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The effect of different corrective feedback methods on the development of motor skills of different difficulty levels in children

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Abstract

This research investigated the effects of three feedback methods with different feedback methods on the acquisition and retention of movement outcome for novel and learned badminton skills. The 48 participants, 10-14 years of age, with 2-3 years of practice experience, were randomly selected and assigned into three groups. Participants were trained for 12 practice units for the acquisition and retention of badminton skills: a) drive with the dominant hand (learned skill) and d) drive with the non-dominant hand (novel skill). Group C received instructional cues for the correct execution of the performance. Group (E) received instructional cues on errors of the execution, and group (E-C) received instructions on errors and how to correct them. A pre-test, a post-test, and a retention test was conducted and a two-way ANOVA (3 groups X 3 measurements) with repeated measures on the last factor was used to analyze the effect of the practice methods on the movement outcome. It was found that feedback for the correct (C) execution (suggestions to correct the error) is beneficial for both learned and novel skills. Additionally, feedback for error and correct (E-C) execution is beneficial only for novel skill. It seems that when the skill is difficult or novel providing a verbal statement that describes the errors and states what needs to be done to correct them (E-C) is more helpful for the early stage of learning. Research for feedback in actual sport conditions with skills of variable characteristics will enrich the motor learning knowledge and shed new light on the role of feedback in both theory and practice.

Keywords: corrective feedback; different difficulty; acquisition; movement outcome; badminton skills; dominant/non-dominant hand.

1. Introduction

In sports coaching, the type and manner of augmented instructions that the coach use in training with individual athletes can have a significant impact on skill development and performance (Otte, Davids, Millar, & Klatt, 2020; Partington, Cushion, Harvey, 2014; Correia, Carvalho, Araújo, Pereira, & Davids, 2019; Lola & Tzetzis, 2020; Lola, Koutsomarkou, & Tzetzis, 2021; Tzetzis, Votsis, Kourtessis, 2008). Many researchers attempted to find the most appropriate instructional methods for providing information via augmented feedback that practitioners can use to develop motor skills. Feedback is widely recognized as an important tool for enhancing performance and learning motor skills. As with all sports, the goals of feedback might be different focusing either on the outcome or the technique, and therefore there might be a goal conflict (Hodges &

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Franks, 2004). Although there is a relationship between outcome and execution the two variables are seldom in tune in early skill acquisition (Hodges & Franks, 2004). When there are goals conflict the instructors must communicate their required goals to avoid confusion.

Research into the role of augmented feedback in learning has focused on its informational properties and been theoretically driven by the guidance hypothesis (Salmoni, Schmidt, & Walter, 1984). The central premise of the guidance hypothesis is that augmented feedback has to guide properties that direct the learner to the correct response but also if given very often might induce dependence since the learner bypasses important intrinsic processing mechanisms and becomes dependent on the external source of information. Research for feedback in motor learning will enrich the guidance hypothesis and shed new light on the role of feedback in both theory and practice (Wulf & Shea 2004; Wulf, 2013). Many researchers attempted to discover the most proper feedback methods for developing motor skills (Lola & Tzetzis, 2020; Tzetzis, et al, 2008; Williams and Hodges, 2005). Lee, Keh, and Magill (1993) suggested that instructors' feedback is usually verbal and in the form of positive, nonspecific evaluative statements. Providing feedback using verbal cues helps the performance of the task by verbally indicating vital form characteristics (Landin, 1996), enhances attention, and provides additional information that may not be available via visual observation (Janelle, Champenoy, Coombes, & Mousseau, 2003). Feedback of the knowledge of results (KR) is about the post-response information relative to the outcome of the action in the environment (Drews, Pacheco, Bastos & Tani, 2021) and it is essential for learning especially when intrinsic feedback is not available. Knowledge of performance (KP) is the feedback most frequently used by coaches and teachers and it tends to focus on kinematic variants. Due to the complexity and variability of the demands for learning motor skills the research is still limited according to the type of KP that is appropriate in different sport skills.

An often debated issue about augmented feedback content is whether the information the instructor conveys to the learner should refer to mistakes he/she made or those aspects of performance that are correct (Magill, 2011). He also stated that research evidence consistently has shown that error information is more effective for facilitating skill learning. Kernodle and Carlton (1992) suggested that providing verbal cues about errors and corrections is more beneficial for novices. Magill (2011) asserted that instructions about the correct or the errors should be adapted according to the stage of learning. Wulf, (2013) suggested that the level of difficulty for motor skills may be a factor that differentiates the effect of feedback. She added that learners who are given feedback while learning difficult motor skills (slalom-type movements on a ski simulator) are more likely to perform at a higher skill level than people who do not receive concurrent feedback. Kernodle and Carlton (1992) asserted that if the participants are at the beginning or middle stage of learning processing, knowledge of performance combined with instructions on errors is a more effective method for difficult skills. Tzetzis & Votsis (2006) supported that the effect of corrective feedback may have been confounded with the level of difficulty of the skills. It seems that the difficulty level of sports skills as perceived by the learners might be a crucial factor that differentiates the positive effects of corrective feedback. Since the scientific results seem to be limited, more research is needed to be conducted in terms of corrective feedback in different difficult motor skills. Thus this experiment manipulates the level of difficulty in terms of the novelty of the task to understand whether feedback methods differentially affect the outcome when the skill difficulty varies.

Despite the extensive literature on the effects of feedback during motor task practice on motor skill acquisition and learning in adults (Anderson, Magill, Sekiya, Ryan,

2005) there is a lack of literature in the area of motor learning especially in children (Lola & Tzetzis, 2021; Sullivan, Kantak, Burtner, 2008). Most of the research investigating the different methods of feedback instruction that improve learning was conducted in laboratory settings (Lola & Tzetzis, 2020; Vickers, Livingston, Umeris-Bohnert, & Holden, 1999) in classroom settings (Scheeler & Lee, 2002) or applied settings (Goode & Magill, 1986). Arguments have arisen that research has been conducted with one-dimensional laboratory tasks with novice performers and these results might be different than the real sport settings. There is not much empirical evidence for the effect of instructors' corrective feedback on skills' learning for different type of skills (Franks, 1997; More and Franks, 1996) including sport-related cognitive complex solving tasks (McCullagh and Little, 1990; Sanchez & Bambouras, 2006; Silverman, 1994). Wulf & Shea (2004) also recommended researching more realistic conditions and test more complex and difficult skills. Rink, French, and Tjeerdsma (1996) proposed that the lack of empirical evidence to support any one approach to the teaching-learning process over another precludes the efficacy of suggesting a 'model' profile for coaches' pedagogical content interventions. Coaches need to know how these different sources of feedback work both alone and in conjunction with other instructional techniques to improve learning of different complexity skills.

Badminton is a very demanding sport, especially at a competitive level (Seth, 2016). Repetitive efforts and great intensity characterize it, which are continuously performed throughout the match. Performance of the great technique, from the early stage of learning, is very important for athletes' success. The great variability of badminton skills requires a lot and different kinds of abilities, which makes coach effort much more difficult (Capello & Gonzalez, 2003). Investigating the effect of different corrective feedback methods for badminton skills of different difficulty levels might have practical and theoretical value for different sports with variable complexity skills.

The current research was designed to investigate the effects of different corrective feedback models (Correct, Error, Correct-Error) on the acquisition and retention of two fundamental badminton skills with different levels of difficulty in terms of novelty (Learned skill - execution with dominant, and Novel skill - execution with non-dominant hand) practiced in a sports field in terms of the movement outcome, for young participants of 10-14 years of age. There is evidence that supports that focusing on what is done correctly while learning a skill, especially in the early stage of learning, is not sufficient by itself to produce optimal learning (Magill, 2011). There is also the need for the individual in correcting errors by operating on error-based augmented feedback during skill acquisition to enhance the performance of the skill (Magill, 2011). Thus, it was hypothesized that cues on errors and directions on how to correct them (E-C feedback) would be more beneficial for the young athletes for the novel skill.

2. Method

2.1. Participants

In the present study, 48 children participated. They were randomly selected from a pool of 110 young badminton athletes participated in a sports club and assigned into three equal groups of 16 individuals . All groups consisted of 10-14 years of age (M = 12.6, SD = 0.5) young athletes, with 2-3 years practice experience (M = 2.6, SD = 0.5). All

participants were healthy and their parents' permission was requested to participate in the present study. All the rules of ethics were observed in all phases of that research.

2.2. Experimental design

All participants were pre-tested on two badminton skills with different difficulty levels in terms of novelty: a) drive with the dominant hand (learned skill), b) drive with the non-dominant hand (novel skill). A 12-week intervention program was applied followed by a post-test at the end of the program and a retention test two weeks later.

2.3. Intervention program

The three groups followed the training program with the same coach but they were instructed by three different methods of corrective feedback. The first group (Correct-C) received feedback and instructional cues about the correct technique – descriptive feedback (Haibach, Collier, & Reid, 2011), for example, “you have to hit the shuttle at a higher level”). The second group (Error-E) received feedback and instructional cues on errors of the execution (e.g. “don’t hit the shuttle at a low level” – descriptive feedback). The third group (E-C) received feedback and instructional cues on errors and directions on how to correct them– prescriptive feedback, for example, “don’t hit the shuttle at a low level. You must hit it at the higher level”. All participants were receiving feedback every 3 attempts. Examples of the three different instructional methods are described in table 1.

Table 1. Different types of instructional methods were followed by the three Groups.

Group C	Group E	Group E-C
Instructional cues for the correct technique	Instructional cues on errors of the execution	Instructional cues on errors and directions on how to correct them
* you have to turn the body when you hit the shuttle.	* do not leave your body straight when you hit the shuttle.	* do not be straight when you hit the shuttle. Try to turn the body at the motion.
* try the elbow to be closer to the head.	* do not do the stroke with the elbow away from the head.	* do not leave the elbow away from the head. As close as you can.

All groups practiced and received instructions two times a week, for 12 weeks. Every practice unit lasted approximately 90 min. At the beginning of every training session, a demonstration was performed by an elite player who answered any questions about the technique of the four badminton skills. All the players practiced five exercises (Partemian, 2003; Paup & Fernhall, 2000; Partemian, 1993) on each skill and every exercise lasted three minutes. The instructor gave corrective feedback, 10 times on each badminton skill, in every training session. The total duration of the exercises was 60 minutes and in the last 20 minutes, they played a game without any instruction called “a free game”. There was also a warm-up and rest period before and after each training unit.

The two badminton skills were categorized as a learned skill (drive with the dominant hand) and an novel skill (drive with the non-dominant hand) in terms of difficulty. The criterion for categorizing these two badminton skills was the training experience (Magill, 2011). They had 2-3 months of training experience in the first skill (drive with the dominant hand), but they did not have any experience with the other skill (drive with the non-dominant hand).

During the training program, there was a video recording from a distance of 8m at an ankle of 45º for checking coach instructions, players' attitude, and the correct application of the teaching methods by a specialized person. The most important point for correct execution of the technique was noted first and the less important later (Magill, 2011).

2.4. Testing procedure

The purpose of the badminton Wall-Volley test (Strant & Wilson, 1993) was to measure the participant's performance ability executing the drive using the dominant hand (learned skill) and using the non-dominant hand (novel skill). A wall of 4 meters high and 3 meters wide was used. A line was placed against the wall at 1.55 meters of the ground, that is the height of the badminton net. The participants hit the shuttle on the wall (drive stroke) for 30 seconds and were trying to make as many successful hits as they could within that time frame. Successful attempts were those in which the shuttle smashed over the line of the wall. This exercise is common in typical badminton training. Each athlete executed three (3) sets of 30 seconds. Before the test, there was a 15-seconds practice. The evaluation of the score was conducted through observation and a total sum of scores was recorded by the sum-up of the attempts during the three sets. The Chronbach's alpha reliability coefficient was a=0.75.

2.5. Training of the instructors

Before introducing the training programs, specific directions were given to the instructor on how to implement the instructional methods. Specifically, written directions were given for the identifications of errors, when to give information, what to say and how to say it (in what order). Specific written directions were also given on where to direct the attention of the participants. A pilot test with another group, four days before the test, assured the understanding and the correct implementation of the training protocol.

3. Results

Two different one-way ANOVAs' were used to analyze the initial differences of the pre-test scores for the three groups for each one of the four badminton skills. There was no significant main effect for the drive with the dominant hand skill (learned skill) ($F_{(2,45)}$=1.379, p=0.37) and the drive with the non-dominant hand skill (novel skill) ($F_{(2,45)}$=1.364, p>.05).

Two-way ANOVA (3 Groups X 3 Measurements) with repeated measures on the last factor was used to analyze the effects of the three corrective feedback methods on the movement outcome of each badminton skill. Whenever an overall significant difference was found a Sheffe post-hoc test was used to analyze the differences of the means.

3.1. Drive with the Dominant Hand (learned skill)

There was no significant interaction ($F_{4,90}$=0.146, p=0.16), for the different measurement periods and the groups in terms of the result of the drive with the dominant hand skill. There was a significant main effect ($F_{(2,45)}$=8.283, p<.05) among the three groups and a significant main effect ($F_{(2,45)}$=4.799, p<.05) among the measurement periods.

3.2. Effect measurement periods

There was a significant ($F_{(2,45)}$=4.280, p<.05) main effect for Group C, and the Sheffe post-hoc analysis revealed that Group C improved its scores from the pre-test (M=78.31) to the post-test (M=87.44) and maintain its performance to the retention test (M=86.56). There was no significant ($F_{(2,45)}$=2.415, p=0.31) main effect for Group E, and the Sheffe post-hoc analysis revealed that Group E didn't improve its scores from the pre-test (M=72.13) to the post-test (M=76.63) and the retention test (M=77.75). There was no significant ($F_{(2,45)}$=1.503, p=0.19) main effect for Group E-C and the Sheffe post-hoc analysis revealed that it didn't improve its scores from the pre-test (M=71.81) to the post-test (M = 77.00) and the retention test (M=77.13).

3.3. Effect group

At the retention test, there was a significant ($F_{(2,45)}$=8.283, p<.05) main effect among groups in terms of result. The Sheffe post-hoc analysis revealed that Group C (M=86.56) was statistically significantly different from Group E (M=77.75) and Group E-C (M=77.13) There were no statistically significant differences among Group E and E-C. The results of this analysis are depicted in Figure 2.

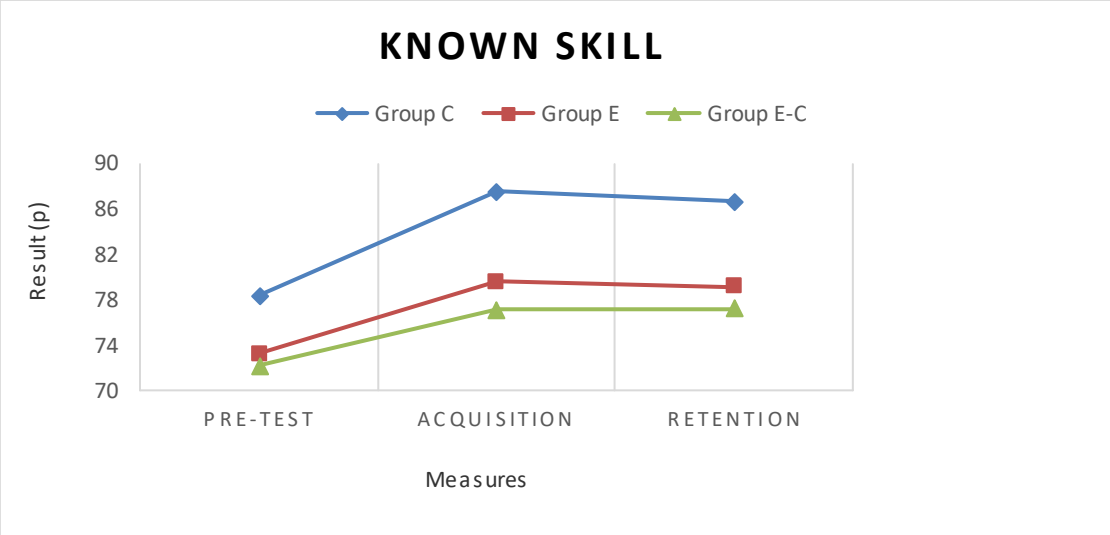

Figure 2. Result scores of the three groups for the three measurement periods of the drive with the good hand (learned skill).

3.4. Drive with the Non-Dominant Hand (novel skill)

There was no significant interaction ($F_{(4,90)}$=0.923, p=0.59), for the different measurement periods and the groups in terms of the result of the drive with the weak hand skill. There was a significant main effect ($F_{(2,45)}$=14.239, p<.05) among the three groups and a significant main effect ($F_{(2,45)}$= 6.583, p<.05) among the measurement periods.

3.5. Effect measurement periods

There was a significant ($F_{(2,45)}$=4.603, p<.05) main effect for Group C, and the Sheffe post-hoc analysis revealed that Group C improved its scores from the pre-test (M = 49.19) to the post-test (M = 59.19) and maintain its scores to the retention test (M = 58.69). There was no significant ($F_{(2,45)}$=.759, p=0.44) main effect for Group E and the Sheffe post-hoc analysis revealed that Group E didn't improve its scores from the pre-test (M =45.31) to the post-test (M=49.63) and the retention test (M=48.7). There was a significant ($F_{(2,45)}$=3.807, p<.05) main effect for Group E-C, and the Sheffe post-hoc

analysis revealed that the Group E-C improved its scores from the pre-test (M = 50.75) to the post-test (M = 60.92) and maintain its scores to the retention test (M = 61.60).

3.6. Effect group

At the retention test, there was a significant ($F_{(2,45)}$= 14.239, p<.05) main effect among Groups in terms of result. The Sheffe post-hoc analysis revealed that there were no statistically significant differences among Group C (M=58.69) and Group E-C (M=61.56) but there were statistically significant differences from Group E (M=48.69). The results of this analysis are depicted in Figure 3.

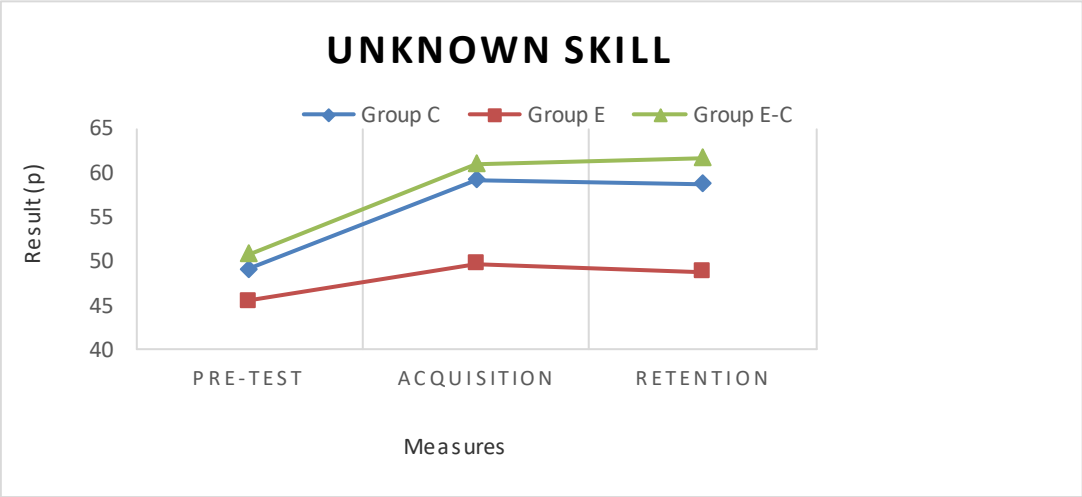

Figure 3. Result scores of the three groups for the three measurement periods of the drive with the weak hand (novel skill).

The overall results of the study are summarized in table 2.

Table 2. Summarised results of the study.

Groups	Drive with Dominant Hand (learned skill)	Drive with Non-Dominant Hand (novel skill)
C	positive	positive
E	neutral	neutral
E-C	neutral	positive

4. Discussion

The present study aimed to compare the effect of three different corrective feedback methods, on the acquisition and retention of the outcome of two badminton skills, with two difficulty levels of the task: a) learned skill, and b) novel skill, for young participants. It was hypothesized that providing corrective feedback with correction and error cues could improve outcome scores for youth participants.

From the comparison among the measurement periods, it was found that feedback with instructions about the correct technique (C) is beneficial for both learned and novel badminton skills, as it was improved from the pre-test to the post and maintain the scores during the retention test in both learned and novel skills. Group (E-C) (participants received feedback and instructions on errors and directions on how to

correct them) improved its scores only for the novel skill. On the contrary, group (E) (participants received feedback and instructions on errors of the execution) did not improve its scores across time in both learned and novel skills. It is concluded that for young novice participants, instructions for the correct technique (C), and instructions on errors, and directions for the correct technique on how to correct them (E-C) are beneficial for novel badminton skills. The conclusion is in line with the literature since there is evidence that supports that focusing on what is done correctly while learning a skill, especially in the early stage of learning, is not sufficient by itself to produce optimal learning (Magill, 2011).

From the comparison among the groups, it was found that for the learned skill, the group (C) that received feedback and instructions about the correct technique was better than the group (E) that received feedback and instructions on errors of the execution and the group (E-C) that received feedback and instructions on errors and directions on how to correct them. It was also found that for the learned skill there were no differences among Group E (instructions on how to correct the technique) and E-C (instructions on errors and directions on how to correct them) (C>E, E-C). It seems that information about the error (E-C group) was not helpful for the result scores of the learned skill for youth participants.

For the novel skill, it was found that groups C and E-C were better than group E and there were no differences between Group C and Group E-C. Finally, they were both better than Group E (C, E-C>E). It is concluded that for young novice participants, cues about the correct execution (C) seem to be very effective for the learning of both learned and novel sports skills. Information about the correct execution seems to be enough for the learning of learned and novel sport skills probably because the participants concentrated their attention on the correct execution and this goal helped them to improve their outcome scores. Haibach, Collier, and Reid (2011) also mentioned that “novice learners need more perspective feedback (suggestions to correct the error) because they have not learned how to correct errors yet” (p.328).

Instructions only about errors (E) were found that they were not enough for the improvement of the learned and the novel skills. It seems that pointing out the errors alone does not help at all in the correct execution, but on the contrary, it works disparagingly for the athletes. Magill (2011) supported that error cues direct an individual to change certain performance characteristics and facilitates skill acquisition. However, he added that cues indicating that the individual performed certain characteristics correctly tell the person that he/she is on track in learning the skill and encourages the person to keep trying.

Finally, it was found that feedback for error and correct (E-C) execution is also beneficial but only when the skill is novel (new). It seems that when the skill is novel providing a verbal statement that describes the errors and states what needs to be done to correct it is more helpful especially for the early stage of learning. Magill (2011) also stated that error-related information works better to facilitate skill acquisition, whereas information about correct performance serves better to motivate the person to continue. Probably, the participants of this group had the information about the error and were also motivated to improve their scores. However, if the skill is a learned skill, augmented feedback about the errors and the correction of them (E-C) is maybe redundant, and complicated for the young learners. Schmidt and Wulf, (1997) in an earlier study suggested that very analytical and complicated instruction and analysis about the correct and the error do not help the athletes when practicing easy or learned skills. In addition, Agethen and Krause (2016) suggested that if a feedback method provides a large amount of information, such as Group E-C (feedback on errors and directions on how to correct them), may curtail and hinder intrinsic feedback system function during self-

organized exploration for functional movement solutions (no one group, decreased the result scores from the acquisition to the retention period since there was no negative effect of the three corrective feedback methods.

To summarize, it seems that verbal instructions prescriptive or descriptive might have a long learning effect on learning sport skills. Feedback with instructions on the correct technique is the best (of the three) corrective feedback method for learning learned and novel badminton skills for young athletes. Additionally, feedback on errors and directions on how to correct them Is beneficial for young athletes only for novel skills. It seems that the level of difficulty of the skill is a critical factor in determining the effectiveness and the appropriateness of the corrective feedback types. The conclusions may be important for sports instructors about the role of corrective feedback methods in sport skills learning.

This study is limited by the testing of outcome scores through a specialized badminton field test. Also, this study is limited to the young participants 10-14 years of age. Even if an effort was made to motivate the participants during the tests, it was not measured whether the children put in their maximum effort. In the present study, feedback was given on the optimal technique, but the effect of the movement outcome was evaluated. Maybe the results would have been different if the technique was evaluated and this is a recommendation for a future study. Finally, maybe the results would have been different if more time was given to the intervention program (more than 12 weeks). Thus, future improvements are recommended.

Research in real sport settings with different skills and sports or different participants' abilities is recommended. In addition, future studies with higher amounts of practice should integrate more complex motor tasks (more degrees of freedom or longer sequences) in order to challenge the generalizability (Krause, Agethen & Zobe, 2018). Since feedback reduction is a recommendation in the area of training methods, there is a need for evaluation for the generalizability of the beneficial effects of feedback reduction. Finally, it has to be explained if the reduction per se or the great reduction of feedback (for example implicit learning) throughout practice is crucial for the development of automaticity in motor tasks. Finally, research for feedback in more realistic sport conditions will also enrich the motor learning knowledge and shed new light on the role of feedback in both theory and practice.

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