Neural Basis of the Ventriloquist Illusion

Bonath, Noesselt, Martinez, Mishra, Schwiecker, Heinze, and Hillyard
Investigating the Ventriloquist Illusion

- Behavioral responses
- EEG
- fMRI
ElectroEncephaloGraphy (EEG)

- Neurons use electrical potentials to communicate.
- Multiple, aligned, synchronously-firing neurons produce enough voltage change to be read by electrodes on the scalp.
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Good and bad about EEG

- Temporal resolution is great!
- Spatial resolution is not so great (scalp maps can be misleading), but methods exist for estimating sources
Event Related Potentials

EEG = Signal + trial-independent noise
fMRI - what is it?

- Angelo Mosso's 19th century balancing experiment
- Late 19th century: blood flow in dog brain
- Blood flow related to brain activity in 1948 (Kety and Schmidt).
- Hemodynamic response
How does fMRI measure bloodflow?

- Giant magnet creates magnetic field in and around head
- Hemoglobin is diamagnetic when oxygenated, paramagnetic when not
- Measuring this difference is called Blood-Oxygen Level Dependent (BOLD) imaging
Good and bad about fMRI

- Bad temporal resolution (response + imaging)
- Good spatial resolution
### Questions about the tools?

<table>
<thead>
<tr>
<th>EEG</th>
<th>fMRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bad spatial resolution</td>
<td>Good spatial resolution</td>
</tr>
<tr>
<td>Good temporal resolution</td>
<td>Bad temporal resolution</td>
</tr>
</tbody>
</table>
What is the Ventriloquist Illusion?

- Spurious perception of sound source at a visual event's location

How does this illusion arise?

- Knowing where and when the illusion arises can tell us about how the visual and auditory signals are integrated for localization.

- Look at EEG and fMRI to find the origins
Experimental Set-up

- Ignore visual stimuli, report location of sound
- Also included blank condition

<table>
<thead>
<tr>
<th></th>
<th>Audio Left</th>
<th>Audio Center</th>
<th>Audio Right</th>
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<tbody>
<tr>
<td>Visual Left</td>
<td></td>
<td>✓</td>
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## Behavioral Results

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Respond Left %</th>
<th>SEM</th>
<th>Respond Center %</th>
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<tbody>
<tr>
<td>$A_L$</td>
<td>69.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.3</td>
<td>27.2</td>
<td>2.8</td>
<td>3.0</td>
<td>0.8</td>
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<tr>
<td>$A_C$</td>
<td>11.6</td>
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<td>18.2</td>
<td>2.6</td>
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<tr>
<td>$A_R$</td>
<td>2.3</td>
<td>0.7</td>
<td>20.7</td>
<td>1.8</td>
<td>75.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2</td>
</tr>
<tr>
<td>$A_{CV_L}$</td>
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<td>$A_{LVR}$</td>
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Revealing Multimodal Interaction (ERP)

- Difference waveform
  - $(AcVr + \text{blank}) - (Ac + Vr)$

- Blank added to account for prestimulus common response

- Multimodal waveforms separated by behavioral response
  - $(AcVr)_{\text{illusion}}$ and $(AcVr)_{\text{no-illusion}}$
Difference Waveform Components

- P 180 - Symmetrical in all conditions
- N 260 - Lateralized in illusion trials, not in no-illusion trials
fMRI Modulations

AV stimuli:
No illusion > Illusion:  

A stimuli:
Contralateral > Central:

Dipolar Sources of N260

Illusion trials:  
No illusion trials:
Lateralization

- Contralateral activation same for illusion trials as for when sound actually came from the illusory location

- Response found in Planum Temporale
  - What is the Planum Temporale?
Planum Temporale

- Responsible for acoustic spatial representation
N 260

- Previously noticed in audio-visual interaction, but not associated with localization

- Latency suggests feedback from higher multisensory areas
  - Retinotopic activity in extrastriate occipital cortex 80-120ms
  - Location-specific audio-visual interactions 140-190ms in occipito-temporal and parietal regions
  - Superior temporal cortex around 200ms
Attention? Probably not

- Lateralization may be due to attentional orientation to perceived sound location
- No differential BOLD response in attentional areas (anterior cingulate, posterior parietal cortex) between illusion/no-illusion trials
- Other behavioral results suggest visual attention has little influence on illusion
Response bias? Probably not

- Maybe audio perceived the same, but response drawn to visual location

- However, significant increase of responses to C when visual and audio presented on opposite sides

- Also, observed hemispheric differences in auditory cortex imply difference in perception
Behavioral Results Again (no response bias?)

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Neural Basis of Ventriloquist Illusion

- Illusion accompanied by contralateral response in auditory cortex

- Similar to response when sound actually comes from illusory location

- Response occurs between 230-260ms after stimulus onset

- Therefore: Auditory information is present very early, but localization itself may depend on longer time scales
  - Example of early information: MMN present for illusory shift of sound source