**Introduction**

Asymmetric, target-directed, bimanual movements – for example, when one arm has a long movement amplitude and the other arm has a short amplitude – take longer to prepare than bimanual symmetric movements (Diedrichsen et al, 2006; Heuer and Klein, 2006; Psychol Res). We have argued that this cost is the result of greater processing demands on response programming (Blinch et al, 2012, NASPSPA). We previously found that the cost is eliminated by temporally separating the preparation of each arm. This was done by providing advanced information (a precue) about the upcoming movement for one arm. The precue likely encouraged advanced preparation (preprogramming) of the cued arm, and eliminated the asymmetric cost. However, it was unclear what was preprogrammed; did preprogramming occur for the cued and uncued arms? The purpose of this experiment was to determine whether one arm of a bimanual movement can be programmed independently of the other arm. Preprogramming was probed with the start-react effect (reviewed by Carlsen et al, 2012, Clin Neurophysiol) to determine how the asymmetric cost was eliminated.

**Method**

Thirteen participants made bimanual symmetrical and asymmetric movements in simple, 2-choice, and unilateral 2-choice reaction time tasks. The movement were forward reaches to long or short distance targets (200 or 100 mm). On control trials, the targets were illuminated simultaneously with an 86 dB tone. This was replaced on startle trials with a 120 dB tone. Surface EMG was collected bilaterally from the sternocleidomastoids (SCMs) and the anterior deltoids. Startle trials with significant SCM activation on either side were included in the analyses.

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**Simple reaction time:** Included to confirm that the start-react effect would occur when the bimanual movement was known and prepared before the imperative stimulus.

**Choice reaction time:** We anticipated that startle trials would result in the early triggering of default forward movements (Forgaard et al, 2011). Online corrections may guide these default movements to the targets, but there will likely be movement errors (Carlsen et al, 2009, Psychophysiology).

**Unilateral 2-choice:** Involved precuing one arm and not the other. We predicted that the cue would allow preprogramming, which would be probed on startle trials.

**Conclusion**

The preparation cost for bimanual asymmetric movements was eliminated when one arm was cued. The pattern of errors in the primary submovements suggests that the cued arm was preprogrammed to the correct target and the uncued arm was preprogrammed to move forward. Therefore, the asymmetric cost may be related to the simultaneous programming of two different movement amplitudes.

**Results**

Control: There was a significant asymmetric reaction time cost of 20.2 ± 4.0 ms in 2-choice blocks (p < .001). The asymmetric cost of 5.0 ± 2.3 ms was not significant in the unilateral 2-choice block (p = .054).

Startle: Premotor reaction times were short (< 100 ms) in all blocks, which suggested that a preprogrammed movement was triggered by the startle tone.

**Primary submovements** were examined to determine if movements were initiated to the correct targets. Forward displacement of Long-Short movements in each task are plotted below. Movements with correct primary submovements are plotted in blue (long) and red (short), incorrect submovements are plotted in green and purple.

**Percentage of correct primary submovements**

Control: Primary submovements in all the blocks were almost always initiated to the correct targets. There was a small but significant decrease in the 2-choice asymmetric block (96 ± 1.2%).

Startle: Movements in the simple reaction time blocks (blue and red) were initiated to the correct targets, which suggested that the movements were preprogrammed to the correct targets. There was a significant decrease in 2-choice (green and purple) and unilateral 2-choice blocks. This suggested that default forward movements may be preprogrammed in conditions with response uncertainty.

Unilateral 2-choice: Primary submovements were further investigated by comparing the performance of the cued arm (left) to the uncued arm (right). On startle trials, the cued arm was initiated to the correct target (99 ± 1.0%), whereas the uncued arm had significantly fewer correct primary submovements (81 ± 6.1%).