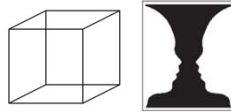


Pitch-brightness crossmodal correspondence modulates perceptual selection of the Necker Cube

Yeha Cha, Minseong Jin & Chai-Youn Kim | School of Psychology, Korea University, Korea.

Introduction

- When a single ambiguous figure, such as the Necker Cube or Rubin's face/vase, viewed, perception alternates between two visual interpretations, which is dubbed bistable perception.
- Crossmodal correspondences (CMCs) refer to associated stimulus pairings across different sensory modalities (Melara, 1989).
- A previous study demonstrated that CMCs can bias the dominant perceptual selection of a bistable stimulus based on figure-ground reversals: the Rubin's face/vase (Zeljko et al., 2021). However, it remains unclear whether such effects of CMCs can be generalized to other types of bistable perception.



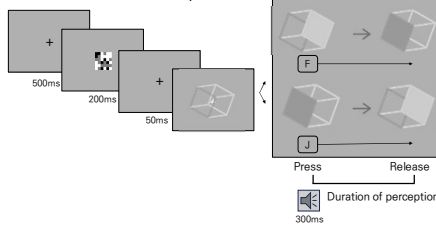
Research Question

This study used the Necker Cube, which is a bistable stimulus based on perspective reversals, to examine whether CMCs can affect to the perception of Necker Cube.

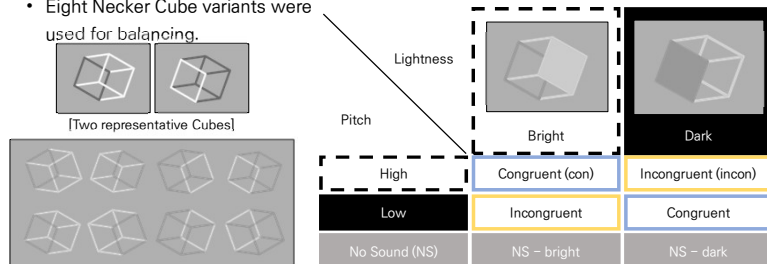
Methods

- Participants**
 - 30 (11 males)
 - Aged 19 ~ 38 (24.3, SD ± 4.3)
- Stimuli**
 - Auditory Stimulus**
 - Pure tone, 300ms
 - 1800 Hz (High) or 600 Hz (Low) or No Sound
 - 3:3:2 ratio
 - Visual Stimulus**
 - Necker Cube
 - One face consisted of four bright (or dark) edges, while the remaining eight edges were shown in the opposite luminance level.
 - Eight Necker Cube variants were used for balancing.

- Procedure**
 - 4 Blocks, 64 trials per block



- Condition**



Analyses

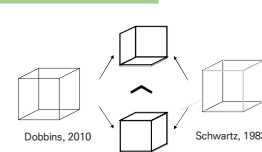
- Trimming window: 300ms ~ 2000ms
- 3 participants were excluded.
- all participants retained a balanced ratio of con, incon, NS (approximately 3:3:2).
 - χ^2 goodness-of-fit test: *ns*, confirming no systematic bias in trial loss.

- Normalized duration of perception in condition A

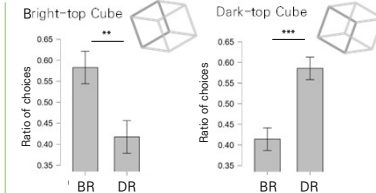
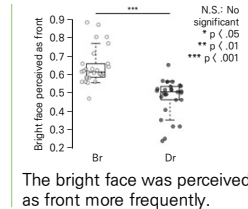
$$= \frac{\text{Mean duration of condition A}}{\text{Mean duration of condition A in NS}}$$
- Normalized duration of perception in condition A > 1: longer than NS condition

Results

Top view bias

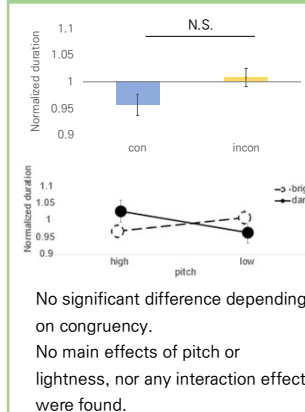


The Necker Cube is more often perceived from above, or with its brighter face seen as the front.



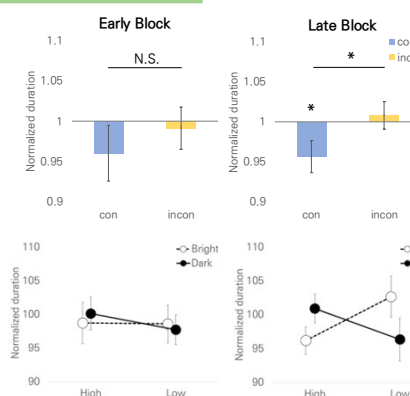
Overall, the bright face was chosen more frequently. Participants also showed a strong top-view bias, irrespective of the brightness of the front face.

Overall Results (All Blocks Combined)



No significant difference depending on congruency. No main effects of pitch or lightness, nor any interaction effect, were found.

Block-wise Differences



Early Block: No significant difference between congruency conditions was observed. Neither pitch nor lightness showed a main effect, and no interaction was found.

Late Block: A significant difference emerged ($p = .011$). Main effects were absent, but a significant interaction effect was detected ($p = .008$).

Reversal Mechanisms?

- Satiation theory:** congruent stimulation accelerates neural fatigue of one percept, prompting earlier switching.
- Predictive coding:** matching audio-visual cues reduce prediction error, allowing rapid model updating.
- Quantum Zeno view:** transient attention shift by sound releases perceptual "freezing," enabling reversal.
- Crossmodal integration:** simultaneous, spatially aligned cues enhance visual salience via multisensory neurons, expediting perceptual change.

Discussion

The effect of crossmodal correspondence—faster reversals in the congruent condition—appeared only in the late block, suggesting that repeated exposure strengthened the pitch-brightness association. Shorter durations in the congruent condition may result from multiple mechanisms, such as efficient audio-visual interaction facilitating faster perceptual updating. Future studies using eye tracking could clarify how auditory cues modulate visual perception.

References

- Melara, R. D. (1989). Dimensional interaction between color and pitch. *Journal of Experimental Psychology: Human Perception and Performance*, 15(1), 69-79.
- Zeljko, M., Grove, P. M., & Kritikos, A. (2021). The Lightness/Pitch Crossmodal Correspondence Modulates the Rubin Face/Vase Perception. *Multisensory Research*, 34(7), 703-713.
- Dobbins AC, Grossmann JK. Asymmetries in perception of 3D orientation. *PLoS One*. 2010 Mar 4;5(3):e9553. doi: 10.1371/journal.pone.0009553. PMID: 20209050; PMCID: PMC2832009.
- Schwartz, B. J., & Sperling, G. (1983). Luminance controls the perceived 3-D structure of dynamic 2-D displays. *Bulletin of the Psychonomic Society*, 21(6), 456-458.