Movement Dependent Variation in the Spike-Triggered Average Effects of Motor Cortex Neurons

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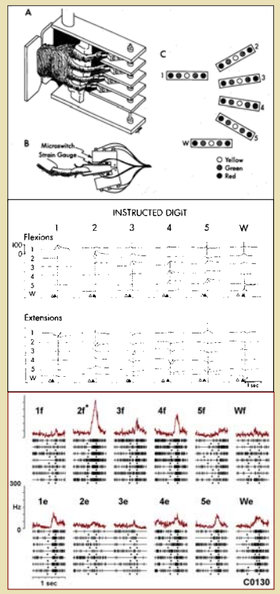
M.H. Schieber*. Departments of Neurology and Neurobiology. University of Rochester, Rochester, NY 14642

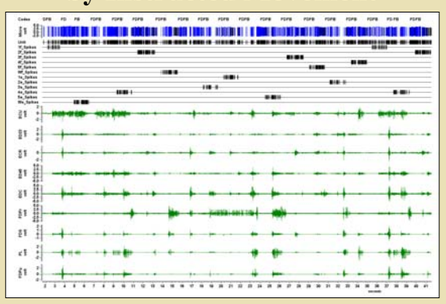
1. Abstract

Cortical inputs to spinal motoneuron pools arrive in part directly via monosynaptic corticomotoneuronal connections, and in part less directly via routes involving other M1 neurons, rubrospinal neurons, reticulospinal neurons and spinal interneurons. Effects in spike-triggered averages (SpikeTAs) of rectified electromyographic (EMG) activity provide evidence of these direct (pure post-spike effects) and less direct (synchrony effects) connections between a given M1 neuron and a motoneuron pool. A pure post-spike effect might be expected to remain relatively constant during different finger movements. In contrast, a synchrony effect might be expected to vary, depending on the activity of other neurons synchronized with the trigger neuron which also contribute to the synchrony effect. To explore this possibility, for each M1 neuron that produced a significant effect in a SpikeTA compiled from all recorded spikes, 12 separate SpikeTAs were compiled using spikes discharged during trials of each of 12 different individuated finger and wrist movements. SpikeTA effects that were robust during some finger movements were smaller or absent during others. In many cases these variations could not be attributed to differences in the number of trigger spikes or in the baseline level of EMG activity during different movements. In other cases, M1 neuron-muscle pairs that showed no significant effect in a SpikeTA compiled using all recorded spikes showed a robust SpikeTA effect when spikes discharged only during a particular finger or wrist movement were used as triggers. The SpikeTA effect of a given M1 neuron-muscle pair thus may vary depending on the movement being performed.

2. Task

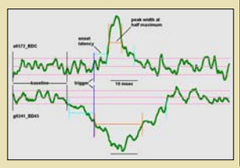


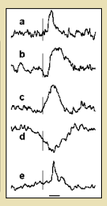
3. Sort Spikes by Instructed Movement



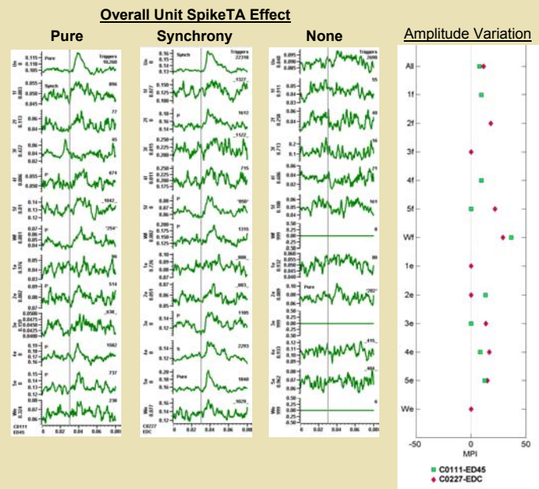
4. Form Spike-triggered average for each movement

- EMG-filter spikes
- No rejection for possible crosstalk
- Significance level set at $p < 0.01$,
  though Bonferonni would be $< 0.05/12 = 0.00417$
- SpikeTA effects classified as Pure if onset latency > 5 ms and PWHM < 9 ms
  otherwise classified as Synchrony



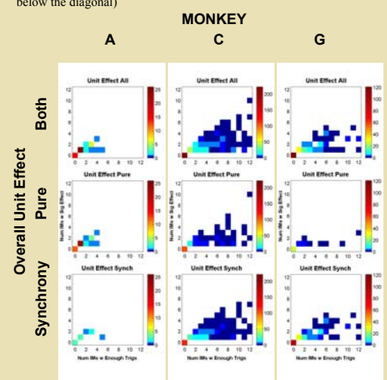


5. Examples



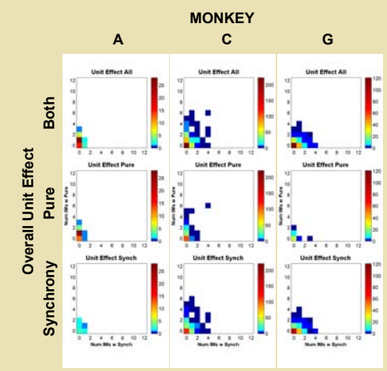
6. SpikeTA Effects: Present ↔ Absent

- Take all neuron-muscle pairs with a significant SpikeTA Effect in the overall recording
- Using those instructed movements with significant effects, find the minimum number of triggers needed to generate a significant effect for that neuron-muscle pair
- Instructed movements for which fewer spikes were available may have shown no effect because of the low number of triggers
- But movements with more triggers than the minimum number, yet no significant effect, suggest that the effect was reduced or absent during those movements (counts lying below the diagonal)

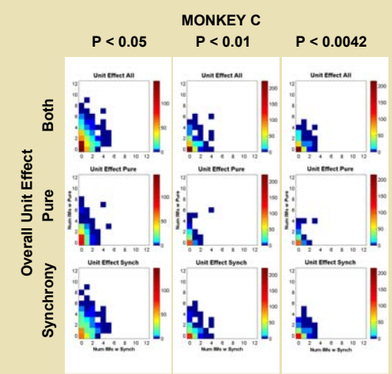


7. SpikeTA Effects: Pure ↔ Synchrony

- All neuron-muscle pairs with a significant SpikeTA Effect in the overall recording
- For a given neuron-muscle pair, is the SpikeTA Effect pure for some movements and synchrony for others?

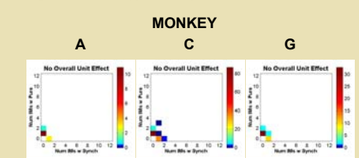


8. Effect of Significance Level



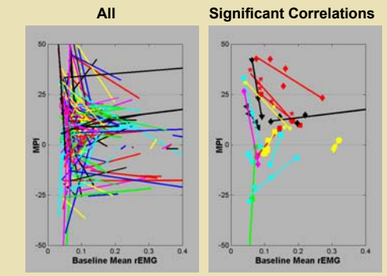
9. No overall Effect ↔ Effect in particular movement(s)

- All neuron-muscle pairs with ***NO*** significant SpikeTA Effect in the overall recording
- Do significant effects appear for any instructed movements?



- For the vast majority of neuron-muscle pairs with no overall effect, no individual movements show an effect. For scaling purposes, we therefore blanked the count at (0,0) in these displays.
- For some neuron-muscle pairs, however, one or two instructed movements showed a significant effect.

10. Effect of Baseline EMG



- Is a higher level of EMG activity during some movements the cause of larger SpikeTA effects?
- NO: Larger MPI tends to be assoicated with lower baseline EMG
- Monkey C, SpikeTA effects $p < 0.05$, correlations $p<0.05$

11. Conclusions

1) SpikeTA effects can vary depending on the movement being performed.

2) Effects may vary in amplitude (MPI), or become undetectable during different movements.

3) Effects may vary depending on the instructed movement whether the overall unit effect is pure or synchrony. Moreover, the same neuron-muscle pair may show pure effects during some movements and synchrony effects during others.

4) A neuron-muscle pair with no overall SpikeTA effect can have an effect during individual movements.

5) Variations in SpikeTA effects could not be attributed simply to differences in the number of trigger spikes or in the baseline level of EMG activity during different movements

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