TEMPORAL DECOUPLING IMPROVES FORCE PRODUCTION DURING SINGLE- AND MULTIPLE-FINGER, BILATERAL KEY-PRESSING TASKS

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INTRODUCTION

In their studies of bimanual coordination, Swinnen et al. (1988) reported that subjects were more successful in “decoupling” limb movements when bilateral reaching tasks were initiated asynchronously. It was suggested that this temporal decoupling strategy lead to improvements in the required motor performances because each limb was able to function more independently. These results were recently extended to include maximum effort isometric knee extension tasks and two-legged vertical jumping performances (Vint & Hinrichs, 1997, 1998). Collectively, these data suggest that tasks initiated simultaneously appear to be constrained by a mechanism that inhibits the expression of maximum voluntary muscular force. Tasks initiated asynchronously, however, are apparently less susceptible to this inhibitory mechanism and result in greater muscular forces.

The primary purpose of this study was to validate the temporal decoupling mechanism during single- and multiple-finger bilateral key-pressing tasks. It was hypothesized that multiple-finger bilateral key-pressing tasks initiated asynchronously would elicit significantly greater forces than analogous tasks initiated simultaneously.

PROCEDURES

Twenty subjects (mean age 24.7 ± 4.7 yr., height 169.0 ± 10.7 cm; mass 71.5 ± 16.1 kg) volunteered to participate in the experiment. Isometric key-pressing forces were obtained from four independent piezoelectric sensors placed beneath the index (I) and middle (M) fingers of the right (R) and left (L) hands. Force data were sampled at 1000 Hz for 5 seconds.

Following a series of sub-maximal practice exertions, each subject was required to complete three maximum effort key-pressing trials in each of the following conditions:
1. unilateral single-finger efforts (RI, RM, LI, LM);
2. unilateral multiple-finger efforts (RIM; LIM);
3. simultaneous bilateral (SBI) and decoupled bilateral (DBI) single-finger efforts;
4. simultaneous bilateral (SBIM) and decoupled bilateral (DBIM) multiple-finger efforts.

During simultaneous bilateral tasks, subjects were specifically instructed to initiate all key-pressing actions at exactly the same time. During “decoupled” bilateral tasks, however, subjects were asked to initiate key-pressing force with fingers on the non-dominant hand only. Then, after a short, self-selected time, subjects added fingers on the dominant hand. Therefore, although decoupled bilateral exertions were initiated asynchronously, subjects eventually developed and maintained key-pressing forces from fingers on both hands throughout the remainder of the exertion.

Test order was counter-balanced across subjects and a minimum of 2 minutes was allowed between successive trials to minimize the effects of fatigue.
Calibrated force data were smoothed with a fourth-order, zero-lag Butterworth digital filter operating at a nominal cutoff frequency of 5 Hz. Maximum isometric key-pressing force was found by extracting the maximum value from the summed instantaneous key-pressing force array.

**RESULTS AND DISCUSSION**

Mean force data for single- and multiple-finger key-pressing tasks are summarized below (Figures 1 & 2). One-way repeated measures ANOVA and subsequent post-hoc analyses revealed that forces produced during unilateral single-finger key-pressing tasks were significantly greater than those produced during simultaneous bilateral key-pressing tasks. No significant differences were observed between forces produced during unilateral and decoupled bilateral single-finger key-pressing tasks (p = 1.0). Forces produced during unilateral multiple-finger key-pressing tasks were significantly higher than those produced during either simultaneous or decoupled bilateral key-pressing tasks. However, decoupled bilateral forces were significantly greater than simultaneous bilateral forces.

**Figure 1.** Single-finger key-pressing forces during unilateral (RI+LI), simultaneous bilateral (SBI) and decoupled bilateral (DBI) exertions. Asterisks above horizontal bars denote statistically significant comparisons (p < .01).

**Figure 2.** Multiple-finger key-pressing forces during unilateral (RIM+LIM), simultaneous bilateral (SBIM) and decoupled bilateral (DBIM) exertions. Asterisks above horizontal bars denote statistically significant comparisons (p < .01).

Compared to simultaneous bilateral exertions, temporal decoupling improved force production by 8.7% and 7.3% during single- and multiple-finger key-pressing tasks, respectively. The magnitudes of these improvements were not significantly different (p = .395). It is therefore concluded that temporal decoupling is an effective strategy in reducing the inhibitory influences that are associated with interlimb coupling.

**REFERENCES**


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