MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES

Cardiac Cycle, Reaching Movements and Motor Imagery

Emma Nesbit*[1,2], Magdalena Gippert*[1], Maria Azanova[1], Arno Villringer‡[1,3], Vadim Nikulin‡[1]

[1] Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany;
[2] International Max Planck Research School on Cognitive Neuroimaging, Leipzig, Germany;
[3] Leipzig University Hospital, Germany
* shared first authorship, ‡ shared senior authorship

1 Background

Successful interaction with the external world requires the **brain** to integrate external sensory input and signals from visceral organs, such as the **heart.**[1]

- Perception is typically enhanced during diastole compared to systole, as seen by faster reaction times [2,3] and movement accuracy might also be enhanced during diastole.[4]
- Primary motor cortex excitability, ocular saccades, and active information sampling are increased during systole.[5,6,7]

Previous studies primarily utilised simple movements or focused on investigating the effects of cardiac phase in self-paced paradigms.[8] The present study investigates **motor adaptation** during **sequential reaching movements** that are more complex and naturalistic.

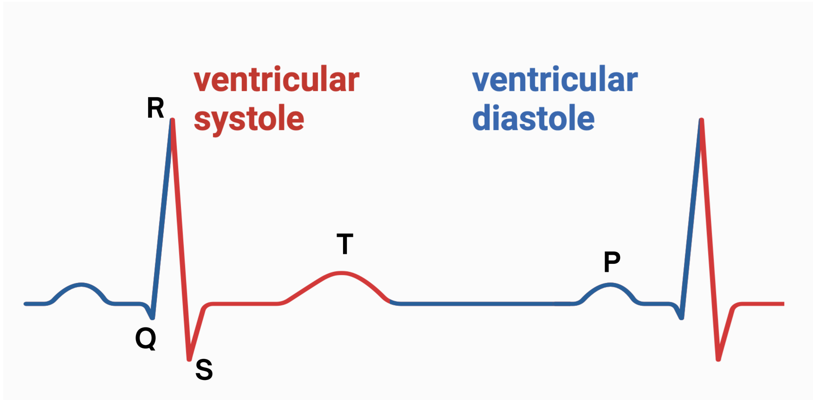

Fig. 1. Cardiac cycle. Typically, researcher distinguish between two phases of the cardiac cycle. Systole (in red) where the ventricles contracts and diastole (in blue) where the ventricles relax and fill with blood.

2 Methods

This **secondary data analysis** utilises behavioural and electrocardiogram (ECG) data from a previous study[9] which employed a force field interference adaptation task in a Kinarm exoskeleton (see Figure 2).

- There were three experimental groups (see Figure 3)[9].
- During the adaptation phase (800 trials), the second reach was randomly perturbed by a force field coming from the clockwise or counterclockwise direction.
- ECG will be analysed to assess the relationship between **cardiac phase (systole or diastole)** and **movement parameters (reaction time and movement error)**.

Participant information:

- n = 60 (30 female, 30 male)
- 20 participants per experimental group
- mean age = 26.1, SD = 4.6
- right-handed, normal or corrected-to-normal vision and no known neurological, perceptual, or motor impairments or disorders

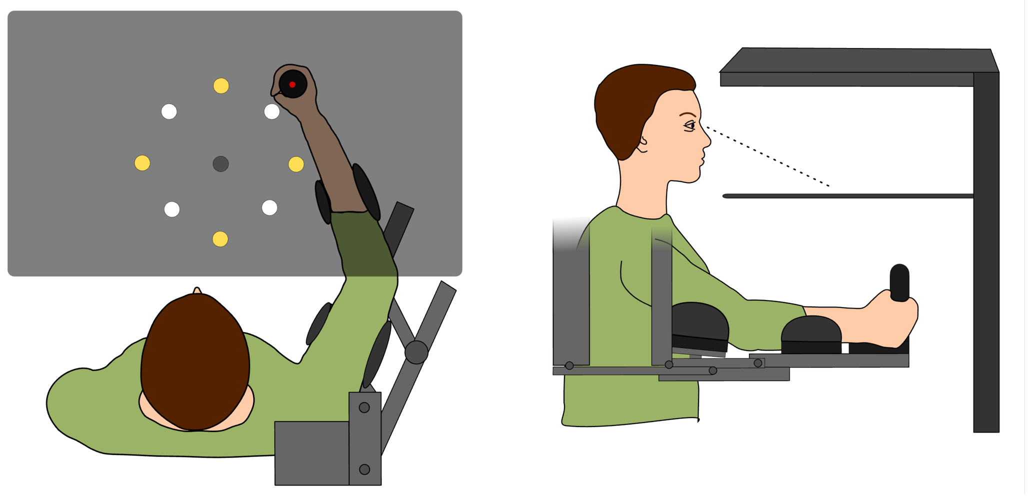

Fig. 2. Experimental set up. Participants are seated in front of a Kinarm exoskeleton, which allowed them to interact with the visual display using their right arm. Their hand was represented in form of a red dot, and they could not see their own arm.

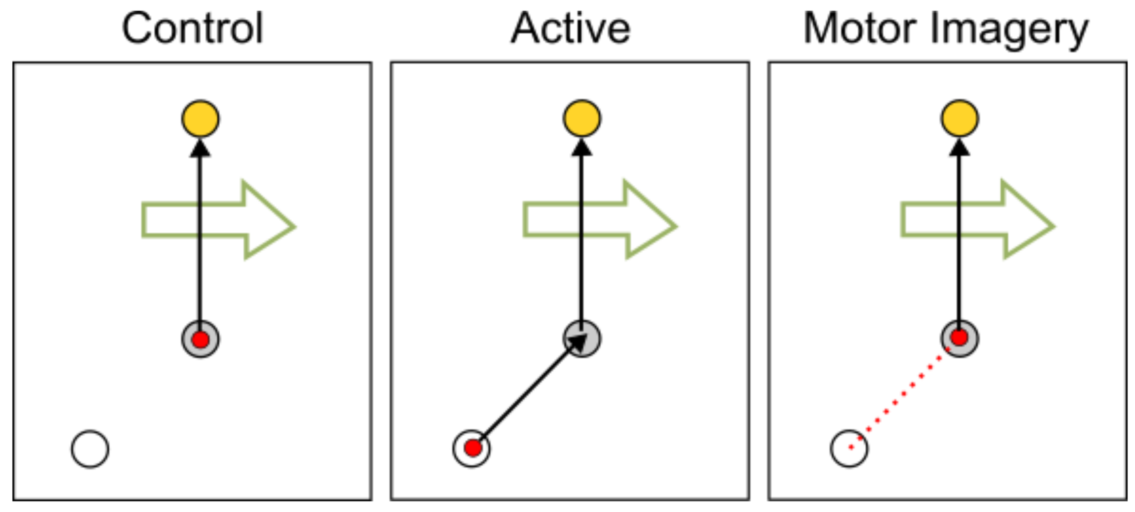

Fig. 3. Experimental groups. There were 3 experimental groups, a control group, an active group and a motor imagery group. The active group performed two consecutive reaches, the motor imagery group imagined a reach before executing a reach and the control group only executed a single reach.

3 Hypotheses

Hypothesis 1:
When two consecutive reaches are executed, reaction times for the initial reach depend on whether the go-signal for movement execution occurred during systole or diastole (see Figure 4 for an example outcome scenario).

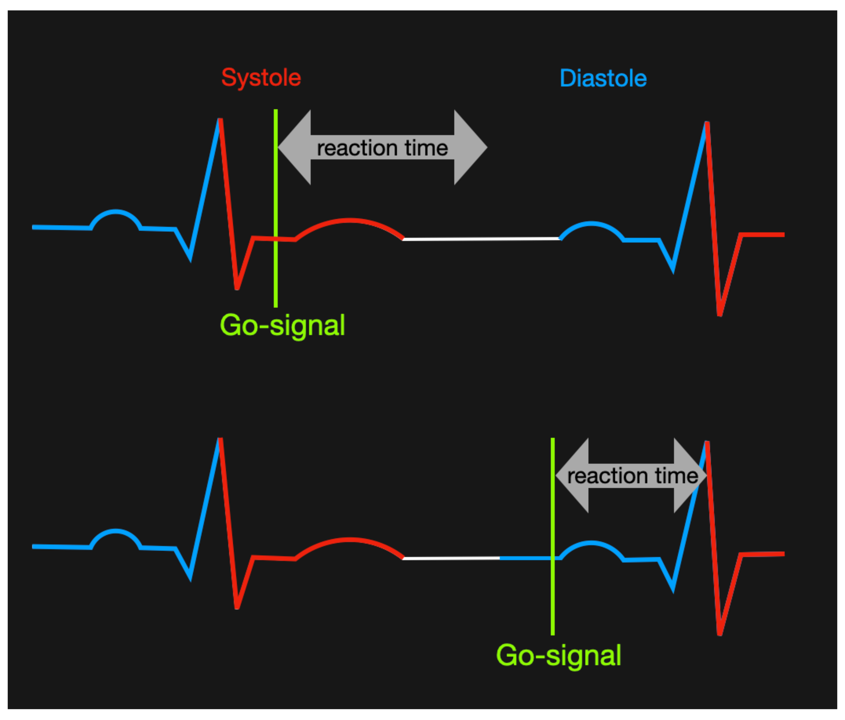

Fig. 4. Hypothesis 1: visual representation of an example how reaction time might differ depending on the cardiac phase at the time of go-signal presentation.

Hypothesis 2:
2a: Movement error differs depending on whether the movement was initiated during diastole or systole.
2b: Movement error varies based on whether the go-signal for movement was given during diastole or systole (see Figure 5 for an example outcome scenario).

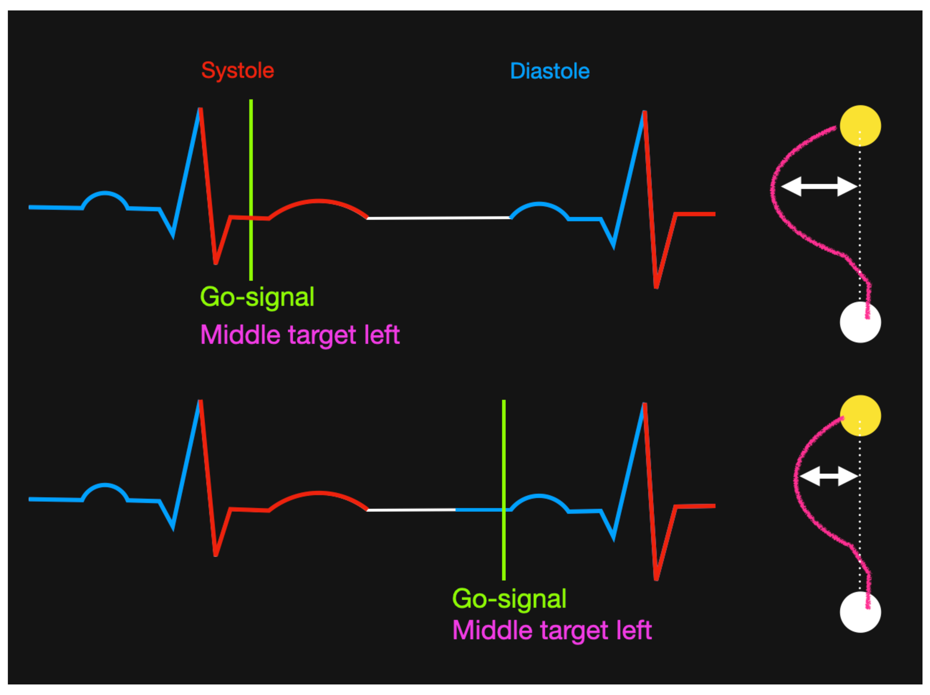

Fig. 5. Hypothesis 2: visual representation of an example how movement error might differ depending on the cardiac phase at the time of go-signal presentation (green) or at the time of movement initiation (pink).

Hypothesis 3:
The cardiac phase at the time point of the go-signal for movement initiation, may **systematically shift over time.** For the active group the go-signal is the first target's colour change and for the control and motor imagery group it is the second target's colour change (see Figure 6 for an example outcome scenario).

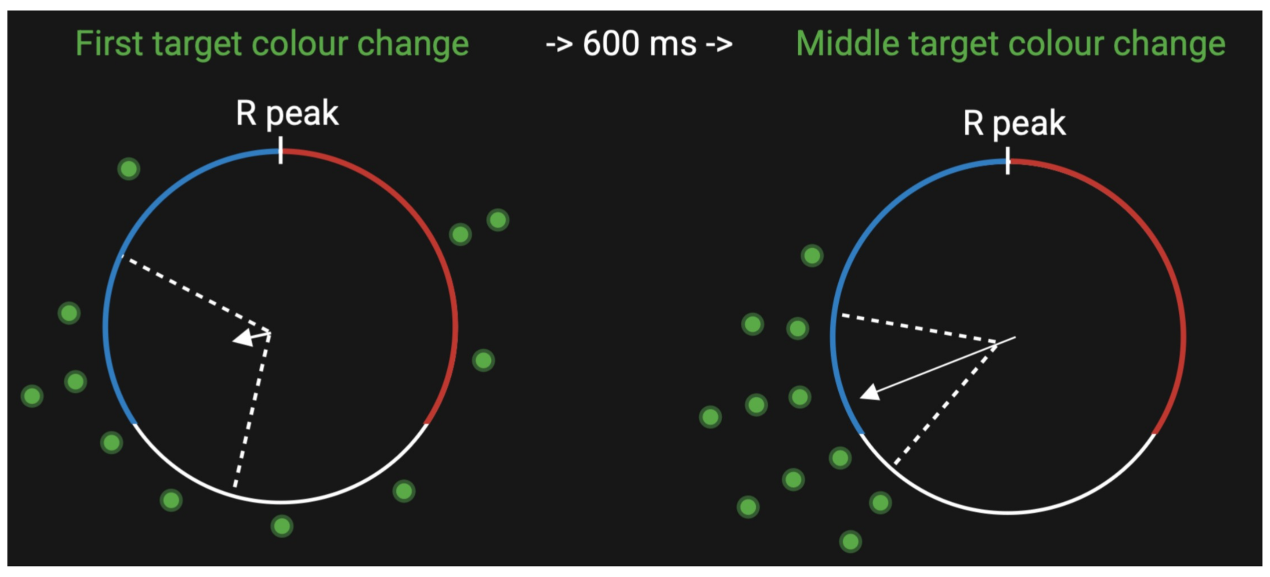

Fig. 6. Hypothesis 3: visual representation of an example how cardiac phase may systematically shift over time (left: earlier, more random distribution and right: later, distributed in a certain cardiac phase, i.e. diastole).

Hypothesis 4:
Systematic differences in cardiac phase are expected when comparing the cardiac phase between two conditions: (1) at the moment the go-signal target is exited (movement initiation) for the **control** group and (2) at the moment the go-signal target is exited (overt movement initiation) for the **motor imagery** group (see Figure 7 for an example outcome scenario).

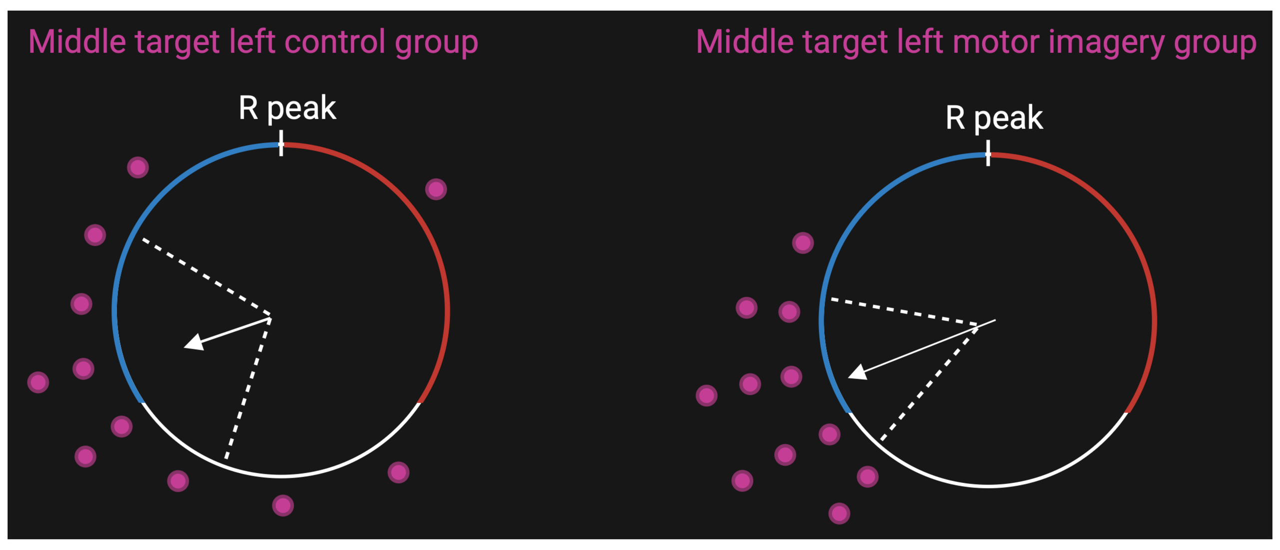

Fig. 7. Hypothesis 4: visual representation of an example how cardiac phases could differ at the time of movement initiation between the control (left) and the motor imagery group (right).

Related literature

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Mail: nesbit@cbs.mpg.de
LinkedIn: Emma Nesbit
Bluesky: @emmanesbit.bsky.social