The Need and Benefit of Augmented Feedback on Service Speed in Tennis

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ABSTRACT

MORAN, K. A., C. MURPHY, and B. MARSHALL. The Need and Benefit of Augmented Feedback on Service Speed in Tennis. *Med. Sci. Sports Exerc.*, Vol. 44, No. 4, pp. 754–760, 2012. **Purpose**: Accurate knowledge of results (KR), in the form of service speed, is important in learning to serve faster. The aim was to determine whether players could accurately judge if their serve was faster or slower than their preceding serve (experiment 1) and if providing them with accurate augmented KR feedback on service speed using a speed gun could enhance learning after training (experiment 2). **Methods**: In experiment 1, 11 high-level national junior players served 10 serves to a target area and were asked to judge whether the serve was faster/slower that the preceding serve. In experiment 2, 12 high-level national junior players, divided into two groups, trained to improve their service speed for 12 wk (three sessions per week). During the first 6 wk (90 maximum-effort serves/session), they received either augmented (group 1) or no augmented (group 2) KR feedback. During the following 6 wk, participants did not complete the 90 serves per session and received no augmented KR feedback (retention test). **Results**: In experiment 1, players could not correctly determine whether serves were faster/slower than the preceding serve. In experiment 2, both groups significantly enhanced their service speed after the initial 6 wk of service training, but the enhancement was significantly greater (P = 0.01) in the augmented versus no augmented KR feedback group (0.84 ± 0.38 vs 0.22 ± 0.04 $m \cdot s^{-1}$). These enhancements were still evident during the retention test (P = 0.01). **Conclusions**: Players cannot accurately judge service speed, and by providing this information in the form of augmented feedback, a player can enhance the process of learning to serve faster with training. Players should therefore use augmented feedback on service speed when training to serve faster. **Key Words:** MOTOR LEARNING, SKILL ACQUISITION, SPORT, KNOWLEDGE OF RESULTS

Motor learning involves the integration of motor control processes through repeated trials of a motor task to guide the system toward identifying and permanently adopting a more optimal movement technique (2,22,23). For example, if a tennis player aimed to improve his/her service speed, he/she would practice numerous serves; when he/she produced faster services, he/she would attempt to more permanently use the associated enhanced technique.

Feedback provides essential information for the motor control processes and therefore for the process of learning. Feedback can relate to the technique used (*knowledge of performance*; e.g., the amount of shoulder internal rotation) or the outcome goal of the movement (*knowledge of results [KR]*; e.g., the speed of service). [Although some authors use the term KR to refer interchangeably to outcome information that can be either (i) intrinsic or (ii) augmented (e.g., Magill and Wood (15) and Schmidt and Lee [23]) without distinguishing between them, we feel this is imprecise (21) and therefore can act to inhibit rigorous understanding of the nuances of KR. Within this article, we clearly distinguish between intrinsic KR and augmented KR information, the former being KR information detected by the performer (e.g., visual determination of ball speed by the performer), whereas the latter relates to KR provided by a source external to the performer (e.g., ball speed measured by a speed gun) (21)]. After practice itself, KR is seen by many as the most important variable in effective motor learning (21,22). Given that KR is used to rate the effectiveness of a technique and that there may be only very small variations in the outcome results for a high-level athlete, it is essential that the KR-based feedback is accurate and precise (4,7). In addition, for the majority of practice time in most sports, there is a low ratio of the number of trials where KR feedback is received from an external source (e.g., from a coach) to the number of trials where feedback comes solely from the player themselves. Therefore, it is perhaps crucial that either the athlete is able to accurately determine KR himself or herself or that the athlete is provided with a source/technology that can. This is particularly true for those theories of learning that espouse the importance of action–perception coupling (e.g., ecological approach).

The serve in tennis is commonly considered the most important stroke in the game because it is a high predictor of match success (11,20), with its effectiveness primarily dependent on ball speed (6). Therefore, as indicated above, if

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an athlete aims to improve his/her service speed, he/she must be able to accurately discern between attempts in service speed. At the very least, he/she should be able to judge from consecutive attempts that are faster or slower. However, no previous studies that examined this for tennis or for similar high-speed striking/projecting actions could be found.

The ability to judge ball speed has been reported to be dependent on optical mechanisms (9) and/or internal models of prediction (24). Irrespective of the mechanism, the ability to gather more visual input information may result in an enhanced ability to judge speed. More information would be available for slower ball speeds as more images are available during the longer-duration flight phase of the ball (a frequency constraint). Therefore, it would be of interest to determine whether the ability to judge whether consecutive serves are faster or slower is dependent on the absolute ball speed. This could be assessed for consecutive serves by taking the average of the two serves. Similarly, the ability to judge whether consecutive serves are faster or slower may be dependent on the difference in the speed of consecutive serves (a sensitivity constraint). This would have implications whether variability between service speeds was small or large, with greater speed differences perhaps being evident in the earlier phases of learning.

Therefore, the aims of experiment 1 were as follows:

1. to determine whether highly trained tennis players could judge if a serve was faster or slower than the preceding serve and
2. to determine whether the ability to judge this was dependent on either (i) the difference in the speed of the serves or (ii) the average of the two service speeds.

On the basis of the ability of players from a variety of sports (e.g., tennis, cricket) to be able to accurately strike fast-moving balls when they enter their (small) "hitting zone" (13) and that this capacity seems to be better in high-level players, it is hypothesized that high-level tennis players will be able to judge if consecutive serves are faster or slower. In addition, it is hypothesized that this ability will be greatest at lower ball speeds and when the difference between ball speeds is largest.

Irrespective of the outcomes of experiment 1, it is possible that the more accurate and precise the KR feedback to players on their service speed is, the more effectively they may be able to identify a better technique and subsequently use it more regularly. Previous studies have highlighted the importance of accurate KR (4,7). However, these studies are limited in their application to the topic of this article because they were nonmaximal effort tasks, and the accuracy of the augmented KR feedback was, in general, artificially made erroneous (subjects were misled). Findings from feedback-based studies using nonmaximal effort tasks may not be wholly applicable to maximal effort tasks because (i) maximal-effort tasks have a much smaller range of techniques that produce the targeted outcome goal (26,28), thereby potentially requiring more accurate KR feedback, and (ii) maximal-effort tasks tend to be produced faster, decreasing the amount of knowledge of performance feedback (a frequency limitation), thereby potentially increasing the reliance on KR feedback information.

An increase in the accuracy and precision of service speed assessment could be provided with the use of specialized equipment (e.g., a speed gun and visual display). To the best of our knowledge, no previous studies have examined this in relation to tennis service speed or ball projection speed in other similar high-speed actions, with such small variations in ball speed between trials. Therefore, the aims of experiment 2 were as follows:

1. to determine whether augmented KR feedback, in the form of service speed, resulted in a greater improvement in service speed after a 6-wk training period; and
2. to determine whether the improvement, if any, was still evident after a further 6-wk retention period during which the augmented KR feedback was removed.

It is hypothesized that improvements will be greater when augmented KR feedback is provided, because it will provide a more accurate source of information (4,7), and that the improvements will still be evident after a 6-wk retention period.

METHODS

Experiment 1

Participants. Eleven national-standard junior tennis players, seven males and four females (15.7 ± 1.6 yr), who were free from injury, volunteered for the study. Players were defined as "high-level" based on fact that they represented Ireland, had been training between 20 and 26 $h \cdot wk^{-1}$ as part of the Tennis Ireland national squad for at least 2 yr, and had completed in at least six internationally recognized junior competitions per year for at least 2 yr. Informed consent was obtained from the participants and their parents/guardians, and ethical approval was received from Dublin City University.

Data collection. Testing took place in the indoor Irish National Tennis Centre. After their normal squad warm-up, players served 15 acceptable serves to the T of the deuce service box. Attempts were deemed acceptable if they were within a 1.5 × 1.5-m area of the T in the service box (Fig. 1). Where a service attempt was not acceptable, it was repeated until sufficient serves were completed so that players had 10 opportunities to judge if their serves were faster or slower than the immediately preceding one. The warm-up consisted of: 3-min jogging at a self-selected "slow" pace and 2 min at a "fast" pace, 8 min of whole-body dynamic stretching, 10 min of rallying which progressively increased in intensity, and 4-min service practice.

Service speed was measured using a StalkerPro speed gun (Stalker, Plano, TX) placed 4 m behind the baseline in line with the intended direction of serve. Absolute errors for the speed gun are small (±0.04 $m \cdot s^{-1}$), and inaccuracies associated

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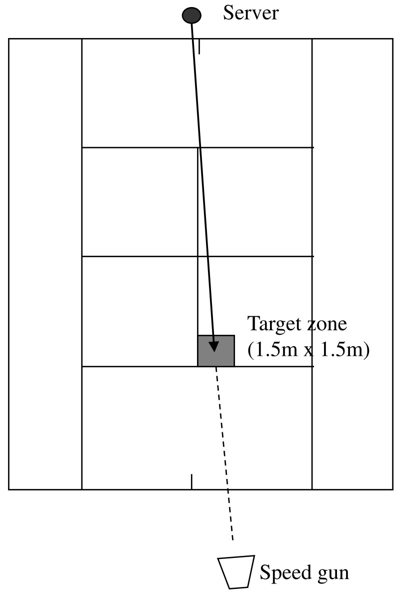

FIGURE 1—Setup for experiment 1.

with ball movements nonparallel to the speed gun were estimated to be a maximum of 0.25% service speed.

Data analysis. To determine whether players could judge if a serve was faster or slower than the preceding serve, a Wilcoxon signed rank test was used ($P < 0.05$). The two inputs were the number of correct differentiations (faster/slower) out of 10 and the number expected due to chance/guessing (=5). To determine whether the ability to judge correctly was dependent on either (i) the difference in the speed of serves or (ii) the average of the two service speeds, both measures were correlated with the number of correct service speed differentiations (faster/slower) using a Spearman rank correlation analysis ($P < 0.05$).

Results. No significant difference was evident between the number of correctly differentiated serves (4.9 ± 1.5) and the number of serves due to chance (=5) ($z = -0.11$ $P = 0.92$). This indicates that the tennis players could not correctly determine whether consecutive serves were faster or slower than each other were. The average speed of serve was 46.07 ± 4.51 $m \cdot s^{-1}$, and the average difference between serves was 1.1 ± 0.5 $m \cdot s^{-1}$. The number of correctly differentiated serves was not correlated with either the difference in the speed of serves ($r = 0.25$, $P = 0.46$) or the average of the two service speeds ($r = -0.03$, $P = 0.92$).

Experiment 2

Participants. Twelve junior national tennis players (11 of whom completed experiment 1) volunteered to participate in this study (15.9 ± 1.7 yr). The additional player was a male, 14 yr 3 months old. Although he did not complete experiment 1, he was as aware of the aim of experiment 1 as those who participated. The same inclusion criteria were used as experiment 1. Informed consent was obtained from the participants and their parents/guardians, and ethical approval was received from Dublin City University.

Participants were ranked in order from 1 to 12 by their senior coach in terms of his "perception of how their service speed could improve during the training period." (No attempt was made by the coach to indicate the magnitude of this difference between them.) Subsequently, they were assigned to either the augmented (participants 1, 4, 5, 8, 9, and 12) or no augmented KR feedback group. The aim of this allocation process was to reduce the likelihood that players who were most likely to improve their serve were not coincidently placed in the same group, thereby potentially skewing the results. Although not being an aim of the process, two girls were coincidently assigned to each group. A Mann–Whitney test indicated no significant difference between the augmented feedback group and the no feedback group for preintervention service speed (46.71 ± 4.70 vs 45.56 ± 3.63 $m \cdot s^{-1}$, respectively; $U = 17.0$, $P = 0.47$).

Data collection. All sessions took place during the participants' usual training times in the indoor National Tennis Centre. Participants attended one pretest session (to determine their baseline service speed), 6 wk of training sessions (three times per week) where they received either augmented or no augmented KR feedback, a posttest session, six further weeks of training sessions (three times per week) where no participants received augmented KR feedback, and a retention test session (Fig. 2). The purpose of the second training

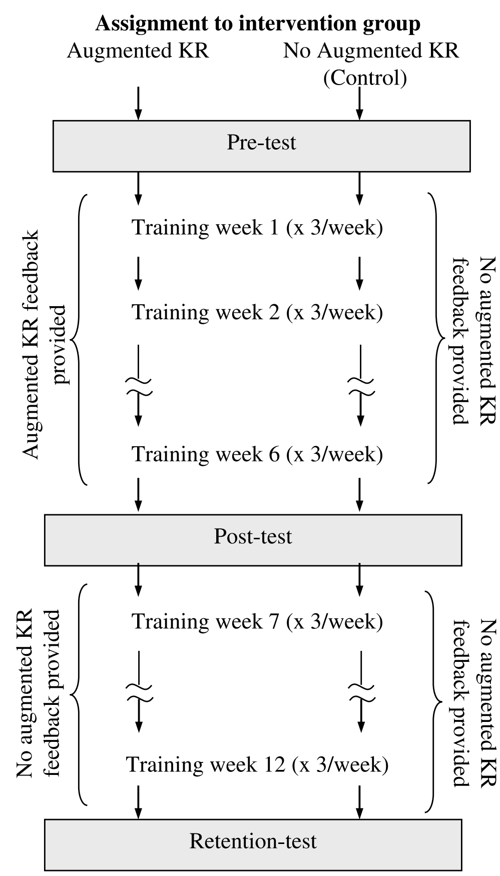

FIGURE 2—Procedures for experiment 2. Note: training in weeks 1–6 consisted of 90 directed serves plus general tennis training, while weeks 7–12 did not include the 90 directed serves.

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period was to determine whether any enhancements in service speed remained after the augmented feedback was removed.

Each training session required the player to complete 90 consecutive serves: 15 wide, 15 central and 15 T, on both the Deuce and Advantage sides of the court. A 1.5-m square target was marked in these three areas. Serves were to be hit "as hard as possible while landing the serve in the target zone." Only serves that landed in the target zone counted toward the total of 90. No players received any coach feedback. Feedback to the augmented KR feedback group was given almost immediately (<2 s) after each serve via a large electronic display. Service speed was measured using a speed gun (StalkerPro; Stalker) placed in line with the intended direction of serve (4 m behind the baseline). In addition, to the dedicated 90 serves, players did complete an unspecified, but smaller number of serves related to match practice drills (e.g., serve and volley) where no feedback was provided.

During the second 6-wk training (retention) period, players did not complete the 90 dedicated serves but did undertake serves related to match practice as previously undertaken in the first 6 wk.

Data analysis. All service speed tests were determined as the average of 15 serves to the 1.5-m square target area of the Deuce service box. A Friedman test was undertaken for each group to determine whether the results were dependent on the test day (pretest, posttest, retention test), where a difference was evident follow-up pairwise comparisons were conducted using a Wilcoxon signed rank test. Where both groups (augmented and no augmented KR feedback) exhibited a significant training effect, a subsequent Mann–Whitney test was used to determine whether there was a significant difference between the two groups in the magnitude of enhancement ($P < 0.05$).

RESULTS

Table 1 details the mean ± SD service speed on all three test days. For both the augmented and no augmented KR feedback groups, there was a significant enhancement in service speed associated with test day ($\chi^2 = 10.17$, $P = 0.006$; $\chi^2 = 10.18$, $P = 0.006$, respectively). Follow-up pairwise comparisons revealed that, for both the augmented and no augmented KR feedback groups, enhancements in service speed were evident between the pretest results and both the posttest ($z = -2.20$, $P = 0.02$; $z = -2.22$, $P = 0.02$, respectively) and the retention test ($z = -2.20$, $P = 0.02$; $z = -2.20$, $P = 0.02$, respectively) results. No differences were evident between the posttest and the retention test ($z = -1.41$, $P = 0.16$; $z = -0.37$, $P = 0.71$, respectively). The magnitude of the enhancements from the pretest to both the posttest and the retention test was significantly larger for the augmented KR feedback group ($z = -2.43$, $P = 0.01$; $z = -2.49$, $P = 0.01$, respectively). The mean ± SD enhancements for the augmented versus no augmented KR feedback groups from pretest to posttest were 0.84 ± 0.38 versus 0.22 ± 0.04 $m \cdot s^{-1}$, respectively, and those from pretest to retention test were 0.89 ± 0.41 versus 0.21 ± 0.05 $m \cdot s^{-1}$, respectively.

TABLE 1. Mean ± SD service speed ($m \cdot s^{-1}$) across three test periods.

	Pretest	Posttest	Retention Test
Augmented KR feedback	46.71 ± 4.70	47.69 ± 4.70	47.74 ± 4.71
No augmented KR feedback	45.56 ± 3.63	45.78 ± 3.65	45.77 ± 3.67

DISCUSSION

KR is used to internally rate the effectiveness of the movement technique that produced the result, thereby providing valuable information to the complex process of motor learning which aims to optimize movement technique (2,22,23). In many movement tasks, accurate KR can easily be determined by the performer, e.g., shooting in basketball (a score or no score, or even the extent of the miss). However, the present study (experiment 1) showed that highly trained tennis players could not correctly differentiate (faster/slower) between the speeds of consecutive maximum-effort serves, thereby potentially severely limiting their ability to effectively optimize their service technique. The challenge of accessing and using accurate and relevant service speed information is in fact likely to be even greater than indicated by the current test method. For players to be able to use service speed information as a driver to optimizing service technique, they would probably have to be able to (i) differentiate (faster/slower) between nonconsecutive serves, not simply consecutive serves, and (ii) possibly determine the relative magnitude of the difference. No studies could be found that specifically examined the ability of high-level athletes to rate the speed of projection of a ball they threw or struck. However, Magill (14) suggests that, in performing a novel movement task as fast as possible, improvements are initially high because individuals can judge accurately between the speed of movements, but with further increases in speed and smaller differences between trials, they do not have the experience to differentiate accurately between them. This results in a reduction or halting of improvements associated with an inability to further optimize the movement technique (14). Given the significant prior training and expertise of the participants in the present study, it is unlikely that the inability to differentiate between serves is due to inexperience, suggesting that it is due to the high magnitude of service speeds (46.9 ± 4.5 $m \cdot s^{-1}$) and/or the small differences between consecutive serves (1.1 ± 0.5 $m \cdot s^{-1}$). Although no correlation was found between the ability to accurately differentiate between serves and either of these measures, it would not be appropriate to conclude that they are not related factors because the range of results was very low. Further study is warranted to determine at which speed and/or at what difference in speeds can players effectively differentiate between.

The findings of the present study raise an interesting question: why could players not differentiate correctly between service speeds? Clearly, in serve-receiving a ball of

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the same speed, players do have the ability to very accurately judge when it will enter their (small) "hitting zone" because they can effectively strike the ball to return it; similar abilities are observed in batting in cricket and baseball. Although this specific topic was not experimentally examined within the present study, there are several possibilities worth noting:

1. *There is a difference between judging the speed of a ball and predicting when it will be in a player's hitting zone*. Although optic variables (e.g., retinal image size, rate of expansion, tau) may theoretically allow the speed of an object to be determined (ecological perspective, see Gibson [9]), in fast-moving conditions such as tennis or cricket, prior knowledge and internal models are used to predict where and when the ball will reach the hitting zone (constructivism perspective, see Shepard [24]). This negates the need to directly determine ball speed (13) (for a review, see Zago et al. [38]).
2. *The server may not be able to judge ball speed because he/she cannot see where the ball is at key points in its flight path*. Even if it was possible to determine high ball speeds using optical variables, the environmental setup for serving differs from that of receiving a serve. When receiving a serve, the ball is (i) struck in front of the receiver and subsequently remains in his/her field of vision for the duration of its flight, and (ii) the player's head does not rotate excessively. In contrast, however, the server may actually (i) lose sight of the ball from very soon after contacting it until he/she can reposition his/her head to "pick up" the flight of the ball again as it travels toward and over the net, again where it may be obscured by the net tape, and (ii) his/her head rotates quickly and significantly.
3. *There may be a difference in judging the speed of objects moving away from the player rather than moving toward them*. Because a player would not have to form an accurate motor response to a ball he/she served away from him/her, in comparison to intercepting a ball served to him/her, there would not be the same requirement to form internal models of the ball's flight behavior. Without these models, it may not be possible to even infer ball speed, even indirectly (38). Overney et al. (17) used a random dot kinematogram to investigate the ability of observers to discriminate speed between two displays of moving dots. They found that tennis players were able to more accurately discriminate speed than triathletes and nonathletes when the dots were expanding (i.e., mimicking moving toward the participants) but not when contracting (i.e., mimicking moving away from the observer).
4. *Proprioceptive signals may dominate.* It is possible that tennis players judge the speed of the ball based on how they rated the effectiveness of the service technique; that is, from proprioceptive information, rather or more so than on visual information. Clearly, this would have limitations because optimization of the movement technique would be dependent solely on feedback about the technique (e.g., speed of shoulder rotation) without direct evidence of outcome success (i.e., ball speed).

In light of the importance of service speed feedback to the learning process and the inability of tennis players to judge it, the second experiment within this article examined if augmented feedback could enhance the learning process during a 6-wk period. Although there is debate over the optimal frequency and delay time of feedback (discussed below), the augmented feedback was provided almost immediately (<2 s) after completing each serve by using a speed gun and large display. The results clearly show that providing accurate and precise knowledge of service speed significantly enhanced the learning process, with a subsequent increase in speed in comparison to the control group who received no augmented feedback (0.8 ± 0.4 vs $0.2 \pm 0.1\ m{\cdot}s^{-1}$, respectively). The enhancements in performance associated with the 6 wk of training with augmented feedback were still present after a further 6 wk of training without the augmented feedback (the retention test). This indicates that the new serving techniques were learned, rather than just a reflection of the presence of the feedback information (22,23).

The present study is not the first to show that the more accurate the KR feedback, the greater the enhancement in performance [e.g., Buekers et al. (4), Ford et al. (7), Magill and Wood (15), and Reeve et al. (19)]. Ford et al. (7) examined the effect of providing erroneous visual (video) feedback to performers on the height to which a ball they kicked cleared a bar. Their results showed that even highly skilled performers accepted and integrated the erroneous visual feedback resulting in the subsequent utilization and adoption of erroneous kicking techniques. However, the present study seems to be the first to show this in relation to service speed in tennis (or ball projection speed in any sport) where effort is maximum, ball speed is high, and where such small variations in ball speed between attempts are evident. In addition, unlike previous studies (4,7) that artificially induced erroneous feedback by misleading the participants, the erroneous KR information determined by the players in the current study was simply due to the players' inability to judge it accurately. However, it is unclear if this information was used by players as part of the motor learning process in attempting to identify a more optimal movement technique.

The importance of this article's findings to the applied setting is perhaps further highlighted when recognizing the nature of the general training environment. The coach clearly plays a critical role in providing feedback to a player. Yet, it is not uncommon for the ratio of players to coach to be high, limiting the opportunity for an individual player to receive feedback from the coach on the speed of his/her serve. In addition, it is unclear if coaches have the ability to accurately identify which serves are faster or slower than others are,

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given that the players themselves cannot. This, itself, requires investigating.

Although early work on augmented KR feedback took the view that feedback should be frequent and immediate (1,3,25), there has been a ground swell of research that takes the opposite view, that it should be less frequent and delayed (16,27,29,30,34). This is in accordance with the guidance hypothesis, which holds as a central tenant that KR helps to guide the performer to identify a more optimal movement technique, but that when the augmented KR feedback is too frequent, especially when given after every trial, it may cause the learner to rely too much on this information source (22). The outcome of this overreliance would be a failure to attend effectively to processing intrinsic feedback, which they must again rely on when the augmented feedback is no longer available (12,22,33). However, in the present study (experiment 2), augmented KR feedback provided almost immediately after each trial resulted in learning, as evidenced by results from the 6-wk retention test. Support for providing feedback after each trial is evident in other studies that have examined learning of complex tasks (10,35,36). For example, Wulf and Shea (36) examined the issue of the frequency of feedback in a complex slalom-type movement, which, in common with the tennis serve in the present study, required the significant muscular effort to move and accurately coordinate the actions of a large number of body segments. They found that learning enhanced when augmented feedback was provided after every trial rather than after every two trials. The contrast in findings between those who advocate decreased frequency and increased delay in feedback and those who advocate increased frequency and immediate feedback may be due to variation in the complexity of the task they studied (10,35,36). In contrast to complex skills based studies, simple skills tend to be novel (which can be mastered in as little as 15 min of practice), to have a single and overly simple temporal or spatial task goal, to use feedback that is either present or not (35), to require only submaximum neuromuscular effort, and to incorporate only a short retention test period. Such limitations reduce the ecological validity of applying the results to complex tasks (8,35) that dominate the sports environment. In fact, in a review of the issue in relation to feedback frequency and delay, Wulf and Shea (35, p. 207) conclude that, "research on more complex skills shows that the manipulation of practice variables that result in enhanced learning of simple skills are actually detrimental to the learning of complex skills." This statement is perhaps all-the-more pertinent when the conservative definition of a complex skill by Wulf and Shea is considered: "if they generally cannot be mastered in a single session [and] have several degrees of freedom" (35, p. 186). Clearly, in highly complex sports skills such as serving in tennis, results from simple skills-based studies may not be fully applicable.

The authors have taken the position in writing this article that the benefit of augmented KR feedback is in providing information to guide the system toward identifying and permanently adopting a more optimal movement technique (2,22,23). However, it is worth noting other popular possible benefits to augmented KR feedback:

1. *Motivation* (2,5). This may be motivation to perform more maximum-effort attempts, thereby increasing the likelihood of the system identifying a more effective movement technique or increasing the strength of the neuromuscular system. Motivation may also increase the amount of attention paid by the performer to the available feedback information (internal and/or external), thereby facilitating learning.
2. *External focus of attention*. Focusing on the outcome of the movement (external focus) rather than how it is produced (internal focus) can enhance learning (31,32,37) (for a review, see Peh et al. [18]). Interestingly, in contrast to the current guidance hypothesis of learning discussed above, this theory of learning indicates that providing feedback after each trial, as used in the current study, is more beneficial than providing feedback less frequently (31).

Limitations. The authors acknowledge the small number of participants in experiment 2 (between-subject design), which is often a consequence of relatively long-term training studies on highly trained athletes. However, this seems to be the first study to examine the role of augmented feedback KR in a skilled group of athletes involved in a high-speed striking/throwing–based action.

CONCLUSIONS

Serving speed is extremely important to service ability (6), which, in turn, is a high determinant of success in tennis (11,20). In attempting to optimize service technique, players need to have access to accurate and precise knowledge of service speed (KR). However, where such accurate and precise information is not intrinsically available, as in the tennis serve of high-level players (experiment 1), this information should be externally provided (augmented feedback) to enhance learning (experiment 2). Specifically, with regard to high-level tennis players, it is recommended that ball speed be measured accurately and relayed to the server after each serve.

Future studies should determine whether players from other sports involving maximum-effort striking and throwing actions (e.g., baseball, cricket, soccer, golf) are similarly unable to judge their speed of projection and, if so, whether the use of technology that can provide this (augmented) feedback could enhance the learning process. In addition, it would be worth while examining if the ability to judge if consecutive serves were faster/slower could be learned, by providing accurate speed of serve information that would act to calibrate a performer's intrinsic information.

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