Preparation of bimanual reaching movements: contributions from directions and amplitudes

Jarrod Blinck1, Jada A Holmes1, Brendan D Cameron2, Ian M Franks1, Romeo Chua1

1 School of Kinesiology, University of British Columbia
2 Universitat de Barcelona
jarrad.blinch@alumni.ubc.ca motorbehaviour.wordpress.com

Introduction

It has been shown that bimanual reaching movements with different movement amplitudes or directions with each arm take longer to prepare than ones with identical amplitudes and directions. We previously investigated which movement parameters contribute to the preparation cost for bimanual movements with asymmetric amplitudes compared to symmetric amplitudes (Blinch et al. in press, Psychol Res). The relative contribution of movement parameters to the asymmetric preparation cost, from most to least important, was movement amplitudes, target locations, and then starting locations. In this study, we compare the relative contribution of movement directions and movement amplitudes. We hypothesised that movements with asymmetric directions would have longer preparation than movements with asymmetric amplitudes. Moving in different directions requires the activation of non-homologous muscles in opposite arms, whereas moving different amplitudes requires different levels of activation in homologous muscles. For continuous movements, it has been shown that coordination is less stable for movements that require simultaneous activation of non-homologous muscles compared to homologous muscles (Swinnen 2002, Nat Rev Neurosci).

Method

Thirty different participants were tested on two experiments. Both experiments involved a button box with five rows and two columns of buttons. The middle row was the home position for the left and right hands, and the other buttons were the potential targets. The experiments were choice reaction time tasks with bimanual reaching movements. Participants were instructed to react and hit the targets as quickly as possible after the go signal.

Experiment 1

Two targets were simultaneously illuminated as the go signal and participants made bimanual reaching movements. There were 16 possible movements and these were separated into 4 conditions. One set of targets in each of the four conditions is shown in the figure below. These conditions were compared to determine the relative contribution of movement directions and amplitudes to the bimanual asymmetric reaction time costs.

![Figure showing the conditions of Experiment 1](image)

**Results**

1. Reaction times were significantly longer for movements with asymmetric directions than symmetric directions (compare bars 3 and 4 to bars 1 and 2)
2. Movements with asymmetric amplitudes had significantly longer reaction times than movements with symmetric amplitudes (compare bars 2 and 4 to bars 1 and 3)
3. Importantly, the reaction time cost for asymmetric directions was significantly larger than the cost for asymmetric amplitudes (compare the cost for point 1 to point 2)

Experiment 2

This experiment involved the same go signals, but several targets were illuminated before the go as precues (similar to Goodman and Kelso 1980, J Exp Psychol Gen). The go signal was two of the precued targets, and therefore, the precues allowed participants to prepare some movement parameters in advance (movement amplitudes or directions), which should shorten reaction times. The more difficult a movement parameter is to prepare, the more reaction time should be reduced by precuing that parameter. There were six different types of precues, and one example of each type is shown in the figure below.

![Figure showing the conditions of Experiment 2](image)

**Results**

1. Reaction times were significantly shorter when symmetric directions were precued compared to asymmetric directions (compare bar 1 to 2)
2. Precuing symmetric amplitudes caused significantly shorter reaction times than precuing asymmetric amplitudes (compare bar 3 to 4)
3. Notably, reaction times were significantly shorter when directions were precued compared to amplitudes (compare bars 1 and 2 to bars 3 and 4)

Conclusion

- The results from both experiments suggest that directions have a larger contribution than amplitudes to the preparation cost of bimanual reaching movements
- The preparation cost for asymmetric parameters likely occurs during response selection (Blinch et al. under review)
  - This cost may be caused by selecting different parameters for each arm and then unifying them into a single bimanual movement (Blinch et al. 2015, Exp Brain Res)