# Visuomotor Coupling during Two-Handed Tasks: An Investigation of Bimanual and Intermanual Coordination

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## Abstract

This study investigated previously observed differences in speed when completing a two-handed task using either the bimanual coordination mode (i.e., an individual completing a two-handed task) or the intermanual coordination mode (i.e., two people completing a two-handed task). When comparing these coordination modes, various research domains have reported an intermanual "mode effect" of speed. Research suggests that the difference in performance may depend on fundamental characteristics of each coordination mode that facilitate or impede speed during two-handed tasks. To further investigate this intermanual speed advantage, a task was constructed to exploit a hypothesized bimanual limitation that may underlie this mode effect: bimanual visuomotor coupling. Results replicated the intermanual speed advantage and showed a higher degree of visuomotor coupling during bimanual performance. Subsequent analyses suggest that speed during two-handed tasks may be a function of visuomotor coupling, regardless of coordination mode.

## Intermanual vs. Bimanual Coordination

Some two-handed tasks are completed faster with a partner compared to completing the same task alone (e.g., Crites & Gorman, 2017; Gorman & Crites, 2013; Zheng et al., 2005).

A two-handed laparoscopic cutting task with a partner was faster than completing the task alone.

This study compared participants completing the same task using two different manual coordination modes:

- The **Bimanual** coordination mode– an individual completing a two-handed task

Tele-operation task where an **individual** uses both hands to control steering and acceleration of a rover

- The **Intermanual** coordination mode– two people completing a two-handed task

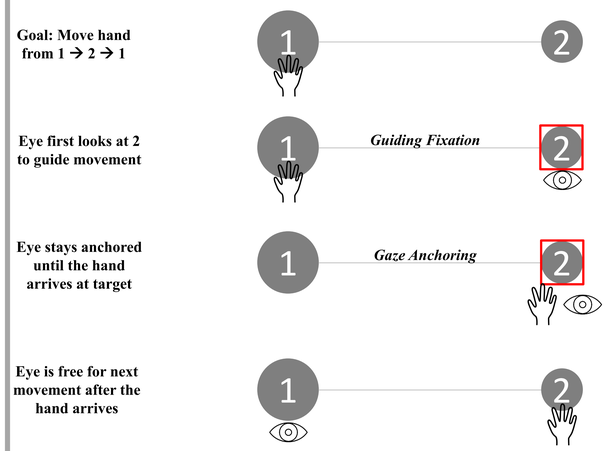
Tele-operation task where a **team** uses two hands to control steering and acceleration of a rover

**Bimanual between-hand coupling** is one variable that can account for the observed differences in **speed** (Crites & Gorman, 2017).

**Some have suggested that shared mental models account for the mode effect of speed (Zheng et al., 2007).**
However, another (simpler) behavioral aspect inherent to bimanual coordination may limit bimanual task performance: ***Visuomotor Coupling***.

## What is Visuomotor Coupling?

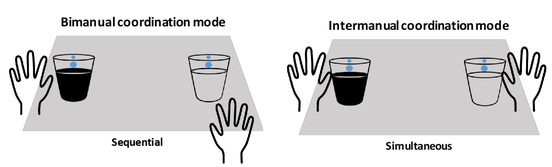
**Visuomotor coupling** refers to the degree to which eye movements and hand movements are coordinated together in space and time when performing reaching, pointing, and grasping tasks.




**Guiding fixations** and **gaze anchoring** create a sequential process during manual coordination tasks (Mennie et al., 2007; Rand, 2014).

## Bimanual Visuomotor Coupling

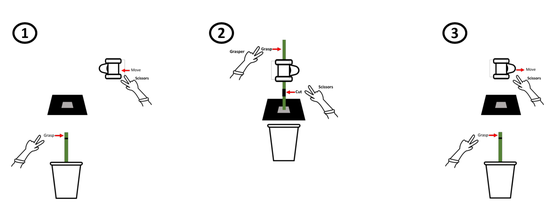
**Bimanual visuomotor coupling** is the the sequential dependence of visually-guided actions during an individual, two-handed task.




The **intermanual** coordination mode completes subtasks **simultaneously** (opposed to **sequentially**) by utilizing two separate **visuomotor systems.**

## The Current Study

A cutting task was constructed to induce **bimanual** visuomotor coupling:

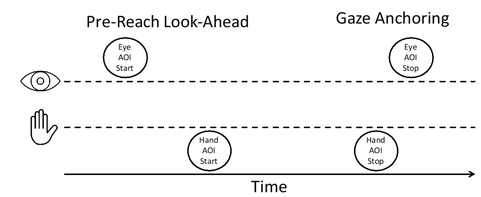



*Participants completed a novel two-handed simulated cutting task both bimanually and as a intermanually.*

Participants moved a pipe to a particular area, place an object through the pipe, and simulate a cutting action at a particular place on the object.

## Measuring Visuomotor Coupling

The measurement of **visuomotor coupling** consisted of to components: "**Pre-Reach Look-Ahead**" and "**Gaze Anchoring**"




**Pre-Reach** is the difference in time between looking at something and starting a manual action.

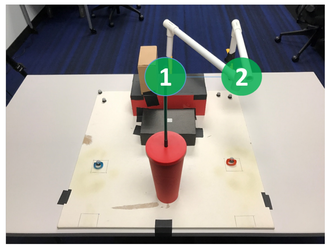
**Gaze Anchoring** is the difference in time between looking away from something and completing a manual action.

## Exploiting Bimanual Visuomotor Coupling

During **bimanual performance**, each subtask was typically completed **sequentially**.

*Hypothetical gaze pathway example of a participant completing the task using the bimanual coordination mode.*

*Green = Participant controlling the grasper and the scissors.*

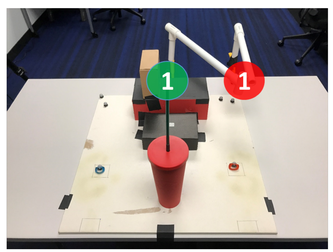



However, during **intermanual performance**, each subtask was typically completed **simultaneously**.

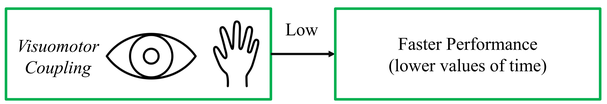
*Hypothetical gaze pathway example of participants completing the task using the intermanual coordination mode.*

*Green = Participant controlling the grasper.*

*Red = Participant controlling the scissors.*

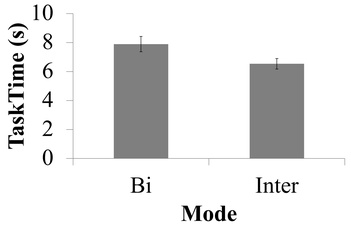



It was predicted that ***low*** **visuomotor coupling** would be associated with **faster** two-handed performance as measured by **speed** (regardless of coordination mode).

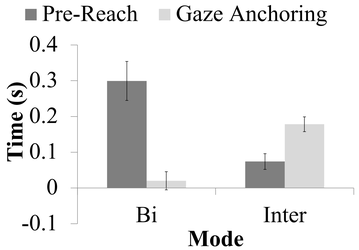



## Results

***Speed.*** As predicted, participants were significantly slower when using the Bi Mode ($M$ = 7.70; $SD$ = 1.14) compared to the Inter Mode ($M$ = 6.07; $SD$ = .98).




***Visuomotor coupling.*** As predicted, **Pre-Reach** was significantly longer using the Bi Mode ($M$ = 0.30, $SD$ = 0.18) when compared to the Inter Mode ($M$ = 0.07, $SD$ = 0.07).




However, **Gaze Anchoring** was significantly longer using the Inter Mode ($M$ = 0.18, $SD$ = 0.07) when compared to the Bi Mode ($M$ = 0.02, $SD$ = 0.08).

**Correlations** between **Speed** and measures of **Visuomotor Coupling** were analyzed as a function of mode.

| | Bi | | Inter | |
|---|---|---|---|---|
| | Pre-Reach | Gaze | Pre-Reach | Gaze |
| TaskTime | 0.77** | 0.57 | 0.61* | 0.68* |

$N$ = 12; * $p$ < .05, ** $p$ < .01

## Conclusions

- In addition to bimanual b**etween-hand coupling** (Crites & Gorman, 2017), bimanual **visuomotor coupling** may negatively impact **speed**.
- Visuomotor coupling measures are explanatory variables of speed.
- Intermanual may sacrifice speed during Gaze Anchoring.
- Future research should experimentally manipulate previous practice.

## References

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