Sequential planning is not always associated with a reaction time cost

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Background

In daily life, individuals perform various movements, many of which contain a sequence of actions that need to be done swiftly and accurately.

Studies have shown that reaction time **(RT) increases when more sequence elements are cued** and this **RT increase** is often taken as evidence that individuals **plan multiple elements** of the sequence before sequence initiation.

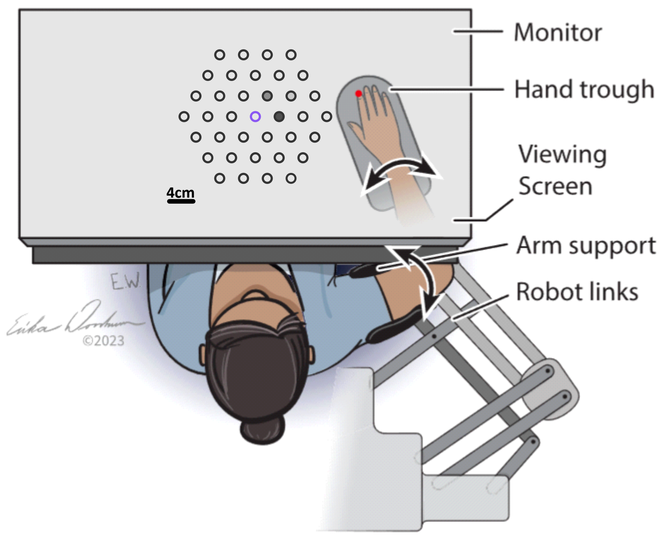
Here, we provide a fresh perspective on RT and how it should be interpreted when it comes to the preparation of sequential movements by answering what causes the RT cost.

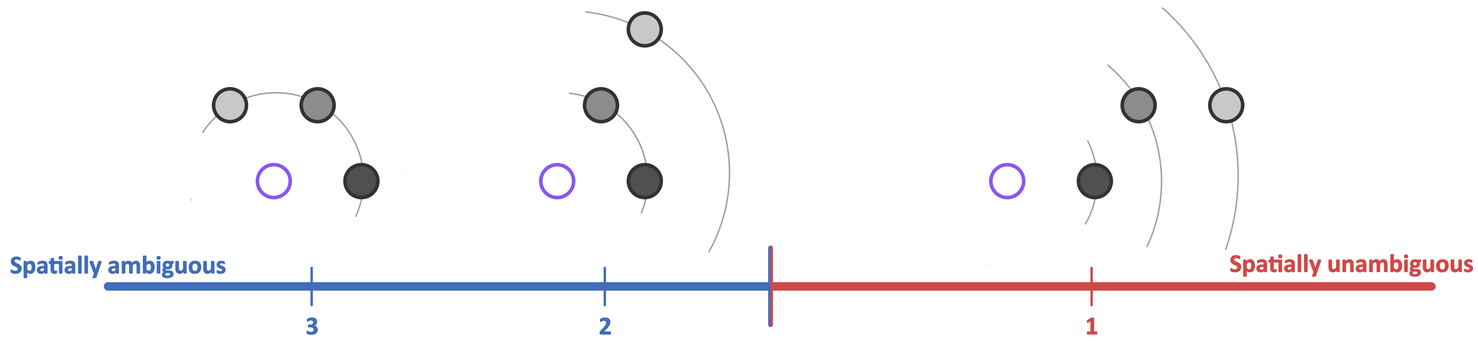
We specifically answer:

- Does sequential planning happen before sequence initiation?
- Is sequential planning reflected in RT?

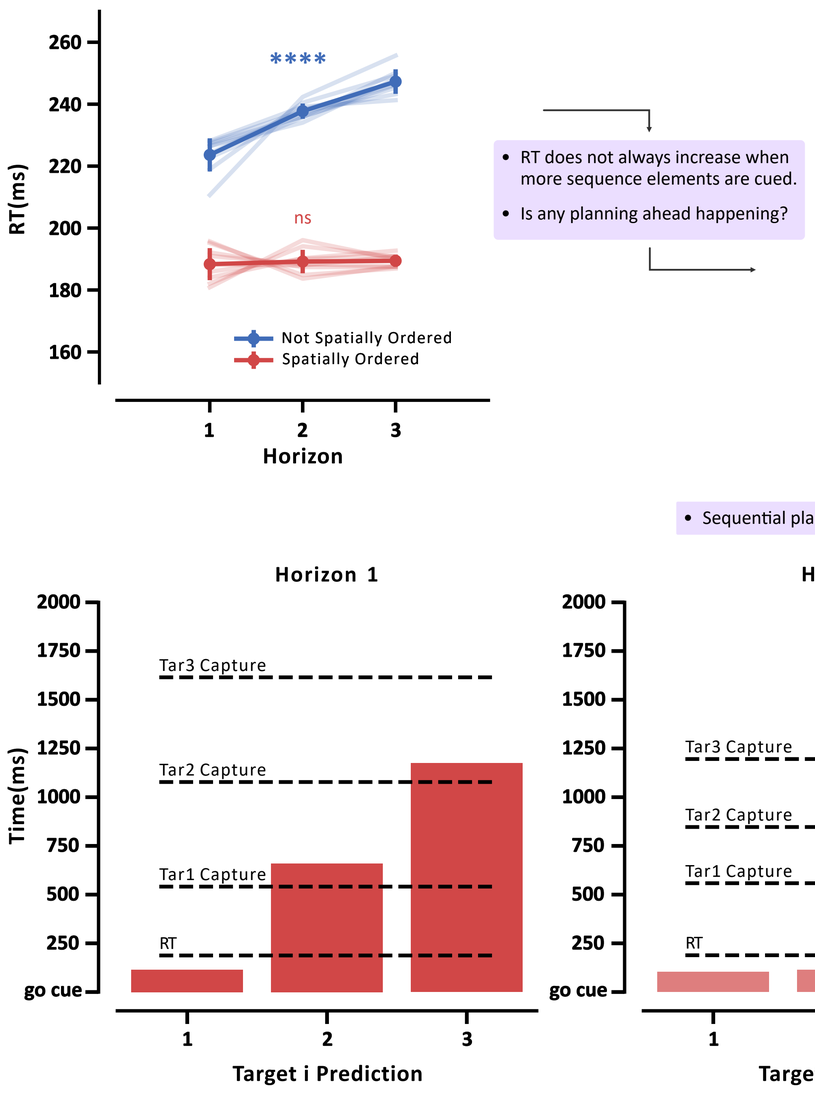
Methods

- Participants (n=9) performed sequences of 5 **fixed-length reaches** to neighboring targets.
- Sequence order was indicated by **target brightness**.
- We manipulated:
  - A) Number of future targets visible (Horizon = 1,2,3)
  - B) **Ambiguity** of resolving the **first target**
    (1, 2, or 3 neighboring targets when initiating)
- Sequences were randomly generated from a grid of equidistant circular targets.
- Dwell time was 50ms.

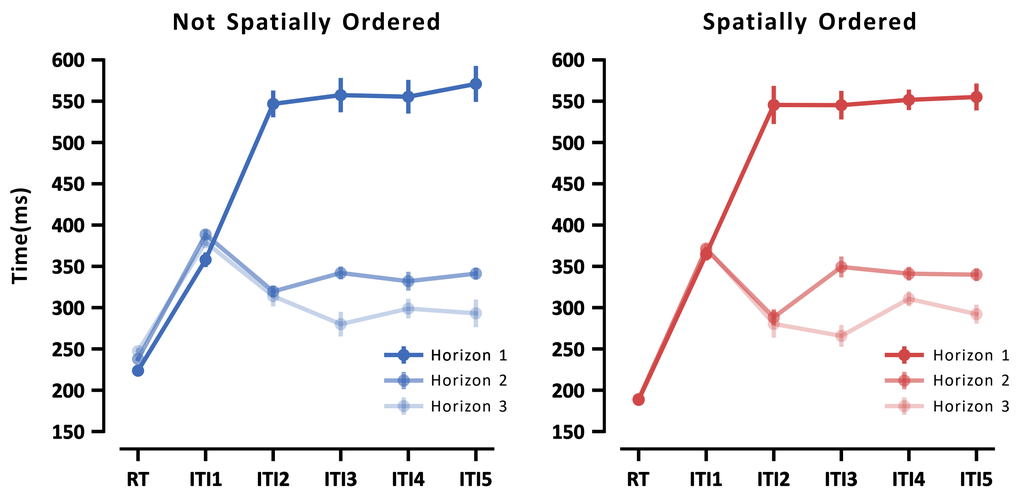


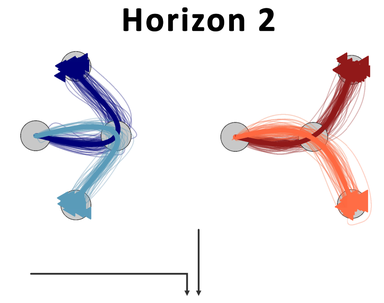


Results - Experiment 1



- RT does not always increase when more sequence elements are cued.
- Is any planning ahead happening?

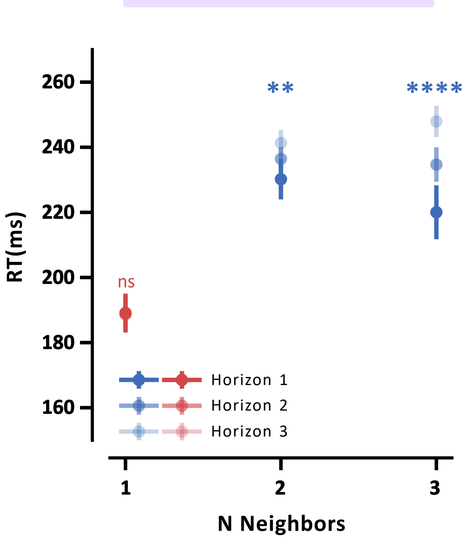




- Participants plan ahead when they are given information about future targets.
- Participants curve their first reach in a way that is biomechanically beneficial for future targets.
- Is this planning ahead happening before initiation or after?

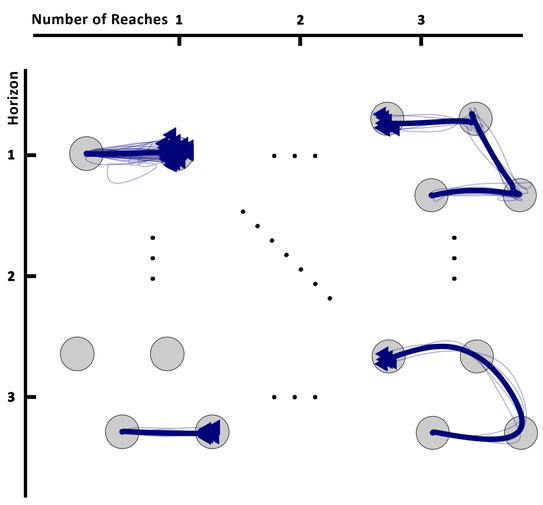
- Sequential planning happens during RT:

- RT cost is more when there is more ambiguity on the first target:

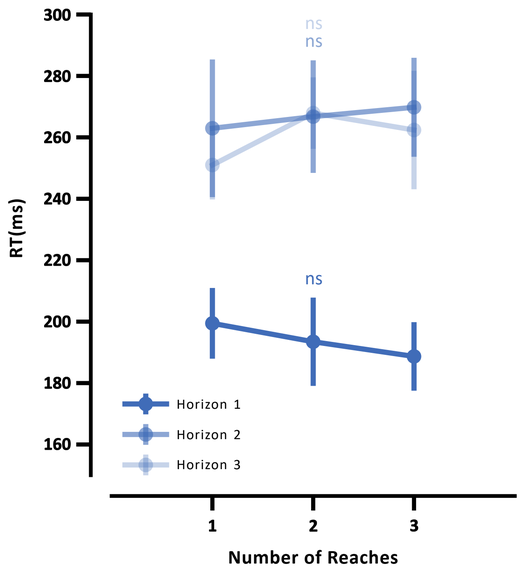


Results - Experiment 2

- To ensure that all the RT cost in ambiguous trials stems from resolving sequence order, we conducted a follow-up experiment where we additionally varied the number of reaches (n=11):



- No RT cost across the number of reaches that participants have to perform:



Summary

- **Sequential planning happens before sequence initiation**

  At least the first three targets are considered.
- **Sequential planning happens either with or without RT cost**

  Depending on how hard it is to resolve the order of the sequence. In our case, ambiguity on the first target.
- **RT cost is not always associated with sequential planning**

  There is no RT cost when performing more reaches; all the cost is due to ambiguity on the first target.
- **Resolving sequence order is facilitated by spatial ordering**

  Determining sequence order when its elements are spatially cued has no cost on RT.
- **Ambiguity intensity is correlated with RT cost**

  The more ambiguity on the first target, the more the cost on RT.

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