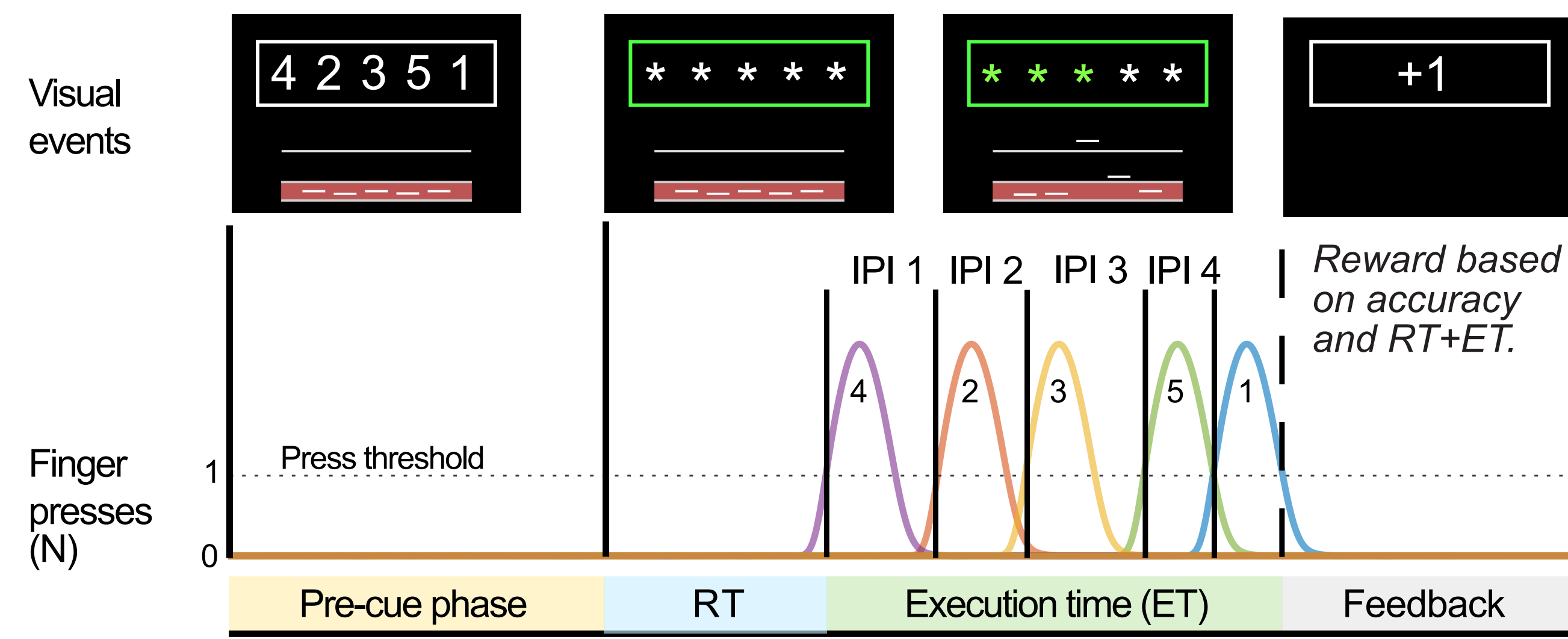


Introduction

How are movement sequences controlled and learned?

- When sequences are repeated, they are executed faster the second time
- Repetition effects occur both in reaction and execution, even if ample time for preparation (Ariani et al. 2020).
- We usually plan only ~3 items ahead (Ariani et al. 2021)
- For longer sequences, we need extra time for online planning
- Repetition effects appear to act on preplanning and online planning of sequences (Ariani et al. 2020).
- Repetition effects can potentially reveal the structure of the processes underlying sequence execution and learning.

Methods



Exp1: 2.5-3.5s
Exp2: 3.0-4.0s
Enough time to complete planning (Ariani, 2019).

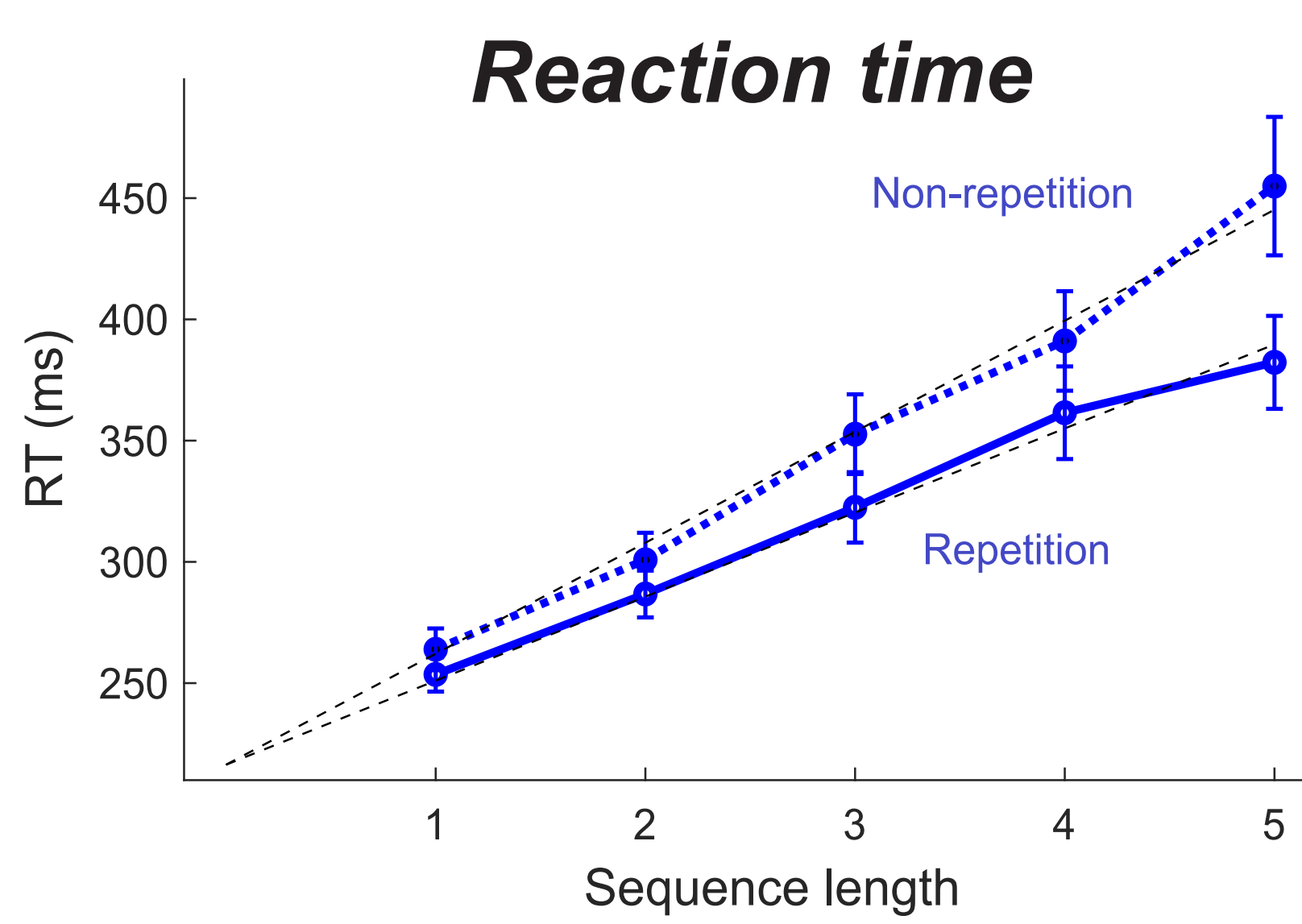
RT reflects the time to initiate pre-planned response

ET is broken up in different Inter-press-intervals (IPIs).

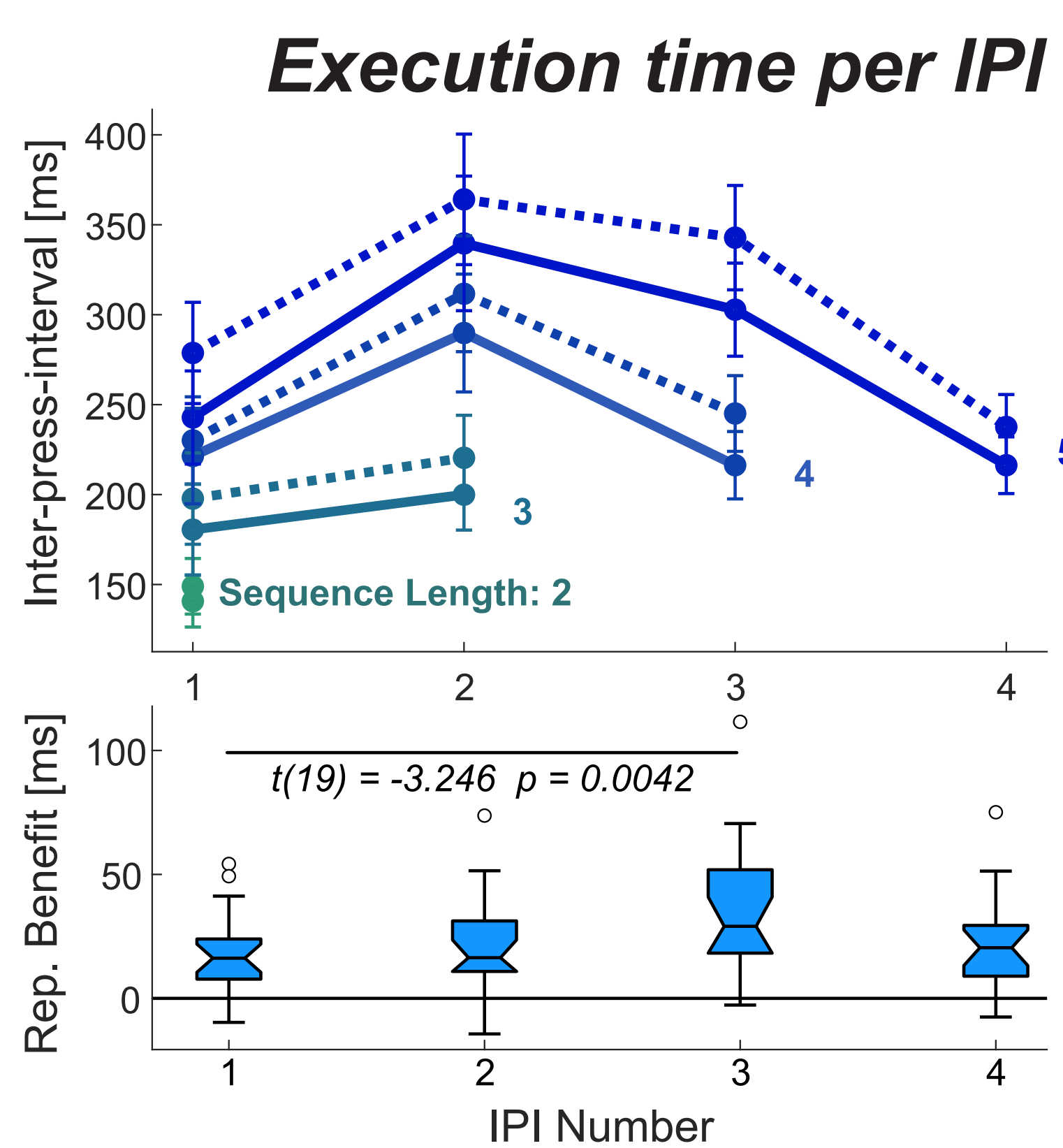
Reward based on accuracy and RT+ET.

Experiment 1

- Vary the length of sequence from 1-5
- At go-cue, the sequence was masked to ensure that participants preplan as much as possible.
- Which repetition effects are due to repeating the first response, and which ones are from the sequence?



- Reaction time increases linearly in sequence length
 - Repetition effect also increases linearly with sequence length.
- > Repetition facilitates the state of readiness of the entire sequence plan.

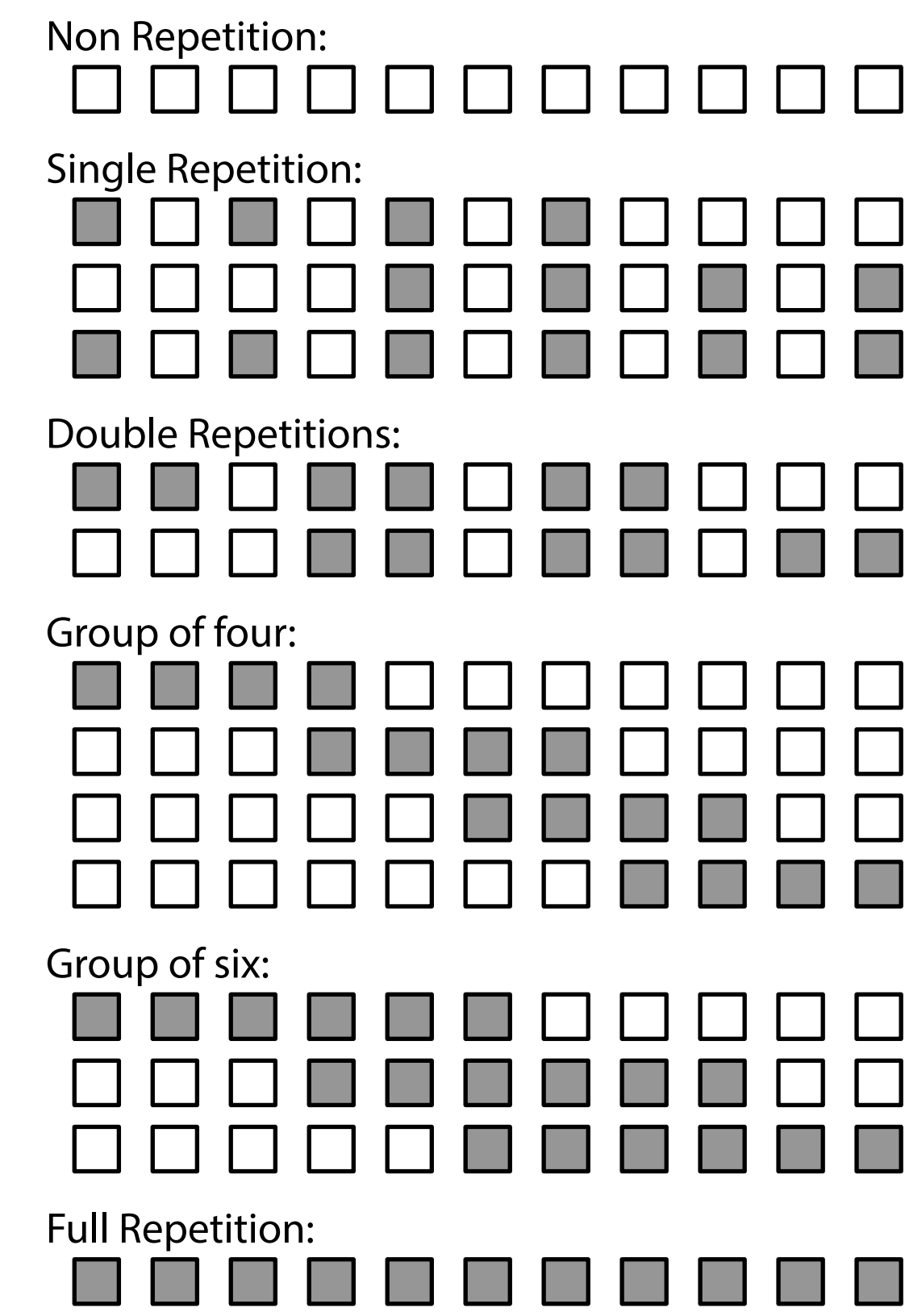


- Inter-press-intervals (IPI) are larger for a longer sequence
 - IPIs are larger for the middle items of the sequence
- > Evidence for online planning
- Repetition benefit is larger in the middle of the sequence
- > Repetition makes online planning faster (Ariani et al. 2020).

Experiment 2

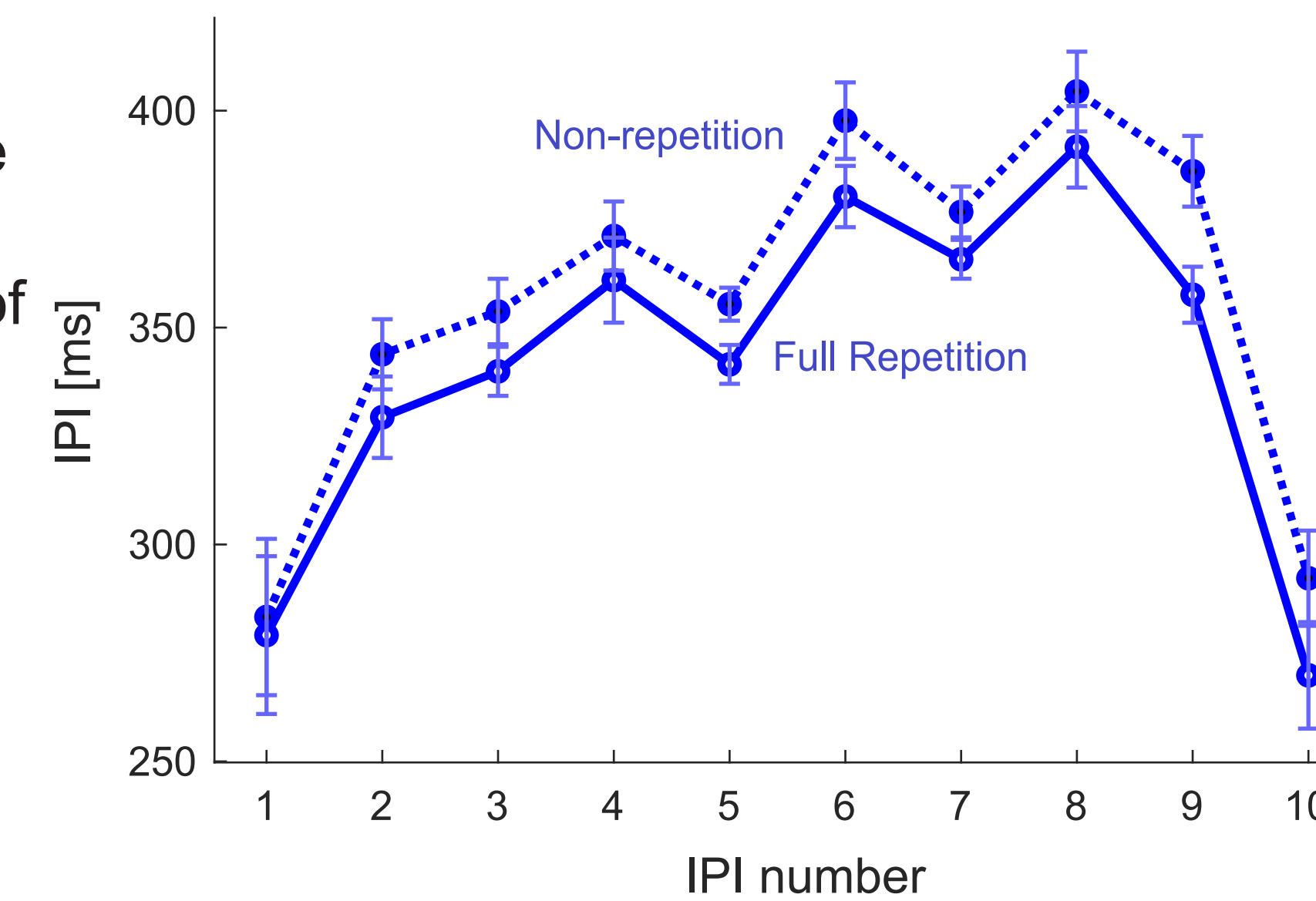
Trial 1: 1 3 5 1 5 4 3 2 1 4 3
 Trial 2: 3 2 1 4 3 2 1 2 1 4 3
 Trial 3: 1 2 1 4 3 2 1 2 4 1 2

■ Repeated items



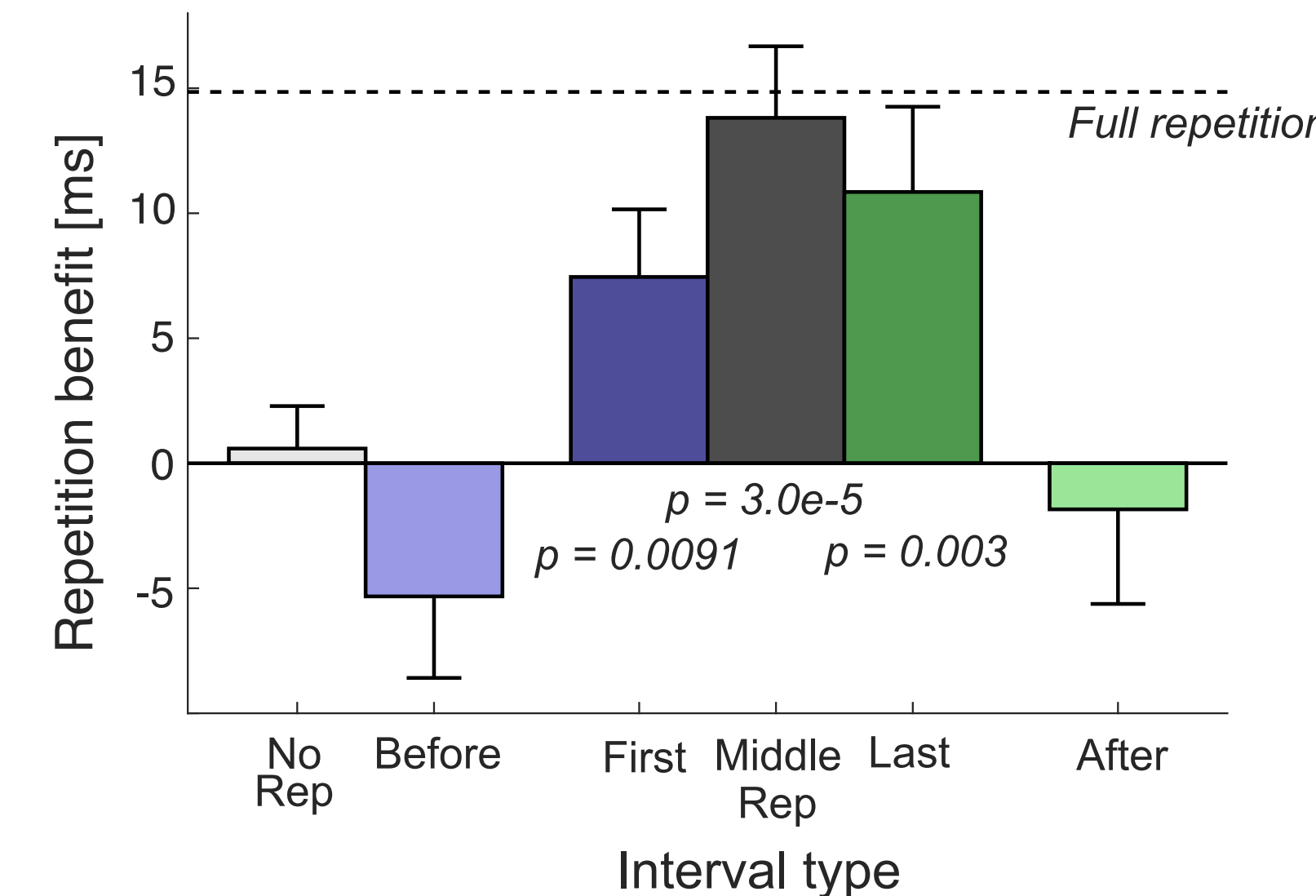
- Sequences of length 11
- Stimuli stay on the screen
- On each trial, any number of presses can be repeated from last time.
- Sequences of length 11
- 4/6 single elements are repeated
- 3 Transitions are repeated
- 4 or 6 elements are repeated in a chunk
- Repetition can happen in beginning, middle, or end
- All items are repeated

Execution time per IPI



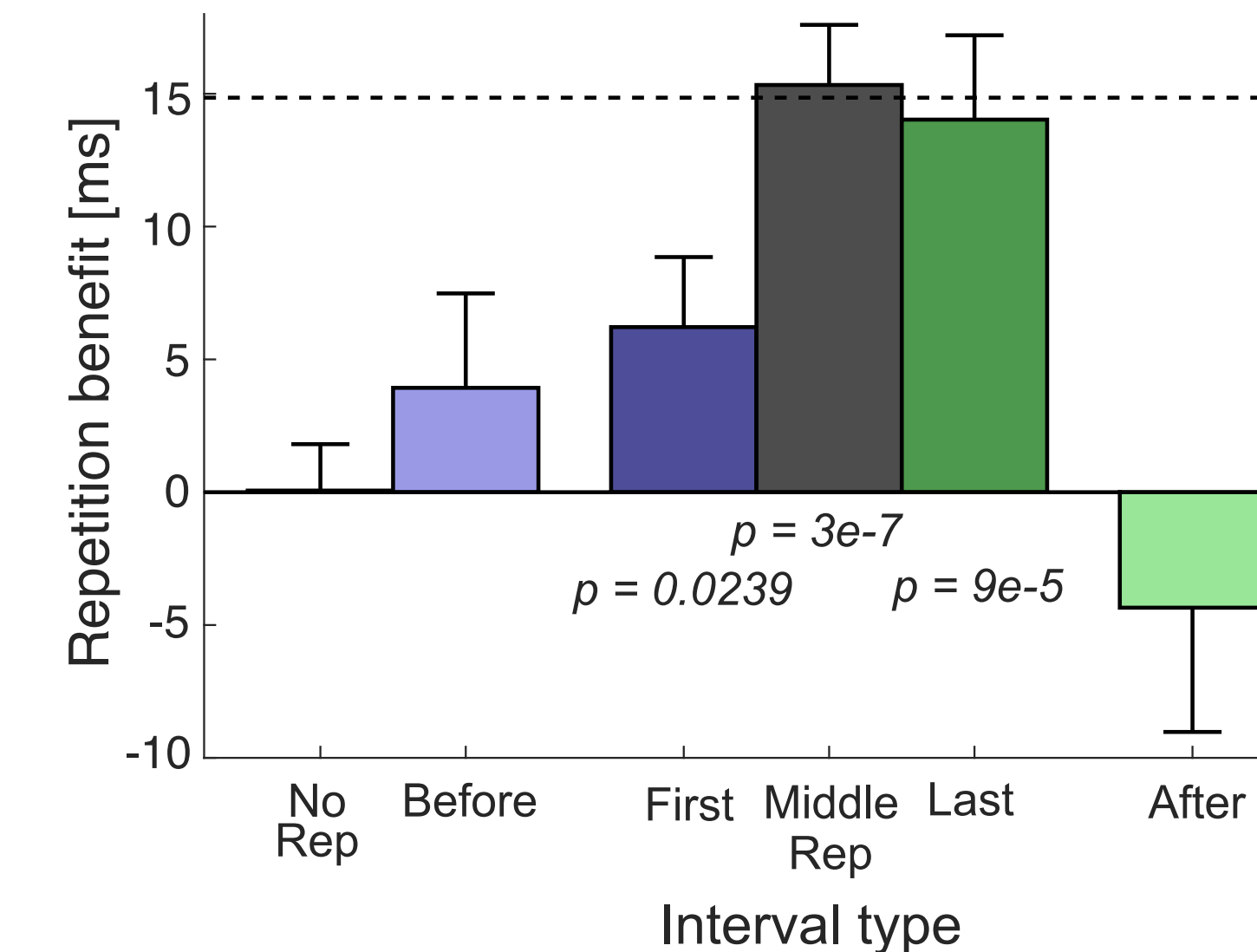
- As in Exp 1, repetition benefits the middle of the sequence more.
- No effects on RT for a sequence of length 11
- No evidence for effects of single repetitions

Repetitions of Fours



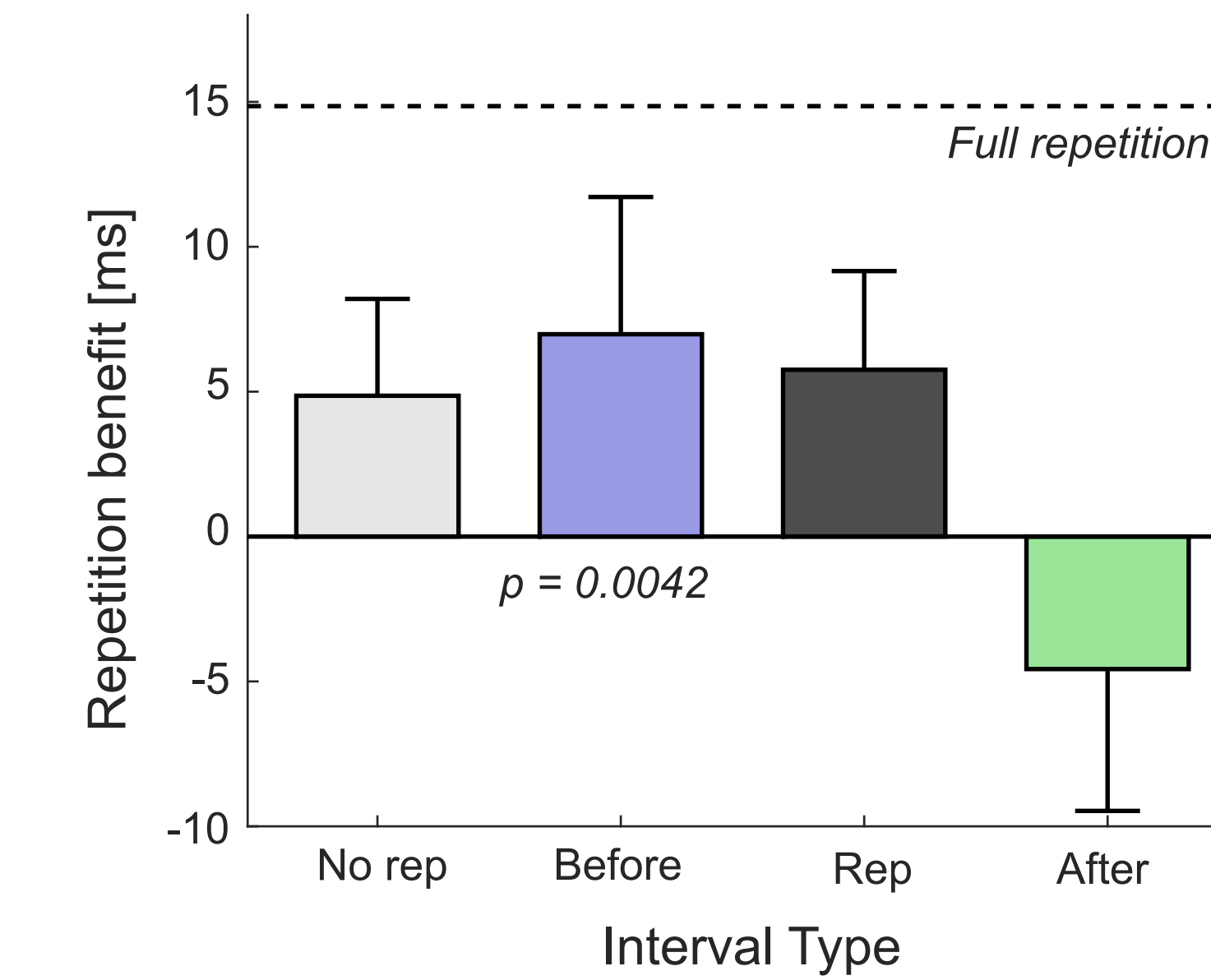
- Substantial repetition benefits only for longer sub-sequence
- No difference for repetitions early, middle, or late,
- In terms of IPI, repetition benefit is largest in the middle of a subsequence.

Repetitions of Sixes



-> Both past and future IPIs influence repetition benefit

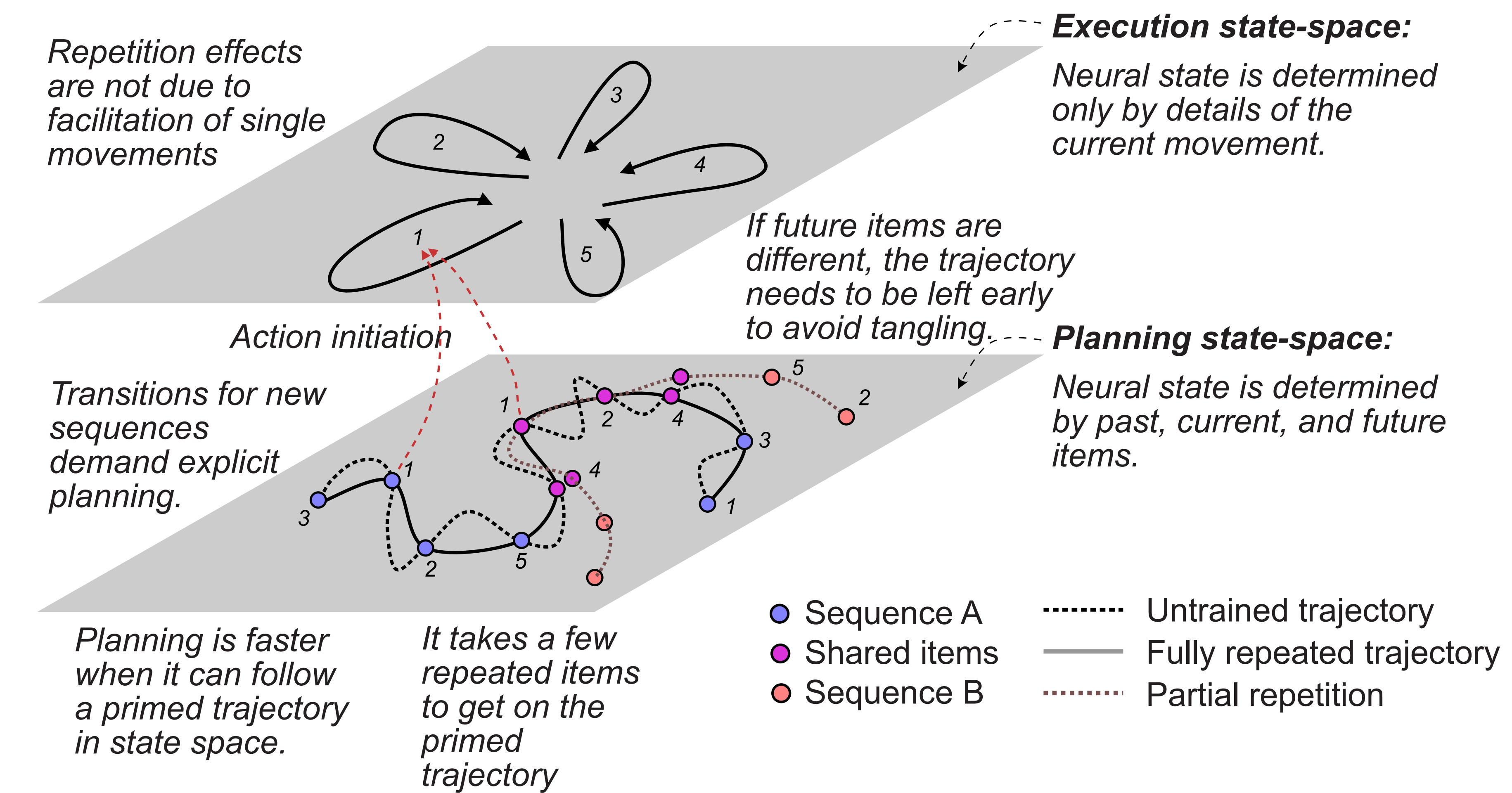
Repetitions of doubles



- No significant benefit for repetitions of isolated transition
 - However, IPIs before repeated transitions were significantly faster
- > Faster online planning for the two repeated items together?

Discussion

- Reaction time + repetition effects increase as a function of sequence length
- > Initiation depends on complexity of preparatory state of the future items
- Repetition benefits online planning equally, whether it occurs at the beginning, middle, or end of the sequence
- > Primed trajectories in planning space can be used flexibly.
- How long do repeated segments have to be to give a benefit?
- > It seems that ~4 items are needed to show full repetition benefit



References

Ariani, G., & Diedrichsen, J. (2019). Sequence learning is driven by improvements in motor planning. *Journal of Neurophysiology*, 121(6), 2088-2100.

Ariani, G., Kwon, Y., Diedrichsen, J. (2020). Repetition facilitates online planning of sequential movements. *Journal of Neurophysiology*, 123(5), 1727-1738.

Ariani, G., Kordjazi, N., Pruszynski, J., Diedrichsen, J. (2021). The Planning Horizon for Movement Sequences. *eNeuro*, 8(2).

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