Multiple factors influence perception in the audiovisual bounce effect

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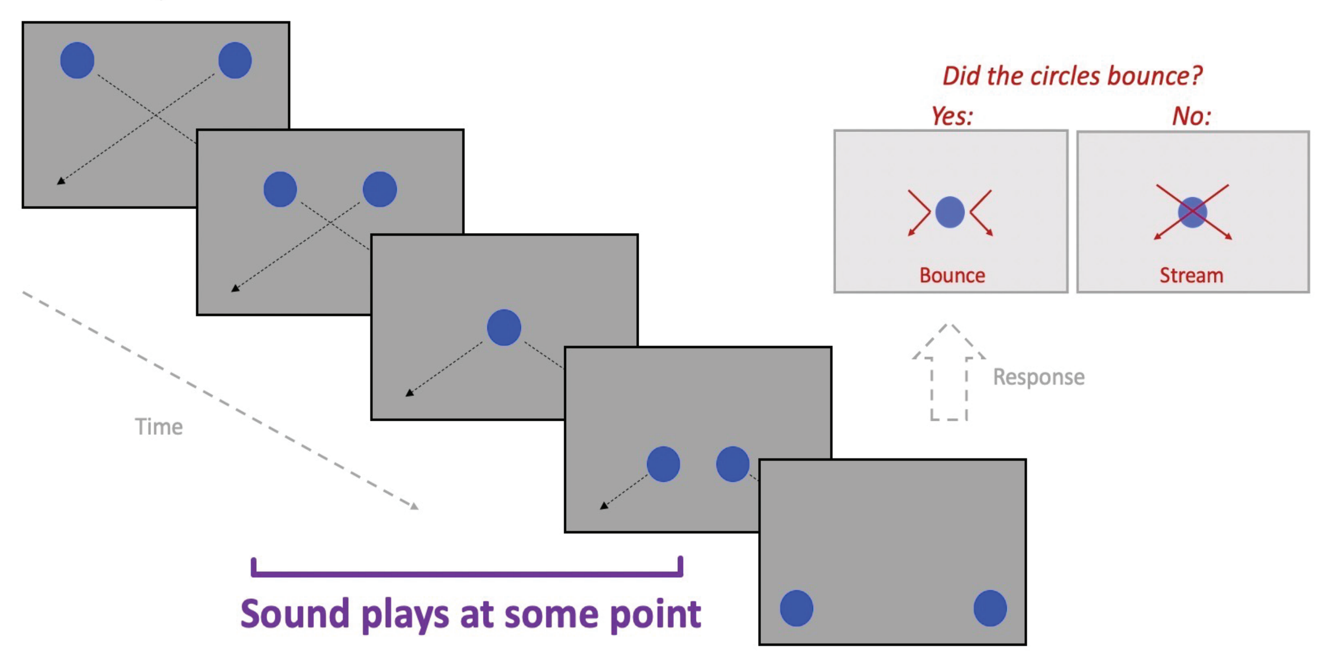
Introduction

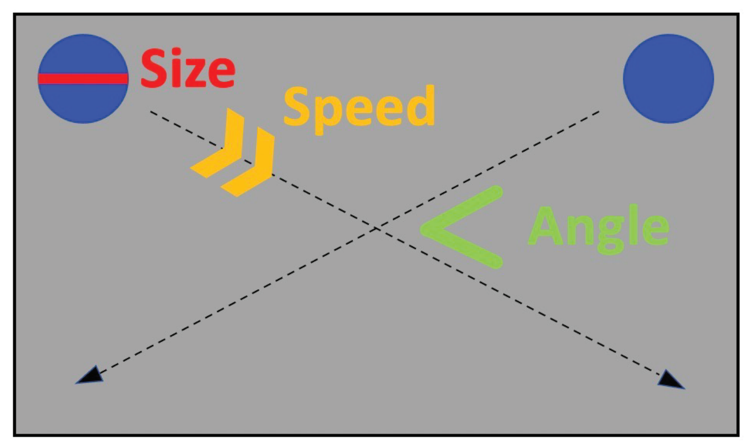
- Auditory and visual information influence one another in the brain
- The Audiovisual Bounce Effect (ABE) [1,2,3] is an illusion in which auditory stimulation affects visual perception.
    - Two circles move towards each other on a computer screen and meet in the middle. If a sound is played when the circles meet, the viewer is more likely to perceive them as bouncing, as opposed to streaming past each other.
    - We lack a full description of the perceptual and neuronal factors in the ABE.
- We performed a behavioral experiment to better understand stimulus factors that modulate viewer perception, as well as the impact of previous trial outcomes on perception.
- We conducted an fMRI study to:
    - Localize multisensory integration involved in ABE [5,6], specifically to guide future high resolution studies
    - Investigate whether distinct brain states influence ABE perception.
    - Understand individual differences in behavioral factors and neural correlates modulating the ABE.

Methods

Paradigm:



Parameters:



Selected randomly for each trial:
- Distance from when sound played: 0-13.9 DVA (degrees of visual angle) from center
- Size: 1.48-4.45 DVA
- Speed: 0.14 – 0.57 DVA per window flip
- Collision angle: 1.08-2.06 radians

Data Collection:

Behavioral Study:
- 12 Participants, 4 male
- Mean age : 26 +/- 6std years
- 1000 trials in 4 blocks each

fMRI Study:
- 7 Participants, 3 male
- Age : 27 +/- 3std years
- 520 trials each, in two sessions
- Experimental Details: Subjects completed two sessions in a Siemens 7T Magnatom MRI. Each session consisted of a T1-weighted MP2RAGE (0.7 mm iso resolution) and five 10-minute (400 vol) runs of task fMRI (CMRR EPI; TR=1.5 s; TE=25 ms; res=1.5 mm iso; multi-band factor=3; GRAPPA=2; partial Fourier=0.75). We also collected one 10-volume run of opposite phase encoding to correct spatial distortions.

Behavioral Results

Parameter Modulation:

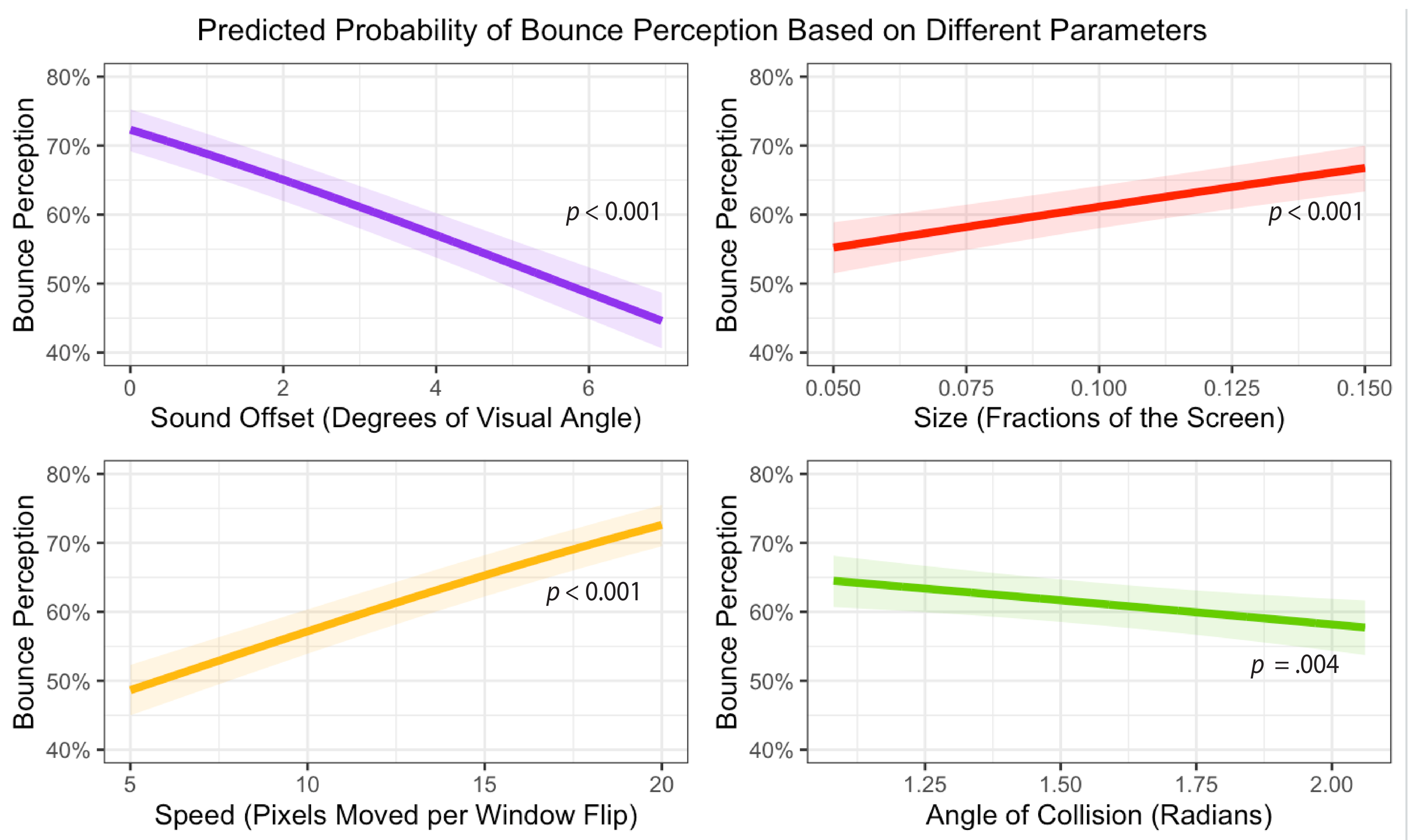


Figure 1. Predicted bounce perception based on different paradigm parameters from logistic mixed effects model. Small sound offset, high circle speed, large circle size, and large collision angle are associated with higher bounce perception. The shaded reagion is the 95% confidence interval.

History Effect:

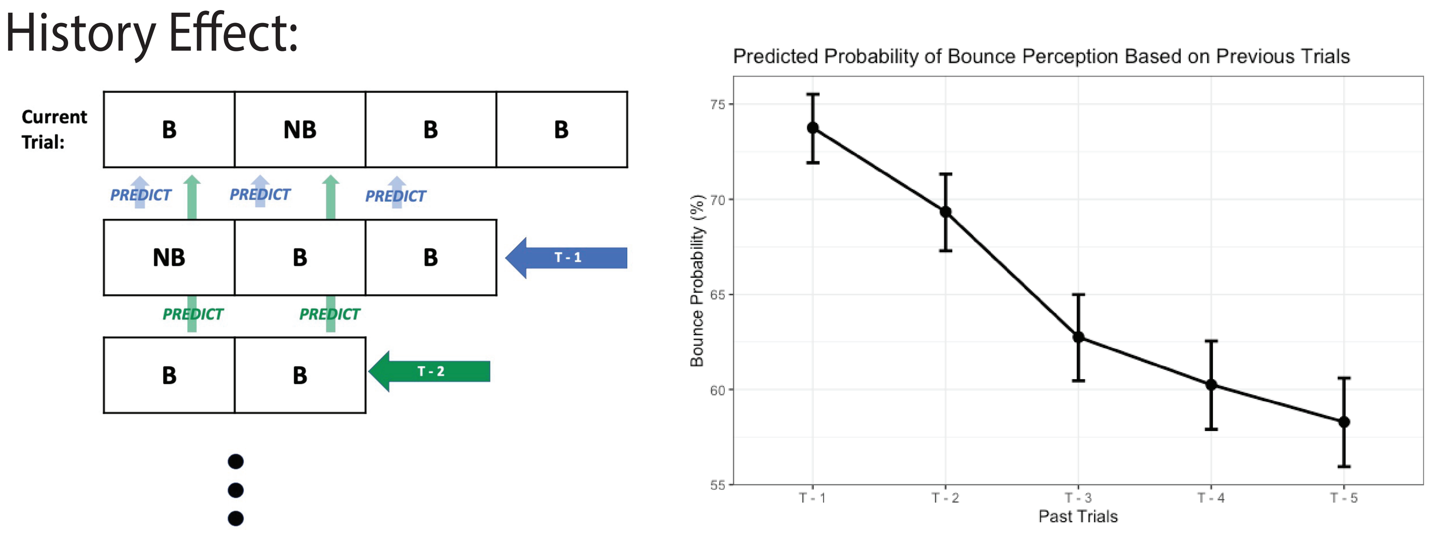


Figure 2. Schematic of "History" calculation. Past perceptions impact current trial likelihoods, i.e. if a trial is perceived as a bounce, the next trial is 74% likely to also be perceived as a bounce. This history effect is larger than any of the 4 stimulus variation effects that we examined.

fMRI Results

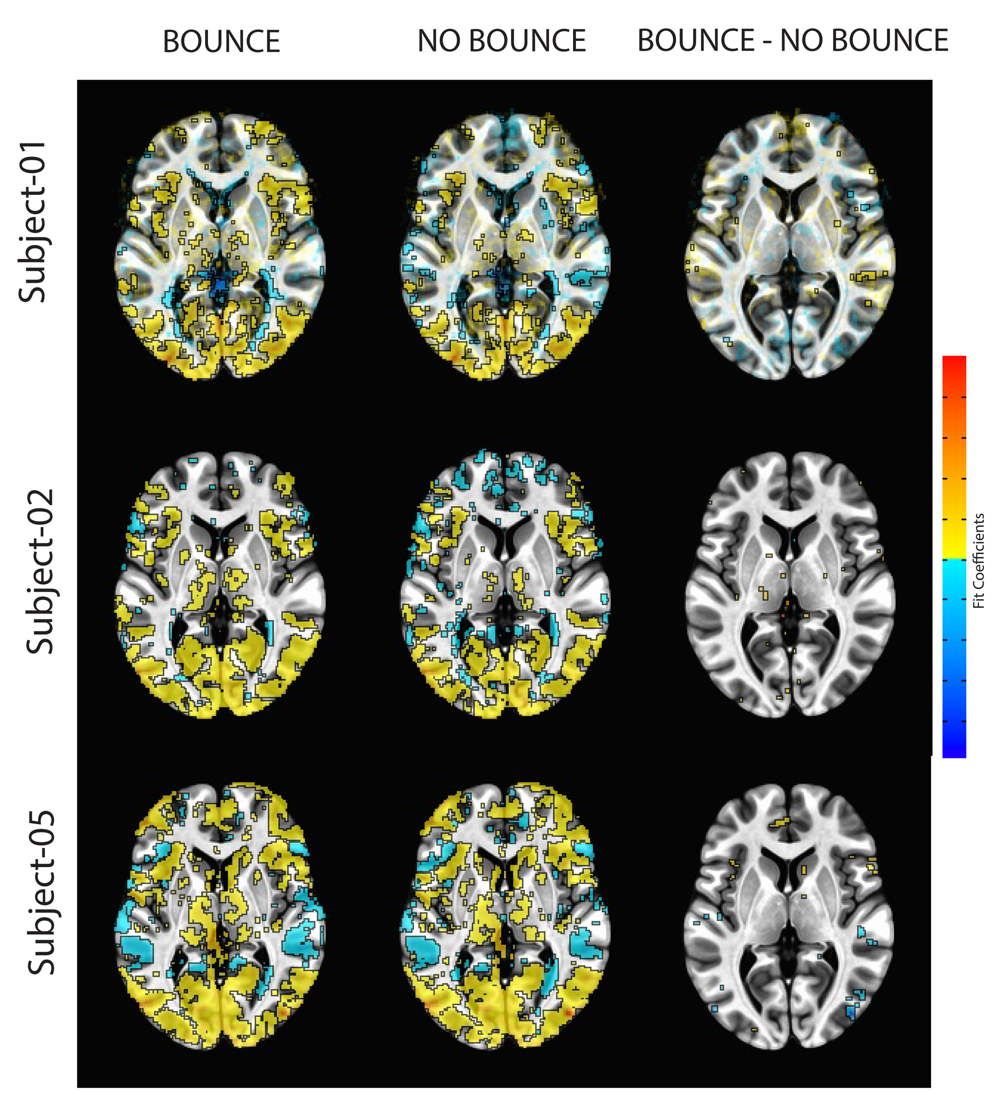


Figure 3. Activation maps from 3 example subjects showing Bounce, No Bounce, and Bounce vs. No Bounce contrast conditions. The color bar range is, +/-16 in the Bounce and No Boucne maps, and +/-4 in the contrast maps. Significant values ($p < 0.001$), are outlines in black. There is very little consistancy in activity across subjects.

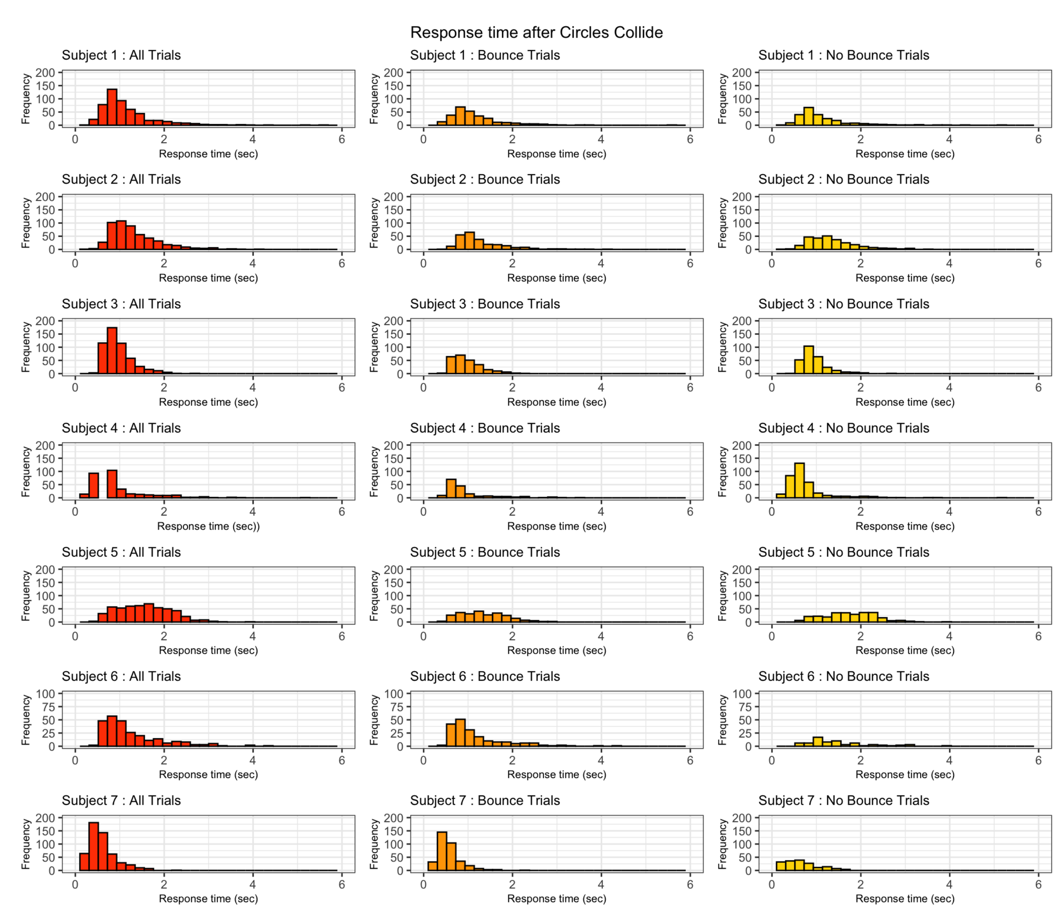


Figure 4. Response time distributions for each subject, split by perception. Clear differences in response time can be observed across subjects and trials. Our original analyses of fMRI data did not account for these differences. We hypothesize this might be one factor contributing the inconsistencies in activation seen in Figure 3 (Note: subject 6 completed half as many trials as everyone else).

Discussion of fMRI results:

- Different participants have different activations for Bounce vs No Bounce contrast. We hypothesize that this may be due to any of the following causes:
    - Differences in response timing that are not accounted for in the current fMRI analyses (see Figure 4)
    - Very wide parameter space could be affecting perception
    - Task compliance
    - Unmodeled sources of variation, like the trial history behavioral effect

Conclusions and Future Directions

- Studying how different parameters impact the audiovisual bounce effect allows us to better understand contextual aspects of multisensory integration
- ABE perception is influenced by more parameters than just the sound timing (as previously shown):
    - Circle Size, Speed, and Collision angle are significant across participants
- There are large individual differences in perception across individuals .
- Trial history has an impact on perception, suggesting there may be different brain states associated with different perceptions.
- Current fMRI results are inconclusive, but reflect significant individual differences and warrent further investigation.

Moving Forward:
- Look deeper into collected fMRI data to localize audiovisual integration
- Investigate gaze location as a modulator for perception using eye tracking
- Move to higher resolution studies to better understand integration at the layer level

References

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