

## Introduction

### Backgrounds

#### Multisensory integration :

- The brain combines multiple inputs across senses by **weighting** them based on the **bottom-up sensory reliability** [1].
- Top-down influences** can flexibly **modulate** the reliability-weighted integration [2].

#### Ventriloquist effect (VE) :

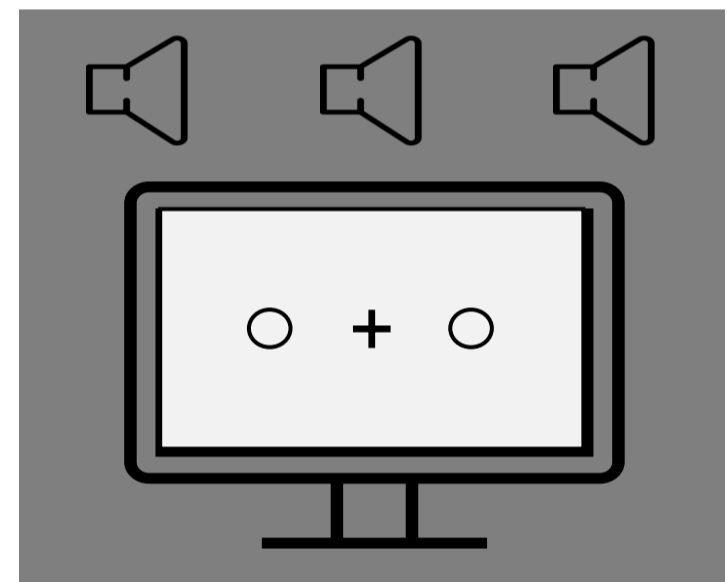
- The perceived location of an **auditory** stimulus is biased toward a task-irrelevant, spatially disparate **visual** stimulus.
- As the visual stimulus **reliability decreases**, the extent of the **VE diminishes** [3].

### Research question

Can **top-down influence compensate** for the diminished VE induced by **degraded bottom-up reliability** ?

## Methods

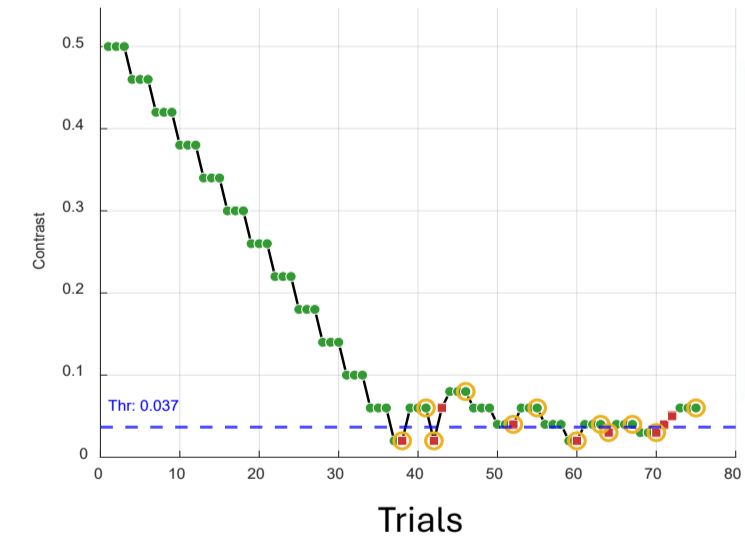
### Experimental setup



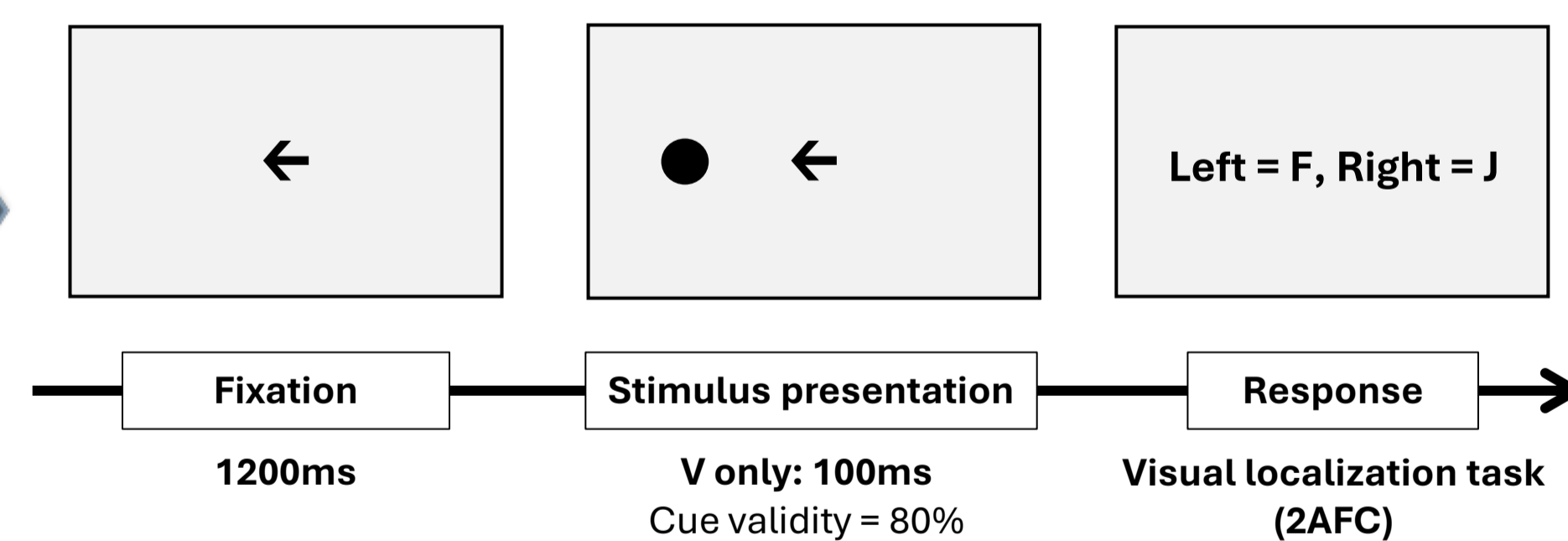
Cue condition	Visual stimulus reliability
Neutral +	Auditory only (baseline)
Spatial ← → Cue validity = 80%	Solid disk (Sd)
	Gaussian blob (Gb)
	Low contrast Gb (Low Gb)
	No-stimulus (Ns)

### Procedures

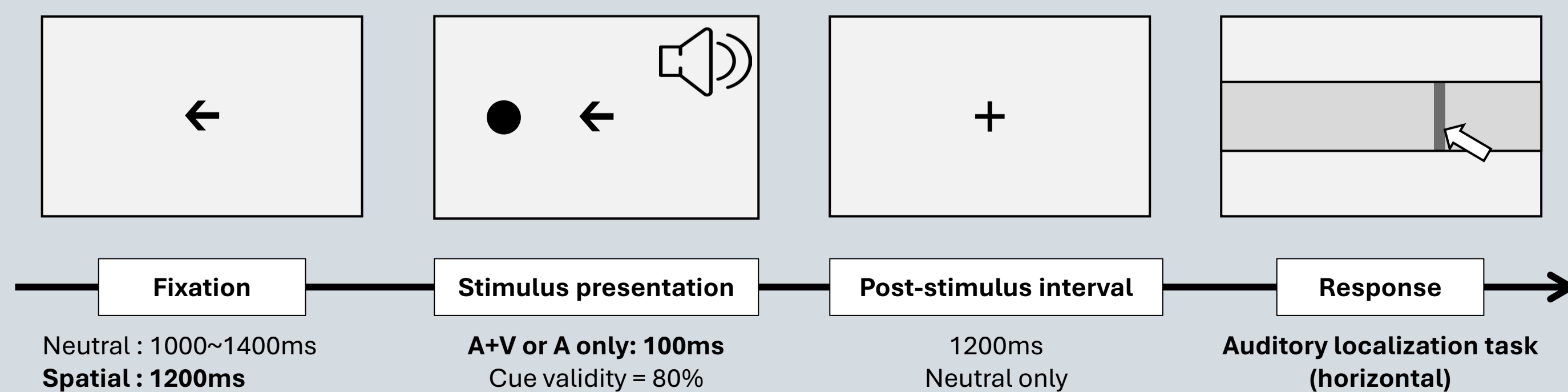
#### 3-down 1-up staircase



#### Practice session: Spatial cue + Sd



#### Main session: 2 fixation types \* 4 visual reliabilities

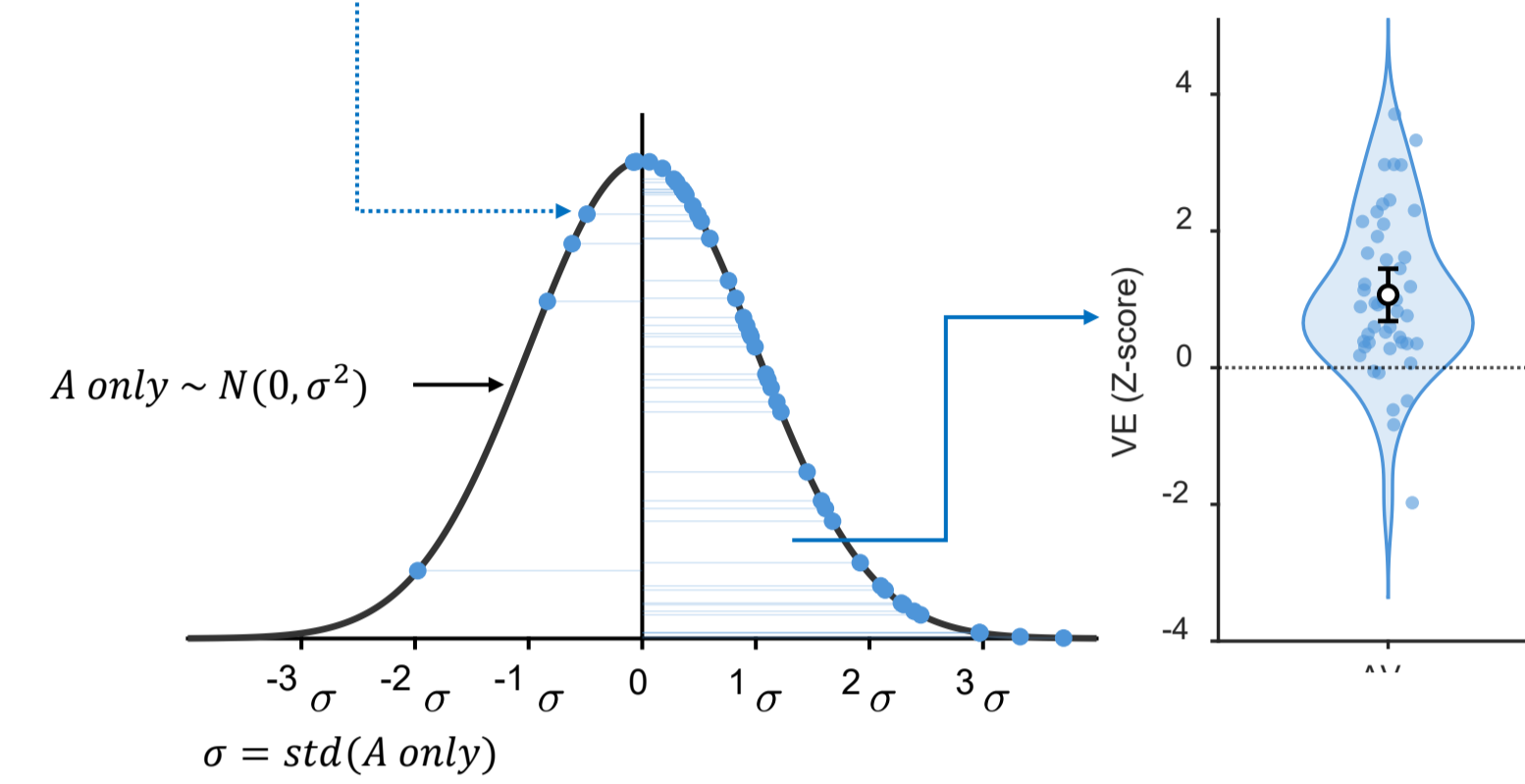


## Results

### 1. Validation of Experimental Setup

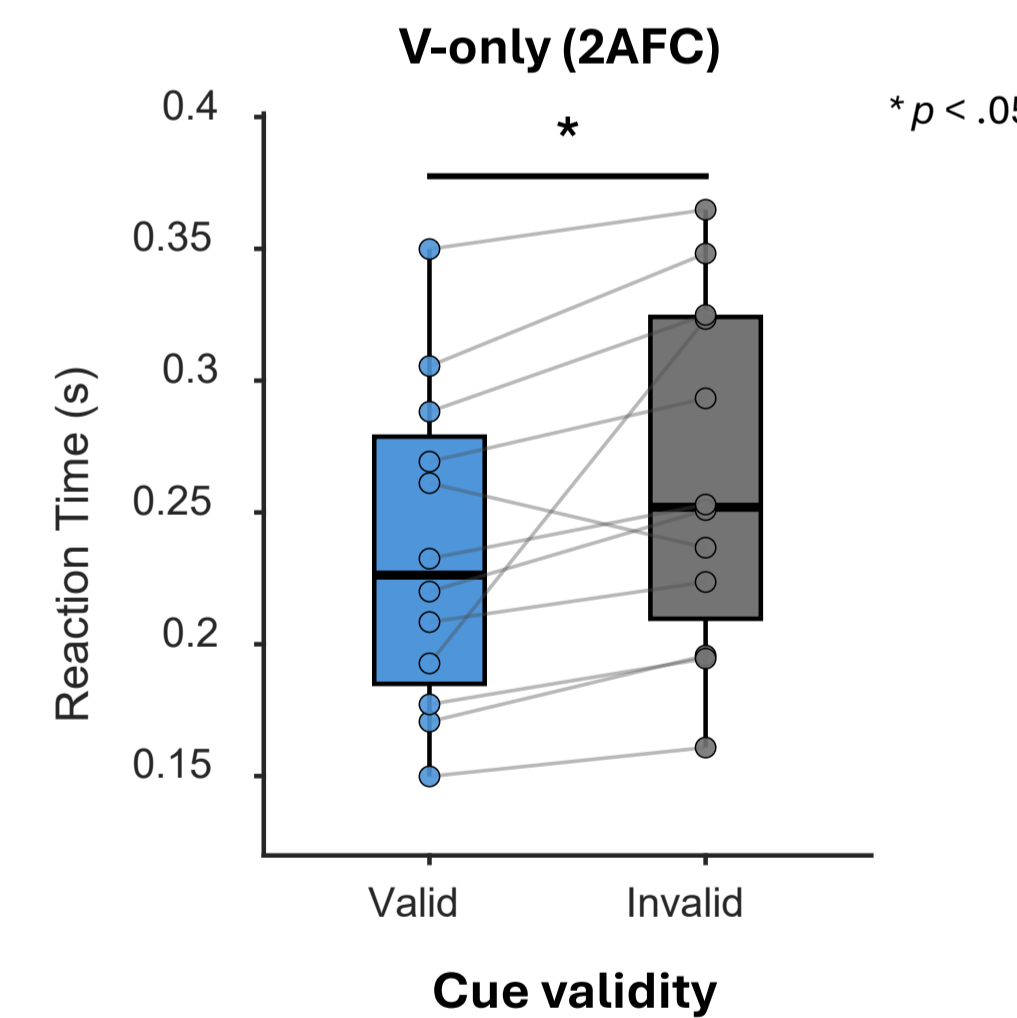
#### Visual stimulus biased auditory localization

$$VE = \frac{X - \text{mean}(A \text{ only})}{\text{std}(A \text{ only})} * \text{sign}$$



- Auditory localization responses were **normalized into Z-score**
- Positive (+) VE score** indicates a bias toward the visual stimulus

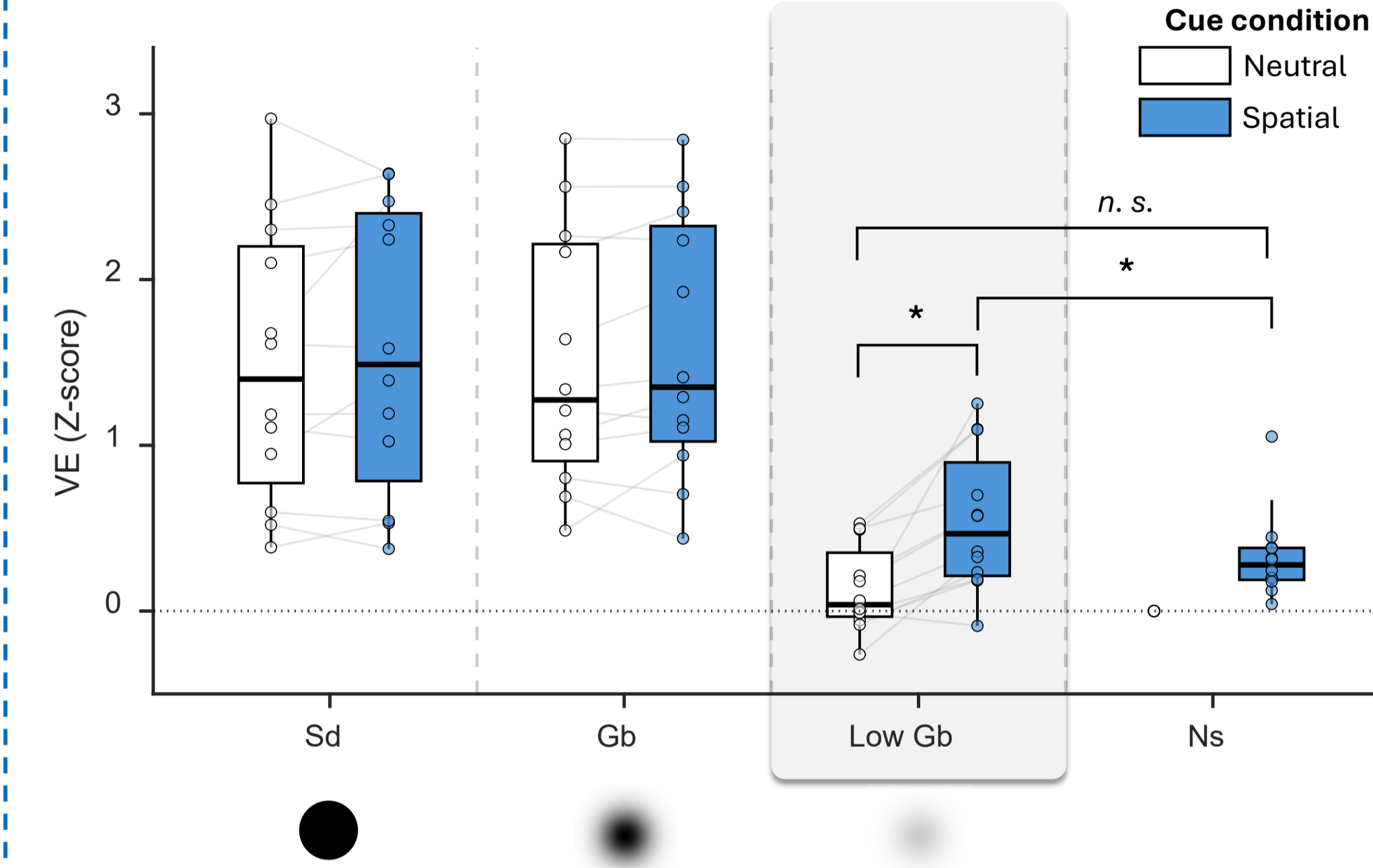
#### Spatial cue engaged top-down influence



- Faster** reaction time for **valid** than **invalid** trials ( $p = .019$ )
- Accuracy : **valid** = 100%, **invalid** = 98.8%

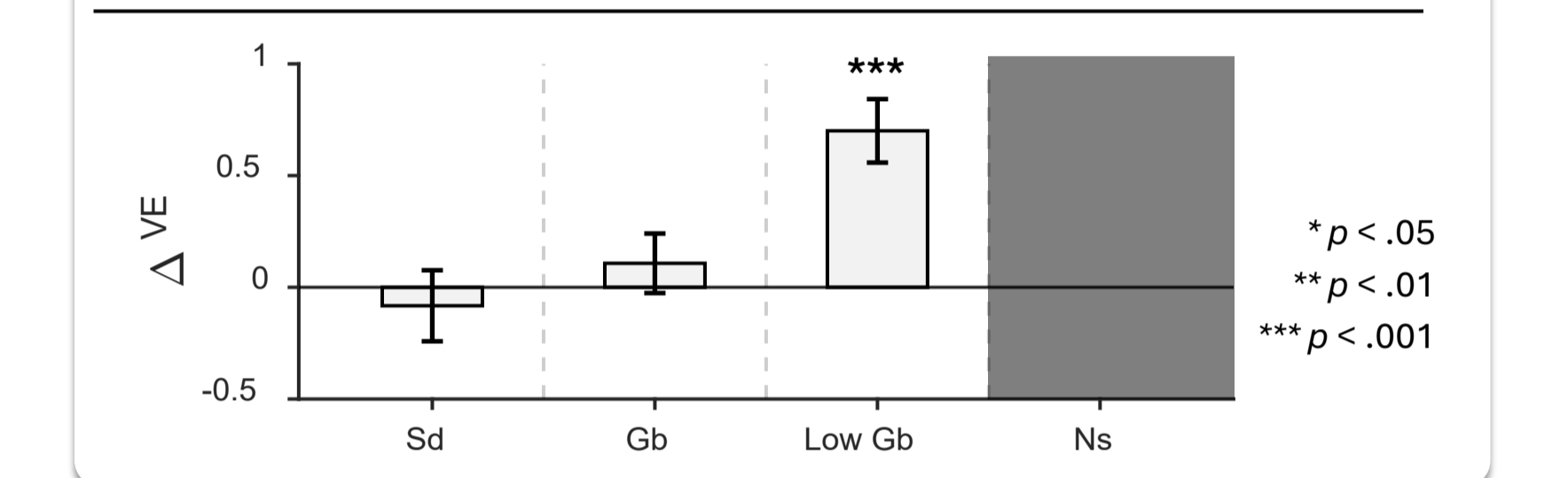
### 2. Interactions between Top-down Influence & Bottom-up Reliability

#### Top-down influence varied with bottom-up reliability

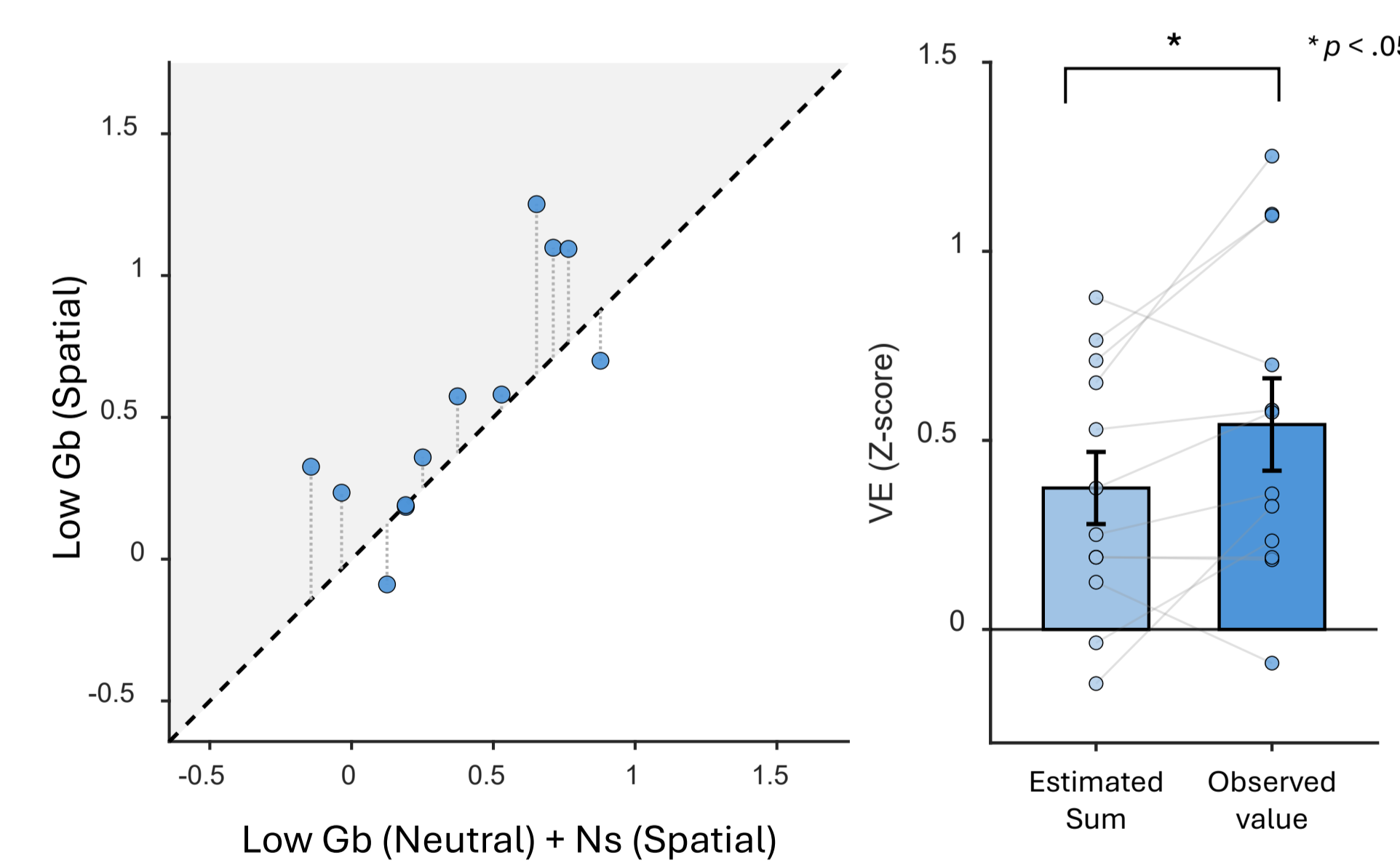


- Degraded visual reliability** significantly **diminished the VE**
  - Neutral :  $Sd \approx Gb > \text{Low Gb} \approx Ns$
  - Spatial :  $Sd \approx Gb > \text{Low Gb} > Ns$
- Top-down influence** intervened under **degraded visual reliability**
  - Neutral vs. Spatial : **Low Gb** ( $p = .016$ )
  - Valid vs. Invalid : **Low Gb** ( $p < .001$ )

#### Cuing effect : $\Delta VE = \text{Valid} - \text{Invalid}$



#### Top-down & bottom-up interaction yielded a supra-additive compensation



- Linear summation vs. Interaction** of top-down & bottom-up effects
  - Estimated Sum** =  $\text{Low Gb}(\text{Neutral}) + \text{Ns}(\text{Spatial})$ 
    - Effect of low visual reliability : **Low Gb** (Neutral)
    - Effect of top-down influence : **Ns** (Spatial)
  - Observed value** =  $\text{Low Gb}(\text{Spatial})$ 
    - Interaction between top-down (**Spatial**) on low visual reliability (**Low Gb**)
- Top-down and bottom-up **interaction exceeded** its linear summation
  - Observed value** > **Estimated Sum** ( $p = .042$ )

**Top-down influence compensated** for the diminished VE induced by **degraded bottom-up reliability**

## Conclusions

### Summary of Findings

- Top-down spatial attention dynamically modulates the ventriloquist effect (VE) depending on bottom-up sensory reliability.
- Top-down modulation was minimal without actual visual input, emerging robustly only when the visual stimulus was highly degraded.

### Implications

- Top-down influence does not independently drive the VE; instead, it requires a minimum level of bottom-up sensory evidence.
- The supra-additive interaction points to a synergistic effect on the VE: top-down influence amplifies the weight of unreliable sensory signals, rather than merely adding an independent spatial bias.

## References

- Körding, K. P., Beierholm, U., Ma, W. J., Quartz, S., Tenenbaum, J. B., & Shams, L. (2007). Causal inference in multisensory perception. *PLoS one*, 2(9), e943.
- Rohe, T., & Noppeney, U. (2018). Reliability-weighted integration of audiovisual signals can be modulated by top-down attention. *eneuro*, 5(1).
- Alais, D., & Burr, D. (2004). The ventriloquist effect results from near-optimal bimodal integration. *Current biology*, 14(3), 257-262.

### Acknowledgement

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