Effects of Timing Feint on the Muscle Activity in Badminton Smash Stroke

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Introduction
In many sports activities, the prediction of external events is very important to perform smooth and quick movements. However, if the prediction is incorrect, as when feinted, the reaction movements often become disordered and the resulting performance deteriorates. There are three kinds of prediction about the external events, i.e., the prediction about the mechanical parameters such as force or speed, the prediction of spatial positions, and the prediction of time of events. This study was designed to elucidate what happens in the motor commands given to the muscles when the prediction about time is betrayed.

Methods
Subjects (5 skilled badminton players and 2 unskilled university students) were asked to smash a badminton shuttlecock aiming at the 45 cm x 45 cm square target on the wall 4 m away from the frontal tip of the subject’s foot using a conventional badminton racket. The shuttle was ejected by a specially-made shuttle ejector. Three successive tones with 1-second intervals were given as cue signals to make subjects predict the time of shuttle release. Ten trials constituted 1 block and 6 blocks were given for one subject. In 8 of 10 trials of each block, the shuttle was released 1 second after the third tone (= Normal timing). In one of ten trials, the shuttle was released at the same time as the third tone (Early feinting), and in another one of ten trials, the shuttle was released 2 sec after the third tone (Late feinting). Surface EMGs were recorded from the flexor carpi ulnaris (FCU), the extensor carpi radialis (ECR), the biceps brachii (BB), the triceps brachii (TB), and the trapezius (T). The FCU and TB are agonists for stroking the shuttle, while the ECR and BB are antagonists. The shuttle impact signal was recorded by the strain gauge attached to the shaft of the racket.

The accuracy of the performance was evaluated by the area of the ellipse of constant distance (Mahalanobis area of 95% confidence) and the distance from the center of the target (= off-target distance). The former value represents the scatter of landing points of the shuttle on the wall about the mean landing point, i.e., the bivariate variable error, and the latter represents the accuracy of target hitting.

Results & Discussion
For the skilled subjects, the Mahalanobis area as well as the off-target distance were smaller in the normal timing trials than in the early feinting trials. The best values of the off-target distance in the early feinting trials were significantly larger than those in the normal trials. Late feinting trials were not different from normal timing. The unskilled subjects showed no clear differences between normal and feinting trials, probably because they could not predict well the time of shuttle release.

In normal timing trials of the skilled subjects, EMGs of the forearm and upper arm muscles showed antagonist-agonist-antagonist “triad” bursts with clear silent period between two antagonist bursts (Figures 1 and 2, left: E1 - F1 - E2 and B1 - T1 - B2). This was the same phenomenon that was reported by Sakurai and Ohtsuki (2000) as a typical EMG pattern for the skillful badminton smash stroke. However, in the early feinting trials of the skilled subjects, the silent period between the two antagonist bursts often disappeared (Figure 1, right, extensor carpi radialis). Especially in the ECR, this silent-period disappeared in four of six trials in three subjects and in two of six trials in one subject, while in the normal timing trials, it existed in all 48 trials in two subjects and in 45 of 48 trials in three subjects. As for the relation to the performance, in four of five skilled subjects, the worst off-target distance was obtained from the trial in which this ECR silent period disappeared.
In addition, as Figure 1 (a, b, c) reveals, in the early feinting trials the burst of agonist (FCU and TB) to stroke the shuttle often continued until well after the impact, while it ceased immediately after the impact in normal timing trials as reported by Sakurai and Ohtsuki (2000). These results indicate that an unexpectedly early appearance of the shuttle may have disordered the skilled player’s motor programs that had been producing an appropriate neural inhibition (i.e., muscular relaxation) for smooth and swift arm movements. An incomplete antagonist silent period and a continued agonist burst after the impact are reported to be the typical features of the unskilled beginners (Sakurai and Ohtsuki, 2000). Therefore, it may be argued that the skill acquisition may not be a replacement of the old motor programs by the new ones, but an addition of the new programs to the old ones.

In the late feinting trials, the subject’s responses were more variable than in the early feinting. However, the EMG pattern unique to this condition sometimes appeared as illustrated in Figure 2. The extra bursts a’ through e’ indicate that the subject had started the motor program in time with the expected shuttle release by predicting the time of shuttle release without recognizing an actual shuttle appearance. This pattern was observed in at least one trial for all skilled subjects.

These results indicate that, if the subjects were compelled to initiate the task movement at an unexpected time, excessive motor commands are given to the motor execution centers that had been normally functioning by appropriately inhibiting motoneuron discharges, and cause an uncontrolled muscle activation.

References
Figure 1: The effects of early feinting on the EMG of badminton smash stroke. (Subj. A)

Figure 2: The effects of late feinting on the EMG of badminton smash stroke. (Subj. B)