Tactile information processing associated with the primate hand is altered by motor cortex lesion

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Abstract

Introduction

Tactile information from the fingertips is crucial for motor control underlying manual dexterity (Smith, 2009). The neuronal processes of this sensorimotor integration remain however poorly understood.

The primary motor cortex (M1) is involved in somatosensory processing in primates. This has been suggested, among others, by sensory inputs from passive hand movements and tactile stimulation recorded in M1 (Rosén and Asanuma, 1972; Wartenberg et al., 1991) by somatosensory evoked potentials recorded after lesion of M1 hand representation (Nudo et al., 2000) and by an increase of activity in the primary somatosensory cortex (S1) forelimb area during reversible inactivation of the M1 forelimb area (Sasaki and Gamba, 1994).

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Material, Methods and Results

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1 part: 
- Macaca fascicularis under general anaesthesia
- 32-electrode EEG recordings of SSEP (Gindrat et al., 2014)

EEG data analysis by using EEGLAB and custom MATLAB scripts (affiliated location based on threshold 1 µV) and on probability distribution (SSD, Macro S-100HC average reference)

Individual passive tactile stimulation (supra-threshold 2-ms pulses, filtered around 1 Hz randomly delivered to the fingertips of right thumb, index finger and middle finger (contralesional hand) with solenoid tappers (Heijo Research Electronics, Beckenham, UK)

Discussion

The M1 lesion had a drastic impact on tactile sensory processing from the fingertips. Interestingly, in comparison to other fingertips, sensory processing from the thumb tip was the most affected.

- We do not think that the lesion-induced distortions in volume conduction could explain the post-lesion observed changes in scalp signals as:
  - 1) both latency and amplitudes were substantially altered after the lesion.
  - 2) the middle finger signals remained largely unaffected by the lesion.
  - 3) the lesion was not between the dipole and the head surface.

- The distinct post-lesion evolution of the finger use according to the tasks suggests that the post-lesion/tactile signals were not a substitute for the normal tactile signals.

- We hypothesise that the M1 lesion may have damaged the pre-existing strong sensorimotor interactions which are normally based toward the hand motor cortex.

Discussion

Goals

1) To investigate how tactile information processing from the fingertips is affected by a unilateral lesion of the hand area in M1 in non-human primates when stimuli are presented repeatedly.

2) To determine the potential validity of cortical activity evoked by tactile stimulation to the fingertips to diagnose e.g. motor cortex damages, instead of the conventional electrical stimulation (more painful) or MRI (more expensive).

Methods

Passive tactile stimulation was performed on the forelimb contralateral to the lesion. Positive waveforms were measured with 10 Hz pulse trains. Tactile stimulation was delivered to the fingertips of the right thumb, index finger and middle finger (contralesional hand) with solenoid tappers (Heijo Research Electronics, Beckenham, UK).

Results

1 Voltage topography: 33 ms after stimulation

- Grand average pre-lesion
- Grand average post-lesion

2 Waveforms at 3 electrodes of interest

- The M1 lesion induced major changes in brain activity after tactile stimulation application to the contralateral fingers, mainly to the thumb (C1, C2).

3 Motor behaviour was not clear, post-lesion behavioural adaptation of the finger use occurred over time: the use of the thumb was not observed in the Brinkman box task with vision whereas it further deteriorated when the task was performed without vision (K).

4 M1 is important for tactile somatosensory processing from the fingers in primates.

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