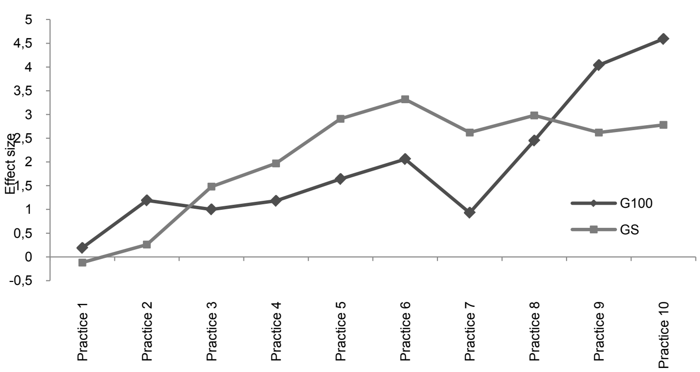

Figure 4. The values of Cohen's d effect size during the acquisition phase in comparison to baseline in G100 and GS

No significant Group x Test interaction ($F_{3,54}$ = 0.07; p = 0.98; $\eta_p^2 < 0.01$), or Group main effect ($F_{1,18}$ = 0.01; p = 0.92; $\eta_p^2 < 0.01$) was found, which indicates that no group performed better than another in the retention and transfer task. There was a significant main effect of Test ($F_{3,54}$ = 317.19; p < 0.001; $\eta_p^2 = 0.95$), with post hoc analyses revealing significant improvements for both groups.

The values of Cohen's *d* effect size in both groups in comparison to baseline are illustrated in Figure 2.

For both groups, a significant improvement compared to baseline was observed in the retention and transfer tests (*d* > 0.8).

Practice performance

Mean AEr values achieved by the two groups during the acquisition phase are illustrated in Figure 3.

There was a significant Group x Practice interaction ($F_{9,162}$ = 12.28; p < 0.001; $\eta_p^2 = 0.41$), with post hoc analyses revealing that group GS scored significantly better than group G100 during practice sessions 4, 5, 6 and 7 (p < 0.05). There was no significant Group main effect ($F_{1,18}$ = 1.3; p = 0.27; η_p^2 = 0.07), and a significant main effect of Practice was found for both groups ($F_{9,162}$ = 63.18; p < 0.001; $\eta_p^2 = 0.78$).

The values of Cohen's *d* effect size during the acquisition phase in comparison to baseline are illustrated in Figure 4.

The values of Cohen's *d* effect size in both groups revealed that a significant improvement compared to baseline (*d* > 0.8) was observed, respectively: group G100 from practice session 2 to 10; group GS from practice session 3 to 10.

Discussion

The aim of this study was to investigate the effect of learning a complex gymnastic routine with different frequencies of externally imposed and self-controlled model demonstration. The findings showed that participants from both groups (G100 and GS) achieved the same large learning effect of the complex gymnastic routine. No significant differences between both groups in retention and transfer tests were observed (p > 0.05). No significant difference between the baseline test and immediate retention test in group GC proves that compulsory gymnastics classes did not affect the motor learning effect.

The values of Cohen's *d* effect size showed that observational learning is an effective method in the learning of complex movement skills. Wulf and Shea [26] indicated that during observational learning, there may be more to extracted information about relatively complex skills, as compared with simple skills. In addition, observation may facilitate the memories structure supporting the movements, thus leading to effectively reduced total memory demands. This result can plausibly be explained by the fact that participants had a higher level of physical fitness than less active people of the same age. Marchal-Crespo et al. [27] established that the use of visual feedback is more effective for people who represent a higher level of physical fitness. In addition, the outcomes of the current study highlight the argument that 100% frequency of model demonstration may not be needed to maximize the effectiveness of motor skill learning [13]. Badets and Blandin [28] also reported a beneficial effect of a reduced knowledge of results frequency for observational learning (33% vs. 100%). In turn, our findings are inconsistent with Sidaway and Hand [12], who claim that 100% frequency of model demonstration is the most effective in the learning of complex movement skills.

In the case of group GS, the frequency of model demonstration averaged 39% (in the range of 24% to 51%). In previous studies, self-controlled frequency was reported, i.e. 27% [15], 48.9% [2], less than 10% [13] and 5.8% [14]. Despite such a low frequency of observing the model demonstration, the participants achieved the high effect of motor skill learning. Also, during the acquisition phase, group GS demonstrated significantly better performance compared to group G100 during practice sessions 4, 5, 6 and 7 ($p < 0.05$). However, the learning effect evened out at the end of the acquisition phase in both groups. The overlearning phenomenon could have had the potential impact on that in the case of group G100 by continually practicing in the same settings and by the prolonged training process. This highlights the fact that self-controlled conditions during physical practice lead to better outcomes than in externally imposed conditions [16, 17]. The findings are consistent with the results of previous research, e.g., in a ballet passé relevé [29], skill sequences on a double mini-trampoline apparatus [2] or golf-chipping task [30], which demonstrated that self-controlled frequency of observing the model demonstration is better than when feedback is externally imposed. In this study, the learners alternately observed the model demonstration and performed task trials. This suggestion is supported by the outcomes of earlier research [12, 31], i.e., when model demonstrations are provided interspersed during physical practice, it leads to enhanced learning.

The values of Cohen's *d* effect size during the acquisition phase revealed that group G100 demonstrated the fastest significant improvement in practice performance ($d > 0.8$) compared to group GS, as it was already possible from practice session 2. This is consistent with the notion that frequent feedback has a beneficial effect on the learning of complex movement skills [26]. Taking into account the results of both groups reported both during the acquisition and post-acquisition phases of the experiment, it is indicated that performance during practice sessions does not always reflect the permanency and adaptability of the motor skill learning. The results of this study are in line with the findings reported by Porter et al. [32], who compared the effectiveness of various basketball exercise schedules.

The results of this study raise the question: Does the learning of complex movement skills really require the use of high frequency feedback? Possibly the learning of the gymnastic routine turned out to be too simple for the participants. The complexity of movement skills could have had an impact on the results of this study. Few research results indicate that increased frequency of feedback during the learning of complex movement skills may have positive effects leading the learner to achieve the set goal [26]. Sigrist et al. [33] suggested that with the growth of task complexity, feedback should be provided more often, thus leading to prevent the learner cognitive overload. Sidaway et al. [34] established that 33% feedback frequency is effective in the learning of simple movement skills, while 100% feedback frequency produces positive effects in the case of complex movement skills. Wulf, Shea and Matschiner [35] and Wulf et al. [36] also confirmed that 100% feedback frequency enhances the learning of complex movement skills (100% vs. 50%; 100% vs. 33%). Our outcomes showed that low frequency in model observation also enhances the learning of the complex gymnastic routine.

The practical implications of the current findings are that they constitute a source of knowledge about the use of the optimal frequency of model observation in the learning of complex movement skills for sports coaches, physical education teachers and physiotherapists. The results of this study indicate that self-controlled frequency of the model demonstration is more effective during motor skill acquisition than when it is an externally imposed schedule. It is useful because coaches, physical education teachers and physiotherapists are not always available during the learner's practice.

Conclusion

The aim of this study was to investigate the effect of learning a complex gymnastic routine with different frequencies of externally imposed and self-controlled model demonstration. It was revealed that observational learning with self-controlled and high externally imposed frequency of model demonstration proved to be equally effective. The differences were found during the acquisition phase only. The self-controlled group achieved higher outcomes than the externally imposed group. It is worth highlighting to sports coaches, physical education teachers and physiotherapists that the learner performance during practice does not necessarily represent the extent or robustness of the skill learning. The main limitation of our study is that we did not examine other externally imposed frequencies of observing the model demonstration. Scientific knowledge about the optimal frequency of model demonstration in the learning of complex movement skills is incomplete. Further research in this vein is recommended.

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