



## Introduction

**Memory Systems Theory** characterizes 2 different types of memory: explicit (declarative) and implicit (non-declarative)<sup>1,2,3</sup>.

- Within implicit learning (IL), both the number of mechanisms and how these support complex cognition, like language, are unknown.

**Implicit perceptual-motor sequence learning** paradigms have effectively isolated IL (improved performance without awareness)<sup>4,5</sup>.

- Statistical learning (SL) paradigms have shown how sequential structure is extracted automatically from experience<sup>6,7</sup>.
- Auditorily cued sequence learning is not well-established

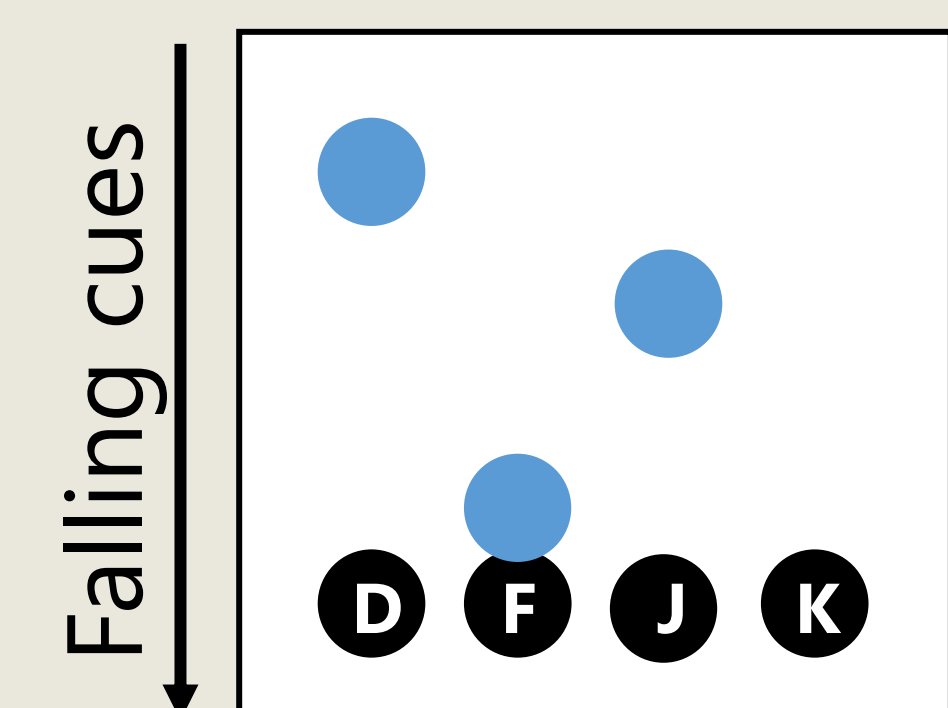
**Research Question:** Are IL of sequences and SL supported by the same neural and cognitive mechanism?

**Hypothesis:** Auditorily-cued motor sequences will produce the similar sequence-specific performance improvements seen in visually-cued implicit sequence learning.

## Methods

### Serial Interception Sequence Learning<sup>4</sup>

- Participants respond to visual cues moving vertically across the screen with a precisely timed action
- Cues follow a covertly embedded 12-item sequence
- Task speed adjusted adaptively to maintain ~80% accuracy



- **Sequence-Specific Performance Advantages (SSPA)** are expressed as increased accuracy for the repeating sequence compared with unfamiliar repeating sequence

**Experiment 1**  $\text{D} \rightarrow \text{D} \rightarrow \text{D}$  3-beep repetition (n=34)

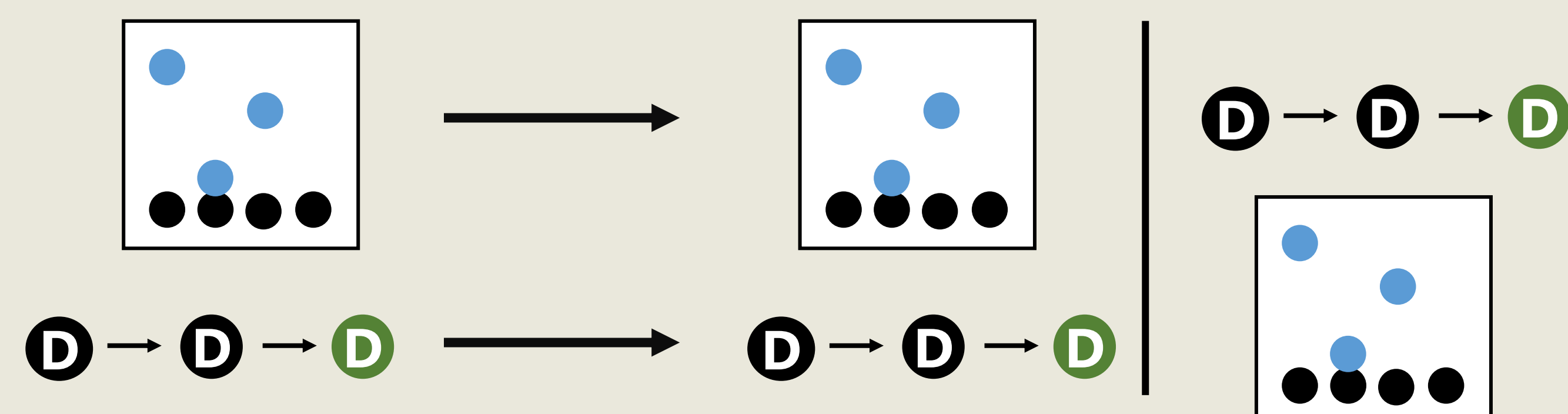
- Response made at onset of the third beep
- 3 Training (108 reps) + 1 Test blocks, 540 trials/block

**Experiment 2**  $\text{D} \rightarrow \text{D}$  Language-like glissando cue (n=26)

- Response made at cue offset
- 2 Training (72 reps) + 1 Test blocks, 540 trials/block

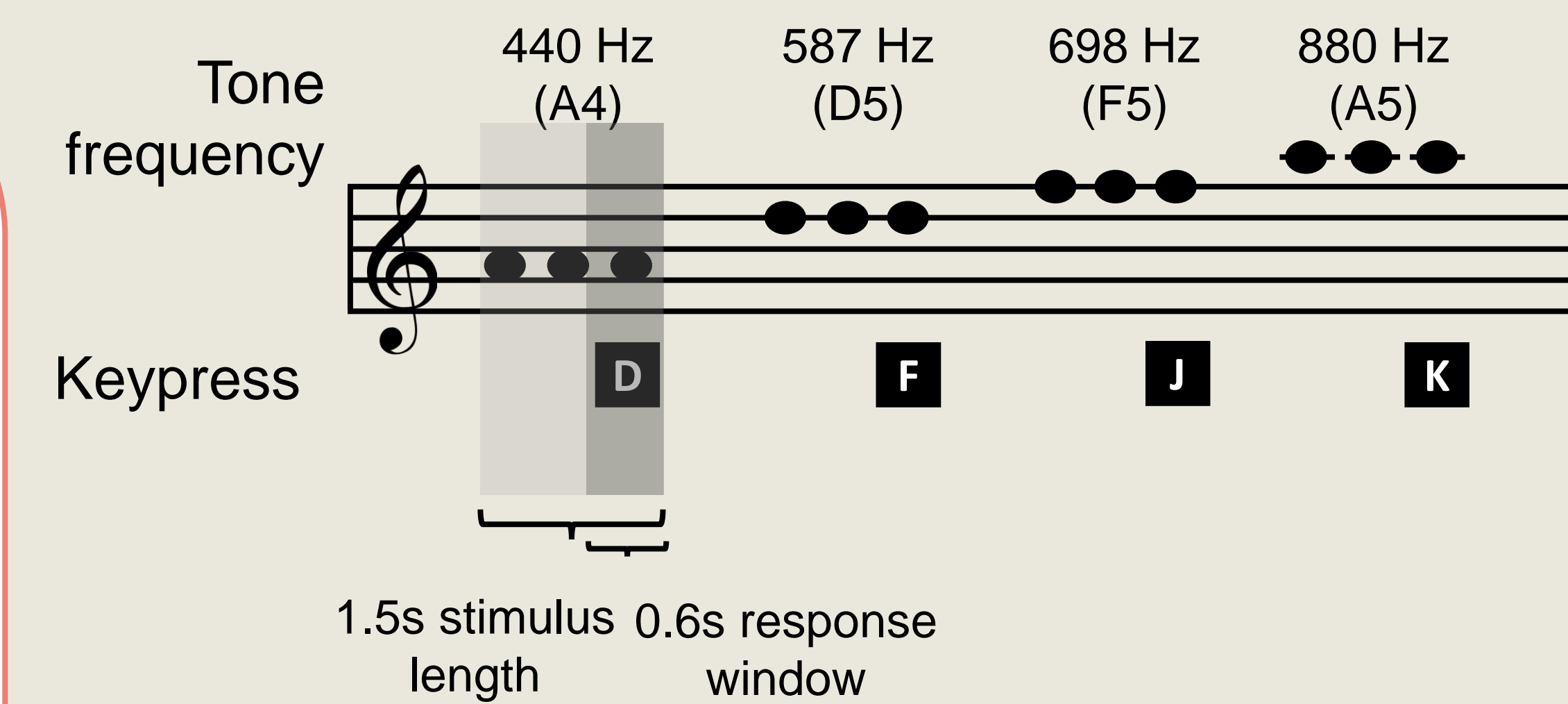
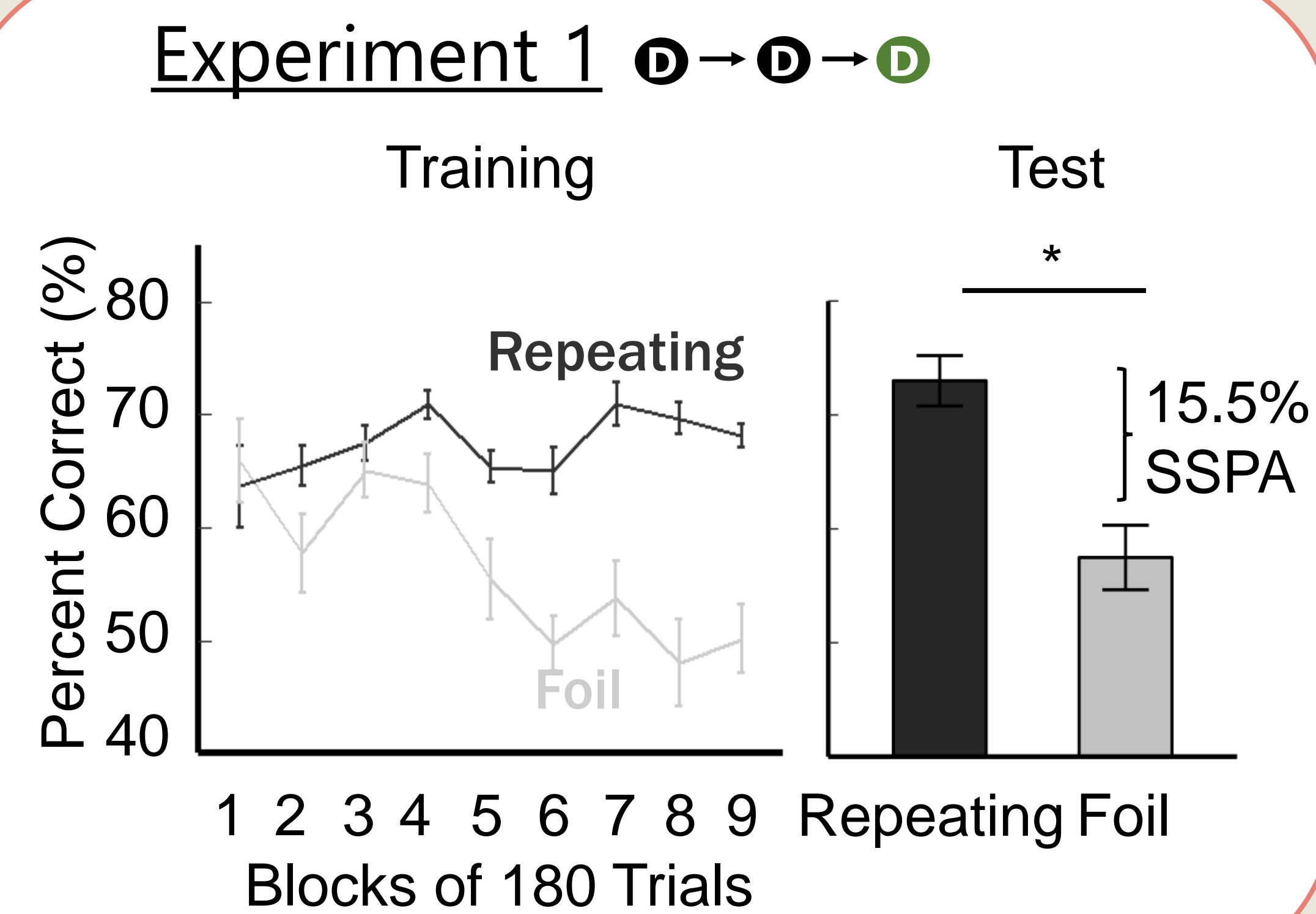
**Experiment 3** (n=70): Knowledge transfer across modalities

Training 4 blocks (360 trials/block) Test (360 trials/block)

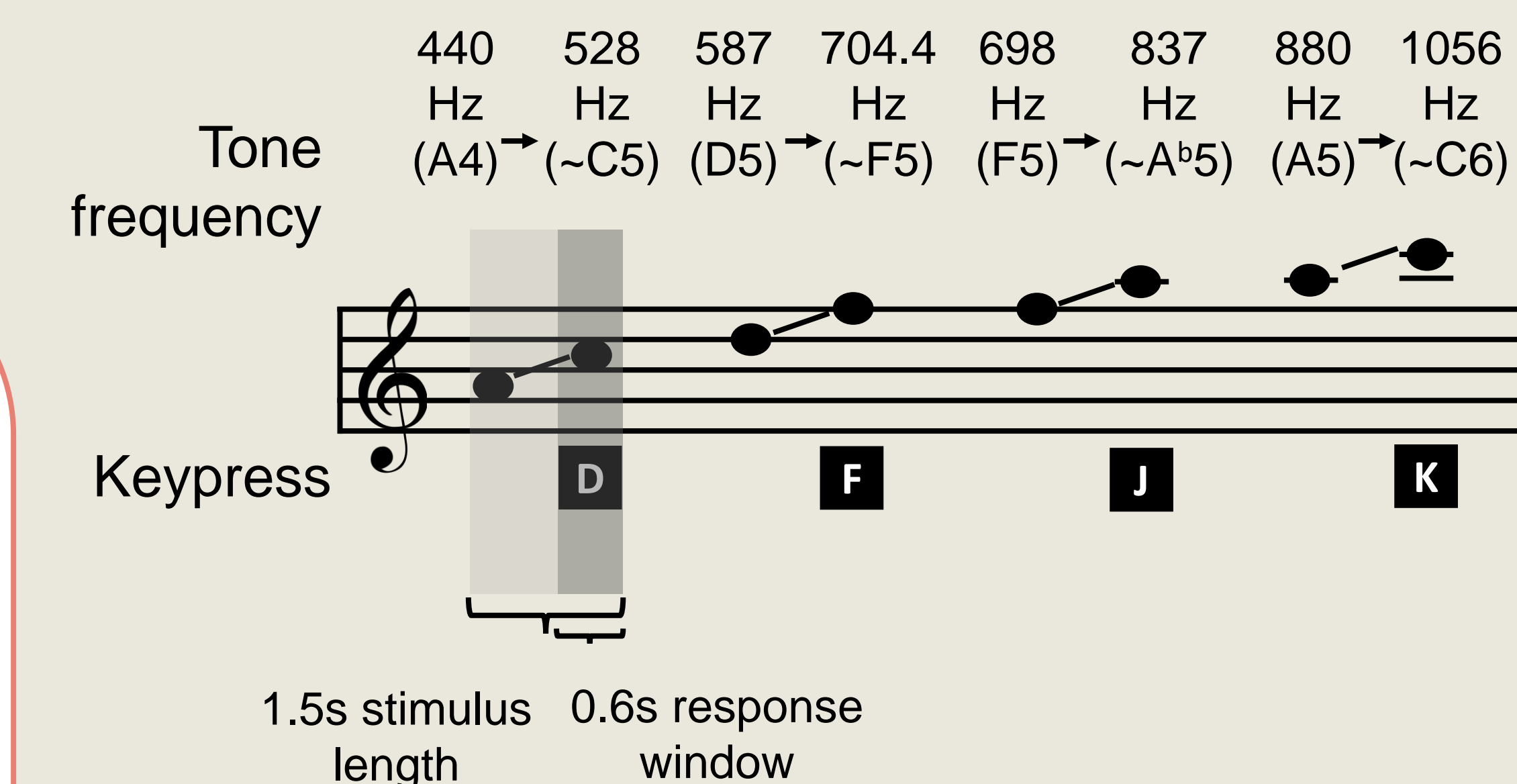
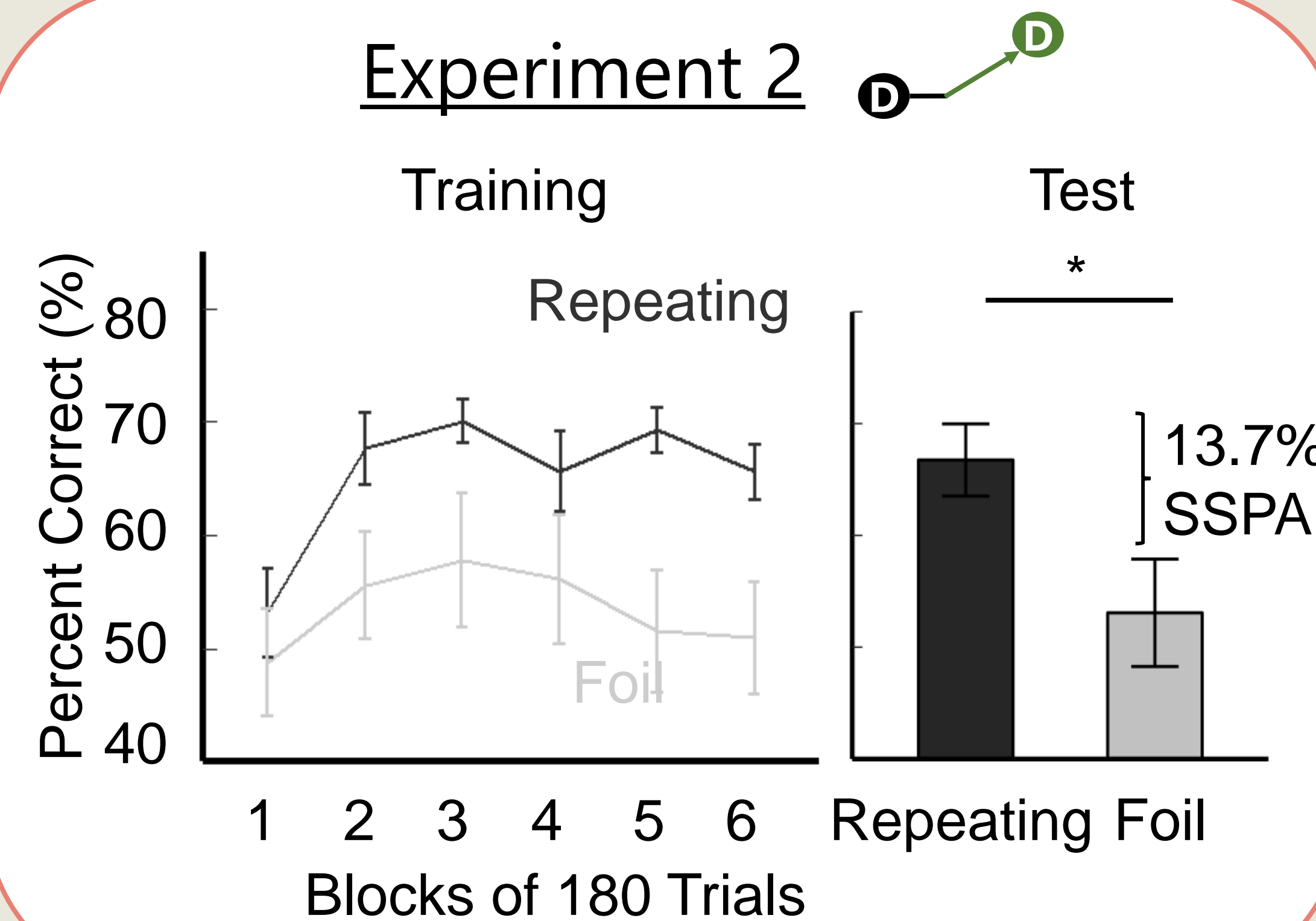


## Results

### Sequence-specific motor learning occurs to auditory cues.



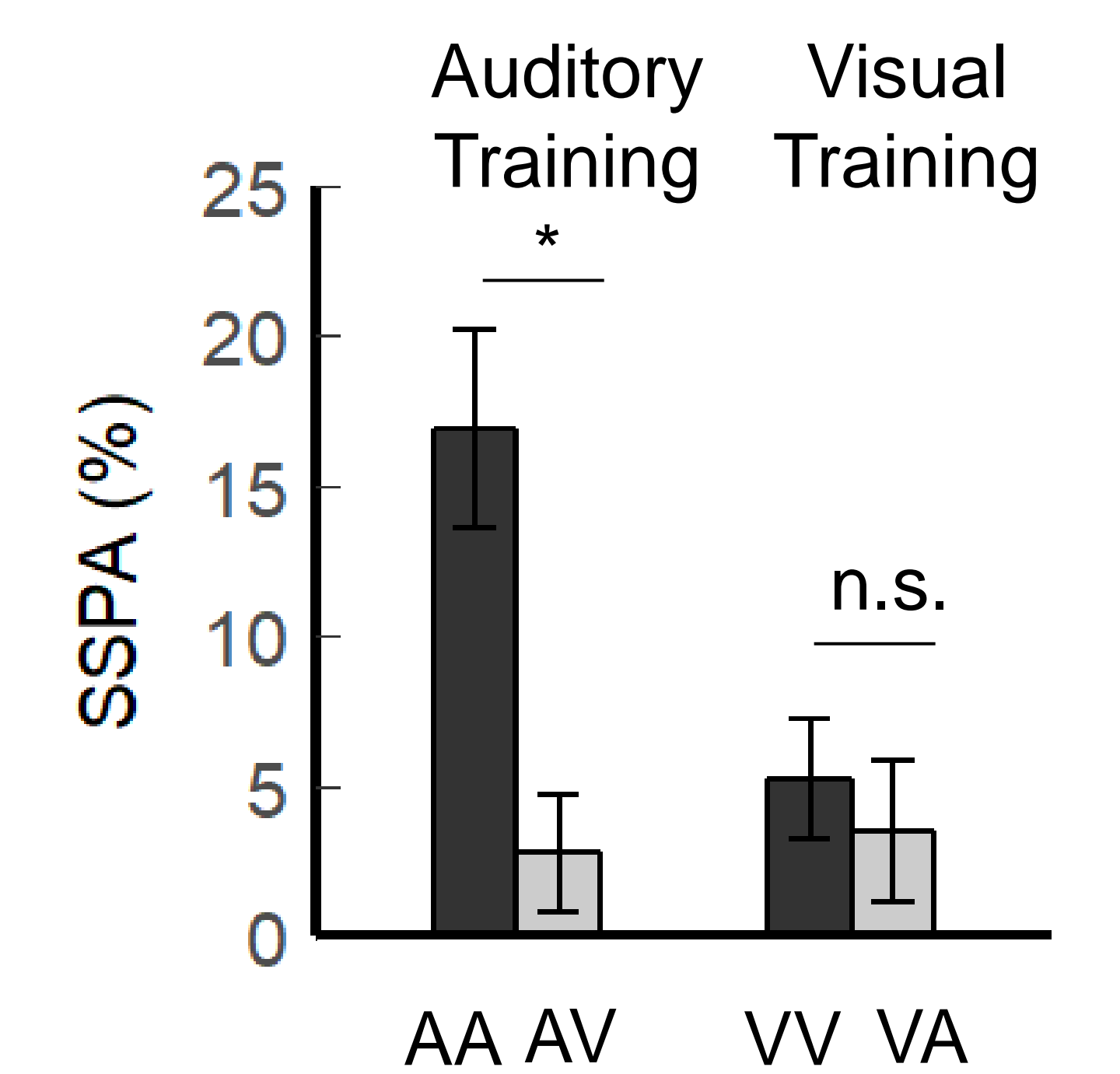
- **Experiment 1:** Participants (n=24) successfully learned the sequence with sets of 3 beeps



- **Experiment 2:** Participants (n=12) successfully learned the sequence with language-like glissando cues
- High task difficulty in Experiment 2, indicated by high attrition rate (54%)

This kind of learning is modality-specific.

### Experiment 3



- **Experiment 3:** No transfer of acquired sequence knowledge occurred across modalities (n=27 per training group)
- Transfer test (AV, VA) SSPA not significantly different from 0

\* **SSPA (%)** = repeating sequence PC minus foil sequence PC

## Summary & Discussion

- The three experiments here produced robust implicit perceptual-motor learning of auditory cues.
- This kind of learning occurred in a relatively modality specific manner, suggesting that implicit perceptual-motor learning is not purely motoric.
- These findings provide evidence for similar mechanisms underlying IL and SL towards language learning.
- Future work will examine:
  - (1) The role of explicit training on implicit auditory sequence performance
  - (2) Passive extraction of auditory statistical information
  - (3) Abstraction of auditory non-adjacent dependencies

## References

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