Electrocorticographic Changes in Alpha, Beta, and Gamma Band Power Following Tactile Sensation in Humans

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Introduction

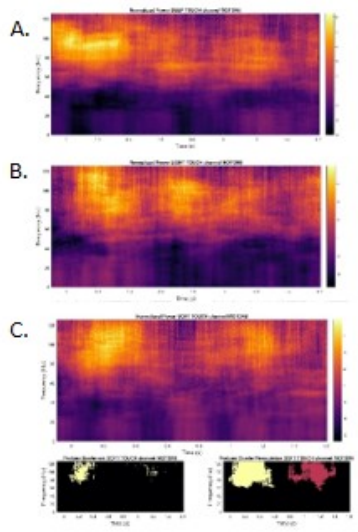
Efforts to produce artificial somatosensation in non-human primates [1,2], and humans [3,4,5] have produced reliable percepts, however the qualitative descriptions are decidedly artificial in nature. We sought to understand the neurophysiologic properties of the local field potential recorded from electrocorticography (ECoG) following real touch in humans.

Methods

Three epilepsy patients (S01: Female age 21, S02 Female age 50, S03: Male age 25) were implanted with a subdural electrocorticography grid over the hand region of somatosensory cortex (S1) (Left sided=2). Grids were high-density ECoG grids with 2mm contacts spaced 3mm apart (FG64C-MP03, Ad-Tech), except in S03, where a standard spaced ECoG grid was used with 4mm contacts spaced 1cm apart (AU4X5P2, Integra Life Sciences Corporation). Location was confirmed by imaging and mapping. A region on the hand, mapped on the grid was subject to 15 trials each of three types of mechanical touch: deep touch (indentation of the skin), light touch (no indentation of the skin), and soft touch (light brushing, repetitively).

Local field potential from these trials was then analyzed off-line using custom Matlab software. Power was calculated and normalized, and then evaluated for significance using a permutation test (N=5,000) compared to the inter-trial intervals. Alpha (8-15 Hz), beta (15-30 Hz), gamma (30-60 Hz), and high-gamma (HG, 60-160 Hz) were evaluated.

Figure 1. Normalized power in a time-frequency analysis for S02 in a single channel over S1.

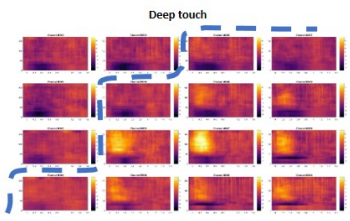


Touch onset is marked at 0. A. Deep touch. Power in the HG (60-160 Hz) band is noted to increase earlier than the other types of touch. B. Light touch C. Soft-touch. Inset. Statistical analysis with a cluster-based permutation test is seen.

Results

All three types of touch showed significant decreases in power in the alpha (8-15 Hz) and beta (15-30 Hz) bands following the onset of touch and returned to baseline around 400ms after onset in the electrode pair associated with the dermatomal region. The spread of high gamma band activity (60-160 Hz) showed a significant increase in power centered around 300ms after touch onset and extinguishing around 600ms. All changes happen earlier in deep touch and light touch vs soft touch ($p < 0.05$) (see Fig 1 and Fig 2).

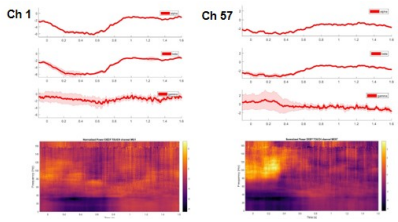
Figure 2. Normalized power for S01 across 16 channels of the grid during deep touch.



The dotted line represents the central sulcus based on mapping; to the left is M1 and to the right S1. High-gamma activity increased most strongly in the electrodes mapped to the area touched. A decrease in alpha and beta activity can be seen throughout the electrodes, including those as far away as the edges of the grid.

The decrease in alpha and beta power was found in the electrodes surrounding the primary two electrodes and extended throughout the grid (see Fig 2 and 3).

Figure 3. Normalized power in S01 during deep touch in channels farthest from the channel of interest.



Top, spectral analysis averaged over the frequency bands alpha, beta, and gamma in channels 1 and 57, the two electrodes at the edge of the grid, as far away as 2.34 cm from the electrode of interest (Ch 47), likely in motor cortex.

Conclusions

Decreases in alpha and beta band power were associated with touch onset as well as an increase in high gamma power centered over the area of S1 associated with the area of touch; similar to prior work.

Learning Objectives

By the conclusion of this session, participants should be able 1) Describe the importance of changes in alpha, beta, and gamma power following mechanical touch. 2) Discuss, in small groups, the implications of changes in frequency bands from mechanical touch in terms of encoding percepts. 3) Identify an effective strategy for creating artificial sensation in a somatosensory brain computer interface system.

References

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