Is a round shape integrated with a /bouba/ sound?
Enhanced neuronal signals at the intermodulation frequencies of congruent audio-visual stimuli

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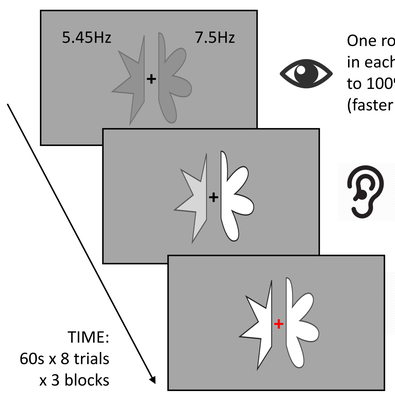
QUESTION:
Are sounds and shapes integrated?

Sound-shape crossmodal correspondence is the association between abstract shapes and seemingly unrelated sounds, such as associating a round shape with a /bouba/ sound and a spikey shape with a /kiki/ sound (Spence, 2011).

Are the stimuli naturally paired in crossmodal correspondence integrated? We used steady state evoked potentials (SSEPs), to examine if and how responses to audio-visual stimuli congruent with sound-shape correspondence are integrated.

METHOD

Procedure and Stimuli



One round and one spikey half-shape was presented in each hemifield, both contrast-modulated from 0 to 100% at either 5.45Hz (slower flickering) or 7.5Hz (faster flickering).

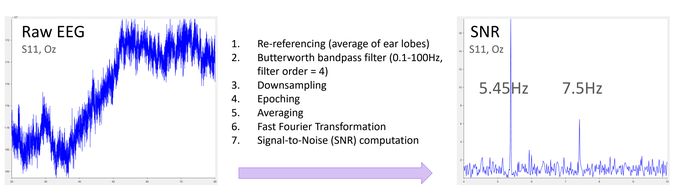
Participants either heard no sound (baseline, for distinguishing good and poor activators), /ba/ or /ki/ sounds. The syllables were repeated at 3Hz.

Participants monitored the color of the central fixation cross and made a key press as fast as possible when it turned red.

Counterbalanced across trials: which side the shape is presented
Counterbalanced across participants: which frequency each shape is associated with; the order of which the auditory conditions were done.

EEG data pre-processing

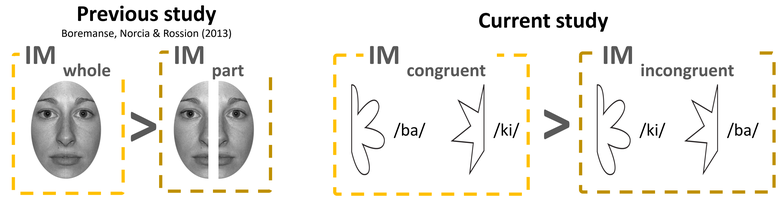
EEG recorded by BioSemi ActiveTwo (32+8 channels) and processed by Letswave 6.0

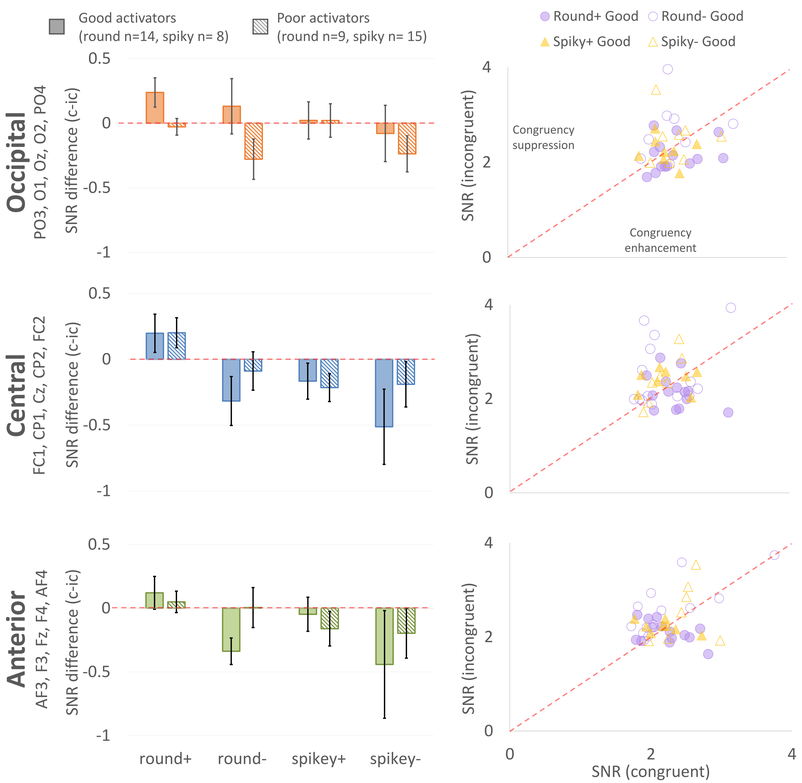


1. Re-referencing (average of ear lobes)
2. Butterworth bandpass filter (0.1-100Hz, filter order = 4)
3. Downsampling
4. Epoching
5. Averaging
6. Fast Fourier Transformation
7. Signal-to-Noise (SNR) computation

RESULTS (Intermodulation frequencies)

Hypothesis: If corresponding crossmodal stimuli are integrated, then IM (Intermodulation, sum or differences of two frequencies) responses should be enhanced for congruent compared to incongruent pairings.

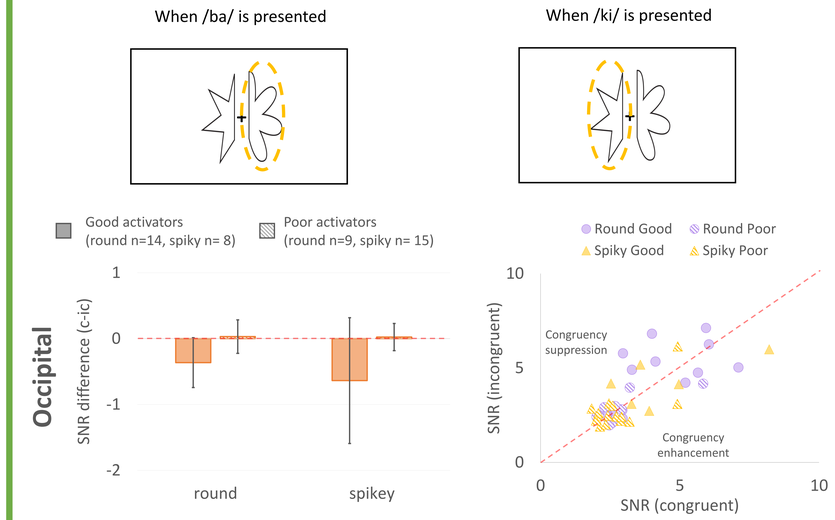




We found *shape-specific* enhanced occipital IM response and *difference-specific* suppressed central/anterior IM response for congruent sound-shape pairs.

RESULTS (Fundamental frequencies)

Hypothesis: If sound-shape correspondence involuntarily directs attention, the SSEPs of a shape should be enhanced when presented with a congruent compared to incongruent sound.



We found no consistent effects of enhanced neural processing of a shape when presented with a congruent sound.

CONCLUSION:
Yes sounds and shapes are integrated*

* Only when looking at IM sum of round shape and congruent sound
Further research is needed to understand the following:

1) Why is IM congruency effect specific to shape type and IM type?
2) What explains the individual differences in entrainment?
3) What is the role of attention on the integration (IM) and orienting effect (fundamental frequency) of sound-shape correspondence?

References:
Boremanse, A., Norcia, A.M., & Rossion, B. (2013). An objective signature for visual binding of face parts in human brain. Journal of Vision, 13(11), 1-18.
Spence, C. (2011). Crossmodal correspondences: A tutorial review. *Attention, Perception and Psychophysics, 73*, 971-995.
Others: Letswave 6.0 (www.nocions.org/letswave)

If you have questions, please email
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