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Direct Electrical Stimulation Evidence for Dorsal Laryngeal Motor Cortex Area

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Highlights

Finding: Direct Electrical Stimulation causes laryngeal motor arrest due to disruption of late-stage or peripheral processes in speech production

Implication: Causal evidence for a dorsal motor area supporting laryngeal muscle control during language production

1-Introduction

- Proximate control of the laryngeal muscles during language production is supported by the ventral laryngeal motor cortex (vLMC), and controversially, by the dorsal laryngeal motor cortex (dLMC)[1,2,3]
- A recent study, utilizing bipolar stimulation to the dLMC, evoked laryngeal movements and involuntary vocalizations, suggesting a causal role of this region for feedback control of laryngeal muscles[4]
- We present causal evidence obtained using DES in a patient undergoing language mapping during removal of a right frontal lobe tumor for a direct role of dLMC in controlling laryngeal muscles

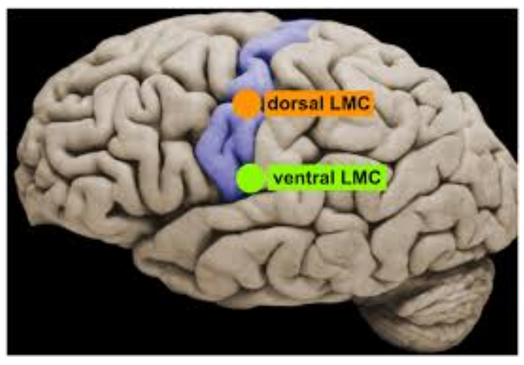

Figure 1. Depiction of the ventral laryngeal motor cortex (vLMC) and the more controversial dorsal laryngeal motor cortex (dLMC). Figure from Belyk et al., (2017). [1]

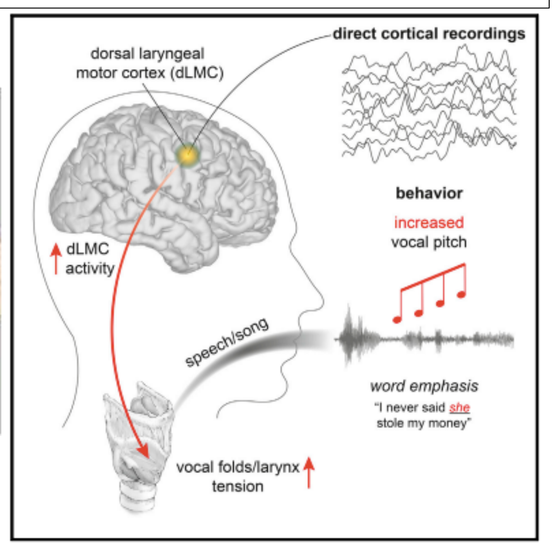

Figure 2. Summary of recent findings by Dichter et al, 2018 in regard to function of dLMC. Figure from Dichter et al., (2018). [4]

2-Methods

- During the awake portion of surgery, JE completed 62 trials of a picture naming task (Fig 3a)
- 33 trials were paired with DES and 29 were trials without
- Of the 33 trials paired with stimulation
  - 11 trials were associated with stimulation to the DLMC
  - 22 trials were associated with stimulation to surrounding structures

3-Results

- JE produced correct and fluent responses on all 29 trials not paired with DES, and 21 of 22 trials associated with stimulation to surrounding structures (Fig 3b)
- All (11/11) trials involving stimulation of the dLMC involved notable disruptions to JE's speech (Fig 3c)
  - Errors marked by involuntary guttural vocalizations, non-linguistic voiced intrusions, or delayed initiation of speech (i.e. transient 'laryngeal speech arrest')
- In 6 'laryngeal speech arrest' trials, stimulation of dLMC prevented JE from producing any form of speech for the entire duration of stimulation
- On speech arrest trials, JE was able to resume the task and respond rapidly and accurately, as quickly as 150 ms after stimulation ended

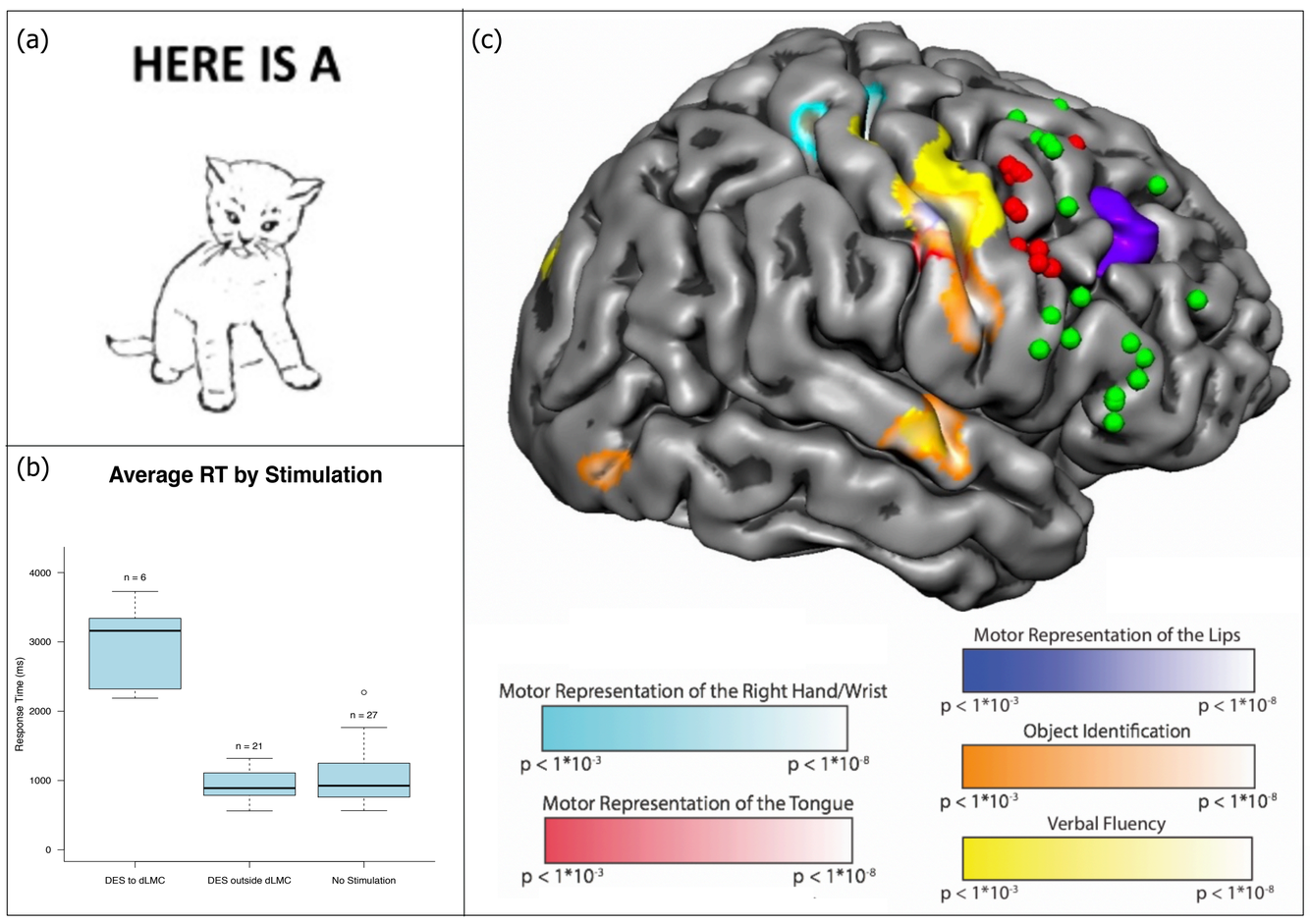

Figure 3. (a) Example of stimuli presented to patient in operating room. (b) Brain mesh with all stimulations and color-coded behavioral results, as well as with pre-operative fMRI. (c) Box-plot depicting distributions of RT given stimulation presence and localization

4-Conclusions

- The location of the dLMC, as defined by intraoperative stimulation mapping, was just anterior to primary speech motor cortex as defined by preoperative functional MRI [1,2,3,4]
- An important clue about the nature of processes supported by dLMC is provided by the observation that when stimulation was removed from the region, JE could produce a correct response within 150ms on several occasion.
- Rapid time-to-recovery from speech arrest indicates that stimulation of dLMC disrupted speech production at a peripheral level of processing, supporting the inference that dLMC supports control of laryngeal muscles

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