Direct bimanual reaching for coupled targets

Ray Luo
rluo@uclink.berkeley.edu
Department of Psychology
University of California
Berkeley 94720
URAP report

Abstract

We examined amplitude and spatial coupling in a bimanual, directly cued reaching task. Subjects were asked to make rapid, sharp movements toward one or two spatial targets arranged on a 2D grid while tracking their eye movements (either saccading or non-saccading). We found that spatial coupling gives a better explanation of experimental results than amplitude coupling. Significant correlation was observed for high amplitude movements. No significant effect of eye movement saccades was found.

1 Introduction

Bimanual interference has been observed when two hands make asymmetric reversal movements [2]. Previous research has shown that using direct cues, reaction time (RT) asymmetries become insignificant, challenging the hypothesis that motor programs interfere with spatial planning [1]. In this study, we further examine bimanual interference in a directly cued movement task using more discriminative targets in an attempt to tease out amplitude coupling from spatial coupling.

A recent study found that movement amplitudes were correlated with eye movements when no transcranial magnetic stimulation (TMS) was applied to

the posterior parietal cortex [3]. We looked for saccade-bimanual interaction in our experiment by asking subjects to fixate, or not fixate on a stationary point.

2 Methods

We tracked the movement of subject index fingers using the mini-Bird system. Subjects placed their fingers in separate circles before the trial begins, and fixate at a central cross above the circles. After half a second, one or two target circles appear above the starting position. Subjects were asked to make rapid but accurate movements toward the target(s). Single target trials required both hands to land on the same target. In some blocks of trials, we asked the subject to fixate while making the movement. In other blocks, we allowed them to make saccades toward either target(s) during movement.

Figure 1: Different target positions for two-target trials in experiment 1 arranged by each possible combination of lower, medium upper, medium upper, and upper movements. Note that the upper right diagonals have the same arrangements, but flipped for the two hands.

Figure 1 shows the target arrangements randomized for each trial. Note that amplitude coupling predicts overshoot for the right hand in the (3, 1) and (4, 2) cases, while spatial coupling predicts no overshoot. Amplitude coupling predicts no undershoot in the (3, 2) case, while spatial coupling predicts undershoot.

3 Results

The next two figures (2 and 3) plot the hand movements for the two-target and one-target cases along with confidence ellipses for a 95interval for the former case. Note the significant undershoot of the left hand in the (3, 2) case. There was a baseline undershoot across almost all trials. Saccade vs. no saccade interaction was insignificant.

ANOVA analyses of the data for the case of no saccades are presented in Figures 4 and 5. We see an insignificant ($p = 0.074$) reverse amplitude interference effect: low amplitude left hand movements produced overshot high amplitude right hand movements. We also see high correlation between hands (p ¡ 0.05): high amplitude left hand movements are associated with high amplitude right hand movements. A regression analysis of the data suggests that spatial interaction better explains the data than amplitude interaction.

4 Future work

Note that because all movements are up in one dimension, we cannot tease out the medium lower and medium upper cases. For the next experiment, we let subjects make inner vs. outer movements, so that the asymmetry can be taken apart. We are also working on a computational model of visuomotor tracking, but not specifically for this task. Inspired by the Kalman filter model of Jordan ([4]), we plan to run experiments in which subjects track a rapidly moving circle in two dimensions. We'll allow them to reach for the circle at a prescribed cue. The generated data will test the validity of the tracking model for motor control.

We also hope to examine the eye bimanual reaching movement interaction. In this experiment, we were unable to find a significant difference between saccading and non-saccading trials. This was because we didn't ask

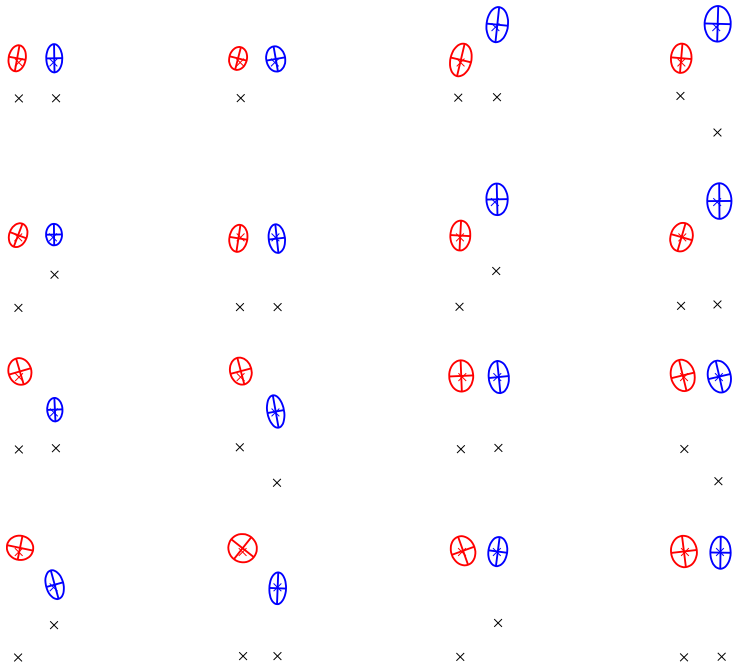

Figure 2: Starting locations and ending locations with confidence ellipses for two-target movements. Displayed targets are shown as crosses. Red is the left hand; blue is the right hand.

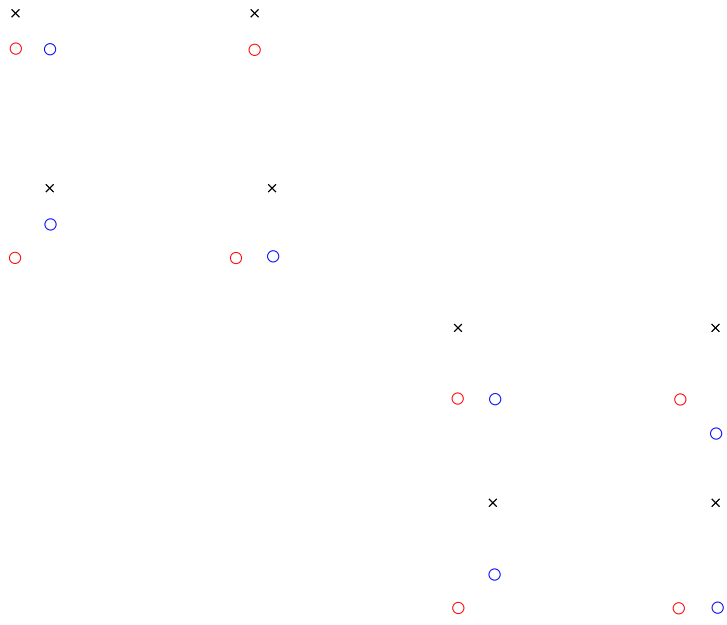

Figure 3: Starting locations and representative ending locations for one-target movements. Red is the left hand; blue is the right hand.

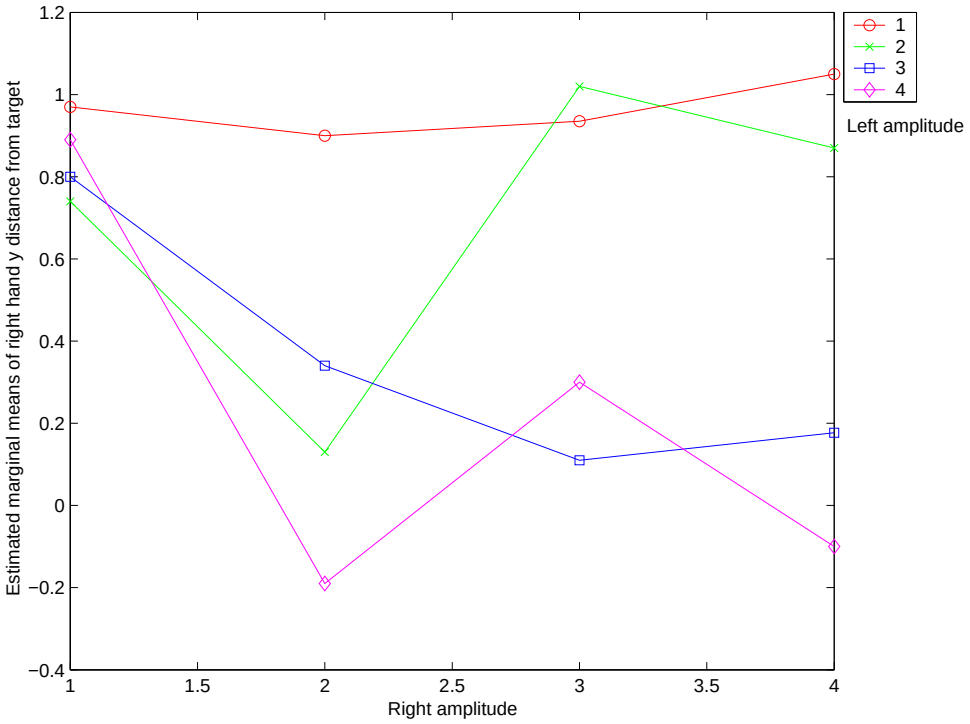

Figure 4: ANOVA analysis of amplitude coupling for y direction of the right hand. 1 lower, 2 medium lower, 3 medium upper, 4 upper movements.

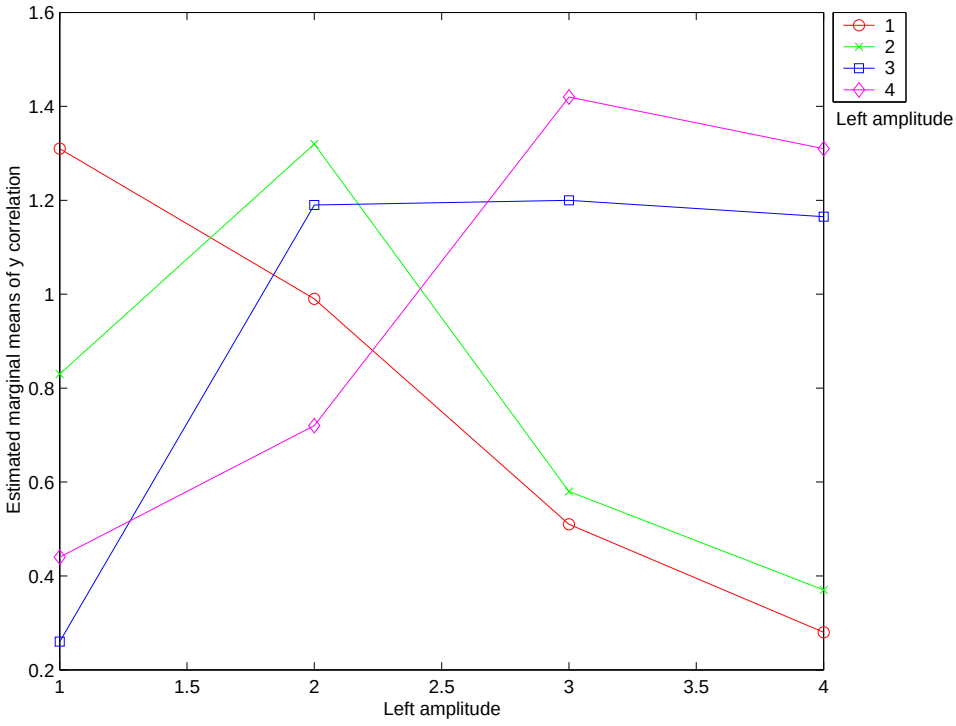

Figure 5: ANOVA analysis of correlation of the two hands for y direction. 1 lower, 2 medium lower, 3 medium upper, 4 upper movements.

subjects to look at a specific target. Subjects tended to drift around the fixation point or to look at one, then the other target. In the future, we plan to devise experiments that examine eye-hand coordination. Specifically, we can compare the performance between trials in which subjects were asked to look at the upper target vs. trials in which they were asked to look at the lower target, regardless of the location of the actual target.

Comments

It has been a great semester working with Rich Ivry and Jörn Diedrichsen. We've have fruitful discussions regarding the project and I hope to make more progress next term. I was responsible for running the experiments and doing some data analysis. I look forward to doing some computational modeling work next semester while running the next experiment. The work I've done here has turned me to an immensely interesting field that I plan to pursue in my future endeavors, consolidating and advancing my research in vision and computer science.

References

[1] J. Diedrichsen, E. Hazeltine, S. Kennerley, and R. B. Ivry. Moving to directly cued locations abolishes spatial interference during bimanual actions. *Psychological Science*, 12(6):493–498, November 2001.

[2] H. Heuer, W. Spijkers, T. Kleinsorge, and C. Steglich. Static and phasic cross-talk effects in discrete bimanual reversal movements. *Journal of Motor Behavior*, 33(1):67–85, 2001.

[3] P. van Donkelaar, J. H. Lee, and A. S. Drew. Transcranial magnetic stimulation disrupts eye-hand interactions in the posterior parietal cortex. *Journal of Neurophysiology*, 84:1677–1680, 2000.

[4] D. M. Wolpert, Z. Ghahramani, and M. I. Jordan. An internal model for sensorimotor integration. *Science*, 269:1880–1882, September 1995.