AUGMENTED KNOWLEDGE OF RESULTS FEEDBACK IN TENNIS SERVE TRAINING

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The purpose of this study was to determine if augmented knowledge of results (KR) feedback, in the form of service speed, could enhance service speed after a six week training period. Twelve national standard junior tennis players completed six weeks of dedicated service training, three times per week; each training session consisted of 90 serves. Six players received augmented KR feedback and six did not. A Wilcoxon signed-rank test was used to compare pre- vs post- intervention results, and a Mann-Whitney test was used to examine if the differences between these results were larger in one of the groups (α = 0.05). Results showed that both the augmented KR feedback group and the no feedback group significantly improved (0.8±0.4 $m.s^{-1}$ *vs* 0.2±0.1 $m.s^{-1}$, respectively), but that the improvement was significantly larger for the augmented KR feedback group. These results suggest that it is beneficial to utilize augmented KR feedback, in the form of service speed, when undertaking a six weeks training program with elite tennis players.

KEY WORDS: augmented feedback, tennis, service speed

INTRODUCTION: The serve in tennis is commonly considered the most important stroke in the game because it is a high predictor of success (Knudson, 2006; Roetert and Groppel, 2001); its effectiveness is primarily dependent on ball speed (Elliot et al., 2003). It is therefore desirable to utilise learning strategies that help improve service technique. To this end knowledge of results [KR] (e.g. tennis serve speed) is an important type of feedback which athletes use, in combination with knowledge of performance [KP] feedback, to enhance technique (Adams, 1987; Salmoni et al., 1984). For some actions KR can be ascertained via internal sensors/systems (e.g. vision, hearing). However, a recent study (Moran et al., 2009) has shown that elite junior national tennis players can not differentiate the speed of consecutive serves, and in consequence it is not possible for them to use this information as an input in optimising technique. In light of this it could be recommended that augmented KR feedback from an external source (e.g. speed gun) may offer important additional information that may facilitate technique optimisation. External augmented KR feedback has been shown to have a positive effect on motor performance (Bilodeau et al., 1959; Kontinnen et al., 2004), however such studies have primarily involved a novel task. No studies could be found that examined the effect of providing feedback on service speed during training as a means of improving service speed. The present study aims to address this.

METHODS: Participants: Twelve junior national tennis players between the age of 13 and 18 (15.9 ± 1.7 years) volunteered to participate in this study. Players were free from any injury that would have prevented them from using maximum effort. All players were training between 20 and 26 hours as part of the Tennis Ireland National Squad programme. Approval by the Dublin City University Ethical Board was obtained in advance.
Participants were ranked by their senior coach in terms of his ‘perception of how good their technique was’. Subsequently they were assigned to either the augmented KR feedback group (participants 1, 4, 5, 8, 9, 12) or the no augmented feedback group. A Mann-Whitney test indicated no significant difference between the augmented feedback group and the no feedback group for pre-intervention service speed (46.7 ± 4.7 $m.s^{-1}$ *vs.* 46.5 ± 3.5 $m.s^{-1}$, respectively; U = 17.0, p = 0.47, effect size r = 0.05].
Data Collection: All sessions took place during participants’ usual training times in the National Tennis Centre. Participants attended one pre-test session (to determine their baseline service speed), six weeks of training sessions (three times per week), and one post-

intervention session. Each training session required the player to complete ninety serves; fifteen wide, fifteen body and fifteen T on both the Deuce and Advantage sides of the court. A 1.5 m x 1.5 m area was marked in the three areas of the court as a target. Serves were to be hit "as hard as possible with the aim of landing the serve in the service box". Feedback to the augmented feedback group was given immediately (< 1sec) after each serve via a large electronic display. Service speed was measured using a speed gun (StalkerPro, Stalker, USA) placed in line with the intended direction of serve (4m behind the baseline). Absolute errors for the speed gun are very small (± 0.04 $m.s^{-1}$). It is acknowledged however that serves to either side of the sensor of the speed gun would contain inaccuracies; these were estimated to be up to 0.25%.

Initial baseline and post-intervention service speed were determined as the average of 15 serves to a 1.5 m x 1.5 m area of the T in the Deuce service box. A Wilcoxon signed-rank test was employed to examine pre- versus post- intervention results ($\alpha = 0.05$). Where both groups exhibited a significant training effect a subsequent Mann-Whitney test was used to determine if there was a significant difference between the two groups in the magnitude of pre- to post- enhancement ($\alpha = 0.05$).

Data Analysis: A Wilcoxen signed rank non-parametric test was employed ($\alpha = 0.05$). The two variables used were (i) the number of correct differentiation (faster/slower) out of 10 and (ii) the number of correct differentiations expected due to chance (5).

RESULTS: For both groups there was a significant enhancement in service speed following 6 weeks of training [$Z = -2.2$, $p = 0.03$, effect size $r = 0.64$]. However, the augmented KR feedback group improved their service speed significantly more than the no augmented feedback group; 0.8 ± 0.4 $m.s^{-1}$ vs. 0.2 ± 0.1 $m.s^{-1}$, respectively [$U = 3.5$, $p = 0.01$, effect size $r = 0.68$]. Average speeds for the augmented feedback and the no feedback groups pre-intervention were 46.7 ± 4.7 $m.s^{-1}$ and 46.5 ± 3.5 $m.s^{-1}$, respectively; and post-intervention were 47.6 ± 4.7 $m.s^{-1}$and 46.7 ± 3.5 $m.s^{-1}$, respectively.

DISCUSSION: The present study showed that augmented KR feedback, in the form of service speed, resulted in a significantly greater improvement in service speed in national standard junior tennis players after a six week training period, in comparison to when no augmented KR feedback was provided. It appears that the augmented information of service speed is important because players at this level can not accurately determine the speed of their serve from trial to trial using intrinsic processes (e.g. vision, hearing) (Moran et al., 2009). As such they can not identify which of their attempts are able to produce the faster serves, which would allow them to possibly select those elements of the technique that optimise it. This supports the view that where there is no, or very limited, source of knowledge of results from intrinsic sources, performance will not improve without augmented feedback (Magill, 1998).

No previous studies appear to have investigated the effects of augmented KR feedback on improvement in tennis serve speed following a period of training; in fact no studies appear to have examined the effect of such feedback on any well learnt striking/throwing task in experienced athletes. The majority of previous studies on KR feedback have examined novel motor tasks or well learnt slow manual tasks. Bilodeau et al. (1959) demonstrated positive significant effects of receiving augmented KR feedback in trials of a linear positioning task. Kontinnen et al. (2004) also demonstrated the positive effects of KR feedback in psychomotor skill learning in precision shooting. However, in contrast to this, Buekers et al. (1992) showed no significant learning effect in a group receiving KR feedback for an anticipation timing task.

It has been postulated that augmented KR feedback may result in an enhancement in technique by: (i) facilitating the process by which elements of a technique from the present and previous attempts are selected for integration and utilisation (Magill, 1998), and/or (ii) motivating the athlete to maximise effort and for longer periods of time (Adams, 1987). No attempt was made in the present study to distinguish between them.

While the present study only examined the use of augmented KR feedback in tennis, it is worth noting that other sports have a similar situation where the path of the ball is impeded (either by a player or the environment) and therefore players can not judge how far the ball 'would have travelled'. Such information would likely provide sufficient information on ball speed because of the clear relationship between speed and distance (and trajectory). Sports facing similar conditions include table tennis, squash, penalty kicks in soccer.

CONCLUSION: Elite junior tennis players are able to improve their service speed using augmented KR feedback, in the form of speed of serve, more than players who receive no augmented feedback. The use of augmented KR feedback should be utilised, at least in short training cycles lasting six weeks.

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