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KNOWLEDGE OF RESULTS ABOUT MORE ACCURATE VERSUS LESS ACCURATE TRIALS: DIFFERENTIAL EFFECTS ON PSYCHOLOGICAL VARIABLES AND MOTOR LEARNING IN ADOLESCENT FEMALES

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Abstract
Introduction. The primary purpose of the present study was to investigate whether providing knowledge of results (KR) on more accurate trials enhanced motivation and self-confidence or whether providing KR on less accurate trials reduced those variables. We also investigated whether anxiety was affected by the provision of feedback. ***Material and Methods.*** Participants performed a volleyball serve over four days of practice under one of two conditions: After each block of six trials, one group received feedback on the three most accurate (MA) trials, whereas the other group received feedback on the three least accurate (LA) trials. One week following practice, participants performed a retention test without feedback. Participants also completed the intrinsic motivation inventory (IMI) and the Competitive State Anxiety Inventory-2 (CSAI2). ***Results.*** Results indicated that the MA group had more effective learning as well as higher motivation and self-confidence scores than the LA group. Additionally, the MA group had lower scores on cognitive and somatic anxiety compared to the LA group. The MA group had higher motivation and self-confidence scores and lower anxiety compared to the values reported on the pre-test. Conversely, the LA group had lower motivation and self-confidence scores relative to the pre-test values, and tended to have increased cognitive and somatic anxiety following practice. ***Conclusions.*** The results of this study demonstrate that providing augmented feedback about more accurate trials facilitates motor learning and increases motivation and self-confidence whilst lowering levels of somatic anxiety.

Key words: feedback, motivation, anxiety, volleyball serve, CSAI2, IMI

Introduction

The use of positive augmented feedback has been shown to influence both the extent and rate of skill acquisition [1]. Numerous studies have demonstrated providing knowledge of results (KR) feedback regarding more accurate performance rather than less accurate performance benefits learning [2, 3, 4, 5, 6, 7]. In these studies, KR was provided in the form of summary feedback following a block of practice trials. One group of participants received feedback referring to the most accurate trials within the preceding block, and the other group received feedback referring to the least successful trials in the previous block. The acquisition phase in the aforementioned studies was short, consisting of one session of 60 trials. Thus, the question arises of whether this effect is only present during the very early stages of learning (i.e., first 60 trials), or whether the same learning benefits continue with an extended period of practice. Consequently, the present study aimed to examine whether the previously reported benefits of providing summary KR related to accurate performances facilitated motor learning with longer periods of practice, relative to providing summary KR about less accurate performances.

One initial study speculated that learning differences were likely due to motivational factors [3]. However, changes in participants' motivation were not assessed in that study. This prompted Badami et al. [8] to directly examine the effects of KR on more accurate versus less accurate trials on intrinsic motivation. Intrinsic motivation refers to being motivated by the inherent satisfaction of performing an activity [9]. Using the Intrinsic Motivation Inventory (IMI) [10], Badami et al. [8] found that KR on more accurate trials generally enhanced learners' intrinsic motivation, and their perceived competence in particular, when compared to KR on less accurate trials. In a related study, Badami et al. [2] examined how providing KR on more accurate versus less accurate trials influenced self-confidence, anxiety, and arousal. Using the Competitive State Anxiety Inventory-2 (CSAI-2) [11], participants' cognitive (i.e., the mental component of anxiety typified by negative expectations of performing a task) and somatic anxiety (i.e., the physical component of anxiety typified by rapid heart rate, shortness of breath, clammy hands, butterflies in the stomach, and tense muscles) as well as self-confidence (i.e., one's belief of being able to successfully perform a specific activity) were assessed. Results showed that KR on more accurate trials enhanced learners' self-confidence when compared to KR on less accurate trials. In addition, learners who received KR on more accurate trials demonstrated more effective arousal management.

In Badami et al.'s studies [2, 8], primary intrinsic motivation (i.e., interest/enjoyment, perceived competence, and effort/importance), self-confidence, and anxiety were not assessed prior to the delivery of KR during the acquisition phase. Thus, it is not known whether KR on more accurate trials enhanced primary motivation and self-confidence or whether KR on less accurate trials reduced those variables. Therefore, the primary purpose of the present study was to address this issue. Investigating the possible enhancing or debilitating effects of KR on self-confidence, motivation, and anxiety, as well as understanding how the amount of practice influences these variables are important to advance our theoretical understanding of augmented feedback in addition to providing deeper understanding to practitioners who are concerned about creating more optimal learning environments. We predicted that providing KR about more accurate trials would result in elevated measures of self-confidence and motivation, and result in reduced amounts of anxiety. Furthermore, we predicted that providing KR about less accurate trials would result in reduced levels of self-confidence and motivation, and result in elevated anxiety. Additionally, we predicted the participants who received KR about more accurate trials would display better motor performance during practice and delayed retention test compared to participants that received KR about less accurate performance during acquisition. Lastly, we predicted that increasing the volume of practice would not diminish the beneficial learning effects of providing KR about more accurate trials rather than less accurate trials.

Material and Methods

Participants

Sixty adolescent (M = 16 years of age, SD = 0.4 years) females participated in the present study. The parents of all participants provided consent, and all participants provided assent. Participants had no prior experience with the experimental task and were not aware of the purpose of the study. All participants were right-handed. The only inclusion criteria was that participants had to be able to physically serve a volleyball, there were no exclusion criteria. The experimental protocol was reviewed and approved by a university Institutional Review Board.

Apparatus and Task

The task required participants to underhand serve a regulation size volleyball on an indoor-volleyball court. A net height of 2.33 m was used for all participants. The score zones were adapted from the standardized volleyball serve accuracy test [12]. See Figure 1 for a schematic representation of the test scoring zones.

The CSAI-2 [11] was used to assess participants' cognitive and somatic anxiety as well as self-confidence. The CSAI-2 consists of 27 items on a 4-point Likert scale ranging from 1 (not at all) to 4 (very much so), with scores ranging from 9-36 for each subscale. This instrument is a sport-specific, self-report inventory shown to be a reliable and valid measure of cognitive and somatic anxiety and self-confidence, with Cronbach' s alpha coefficients ranging from 0.70 to 0.90 [11].

A short 9-item version of the IMI (McAuley et al., 1989) was implemented to assess participants' interest, perceived competence, and effort. The three subscales of the IMI were summed to yield a composite measure of intrinsic motivation. Responses were on a 7-point Likert scale that ranged from 1 (strongly disagree) to 7 (strongly agree). Negatively worded items were rescaled before analysis. This inventory is a reliable and valid measure of interest, perceived competence and effort, with Cronbach's alpha coefficients ranging from 0.80 to 0.90 [8].

Procedure

Participants were randomly assigned to groups receiving KR either on more accurate trials (MA group) or less accurate trials (LA group). Participants were not aware which group they were assigned to, nor were they told they would be receiving feedback about the more or less accurate trials in the block. Participants were only informed they would receive feedback regarding three of the previous six trials. Similar to previous studies [2, 8], after each block of six trials, participants in the MA group received KR on their three most accurate (i.e., best) serves in that block, whereas those in the LA group received KR on their three least accurate serves. Participants were allowed to look at the target area prior to each set of six trials, but were prevented from viewing the results during those six trials by wearing opaque swimming goggles. Participants completed a total of 36 volleyball serves each day for four days, totaling 144 trials during the practice phase. Each session of 36 trials was organized into blocks of six serves. Before the beginning of the first session (i.e., Day 1), the experimenter spent a few minutes with each participant describing the basic technique of the serve. The technique that was described to all participants was adopted from a popular volleyball coaching textbook [13]. After the underhand serve technique was described to each participant, they performed 10 familiarization trials. Participants were informed about the scoring zones located on the opposite side of the net (Fig. 1), and they were instructed that their goal was to score high point values on each serve. They were also informed that feedback would be provided to them on three of the six trials completed in each block of serves. Before the beginning of each testing session, participants were encouraged to warm up their muscles by stretching and performing exercises such as arm circles. Each participant was tested individually. Seven days after the conclusion of the fourth and final day of practice, participants returned and performed a transfer test consisting of 10 trials without KR. Participants did not wear the opaque swimming goggles during the transfer test. Participants completed the IMI twice; after the initial block of practice (i.e., trials 1-6) on day one and following the final block of practice (i.e., trials 139-144) on day four. Participants also completed the CSAI-2 twice; before the initial block of practice (i.e., trials 1-6) on day one and prior to the transfer test.

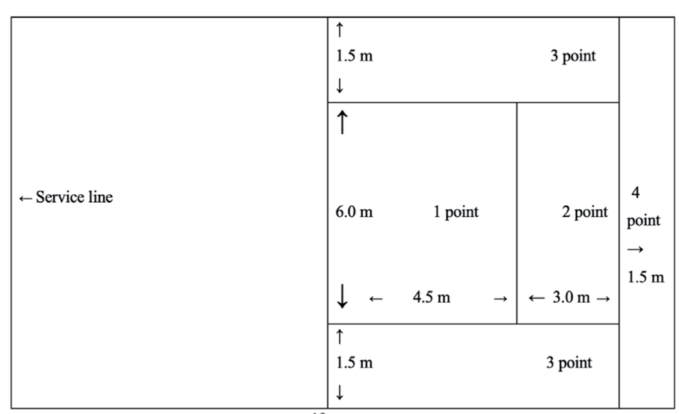

Figure 1. Volleyball court dimensions and point values for each zone for the AAHPERD (1969) volleyball serving test.
The vertical line down the middle of the diagram represents the net. Participants served the volleyball from behind the line on the opposite end of the court.

Data analysis

Service accuracy scores were analyzed in a 2 (groups: MA, LA) × 24 (blocks of 6 trials) analysis of variance (ANOVA) with repeated measures on the last factor for the practice phase. Independent t-tests were conducted to evaluate potential differences between experiment groups on the transfer test as well as the three subscales of the CSAI-2 and the IMI questionnaires. Paired t-tests on the three subscales of CSAI-2 and IMI questionnaires were conducted to test for potential differences between pre- and post-tests.

Results

Practice

Both experimental groups increased their service scores across practice blocks (Fig. 2), with the MA group tending to have higher scores than the LA group. The main effects of Group (F (1, 58) = 4.30, p = 0.04, Eta^2 = 0.07), Block (F (23, 1334) = 6.10, $p < 0.001$, Eta^2 = 0.70), and the Group × Block interaction, F (23, 1334) = 2.32, $p < 0.001$, Eta^2 = 0.63 were all significant.

Transfer

On the transfer test, which was performed seven days after the practice phase, the MA group had higher accuracy scores than the LA group (M = 2.75, SD = 0.7; M = 1.63, SD = 1, respectively). This group difference was significant, $t_{(58)}$ = 4.63, $p < 0.0001$, Eta^2 = 0.27.

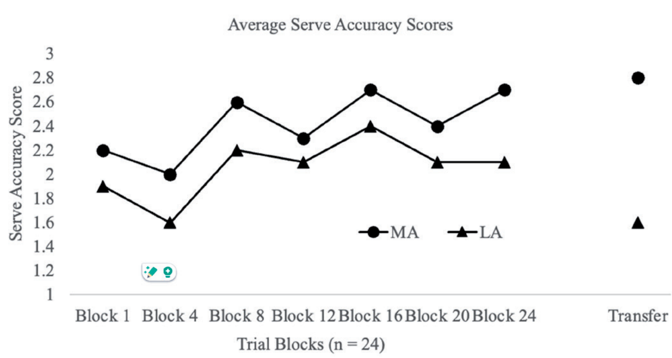

Figure 2. Accuracy scores for the More Accurate (MA) group and Less Accurate (LA) group during acquisition and transfer testing. Each trial block represents the average score of the six trials completed in the respective trial block.

CSAI-2 and IMI Inventory

The means and standard deviations for the three subscales of the CSAI-2, overall motivation, and the three subscales of IMI are displayed in Table 1. There were significant differences between pre- and post-tests in both groups for all variables (Tab. 1). Consistent with our predictions, the MA group had higher interest, perceived competence, effort, motivation and self-confidence scores on the post-test compared to the values reported on the pre-test. Moreover, the MA group had lower scores on cognitive and somatic anxiety following the practice session. Conversely, the LA group had lower interest, perceived competence, effort, motivation, and self-confidence scores on the post--test relative to the pre-test values, and tended to have increased cognitive and somatic anxiety following practice. There were no significant differences between groups in any of the pre-test measures (t < 1). However, there were significant differences between groups in all variables on the post-test. The MA group had higher interest ($t_{(58)}$ = 8.90, $p < 0.001$, Eta^2 = .58), perceived competence ($t_{(58)}$ = 5.88, $p < 0.001$, Eta^2 = .37), effort ($t_{(58)}$ = 9.93, $p < 0.001$, Eta^2 = .63), motivation ($t_{(58)}$ = 10.55, $p < 0.001$, Eta^2 = .66) and self-confidence ($t_{(58)}$ = 7.23, $p < 0.001$, Eta^2 = .47) scores than the LA group. Additionally, the MA group had lower scores on cognitive ($t_{(58)}$ = 6.03, $p < 0.001$, Eta^2 = .39) and somatic anxiety ($t_{(58)}$ = 7.23, $p < 0.001$, Eta^2 = .33) compared to the LA group.

Discussion

In the motor learning domain, numerous studies involving younger and older adults, as well as children, have demonstrated more effective learning when KR is related to more accurate rather than less accurate trials [2, 3, 4, 6, 8]. Volume of practice has been shown to interact with the efficacy of augmented feedback [14]. In previous studies, the acquisition phase was short, consisting of one session of 60 trials. Thus, one purpose of the present study was to examine whether previously found benefits of feedback on more accurate trials would generalize to an acquisition phase that spanned four days of practice totaling144 trials. The results of the present study demonstrate that these benefits do generalize to lengthened practice trials over multiple practice sessions. Interestingly, in previous studies [2, 3, 4], no group differences were found during practice (i.e., when feedback was provided). Rather, group differences were only found on post-tests without KR. However, in the present study, group differences were observed during practice as well

Table 1. Means and standard deviations for Pretest-posttest data for the More Accurate (MA) and Less Accurate (LA) groups.

Variables	Groups					
	MA group			LA group		
	Pre-test	Post-test	Paired t-tests	Pre-test	Post-test	Paired t-tests
Interest	15.33 ± 3.1	18.23 ± 2.8	$t_{(29)}$ = 7.3*	14.83 ± 3.8	10.86 ± 3.5	$t_{(29)}$ = 9.5*
Perceived Competence	15.03 ± 4.2	17.30 ± 3.8	$t_{(29)}$ = 8.9*	15.90 ± 3.7	11.31 ± 4	$t_{(29)}$ = 12.6*
Effort	16.13 ± 3.4	19.06 ± 2.3	$t_{(29)}$ = 10.2*	15.36 ± 3.2	11.36 ± 3.5	$t_{(29)}$ = 8.7*
Motivation	46.90 ± 8.1	54.60 ± 6.6	$t_{(29)}$ = 11.3*	45.93 ± 8.6	33.26 ± 8.8	$t_{(29)}$ = 12.3*
Cognitive Anxiety	24.73 ± 6.6	17.56 ± 5.4	$t_{(29)}$ = 12.4*	22.46 ± 8.2	27.33 ± 6.9	$t_{(29)}$ = 10.5*
Somatic Anxiety	22.13 ± 5.8	16.76 ± 4.2	$t_{(29)}$ = 6.2*	20.73 ± 6.6	24.26 ± 6.4	$t_{(29)}$ = 7.4*
Self-Confidence	22.80 ± 5.6	28.66 ± 5.7	$t_{(29)}$ = 11.1*	23.30 ± 6.8	17.83 ± 5.8	$t_{(29)}$ = 12.2*

* – p < 0.001.

as transfer. This difference is likely related to the longer period of practice utilized in the present study, resulting in observed differences between groups during skill acquisition.

Psychological factors such as intrinsic motivation have been suggested for the learning benefits of feedback on more accurate trials [8]. Our findings provide further support for this, demonstrating that intrinsic motivation and perceived competence were higher when feedback was provided on more accurate trials. Many researchers have proposed that positive information-based feedback, given in response to a learner's performance, results in increased perceived competence, which in turn increases individual levels of intrinsic motivation [15, 16, 17, 18, 19]. Numerous studies have shown that perceived competence is positively associated with intrinsic motivation: If learners feel they are competent, they enjoy their participation [20, 21, 22]. Consistent with this perspective, our results indicate that enjoyment was indeed higher when feedback was provided regarding more rather than less accurate trials. In line with previous findings, our results demonstrated there was a meaningful relationship between enjoyment and perceived competence [23]. However, this result is not consistent with findings reported by Badami et al. (2011), who found no significant differences between groups in enjoyment, despite the significant difference in perceived competence between groups. A probable reason for this discrepancy is related to the increased amount of practice utilized in the present study. In our study, the perceived competence difference between groups was larger compared to the differences reported by Badami et al. [8]. The present study's findings also indicate that individuals' effort was higher when feedback was provided on more accurate trials. This result is consistent with previous studies demonstrating that perceived competence determines the effort students exert in physical education classes [24, 25].

Consistent with our predictions, the results of this experiment also demonstrate that KR on more accurate trials enhanced all aspects of intrinsic motivation (i.e., primary interest, perceived competence, effort), whereas providing KR on less accurate trials decreased the same measures. These results are consistent with previous findings demonstrating that positive feedback enhanced all aspects of intrinsic motivation, whereas feedback about poorer performances decreased them [22]. However, it is worth noting that, unlike Lewthwaite and Wulf [26], Whitehead and Corbin [22], and Wulf et al. [27], we did not provide fictitious feedback.

In the present study, we were interested in determining how providing feedback about accurate trials affected a learner's self-confidence and, consequently, the efficacy of motor learning. As previously discussed, having higher self-confidence has been shown to have a positive impact on performance. Additionally, Vealy [28] concluded that prior performance influences confidence more strongly than confidence influences performance. It has also been reported that feedback from a coach influences an individual's beliefs of performance capability [29]. Presumably, if this feedback references positive performances it, in turn, increases the learner's self-confidence. The findings of the present study support this conclusion. Furthermore, our findings suggest that this effect has a positive influence on motor learning.

Additional conclusions that can be extrapolated from our study are that providing KR about more accurate trials decreased somatic and cognitive anxiety, whereas KR about less accurate trials elevated them. Our findings also demonstrated that one of the unfortunate side effects of having increased cognitive and somatic anxiety is a lowered perceived confidence. This result aligns with previous findings revealing a negative correlation between perceived competence and anxiety [30, 31]. The present study is not without limitations, which illustrate the need for additional research. For example, we only investigated the effect of providing feedback following more or less accurate trials with adolescent females within the context of serving a volleyball. Future research should test the generalizability of the findings reported here in more diverse populations and motor skills.

Conclusions

The present findings demonstrated that augmented feedback after relatively accurate trials enhanced the learner's perceived competence whereas KR on less accurate trials decreased it. According to White [32], individuals have an innate desire to feel competent. This feeling, in turn, serves to maintain or increase a person's intrinsic motivation toward the behavior (e.g., motor learning). Perceptions of competence, in turn, presumably increases the learner's self-confidence, as demonstrated by our findings. Self-confidence has been shown to positively predict athletes' effort and persistence in sport. It also affects the choices that athletes make about continuing participation in sport and related tasks. Confident athletes have been shown to think better, cope better, set more challenging goals, concentrate more effectively, and tolerate elevated levels of anxiety before experiencing decrements in performance compared to less confident athletes [28]. Furthermore, the lowered anxiety that was experienced by feedback on more accurate trials may have led to constructive thoughts or negative affect suppression. The present findings add to the converging evidence that feedback plays a clear psychological role in the motor learning process.

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