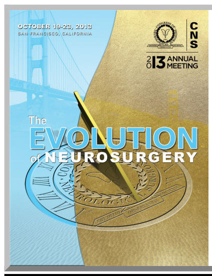

A Probabilistic Map of Functional Organization of the Human Ventral Sensorimotor Cortex (vSMC) by Cortical Electrical Stimulation

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Introduction

In 1937, Penfield and Boldrey published their seminal work on the homuncular organization of human sensorimotor cortex. Despite playing an important role in speaking, eating, and oral gestures, the ventral half of the SMC (vSMC) remains understudied. In this study we qualitatively describe stimulation-evoked responses of the vSMC and determine the probability of observing a given response at any given cortical position when stimulated in an individual.

Methods

Video, photographs, and MRI stereotactic co-registration images of intraoperative electrical stimulation of the vSMC were collected for 33 patients undergoing awake craniotomy. Stimulation sites were converted to a 2D coordinate system based on anatomic landmarks (Fig 2). Patient responses to stimulation were iteratively reviewed & classified. Probabilistic maps of stimulation responses were generated.

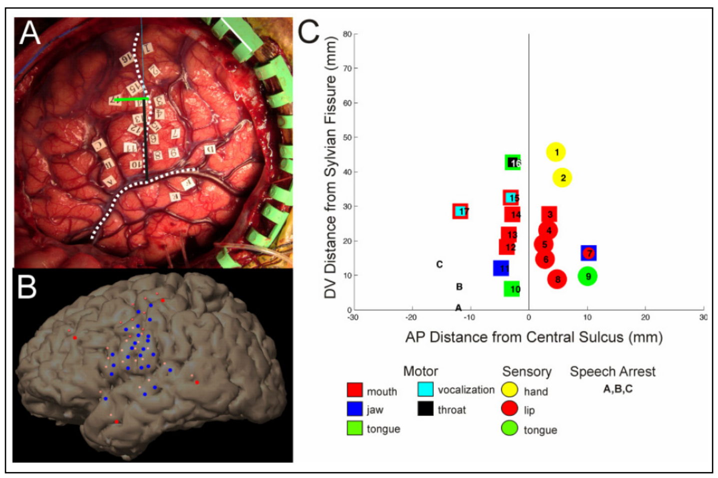

Figure 1. Intraoperative photograph after the completion of cortical mapping with electrical stimulation. Example AP (green line) and DV (black line) measurements are shown for site #17. The central sulcus and Sylvian fissure are identified with the assistance of stereotactic neuro-navigation (B) and traced on the photograph (white dashed lines). All stimulation response sites for the individual are plotted in the 2-dimensional AP, DV coordinate system (C).

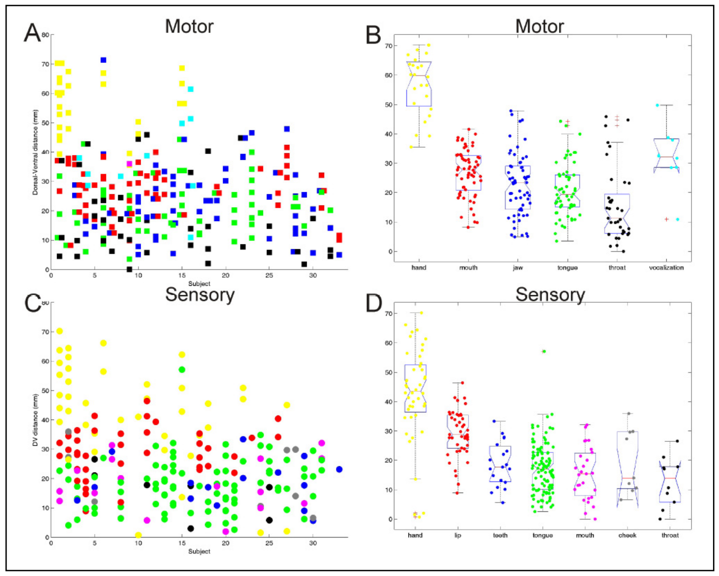

Figure 2. Motor (A) and sensory (C) responses to stimulation are shown in dorsal ventral order for 33 individual patients. Not all response types are present in each individual, but the DV order is largely preserved. The population distributions of DV locations are shown for motor (B) and sensory responses (D).

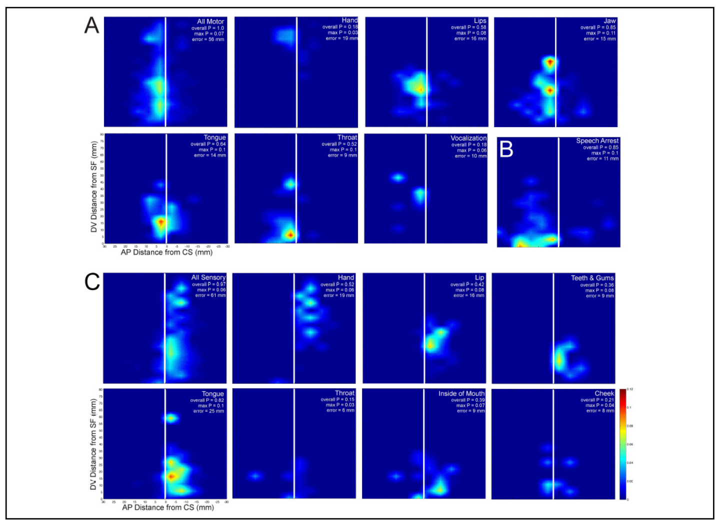

Figure 3. vSMC probability maps for observing a motor (A), speech arrest (B), or sensory (C) response to electrical stimulation

Results: We identified 194 motor, 212 sensory, 61 speech arrest, and 27 mixed responses. Responses were complex, stereotyped, and mostly non-physiologic movements, involving hand, orofacial, and laryngeal musculature. Within individuals, the presence of complete representation of the oral movements varied, however the dorsal-ventral order was maintained (Fig 2). The most robust motor responses were: jaw (probability = 0.85), tongue (0.64), lips (0.58), and throat (0.52). Vocalizations were seen in 6 patients (0.18) near lip and dorsal throat areas. Sensory responses were spatially dispersed however patients' subjective reports were highly precise in localization to parts of the mouth. The most robust included: tongue (0.82), and lip (0.42). The probability of speech arrest was 0.85, highest 15 - 20 mm anterior to the central sulcus and just dorsal to the Sylvian fissure in the region of the pars opercularis (Fig 3).

Conclusions: We report probabilistic maps of function in the human vSMC based on intraoperative cortical electrical stimulation. These results define the expected range of mapping outcomes in the vSMC of a single individual, and shed light about the functional organization of the vSMC supporting speech motor control and non-speech functions.

Learning Objectives: By the conclusion of this session, participants should be able to:
1) Describe the expected responses to cortical electrical stimulation of the vSMC
2) Discuss the range of individual variability in responses to stimulation
3) Describe the spatial probability distribution of a given stimulation response in the vSMC

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