# Behavioral and neural factors underlying the perception of the audiovisual bounce effect

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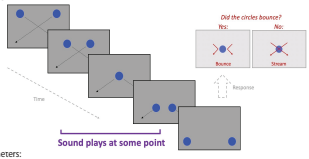
## INTRODUCTION

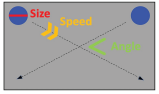
- Auditory and visual information interact in the brain.
- The Audiovisual Bounce Effect (ABE)[1,2,3] is an illusion in which auditory stimulation affects visual perception.
  - Two circles move towards each other on a computer screen and meet in the middle. If a sound is played when the circles meet, 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 modulating the ABE.
- We performed a behavioral experiment to better understand stimulus factors that modulate the ABE, as well as the impact of previous trial outcomes on perception.
- We conducted an fMRI study to:
  - Localize multisensory integration involved in ABE [3,4] , specifically to guide future high resolution studies.
  - 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: 0.84 – 3.42 DVA per 100ms
- Collision angle: 61.8-118.0 degrees

Data Collection:

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

fMRI Study:
- 7 Participants, 3 male
  - Mean age : 27 +/- 3 years
- 520 trials each, in two sessions

fMRI 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), with minimum trial ISIs of 6s . We also collected one 10-volume run of opposite phase encoding to correct spatial distortions.

## BEHAVIORAL RESULTS

Parameter Modaultion:

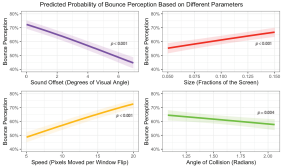



Figure 1. Marginal effects of different paradigm parameters on bounce perception, from a logistic mixed effects model. Small sound offset, high circle speed, large circle size, and large collision angle are associated with higher bounce perception. The shaded reagion is the 95% confidence interval.

History Effect:

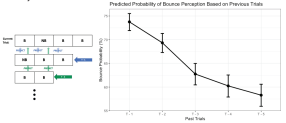



Figure 2. Schematic of "History" calculation. Past perceptions impact current trial likelihoods, i.e. if a trial is perceived as a bounce, the next trial is 74% likely to also be perceived as a bounce. This history effect is larger than any of the 4 stimulus variation effects that we examined.

Intersubject Variability:

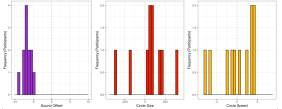



Figure 3. Correlations of Bounce Perception Rate vs each of the parameters, for the 12 participants. This demonstrates the variability among individuals, with some having opposite (negative or positive) correlations for Size and Speed. Angle is not shown because there is no significant correlation for individual participants.

## fMRI RESULTS

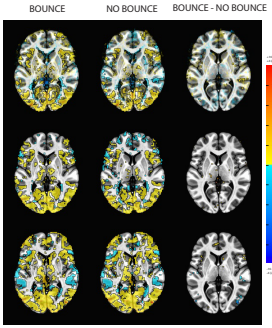



Figure 4. Activation maps from 3 example subjects showing Bounce, No Bounce, and Bounce vs. No Bounce contrast conditions. We modeled trials as Bounce or No Bounce based on subjects responses. All trials were modeled as 3s events with onsets aligned to the start of the stimuli. $p < 0.001$, uncorrected, are outlined in black.

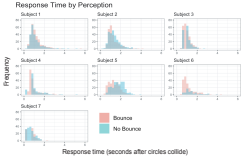



Figure 5. Response time distributions, by subject, for bounce (pink) and no bounce (blue) perceptions. The differences in distributions differ between conditions for some subjects.


Figure 6. Response time distributions, for all trials, for each subject. Different subjects have different response time distributions. We did not account for this variability in the fMRI analysis, and this may be contributing to the differences in brain activation across subjects.

## 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 Figures 5 and 6)
- Very wide parameter space could be affecting perception
- Task compliance
- Unmodeled sources of variation, like the trial history behavioral effect

## CONCLUSIONS and FUTURE DIRECTIONS

- 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 people, including differences in response timing.
- Trial history has an impact on perception.
- Moving Forward:
  - Work to understand the causes of intersubject variability.
  - In future scans, acquire and investigate gaze location as a modulator for perception and intersubject variability.

## AKNOWLEDGEMENTS

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