Background

- Emotional events are often remembered better than neutral events.1,2
- This emotional benefit to memory depends on the amygdala, a key brain region involved in both memory and emotion.1,2
- We have previously demonstrated that brief basolateral amygdala (BLA) electrical stimulation enhances memory in rodents3,4,5 and humans without eliciting an emotional response.5
- An electrophysiological marker of prior stimulation, theta and gamma synchronization and coherence, has been reported in medial temporal lobe (MTL) subregions at the 1-day delay.6
- The present study examined the lasting behavioral effects of BLA stimulation on memory enhancement without evoking subjective emotional arousal.

Previous Findings and methods

![Previous Findings and methods](image)

- Inman, Manns et al., (2018)

Methods

- Participants: 37 patients (21 females; M±SD = 36±15) with intractable epilepsy in the Emory University Hospital for intracranial monitoring (ECoG).
- Individual contacts implanted in both hemispheres in the basolateral amygdala (BLA).
- No epileptiform activity or stimulation awareness was elicited by the stimulation.
- Stimulation did not evoke emotional arousal in patients.
- No differences in stimulation-related memory enhancement based on the hemisphere of the stimulated amygdala.

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Stimulation condition</th>
<th>Delay</th>
<th>N subjects</th>
<th>N sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original</td>
<td>1 s after</td>
<td>1 day</td>
<td>14</td>
<td>14</td>
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<tr>
<td>Duration</td>
<td>1s or 3 s after</td>
<td>1 day</td>
<td>5</td>
<td>7</td>
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<tr>
<td>Timing</td>
<td>1s before, during, and after</td>
<td>1 day</td>
<td>12</td>
<td>15</td>
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<tr>
<td>Long Delay</td>
<td>1s before, during, and after</td>
<td>2-12 days</td>
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<tr>
<td>Total</td>
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<td></td>
<td>37</td>
<td>42</td>
</tr>
</tbody>
</table>

Study paradigm

- 8 Hz
- 50 Hz
- 0.5 mA

- Prior Direct Amygdala Stimulation
- Immediate Test
- Delayed Test 1-12 days

- Free Recall
  - 1. "Key"
  - 2. "Ship in Bottle"
  - 3. "Basketball"
  - 4. "Ring boyo"
  - 5. "Butterfly"

- Recognition
  - 1. 1s after image stim memory performance up to 12 days
  - 2. After image stim memory performance at 12 days

- 1s after stim
- 1 day delay
- 12 days delay

Ongoing analyses focus on examining the effects of amygdala stimulation on regions throughout the brain, beyond the MTL.

Conclusions & Current Directions

- Brief electrical stimulation to the human amygdala reliably improves long-term declarative memory up to 12 days for images of neutral objects without eliciting an emotional response.1
- Our team is currently examining amygdala stimulation on objects vs. scenes, with closed loop stimulation, and up to 1 week delay.
- Ongoing neural analyses examine the lasting effects of amygdala stimulation inside and outside of the medial temporal lobe up to 12 days.
- Ongoing analyses investigate amygdala stimulation parameters like electrode location, stimulation timing, and stimulation duration to better understand its memory modulatory effects.

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References