



# A multi-fragment approach to identifying significant changes in spike-triggered averages of EMG

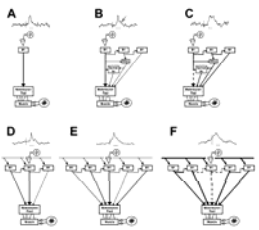
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## 1. Abstract

Do spike-triggered averages (SpikeTAs) of rectified EMG change during different movement tasks? Although SpikeTA effects from a given neuron-muscle pair may appear different during different tasks, means of identifying significant changes are lacking. We therefore extended the multi-fragment approach to compare SpikeTA effects obtained while a monkey performed a simple squeeze task (our standard individualized finger movement task) with SpikeTA effects obtained while the monkey performed direct reinforcement of physiological discharge (attempted a novel finger movement task). Comparing SpikeTA effects sometimes was complicated by an underlying curvilinear trend in the average EMG baseline. We therefore made an increment shifted average (ISA) of EMG around each spike by creating artificial triggers in 1 ms increments from 30 ms before to 50 ms after the spike. We then used these 81 triggers to compile an average of rectified EMG. All these single-spike ISAs then were averaged to produce an overall ISA. This overall ISA captured slow trends in the baseline EMG, while distributing any spike-locked features evenly throughout the 80 ms analysis window. The overall ISA then was subtracted from the raw SpikeTA, removing any slow baseline trends for more accurate measurement of SpikeTA effects. Spike trains recorded in each task were divided into non-overlapping fragments of 100 spikes each, and a separate, ISA-corrected, SpikeTA was compiled for each fragment. The peak percent increase (PPI), onset latency, offset latency, and peak width at half maximum (PWHM) then were measured for each fragment-SpikeTA. Changes in a SpikeTA effect were considered significant when the PPI, onset, offset, or PWHM of these fragment-SpikeTAs differed significantly between tasks. For many neuron-muscle pairs, SpikeTA effects showed no change. But for some neuron-muscle pairs, SpikeTA effects present during one task were absent during the other task while for other neuron-muscle pairs PPI, onset and offset latencies, or PWHM changed significantly between tasks. Support: NS27666.

## 2. Potential mechanisms for producing various SpikeTA effects



Each frame shows an actual SpikeTA effect above and a schematic potential mechanism below. Horizontal bars beneath the SpikeTA effects represent 10 msec; vertical bars indicate spike onset time.

## ?? Are different mechanisms active for the same neuron-muscle pair during different behaviors?

## 3. Behavioral Tasks

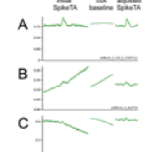
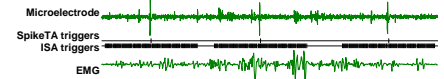
### Squeeze Task



## Reinforcement of Physiological Discharge (RPD)



## Sidebar: Increment Shifted Average (ISA) adjusts SpikeTA to correct for curvilinear baseline



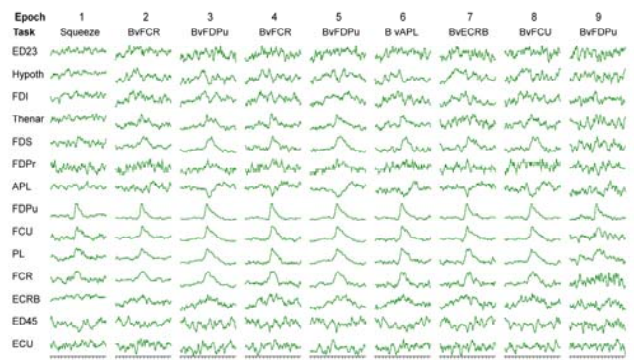
**ABOVE:** Microelectrode recording with spikes from one neuron discriminated as pulses used as triggers for Spike-triggered averaging of EMG. Eighty-one triggers for the increment shifted average of EMG were generated at 1 ms intervals centered on each pulse discriminated from the neuron.

**LEFT:** Examples of various baselines (shown in 160 ms initial SpikeTAs) removed from the adjusted SpikeTA (80 ms) by subtraction of the ISA

**RIGHT:** Example of multiple SpikeTAs of a single neuron adjusted by subtracting the ISA estimate of the baseline trend in the initial SpikeTA

Epoch	Task	1	2	3	4	5	6	7	8	9
ED23	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Hypoth	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDI	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Thenar	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDS	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDP	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
APL	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDPu	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FCU	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PL	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FCR	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ECRB	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ED45	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ECU	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

## 4. Variation in SpikeTAs across behavioral epochs in a single session



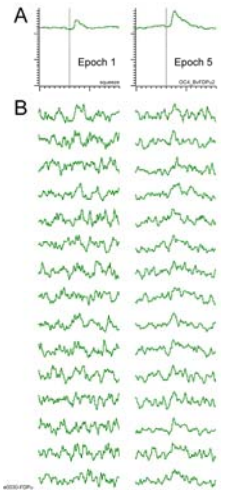
**ABOVE:** SpikeTAs of 14 muscles from a single neuron during 9 epochs of a single continuous session in which the monkey first performed the squeeze task, and then performed RPD of the neuron paired with various muscles.

**RIGHT:** Variation in the Onset latency and Peak-Width at Half Maximum of the SpikeTA effects shown above.

**BELOW:** For each Spike-triggered average above, tables give 1) the P-value for the presence of a peak or trough in a window 6-16 ms after the trigger, and 2) the number of EMG-filtered triggers used to compile the average.

Epoch	Task	1	2	3	4	5	6	7	8	9
ED23	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Hypoth	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDI	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Thenar	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDS	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDP	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
APL	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FDPu	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FCU	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
PL	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
FCR	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ECRB	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ED45	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ECU	Squeeze	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

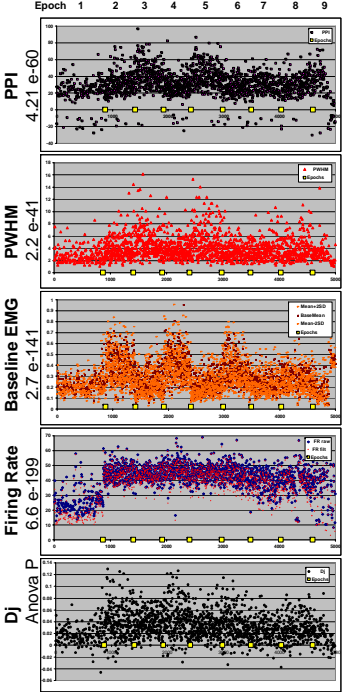
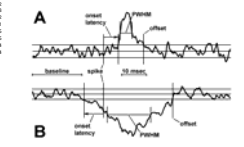
## 5. Multi-fragment Approach



**ABOVE:** For each of the two SpikeTAs from e0303-Unib-FDPu shown in A, B shows filtered sequential fragment SpikeTAs each compiled from 100 spikes. (All traces are 80 ms)

**RIGHT:** Peak Percent Increase (PPI), Peak Width at Half Maximum (PWHM), baseline EMG, neuron firing rate, and MFSA statistic  $D_j$ , measured for each 100-spike fragment for e0303-Unib-FDPu, are plotted as a function of the time at which the fragment started.

**BELOW:** Measurements made on SpikeTA effects or on SpikeTA fragments.



## 6. Conclusions

1. The SpikeTA effect of a given neuron-muscle pair can change rapidly.
2. Such changes may reflect activation of different networks of neurons in conjunction with the trigger neuron to activate the same muscle during different behaviors.
3. Increment Shifted Averages effectively adjust SpikeTAs to correct for curvilinear baseline trends.

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