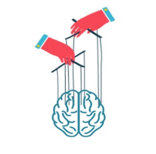

Version 1

Jun 26, 2020

Bimanual Interference Experimental Paradigm V.1

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1 Works for me dx.doi.org/10.17504/protocols.io.7r3hm8n

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ABSTRACT

Successful bimanual coordination is accomplished by overcoming a variety of cognitive, perceptual and neuromotor constraints, e.g. higher-order representation of task goals, visual perceptual demands, attention demands, task demands (i.e., speed, accuracy) and sensorimotor integration. Sensorimotor interference in planning, executing and correcting bilateral movements especially arise when the hands are required to accomplish two independent or disparate goals.

In this study, we describe the experimental paradigm to study sensorimotor interference during performance of a planar reaching task, in which the experimental condition consists of the two hands moving to two visually cued targets at separate distances (spatially asymmetric). Whereas the control conditions consisted of same-size movements performed unimanually with each limb and bimanually to symmetric targets.

The paradigm is a modification of a previously conceptualized model task paradigm (e.g. 1-5) to study interference in discrete bilateral movements, wherein the two limbs are tasked with accomplishing asymmetric movement goals. However, our study paradigm involved important modifications to task design such as absence of online visual feedback (so as to test fairly rapid preprogrammed movements) and task instructions which emphasized speed and accuracy but not interlimb synchrony.

The study aims: 1) to characterize sensorimotor interference in discrete bilateral reaching movements in young adults, and subsequently, 2) to determine the influence of the side of stroke on such sensorimotor interference.

The experimental paradigm was conducted using the KineReach kinematic data collection system and accompanying software (Sainburg, Pennsylvania State University). MATLAB code to generate session and target files for this experiment are included in this protocol. Details of data processing and analysis will be published in the primary papers and code will be made available thereafter.

References:
1. Kelso (1979)
2. Marteniuk (1984)
3. Swinnen (1991)
4. Diedrichsen (2006)
5. Blich (2011)

DOI

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KEYWORDS

bimanual, sensorimotor, interference, inter limb, stroke

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Abbreviations

1 f = fixed
v = variable (random value or range of values is specified alongside)
DoF = degrees of freedom
psi = pounds per square inch (units of pressure)

Apparatus

2

KINEREACH® KINEMATIC DATA COLLECTION SYSTEM

The Kinereach system comprises of

- a glass table-top,
- a **60 in (f)** flat-screen high-definition display with
- a mirror virtualization (which is **35 cm (f)** above the table surface) and blocks the direct vision of the arms and hands.
- a trakSTAR electromagnetic motion tracking system (Ascension Technology) consisting of **4 sensors (f)** providing **20 DoF (f)** measurement of upper limb movements
- with a sampling rate of **116 Hz (v, range: 100-200)**
- two air sleds (one for each upper limb) that use a compressed air delivery mechanism to enable zero-gravity, minimal friction movements,
- a height-, tilt-, and distance-adjustable chair with trunk support, and
- an iMac computer installed with the Kinereach support software

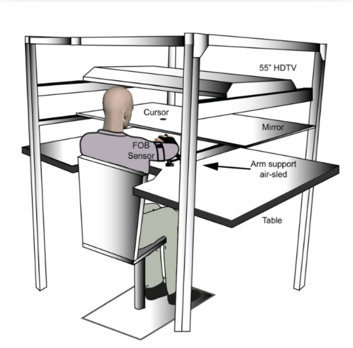

FIGURE 1: KINEREACH Kinematic Data Collection System (Sainburg, Pennsylvania State University)

Mani S, Mutha PK, Przybyla A, Haaland KY, Good DC, Sainburg RL (2013). Contralesional motor deficits after unilateral stroke reflect hemisphere-specific control mechanisms.. Brain : a journal of neurology. https://doi.org/10.1093/brain/aws283

3 General Setup

GENERAL SETUP

FIGURE 2: KINEREACH setup at the Motor Behavior and Neurorehabiltation Laboratory
Division of Biokinesiology and Physical Therapy, University of Southern California

Participants are seated comfortably on an adjustable chair facing the table.

Chair Position

- Secured the participant to the chair using a horizontal harness across the waist.
- Strap a vertical harness around each shoulder to secure the torso in the upright position.

Chair Height Adjustment

- Adjust the height of the chair using the lever below so the virtualization mirror is at participant's chin level.
- Ask whether the target display is visible to participants

| *Are you able to see most of the screen?*

Chair Distance Adjustment

- Carefully push the chair inward until the participant can comfortably place both arms at shoulder height on the table. Lock the chair in place.
- Ensure that the participant's legs do not move the transmitter located under the table.
- Participants rest their feet on a small wooden step stool beneath the table.

Sensors & Sensor Placements

Four Ascension TrakStar electromagnetic sensors were used for the current experiment. They were secured using adhesive tape and a soft pre-wrap at the following locations on the upper extremity :

- Sensor 1: the dorsum of the left hand on the second metacarpal (as close in line to the middle finger as possible)
- Sensor 2: the mid-upper left arm
- Sensor 3: the dorsum of the right hand on the second metacarpal (as close in line to the middle finger as possible)
- Sensor 4: to the mid-upper right arm

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FIGURE 3: TrakStar EM sensors

Note that only Sensors 1 and 3 are required to conduct this experiment. Sensors 2 and 4, however, allow real-time inverse kinematic computations of joint angles which will be outputted on the data text file. In order to do this, follow the below calibration/digitization routine:

If the KINEREACH is used, *the following calibration routine is followed:*

Reference sensor (sensor 2) is placed on anatomical landmarks in the below specified order:

Anatomical Landmarks	**Key to be pressed to calibrate for Left Hand**	**Key to be pressed to calibrate for Right Hand**
2nd metacarpal	F1	1
Between 2nd and 3rd metacarpal	F2	2
Below “snuff box” (medial [inside] side of wrist)	F3	3
Below styloid process of ulna (lateral [outer] side of wrist)	F4	4
Medial epicondyle of elbow (bump on lower side of elbow)	F5	5
Lateral epicondyle of elbow (bump on top side of elbow)	F6	6
Acromion process (lateral to where the clavicle and scapula meet)	F7	7
After placing Sensor 2 on left upper arm (mid)	-	8

TABLE 1: Digitization Routine

NOTE: For the current bilateral experiment, both limbs are calibrated/digitized with left arm first followed by right arm.

Note the following safety and validation measures *when setting up in Kinereach*:

- The TrakStar is an electromagnetic system and even though it has a relatively small magnetic field, ensure that the participants do not have metal implants or pacemakers.
- To avoid the wires from getting tangled, position the wire along the arm.
- The purpose of the soft pre-wrap is to keep the sensors from moving during the experiment. However, if too tight it may cut off circulation. Ask the participant if the wrapping is too tight. If it is, then redo the wrapping.
- Ensure that the participant remains still during calibration for accuracy.
- Check the arm and elbow angles to ensure they are correct. It’s easiest to check elbow at 90 degrees and arm 0 degrees.

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Arm Position on Air Sled System

FIGURE 4: Kinreach System Air Sleds

- Instruct the participant to rest their thumb in the groove and align their forearm with the air sled.
- Secure each arm to the sled with the velcro straps without cutting off the airway of the tube. The intial position of the elbow is **70-80 degrees** flexion and the shoulder is **20-30 degrees** horizontoal abduction.
- The start circle/s are **25 cm** from the edge of the table and **24 cm** apart.

Important steps to check:

- Air flow must be turned on. Check for pressure to be set to **13 psi (v)**. May vary from device to device.
- Ask participant to confirm air flow is even between hands and smooth (without interruptions).
- Turn on the HDTV.
- Turn on the trackSTAR box by flipping on the switch located on the back.
- Turn on computer.

Task Setup

4 TASK SETUP

The task goal is to move to the target quickly and accurately in a single uncorrected motion.

♣ Appearance
Within each trial, the participant sees on the virtualization mirror —

- ***Start circle:***
  - diameter = **1 cm (v)**
  - color = green

- ***Concentric target circle:***
  - diameter = **3 cm (v)**
  - color = 3 graded colors (see Figure 5 for gradations)
  - distance = **5 cm (v)** OR **15 cm (v)**
  - number of targets = **1 unit** OR **2 units** (v) (depending on Experimental Condition)

- ***Visual cursor representation*** of the position of the first proximal interphalangeal joint:
  - diameter = **1 cm (v)**
  - color = black crosshair
  - number of cursors = **1 Hz** (depending on Condition)

♣ Timeline

- Hold cursor within start circle for: **500 ms (v)**
- "Go" tone delay (target foreperiod) = **350 ms** TO **500 ms (v, random)**

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- Trial max duration = **5 seconds (v)**

♣ Instructions

- Instructions emphasize speed and accuracy but not interlimb synchrony (for bimanual conditions). A loosely paraphrased instruction is as follows:

> *After the beep, move as quickly and accurately as you can to the target. Stop at the target.*

- Participants are reminded to be quick and accurate from time to time throughout experimental session (approximately every **5 trials** TO **10 trials.**

♣ Feedback

- Feedback provided concerns the accuracy of the movement but not the speed.
- Speed is emphasized by the researcher verbally as) | *Try to go faster* | particularly in stroke survivors when slowing is especially noted.
- Augmented feedback is provided in the form of KR and KP, which is available for **1 second (v)** at movement end* after which the next trial begins.

IMPORTANT NOTE: During acquisition, real-time velocity is computed by the Kinereach software and movement end is **defined programmatically as velocity of hand <= 0.02 m/s (f).**

1. ***Knowledge of Results (KR):*** Participants receive visual and auditory feedback regarding the accuracy of their hand position. KR feedback is provided in a graded manner with three levels as described below:

Screen Shot 2020-01-24 at 3.03.49 PM.png

FIGURE 5: KR Feedback Gradations

10 points (f): if hand position is ***at*** the center of the target
3 points (f): if hand position is ***within*** the second concentric target circle (= diameter x 2)
1 point (f): if hand position is ***within*** the third concentric target circle (= diameter x 3)

2. Knowledge of Performance (KP): Veridical cursor position is visible at movement end as a red dot.

A schematic representation of the trial set up for each trial is shown below:

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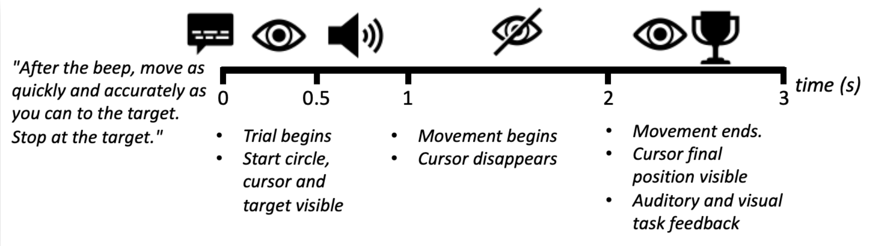

FIGURE 6: Trial timeline

Experimental Conditions

5 EXPERIMENTAL CONDITIONS

The participant will perform a rapid reaching motion toward a concentric target circle 20 times in unimanual and bimanual conditions (80 trials, excluding practice trials)

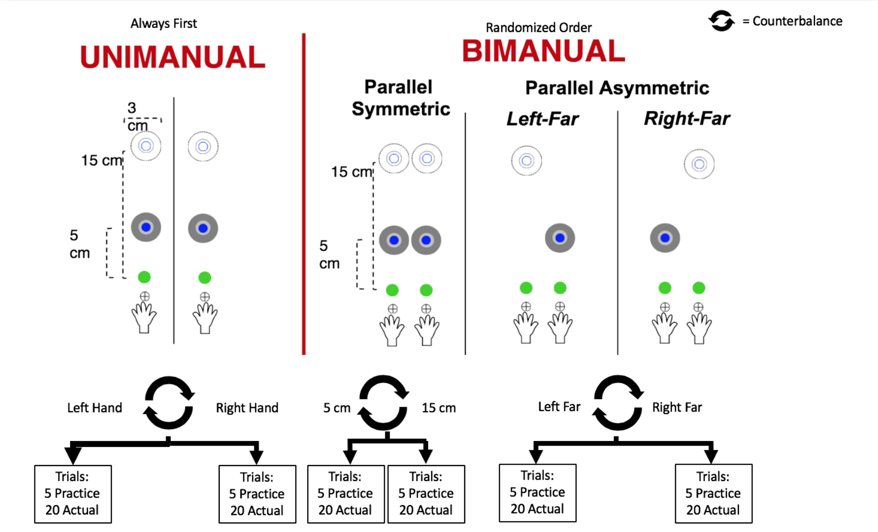

Figure 7: Experimental Conditions

Code & Task Simulation

6 Code to Generate Session Files and Example Session Files for KineReach

If you plan to use the Kinereach Kinematic Data Collection Device to reproduce this experiment, you will need a target file, a trial session file and a target session file to specify the above-described parameters.You can access our MATLAB code to generate these files on your own OR use an example set on GitHub here:

https://github.com/rinivarg/kr-expts

Task Simulation Video

Citation: Rini Varghese, Robert L. Sainburg, Carolee J Winstein (06/26/2020). Bimanual Interference Experimental Paradigm. https://dx.doi.org/10.17504/protocols.io.7r3hm8n