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THE EFFECTIVENESS OF DIFFERENT TYPES OF VERBAL FEEDBACK ON LEARNING COMPLEX MOVEMENT TASKS

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ABSTRACT
Purpose. The purpose of the study was to assess the effectiveness of different types of verbal feedback in the learning of a complex movement task. **Methods.** Twenty university students took part in a six-week training course learning how to correctly execute the vertical jump. The participants were randomly assigned to one of three groups: Group E&P received verbal feedback on errors made during movement execution and on how to improve, Group P obtained verbal feedback only when they correctly performed the task, and Group E was provided with verbal feedback only when an error was made. Performance was measured on three separate occasions, before the training course (pre-training), one day after (post-training) and seven days after completing the course (retention) by executing the vertical jump in front of three gymnastic judges who scored their performance on a scale of 1 to 10. Jump kinematics were also measured pre-training and post-training by recording landing force and flight time on a force platform. **Results.** Post-hoc comparison indicated that a significant improvement in performance was observed only in the group receiving verbal feedback on errors (E). Judges' scores received in post-training were significantly higher than those measured pre-training (10.3 %; $p < 0.0003$) and further increased to 14.4 % in the retention test ($p < 0.0001$). Judges' scores for the groups receiving verbal feedback on errors and correctness (E&P) and only correctness (P) improved insignificantly. **Conclusions.** Providing too much verbal feedback when learning the vertical jump turned out to be less effective than providing limited verbal feedback only when errors were made.

Key words: training sessions, verbal feedback, vertical jump, complex task

Introduction

One of the most important factors in the motor-learning process is the feedback provided to a learner attempting to acquire a new motor skill. Many researchers have attempted to find the most appropriate methods of providing information through feedback to aid the learning and refinement of motor skills or body position control [1–5]. Supplementary information on how a task was completed, when coming from a source external to the performer, e.g. a teacher or a coach, is known as extrinsic or augmented feedback. There is a bulk of research providing experimental evidence on such factors as the frequency of feedback, organization of feedback, types of augmented feedback, forms of knowledge of result (KR), or knowledge of performance (KP) [6, 7].

Because augmented feedback is such an important part of motor skill learning, teachers and coaches should understand what types of information as well as how often and how precise it should be provided to facilitate the process of learning new skills. Feedback that is too precise is as useless as that which is too vague [8]. Some researchers [9] postulated that the amount and precision of KR are often too overwhelming, with the learner unable to correct a certain response due to the fact that individuals can effectively process only a limited amount of information at a time. Hence, it has been argued that coaches should develop the form and content of how augmented feedback would be presented ahead of time.

Furthermore, the complexity of a motor task is believed to determine which learning method or feedback strategy would be most successful, where, for example, numerous sources of task-related information are considered to be beneficial for learning complex tasks [10, 11]. As many studies have revealed, learning principles derived from the study of simple skills are not transferable to that of learning more complex skills [12]. Schmidt and Lee [13] claim that further research is required to establish relationships between the level of motor task complexity and forms and types of feedback. Currently there is a lack of data on how different types of feedback affect the effectiveness of completing tasks at varying levels of complexity [2, 11, 14–16].

However, some researchers have highlighted the fact that it may be extremely difficult to establish the influence of different types of content and form of feedback on task performance, due in part to the numerous intricate mechanisms that occur during this process [14, 17]. Others stress the necessity of such research in order to develop guidelines for learning motor tasks at different levels of complexity [11, 18–20].

Therefore, in order to contribute to the literature on the subject, the purpose of this study was to assess the effectiveness of different types of verbal feedback in the learning of a complex movement task.

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Material and methods

Twenty students were recruited and randomly assigned to one of three groups. Each of the groups differed in terms of the feedback they were to receive when executing a motor task. The groups were as follows: group E&P obtained information on the errors they made and on how to correct them (n = 7, height 177 cm ± 5.0 cm, body mass 81.2 kg ± 3.8 kg, age 20.3 ± 1.1 years), group P received feedback only when they correctly executed the task (n = 6, height 177 cm ± 5.0 cm, body mass 81.2 kg ± 3.8 kg, age 20.3 ± 1.3 years), and group E obtained information only on the errors they made (n = 7, height 178 cm ± 4.0 cm, body mass 79.4 kg ± 3.6 kg, age 20.4 ± 1.2 years) (Tab. 1).

A six-week experiment was conducted, with 60-min training sessions held three times per week (on Mondays, Wednesdays, and Fridays), with each subject participating in a total of 16 sessions. The subjects learned how to correctly execute the vertical jump by swinging the arms forward and upward, pulling the knees up to the chest while grabbing the shins followed by a half-squat landing with the arms extended sidewards. All of the subjects were unfamiliar with this type of task. The progressive-part method was applied to the training process, i.e., the task was divided into parts. The subjects mastered the preparatory phase during training sessions 1–4; sessions 5–8 were devoted to acquiring the main phase, while sessions 9–12 focused on learning how to perform the final phase. Sessions 13–16 were devoted to performing the entire movement. Each training session involved performing 20 sets of 5 repetitions each of the aspect being taught. After each set the subjects received feedback (knowledge of results).

Performance was measured on three separate occasions, before beginning the training course (pre-training), after (post-training) and seven days after completing the course (retention). The assessment tests began with a standard warm-up followed by the participants perform a single execution of the movement task. Three gymnastic judges rated their performance on a scale of 1 to 10 based on the criteria of the International Gymnastics Federation (FIG). Each minor error received a deduction 0–0.3 pts., for a medium error 0.4–0.6 pts. were deducted, while a major error cost the participant 0.7–1 pts. The inter-rater reliability of the experts' scores was confirmed by the concordance correlation coefficient (= 0.94).

Table 1. Examples of feedback: Group E&P – verbal feedback on errors and on how to improve, Group P – verbal feedback only on correct movement execution, and Group E – verbal feedback only on errors

(Group E&P)	(Group P)	(Group E)
– you performed the jump learning too far forward, jump straight up – you performed the jump leaning too far backwards, jump straight up – you did not perform the jump while simultaneously swinging the arms up, try it again with arms swinging up at the same time – you drew the knees up to your chest too early, pull your knees at the end of the rising phase – you drew your knees up to your chest too late, pull your knees at the end of the rising phase – you did not grab your shins with your hands, hold your shins next time – tucking done too early, do it during the ascending flight phase – tucking done too late, do it during the ascending flight phase – untucking done too early, do it during the beginning of the descending phase – untucking done too late, do it during the beginning of the descending phase – landing without bending the knee and hip joints, do it by cushioning the landing at the knee and hip joints – you did not keep your arms in front of you out to the side, hold your arms out next time	– good vertical jump while simultaneously swinging the arms up – you drew knees at the right time – hands correctly grabbed the shins – correct body tuck during the rising flight phase – correct body tuck during the beginning of the descending flight phase – correct landing by absorbing impact with the ankles, knees, and hips – direction of the arms to the side and up in front was correct	– jump was performed leaning too far forward – jump was performed leaning too far backwards – you did not simultaneously swing your arms up – you drew your knees to your chest too early – you drew your knees to your chest too late – hands grabbed the shins too early – hands grabbed the shins too late – tucking done too early – tucking done too late – untucking done too early – untucking done too late – landing done without bending the knee and hip joints – you kept your arms to the side

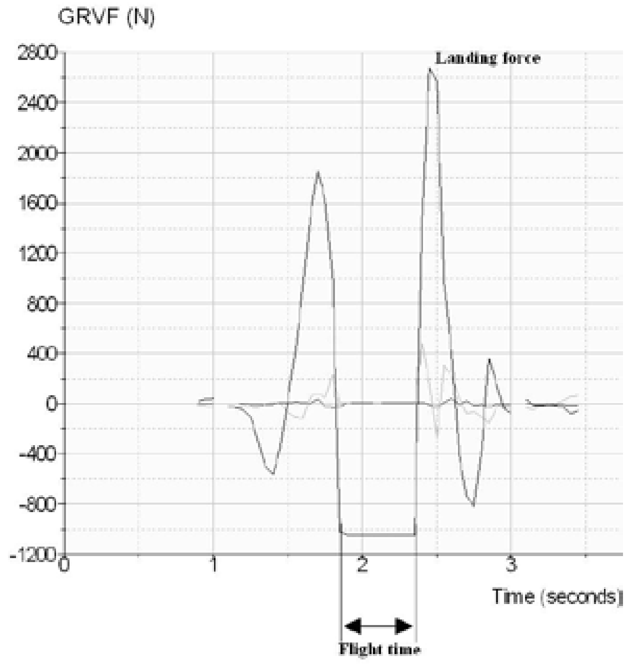

Figure 1. Example of ground reaction vertical force (GRVF) measure with flight time and landing force marked

A jumping and landing assessment was performed at pre-training and post-training by quantifying jump performance by flight time and recording vertical ground reaction force (VGRF). The participants performed two maximal height jumps, a countermovement jump (Test A) and a vertical jump by pulling the knees up to the chest (Test B). Kinematic data were measured on a Type 2812A1-3 Force Plate System with BioWare software v. 3.23 (Kistler, Switzerland) at a sampling rate of 400 Hz. Body mass was also measured on the force plate, which was calibrated prior to each measurement. Participants were instructed to begin from a standing position and jump as high as they could. No other specific instructions were provided during the test as to not influence performance. Three jumps were completed for each test, with ample rest provided between each trial. Only the jump attaining the greatest height was selected for analysis, with landing force and flight time (Fig. 1) evaluated to estimate jumping and landing effectiveness.

Statistical significance was assessed with ANOVA. Normality of distribution and homogeneity of variances were tested with the Shapiro-Wilk test. If normal distribution was verified, the studied variables were then analyzed by two-way mixed-factor analysis of variance, Group (3) x Time of Measurement (3) for the judged jumps and Group (3) x Time of Measurement (2) for the force measurements, with the three experimental groups representing a between-subjects factor and the three testing periods representing a within-subjects factor. Statistical significance was set at $p < 0.05$. Post-hoc Fisher's LSD test was used for pairwise comparison. The results were analyzed using Statistica v. 7.1 software (StatSoft, USA).

Results

ANOVA with repeated measures for the judges' scores revealed a significant effect of Test Time ($F(2,32) = 8.30$; $p = 0.001$). There were no interaction effects of Group ($F(2,16) = 2.15$; $p = 0.809$) as well as Group x Time of Measurement ($F(4, 32) = 1.91$, $p = 0.133$). Means and standard deviations are presented in Table 2. The rate of how the scores improved is displayed in Figure 2. Fisher's LSD test ($p < 0.05$) was performed for post-hoc pairwise comparison, indicating that a significant improvement in performance was observed only in the group that received verbal feedback about errors (E).

Table 2. Means (± SD) of judges' scores at pre-training, post-training, and retention for Groups: E&P – verbal feedback on errors and how to improve, P – verbal feedback on correctness, and E – verbal feedback on errors

	Pre-training	Post-training	Retention
E&P	7.15 ± 0.16	7.27 ± 0.22	7.35 ± 0.22
P	7.19 ± 0.15	7.47 ± 0.2	7.5 ± 0.2
E	6.8 ± 0.16	7.5 ± 0.22	7.78 ± 0.22

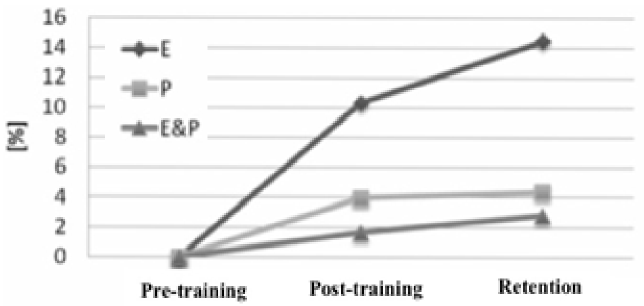

Figure. 2. Percent increase in judges' scores at pre-training, post-training, and retention by Groups: E&P – verbal feedback on errors and how to improve, P – verbal feedback on correctness, and E – verbal feedback on errors

Scores received in post-training were significantly higher than in pre-training (10.3 %; $p < 0.0003$) and further increased to 14.4 % in the retention test ($p < 0.0001$), pointing to an improvement in task performance. Judges' scores observed in the group with verbal feedback on errors and correctness (E&P) and correctness (P) improved insignificantly.

ANOVA on the groups' jumping performance revealed significant interaction effects of Group x Time of Measurement for landing force (VGRF) in Test A ($F(4, 32) = 3.24$, $p = 0.066$). There were no effects of Group ($F(2, 16) = 2.0101$, $p = 0.16642$) as well as Time of Measurement ($F(1, 16) = 0.00551$, $p = 0.94174$). There were no interaction effects of Group, Time of Measurement, and Group x Time of Measurement for flight time (T) in Tests A and B as well as for landing force in Test B. Means and standard deviations are presented in Table 3.

Table. 3. Means (± SD) of flight time (T) and landing force (LF) recorded during Tests A (countermovement jump) and B (vertical jump) across test times (pre-training and post-training) for the groups receiving verbal feedback on errors and how to improve (E&P), verbal feedback only on correctness (P), and verbal feedback on errors (E)

		Pre-training E&P	Post-training E&P	Pre-training P	Post-training P	Pre-training E	Post-training E
T [s]	A	0.49 ± 0.02	0.49 ± 0.02	0.49 ± 0.02	0.51 ± 0.02	0.52 ± 0.02	0.52 ± 0.02
	B	0.54 ± 0.02	0.57 ± 0.02	0.54 ± 0.02	0.57 ± 0.02	0.55 ± 0.02	0.59 ± 0.02
LF [N/kg]	A	31.4 ± 6.1	37.4 ± 5.7	26.4 ± 6.4	33.7 ± 6.1	45.1 ± 5.9	33.6 ± 5.6
	B	28.5 ± 3.9	35.9 ± 4.0	32.8 ± 4.1	31.9 ± 4.2	30.8 ± 3.8	30.9 ± 3.9

The highest flight time was recorded for the group receiving verbal feedback on errors (E), although the results were very similar among all three groups. Post-hoc comparisons indicated a significant decrease in landing force in Test A only for Group E. Landing force in post-training was significantly higher than in pre-training (25.5 %; $p < 0.06$) for the other two groups, although the increase in landing force was statistically insignificant for Group E&P for both Tests A and B in post-training. A decrease in landing force was only observed in Group P for Test B, although this result was statistically insignificant (2.74%, $p > 0.05$).

Discussion

The purpose of the study was to assess the effectiveness of different types of verbal feedback in the learning of a complex movement task, finding that the effectiveness of learning the task was different among the groups receiving different feedback. Providing verbal information on what errors were made and what should be improved (E&P) as well as feedback only when the task was correctly performed (P) turned out to be the least effective strategies. Instead, participants from Group E, who received feedback only when they made an error, obtained the best results.

This may stem from the fact that too much verbal feedback particularly at the initial stage of learning a complex movement task is not beneficial. Some researchers believe that providing too much feedback is too overwhelming for learners, making them unable to effectively process new information. Moreover, it is believed that providing too much information causes learners to become overdependent on extrinsic sources of information. As a result, the use of intrinsic information becomes more limited, which leads to difficulties in performing a task once the amount of extrinsic information is reduced [4].

In line with the above assumptions, although the subjects from Group E received 22% and 15% less feedback than those from Group E&P and Group P, they exhibited better learning effects. Similar results were obtained by Sadowski et al. [21], who noted that providing feedback both on errors and how to improve performance was not as effective as providing feedback only on the correctness of performing a complex movement task. Conversely, Kernodle et al. [18] claim that when a task is complex and difficult, it is advisable to provide feedback both on errors and on how to improve. Williams and Hodges [20], Tzetzis et al. [10], and Wulf et al. [15] also maintain that the simultaneous employment of prescriptive and descriptive feedback brings about better learning results. It appears that it is still hard to state unequivocally which type of feedback is the most effective in learning complex movement tasks. Our findings, however, are in line with those of Wulf and Shea [12], and Williams and Hodges [20], who found that learning effects depended, inter alia, on types of feedback on knowledge of result (KR) or knowledge of performance (KP).

In our opinion, learning effects depend not only on the content of feedback but also on the complexity of the movement skills needed to perform a task. Similar observations were made by Tzetzis et al. [16], Tzetzis and Votsis [19], and Tzetzis et al. [10], who investigated correlations between the correctness of task performance and feedback quality as well as the complexity of a skill. Tzetzis et al. [10] found that in the process of learning the difficult backhand-clear in badminton (a high return stroke on the non-dominant side of the body that carries the shuttlecock deep into the backcourt), the group receiving positive feedback, correction cues, and feedback on errors performed better than the group receiving only correction cues and positive feedback or the group that received only feedback on errors. It ought to be emphasized that Tzetzis et al. [10] conducted their study on badminton players with already some form of experience, whereas our investigation involved students with no prior experience of the task. This may indicate that, in the learning of movement tasks, the learning effect is determined not only by the content of feedback and task complexity but also by athletes' experience. Therefore, the findings of the above-mentioned researcher are not generalizable to athletes other than badminton players. Similarly, our findings refer to the learning of movement tasks that were new and unfamiliar and this may account for the fact that different types of feedback were found to be more effective than others.

The training method employed in our study may also account for the differences between our results and the findings of the aforementioned researchers. The progressive-part method was used, where task learning is divided into consecutive parts. This allows for a relatively complex task to be simplified and, in the present study, did not require the use of extremely extensive or very precise feedback. Winstein and Schmidt [7] proved that too much feedback was no more effective than little feedback, while Janelle et al. [22] showed that, in learning an overhead throw, only 11% of total feedback provided was utilized by learners. Guadagnoli et al. [23] stated that longer summaries are better in the learning of simple movement tasks, while shorter summaries are more appropriate in complex tasks. Magill and Schoenfelder-Zohdi [24] claimed that multiple sources of task-related information are redundant for simple tasks as single sources already provide enough adequate information for the development of cognitive representations and overt performance.

In turn, Laguna [11] proved that during the observational learning process the performance of a complex task benefited from a combination of task-related information (model demonstration and knowledge of performance). However, it should be noted that the task adopted in Laguna's study used arm movement only, while the present study applied a task using the whole body.

Also of interest was the fact that Group E finished their jumps in a better landing position, with landing force generated by Group E being lower than in Groups P and E&P. Other researchers observed a decrease in landing force after physical [25, 26] and technical training [27] as well as after being provided with specific instructions. Prapavessis and McNair [28] noted a decrease in landing force (19%) immediately upon providing technical guidelines regarding the kinematics of the lower limbs. These researchers drew similar conclusions when applying imagery-based feedback. In other studies, providing augmented feedback during landings decreased landing force by 13% to 19% already after one session [29, 30].

Our results confirmed that applying verbal feedback on errors not only determines better learning effects than verbal feedback on task error and improvement cues and only on execution correctness, but that it may help in the prevention of injuries by decreasing landing force. Therefore, the results of such verbal feedback may aid in developing appropriate guidelines and principles when learning complex motor skills.

One of the limitations of this study that need attention is the fact that the participants demonstrated similar levels of general physical fitness and development and did not reveal any significant differences regarding maximal vertical jump performance. As a result, the findings should not be directly compared to athletes for example, as these individuals feature high levels of physical fitness and motor skill development. Moreover, the force-velocity potential of athletes is much higher than in less active people. To further clarify the most appropriate methods in learning complex tasks, future investigations should be carried out on subjects having different motor competences and testing carried out with the use of various motor tasks and types of feedback.

Conclusions

The learning effects of new complex movement tasks depend on the content of providing feedback on task performance (KP). Providing too much verbal feedback when learning the vertical jump turned out to be less efficient than limited verbal feedback focused only on the errors being made when performing the task.

The learning effects depend on the type of feedback, its amount and the content of information as well as the complexity of the task. The progressive-part method is recommended in the motor learning of new complex tasks, providing short cues on what errors are made.

Further research is needed to determine the principles behind learning complex motor skills. It is advisable to carry out studies on complex motor tasks with varying degrees of freedom. The complexity of the task should be estimated using a clear task-characteristic scale to avoid ambiguous results.

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