UE Subclinical EMG analysis overview

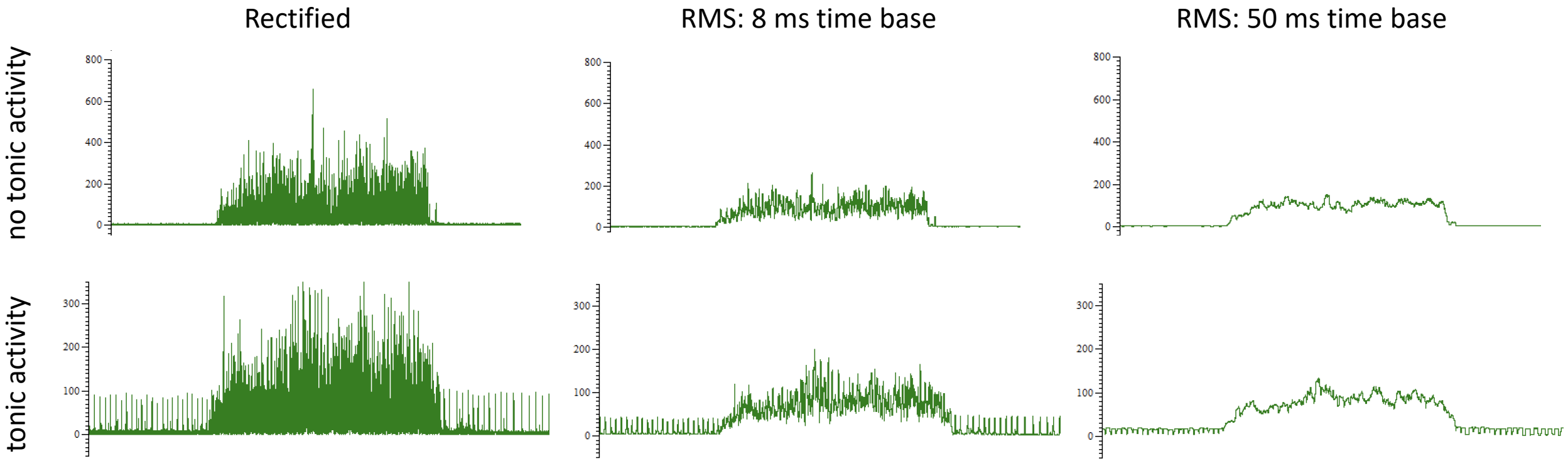
EMG outcomes of interest:

- EMG onset: time from trial start to onset of EMG activity
- EMG offset: time from trial end to return of EMG to baseline
- Average EMG amplitude for:
  - 5 sec trial duration
  - 5 sec time period immediately preceding trial
  - 5 sec time period immediately after trial
- Peak EMG amplitude during trial
- Time to EMG peak: time from trial start to peak EMG activity
- Percent contribution of each muscle group to total EMG activity during trial (i.e. co-contraction index)
- EMG duration: time from EMG onset to first EMG offset
  - EMG area may be more appropriate for this

UE Subclinical EMG analysis overview

EMG data reduced 3 ways:

1. Rectified
2. RMS with 8 ms time base
   Ref: Manella_EFF13_Operant conditioning
3. RMS with 50 ms time base
   Ref: McKay11_Characterization of motor recovery in acute SCI



UE Subclinical EMG analysis overview

5 criteria methods tested for EMG onset/offest:

1. 1 SD/10 ms
   Ref: Hodges_Bui96
2. 1 SD/50 ms
   Ref: Hodges_Bui96
3. 1.5 SD/25 ms
   Ref: Kobelt18
4. 3 SD/25 ms
   Ref: Hodges_Bui96
5. 4 SD/no duration criteria
   Ref: Federico_Perez17

- Hodges & Bui recommend selecting criteria that align most closely with visually derived onset for data set being analyzed
- Kobelt18 followed this recommendation and selected onset criteria based on which most closely match visual onset identification

EMG Quantification vs BHUEF: Rectified EMG

	Opposition Trials, EMG Rectified									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	118	91	51	10	79	25	58	16	137	138
EMG response, no active hand function	23	12	4	0	6	2	6	0	61	63
No EMG response, active hand function	20	47	87	128	59	113	80	122	1	0
No EMG response, no active hand function	46	57	65	69	63	67	63	69	8	6

	Power Grasp Trials, EMG Rectified									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	123	103	30	9	58	45	39	24	138	138
EMG response, no active hand function	25	23	3	0	3	4	2	2	62	65
No EMG response, active hand function	15	35	108	129	80	93	99	114	0	0
No EMG response, no active hand function	44	46	66	69	66	65	67	67	7	4

EMG Quantification vs BHUEF: 50 ms time base RMS

	Opposition Trials, EMG RMS: 50 ms									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	137	138	137	92	137	136	131	126	128	123
EMG response, no active hand function	65	67	63	43	59	65	49	39	43	40
No EMG response, active hand function	1	0	1	0	1	2	7	12	10	15
No EMG response, no active hand function	4	2	6	3	10	4	20	30	26	29

	Power Grasp Trials, EMG RMS: 50 ms									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	138	136	138	136	138	136	136	131	134	129
EMG response, no active hand function	66	69	66	65	66	67	54	48	48	46
No EMG response, active hand function	0	2	0	2	0	2	2	7	4	9
No EMG response, no active hand function	3	0	3	4	3	2	15	21	21	23

EMG Quantification vs BHUEF: 8 ms time base RMS

	Opposition Trials, EMG RMS: 8 ms									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	137	138	118	118	133	131	118	107	134	130
EMG response, no active hand function	69	69	28	21	57	48	29	24	64	60
No EMG response, active hand function	1	0	20	20	5	7	20	31	4	8
No EMG response, no active hand function	0	0	41	48	12	21	40	45	5	9

	Power Grasp Trials, EMG RMS: 8 ms									
	Method 1: 1 SD, 10 ms		Method 2: 1 SD, 50 ms		Method 3: 1.5 SD, 25 ms		Method 4: 3 SD, 25 ms		Method 5: 4 SD, no duration	
	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar	Thenar	Hypothenar
EMG response, active hand function	138	138	132	116	137	133	129	116	137	134
EMG response, no active hand function	69	69	34	32	61	53	34	32	68	64
No EMG response, active hand function	0	0	6	22	1	5	9	22	1	4
No EMG response, no active hand function	0	0	35	37	8	16	35	37	1	5

UE Subclinical EMG MATLAB code analysis overview

- Analysis begins 5 sec prior to trial start and stops 5 sec after trial end
- Identification of trial start: point at which marker input changes by more than 2.5 standard deviations
  - To prevent false detection of trial start, marker must meet 2.5 std dev criteria for 5 consecutive data collection points
  - Marker average and standard deviation calculated using a 1 sec window

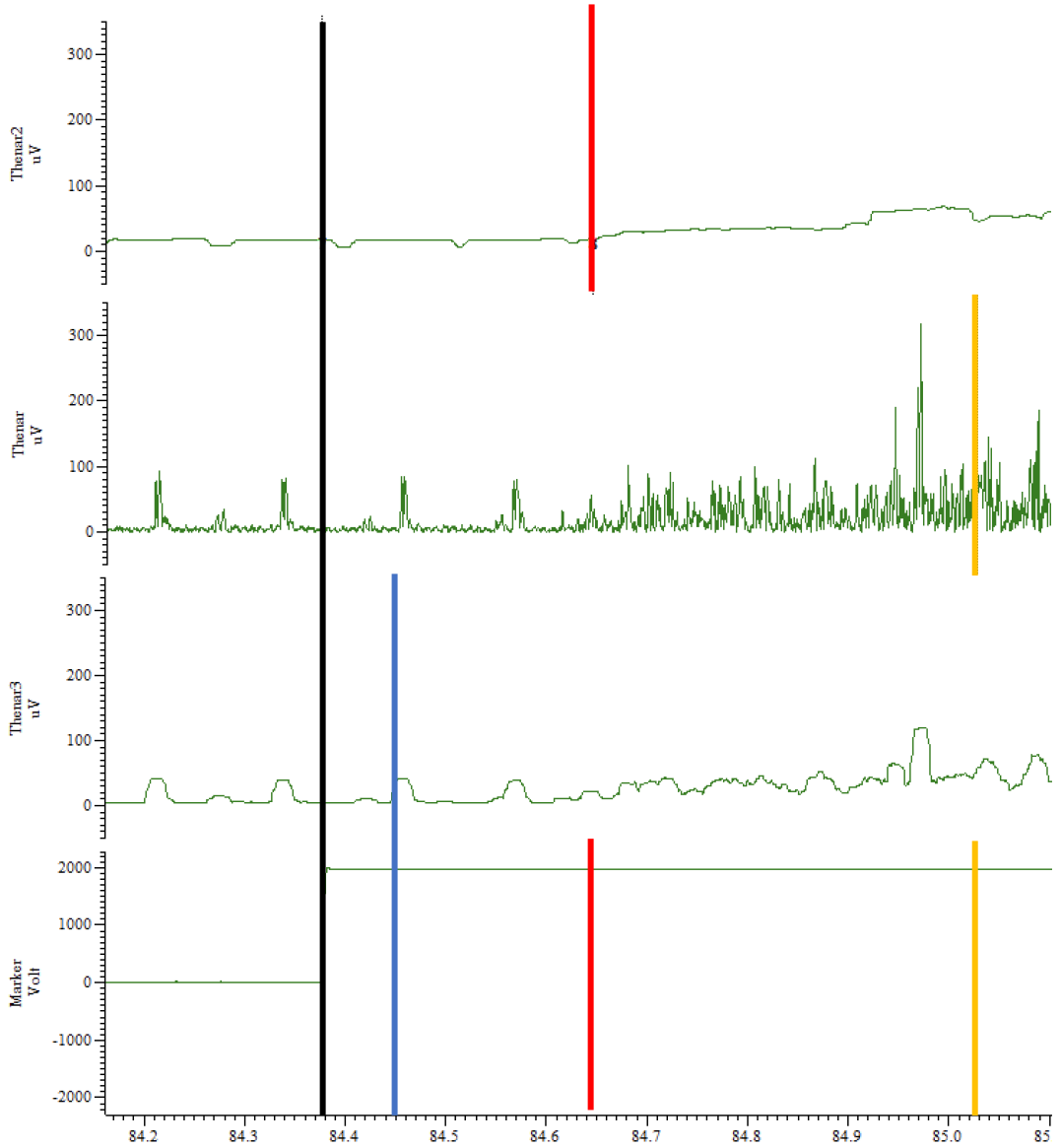


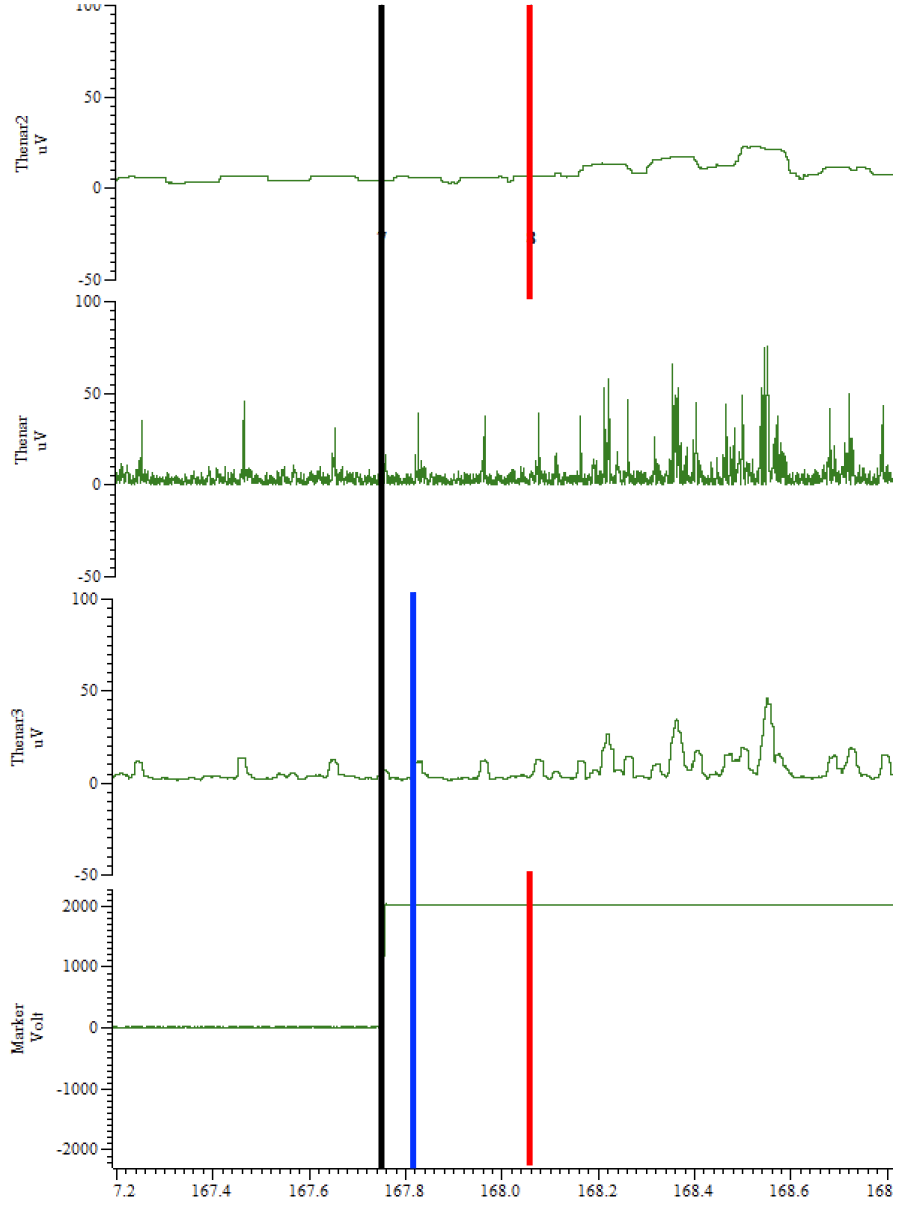
Figure: Representative screenshot of 3 thenar EMG reduction methods and marker channel

- Black line: trial start
- Yellow line: rectified EMG onset
- Blue line: 8 ms RMS EMG onset
- Red line: 50 ms RMS EMG onset

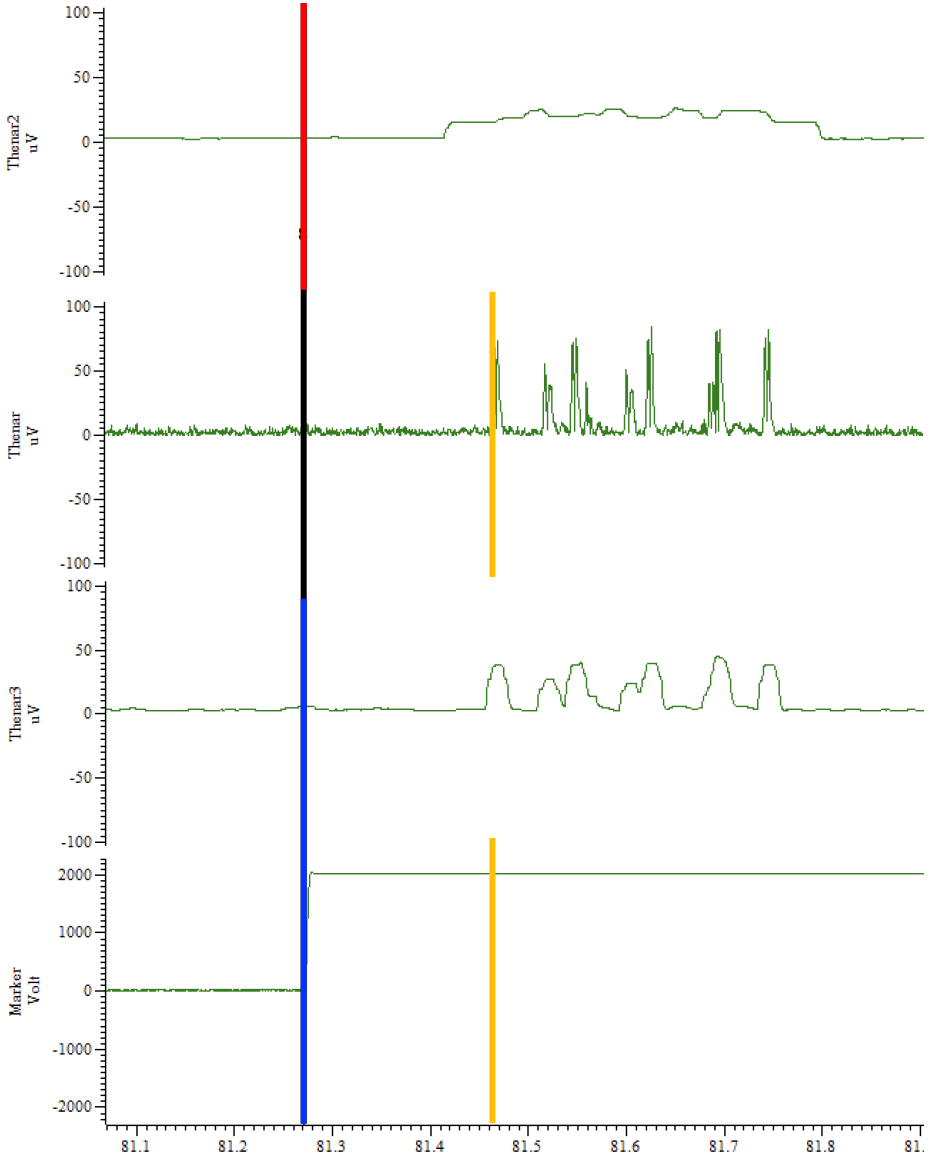
Method 1: 1 SD, 10 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, minimal response



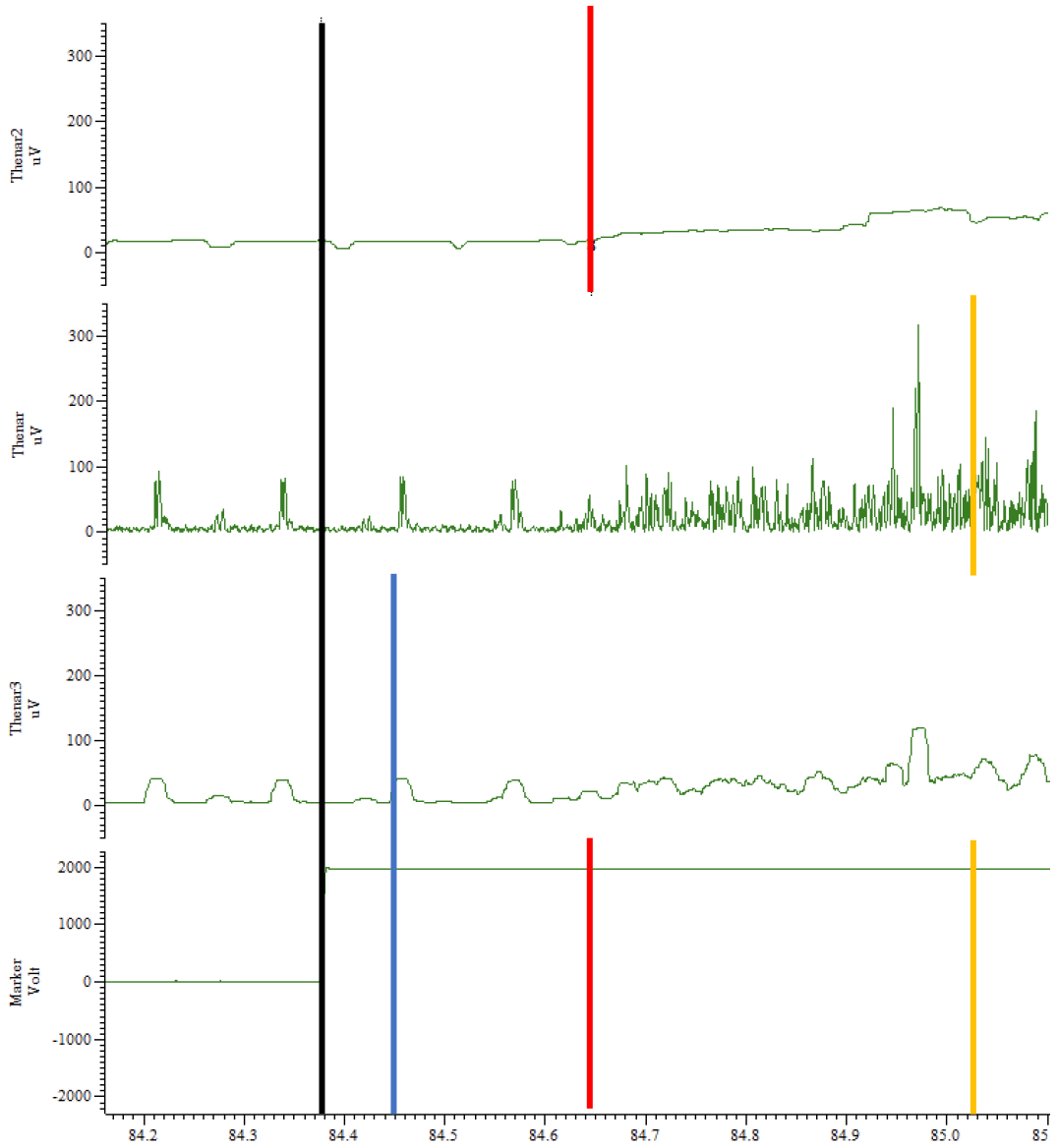
No tonic EMG, minimal response



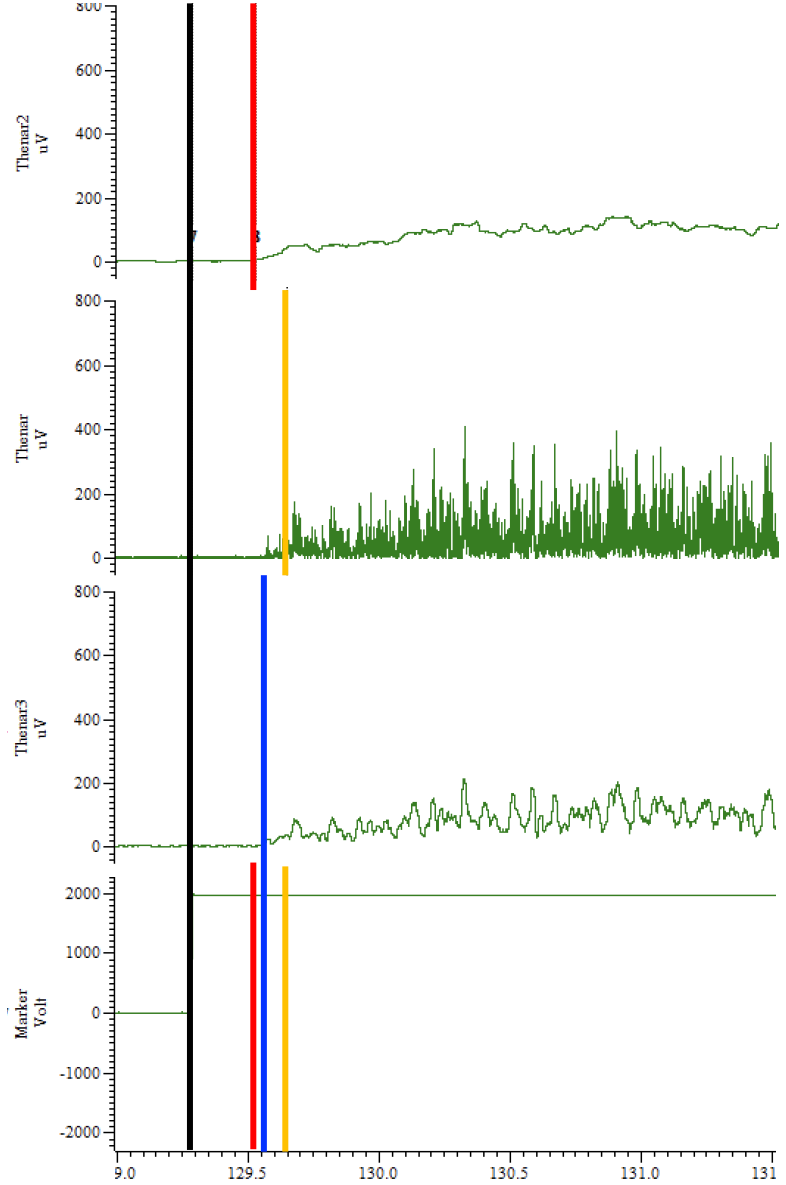
Method 1: 1 SD, 10 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, clear response



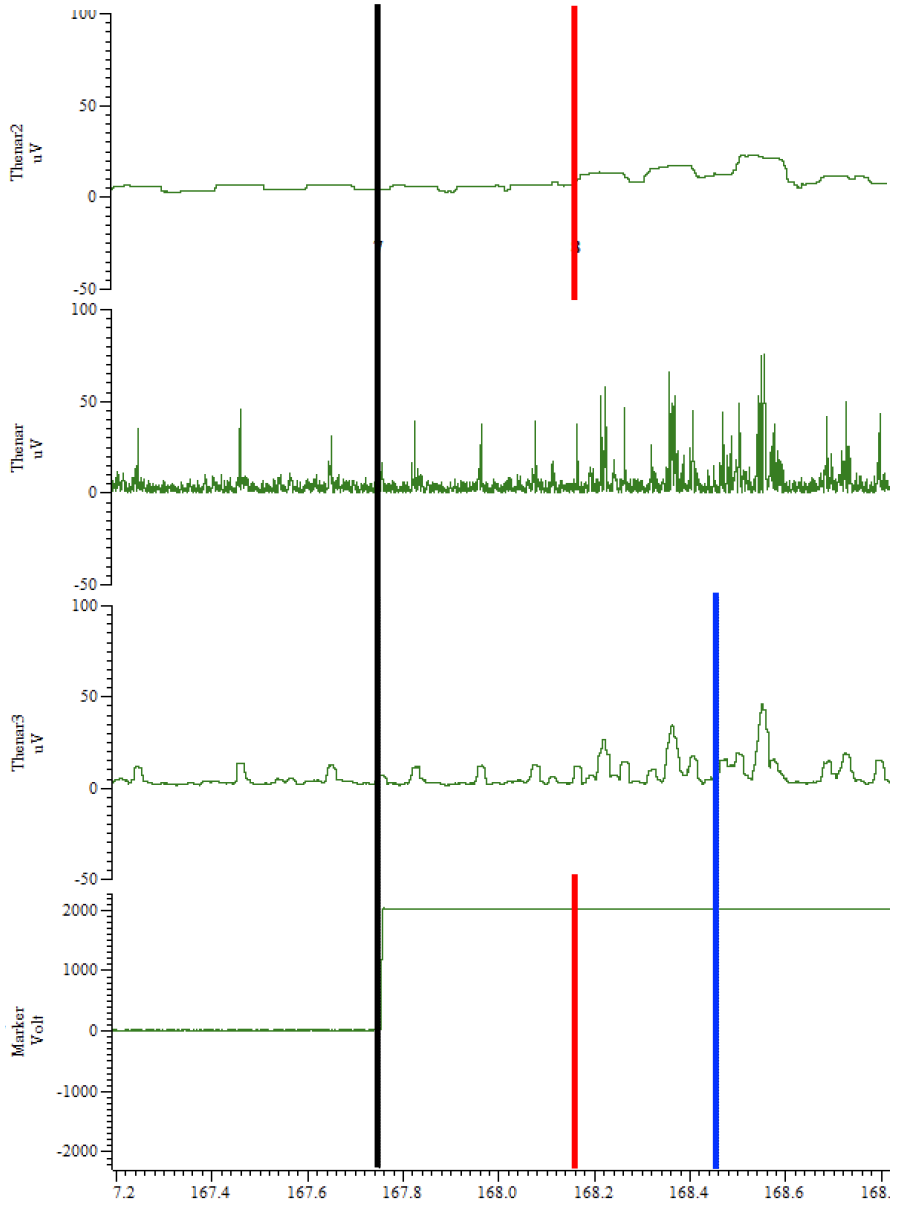
No tonic EMG, clear response



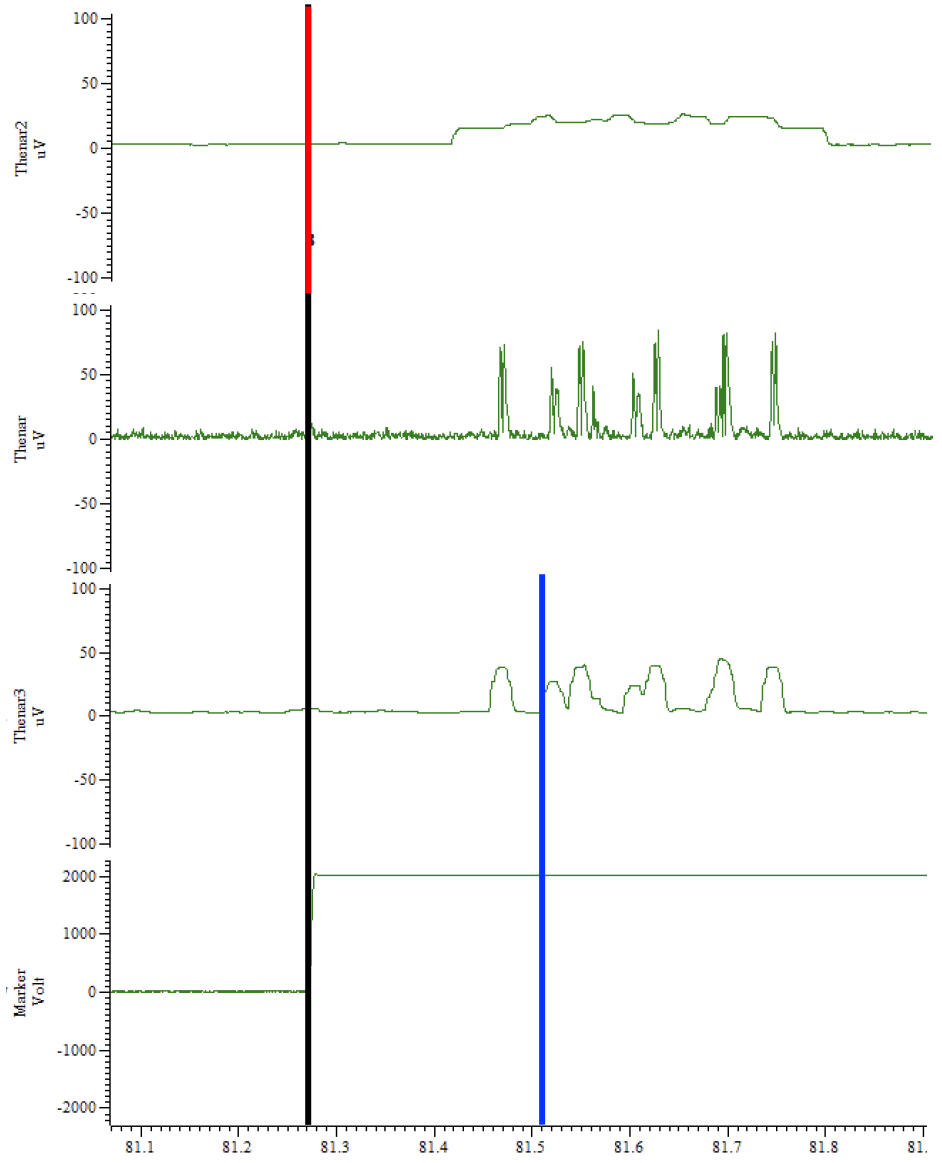
Method 2: 1 SD, 50 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, minimal response



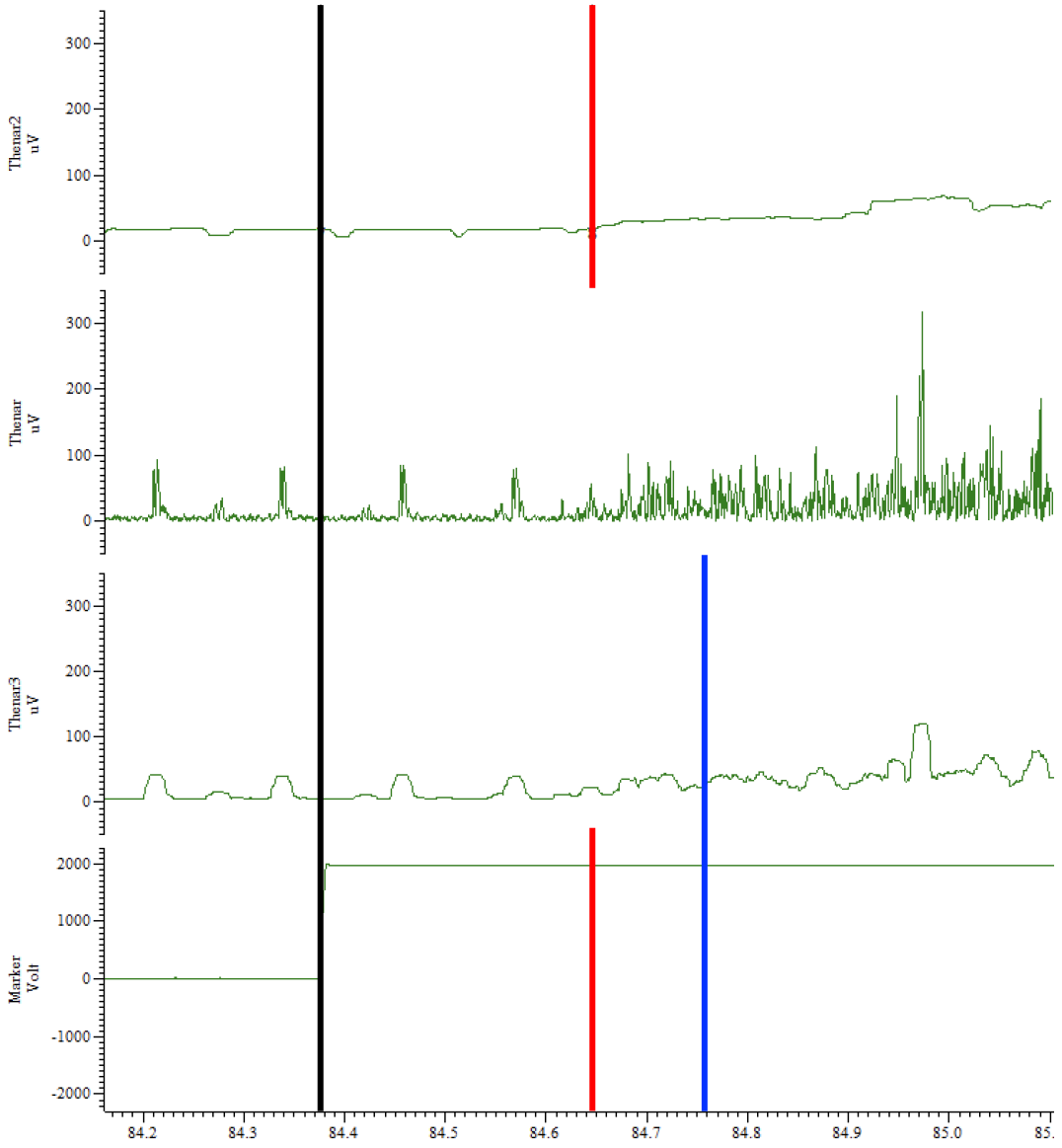
No tonic EMG, minimal response



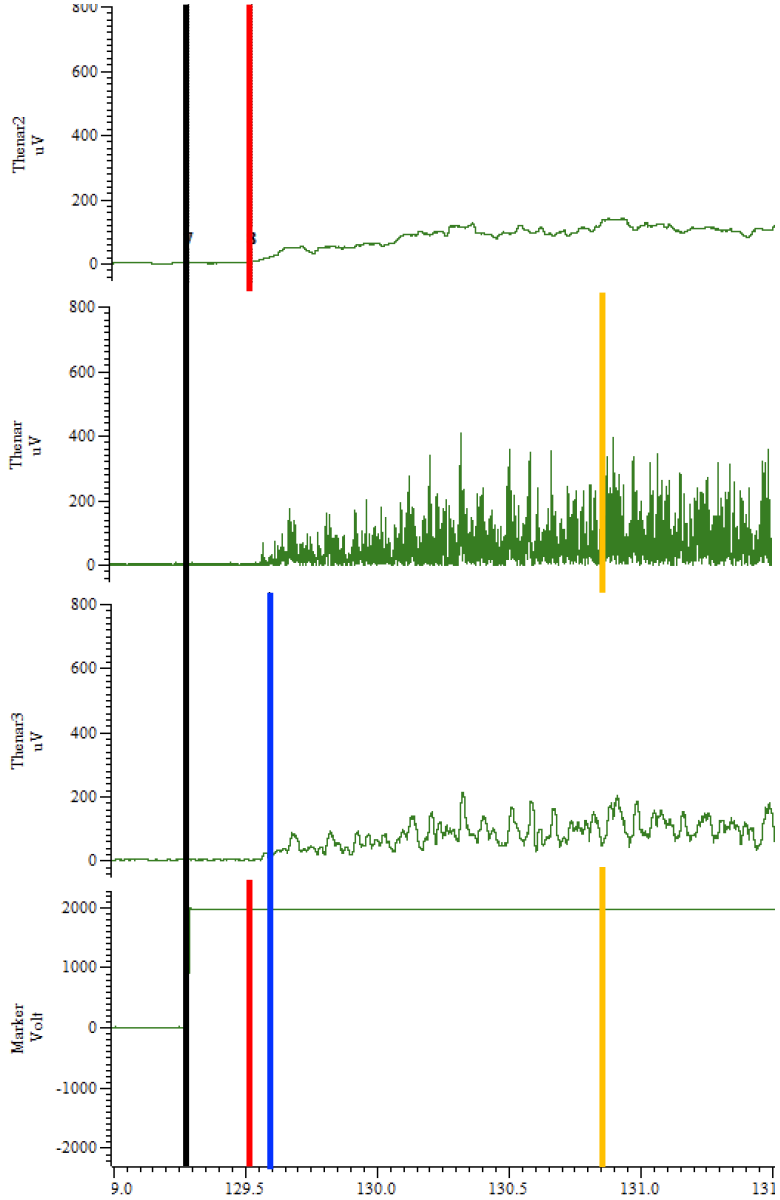
Method 2: 1 SD, 50 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, clear response



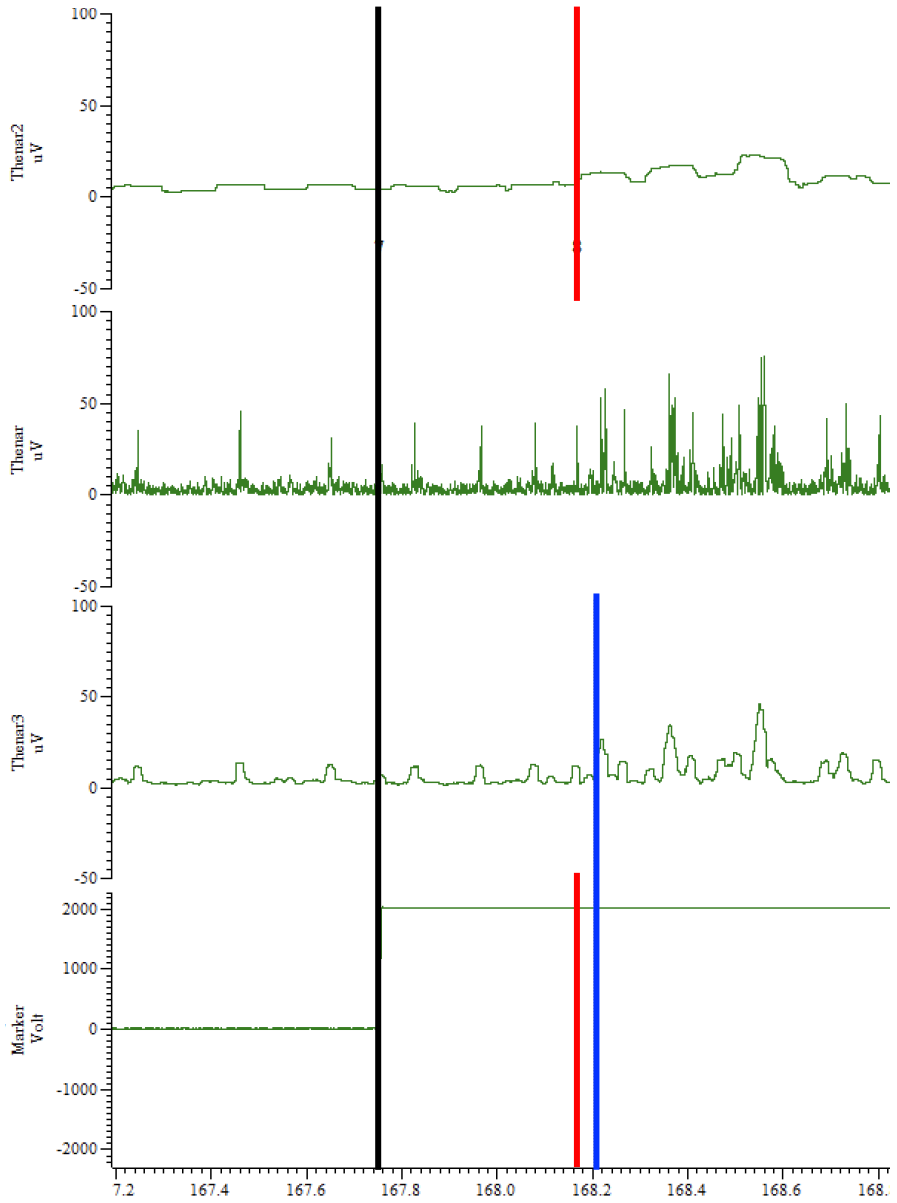
No tonic EMG, clear response



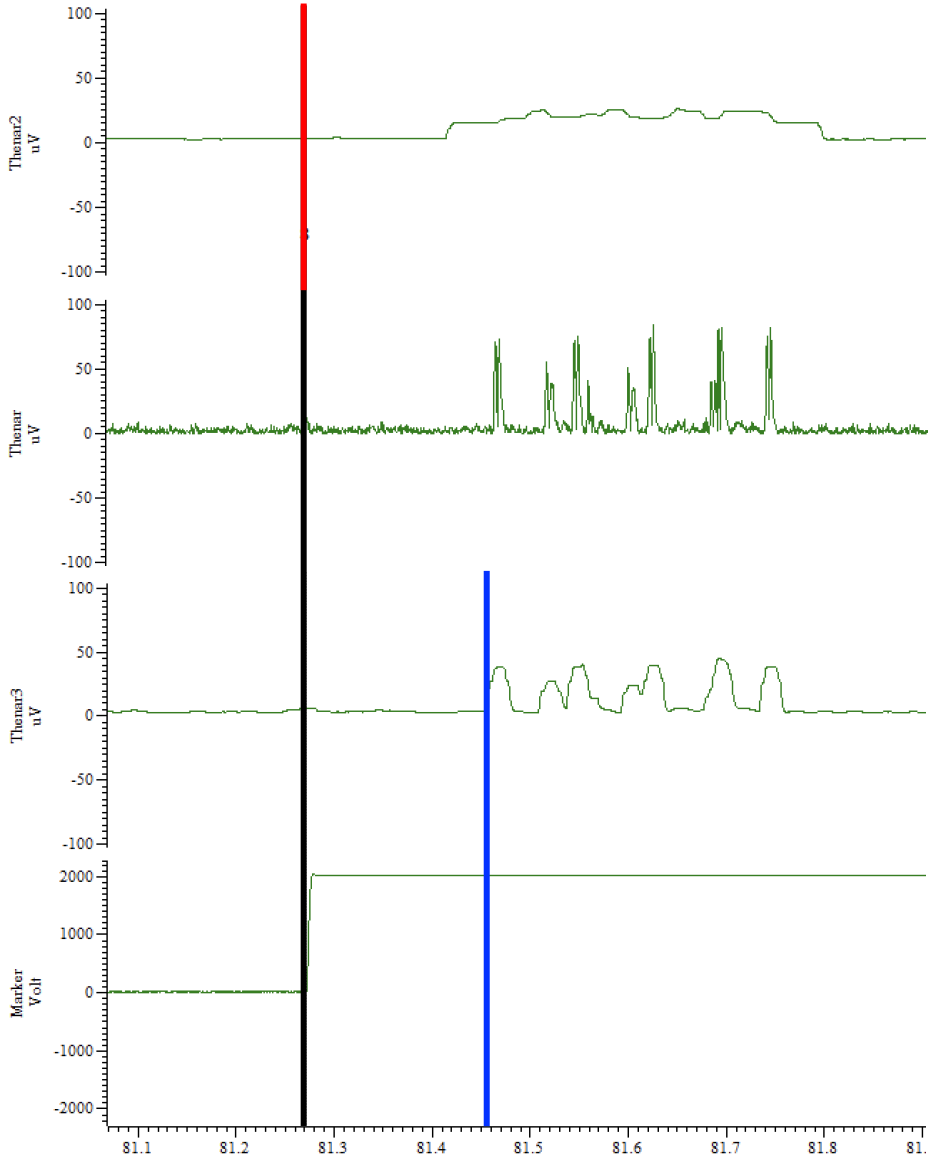
Method 3: 1.5 SD, 25 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, minimal response



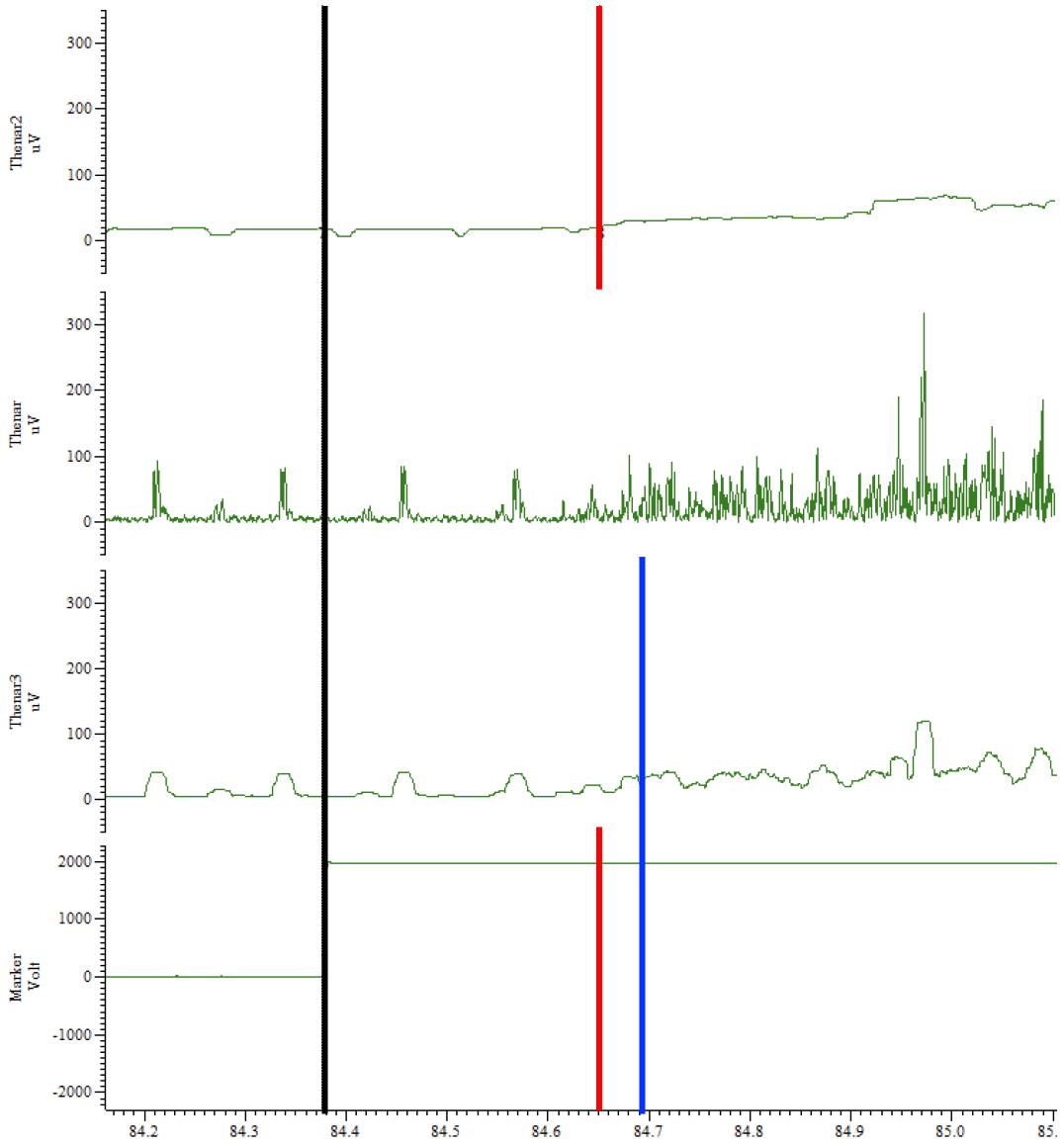
No tonic EMG, minimal response



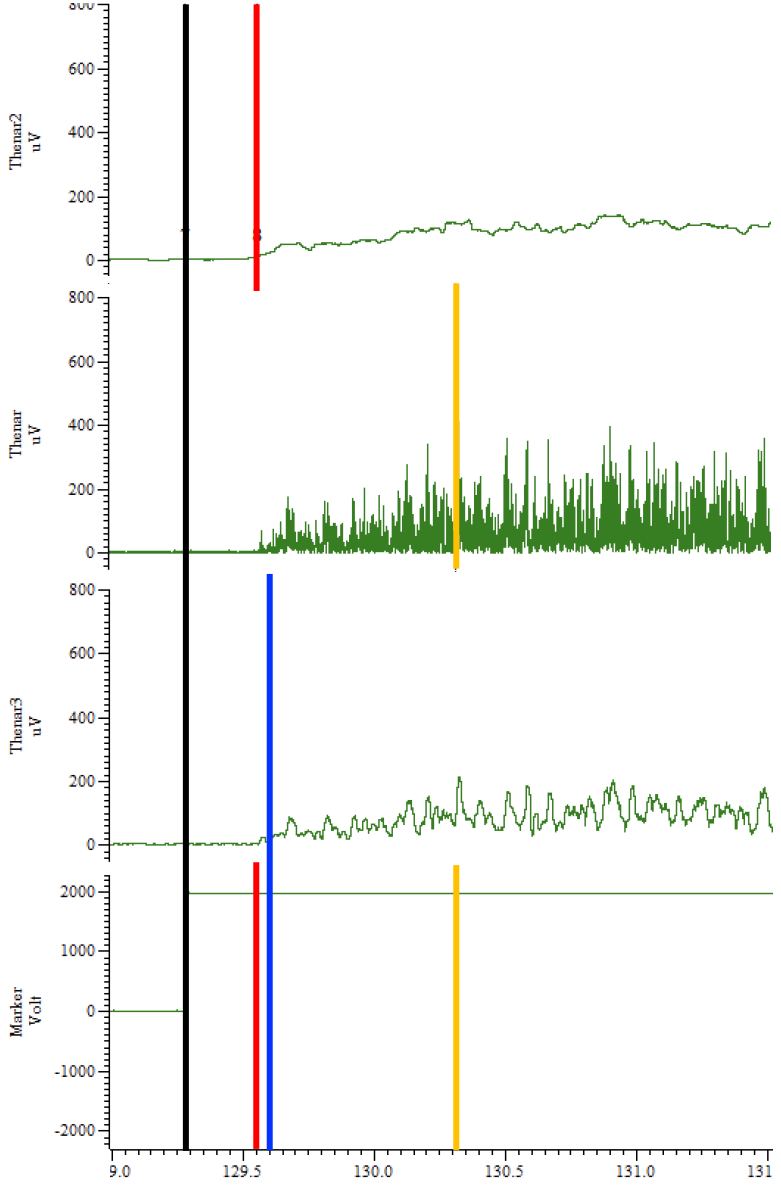
Method 3: 1.5 SD, 25 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, clear response



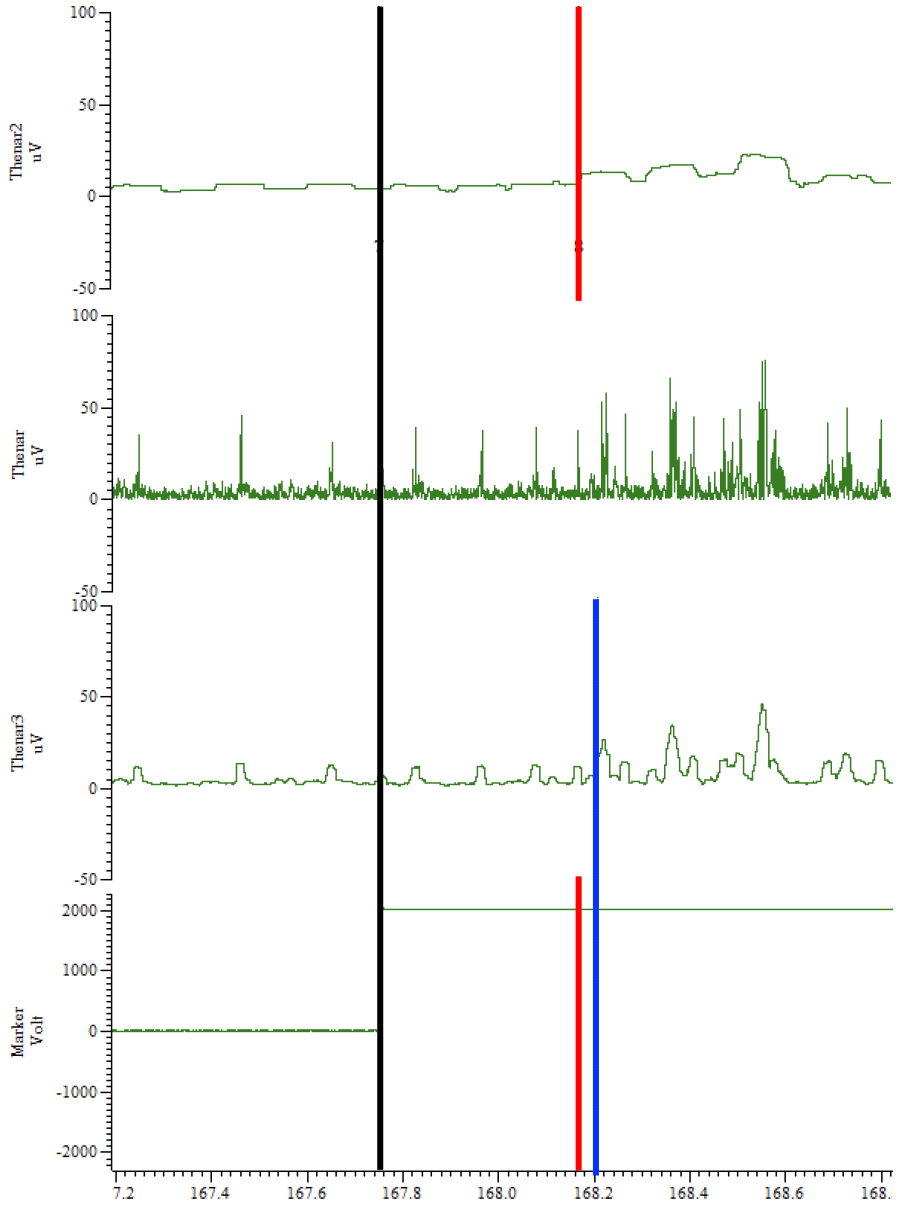
No tonic EMG, clear response



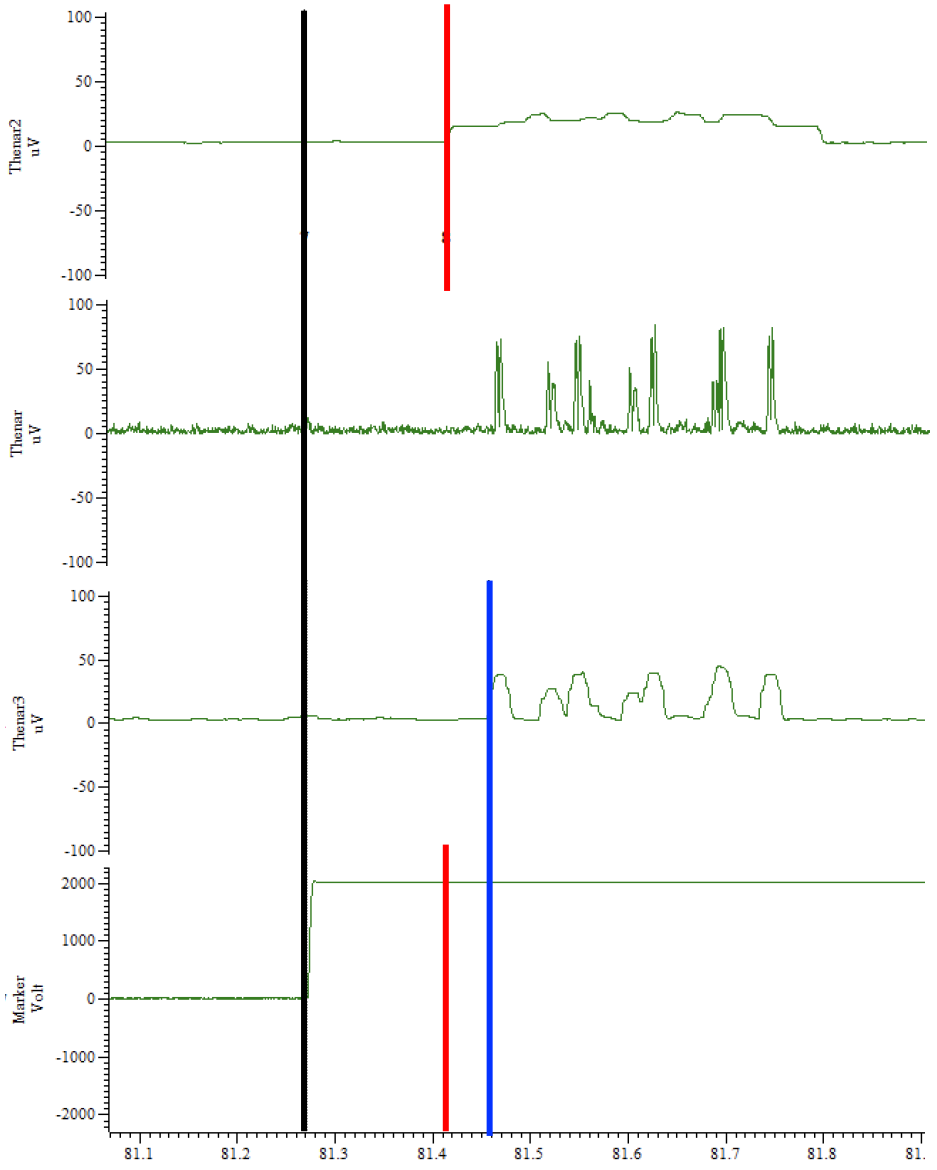
Method 4: 3 SD, 25 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, minimal response



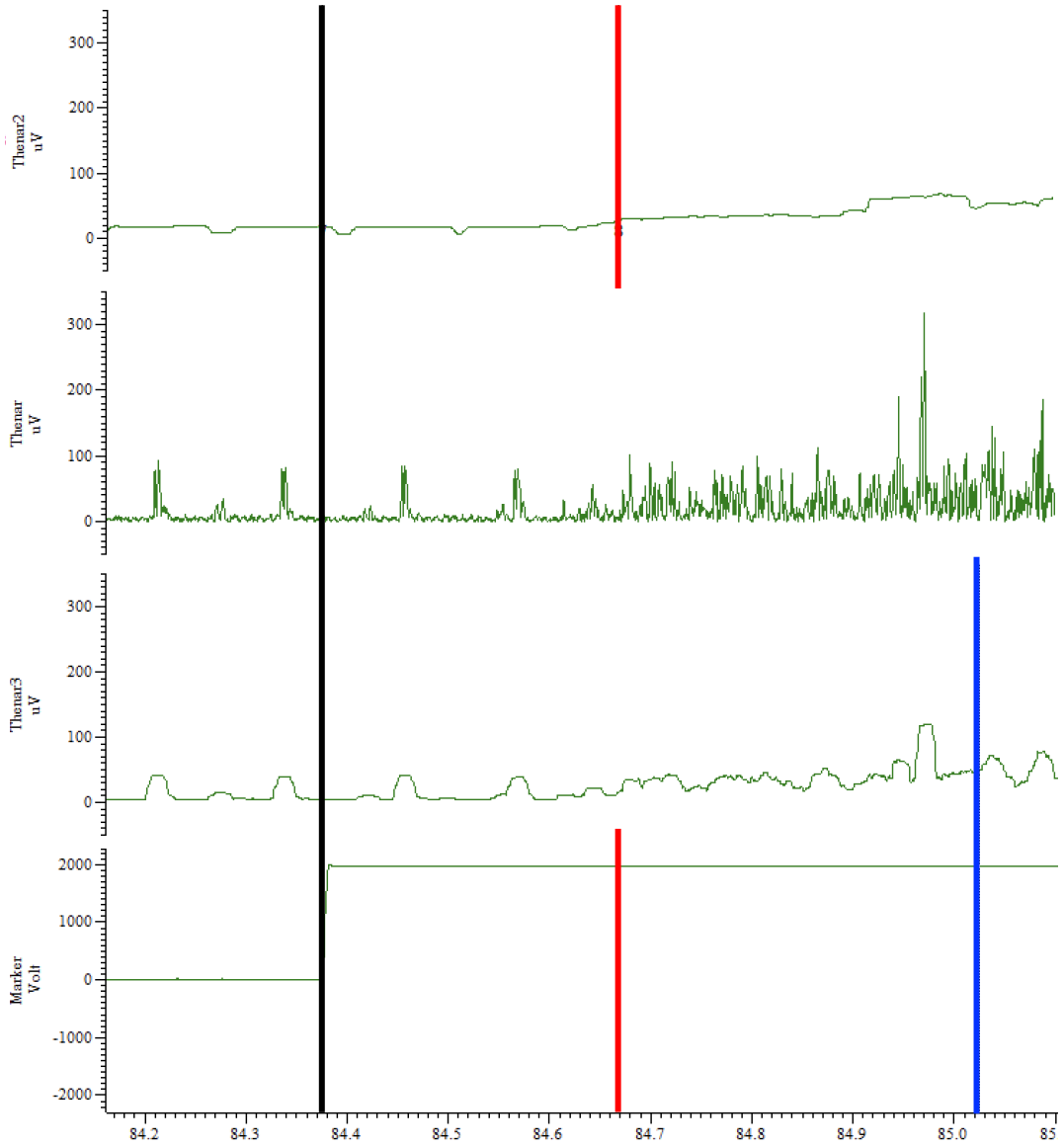
No tonic EMG, minimal response



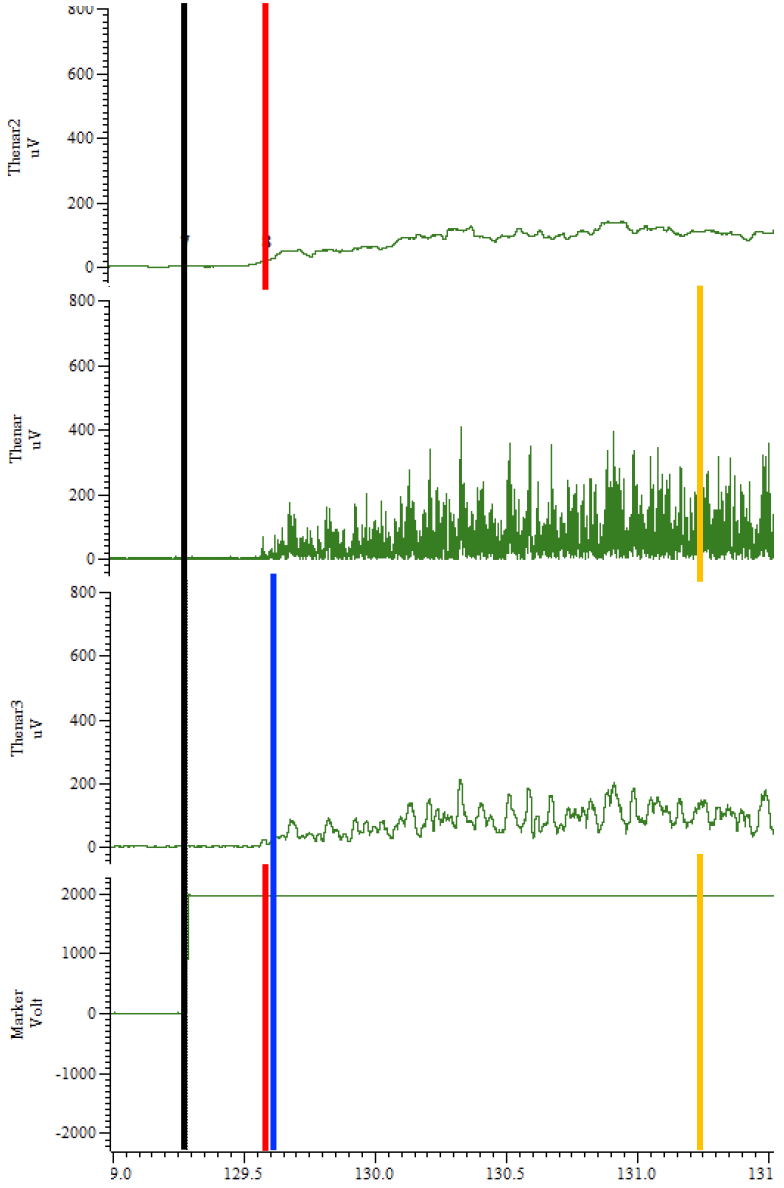
Method 4: 3 SD, 25 ms

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, clear response



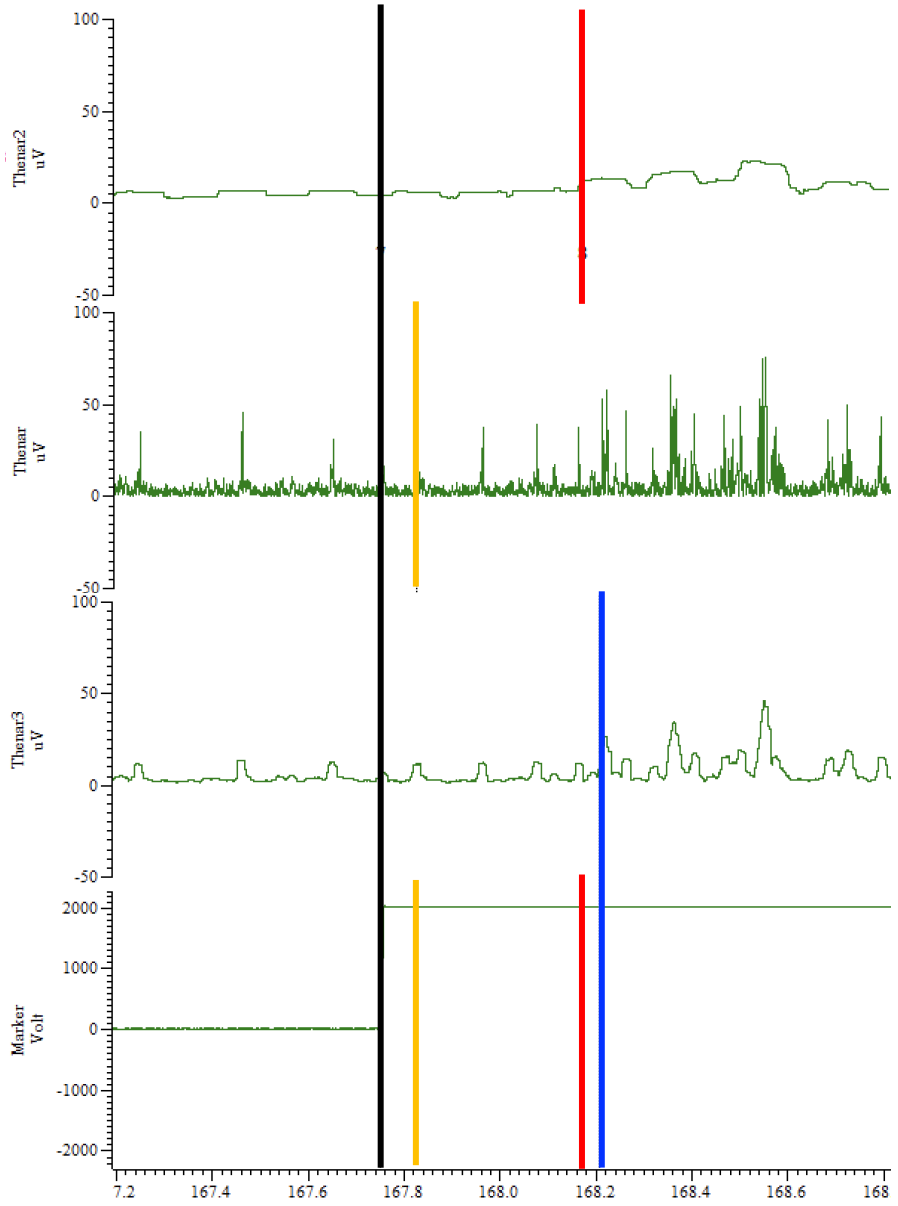
No tonic EMG, clear response



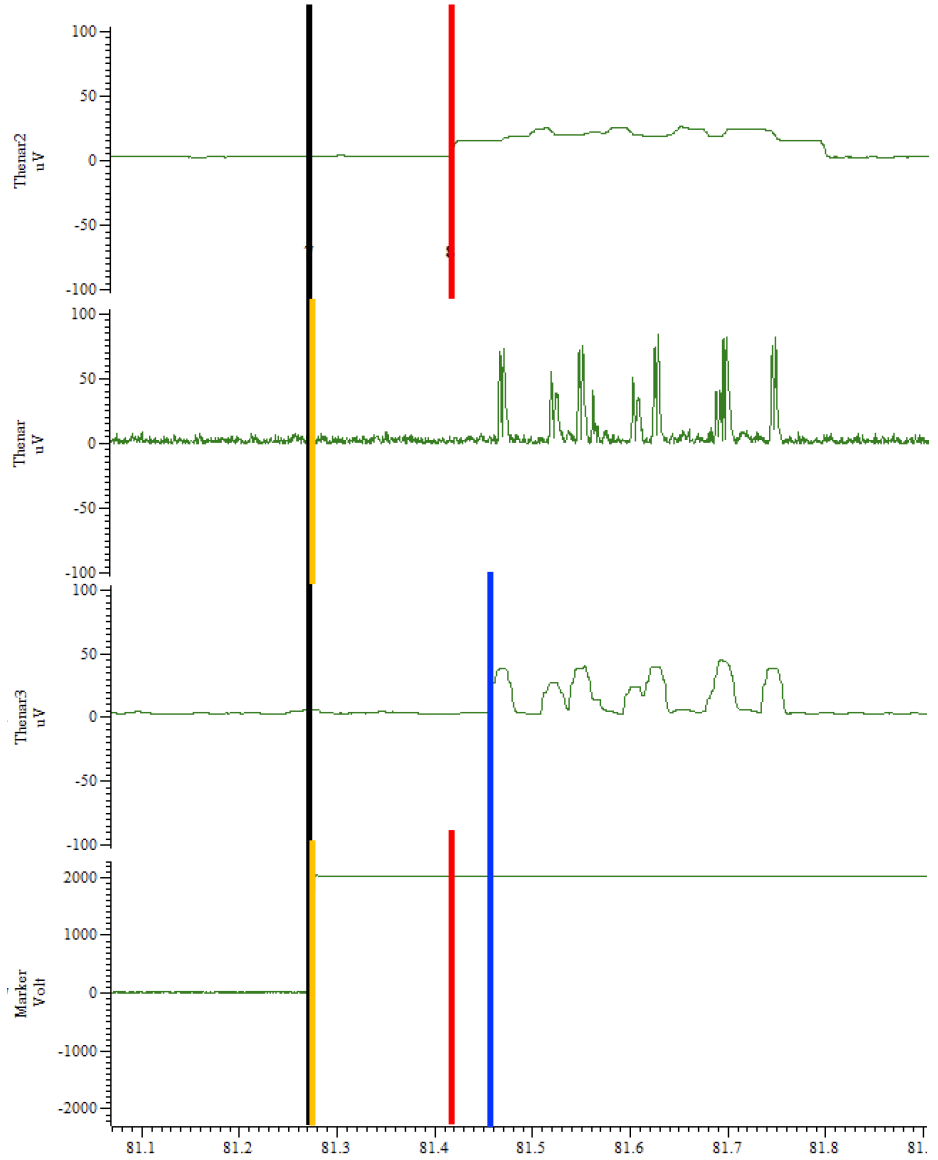
Method 5: 4 SD, no duration criteria

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, minimal response



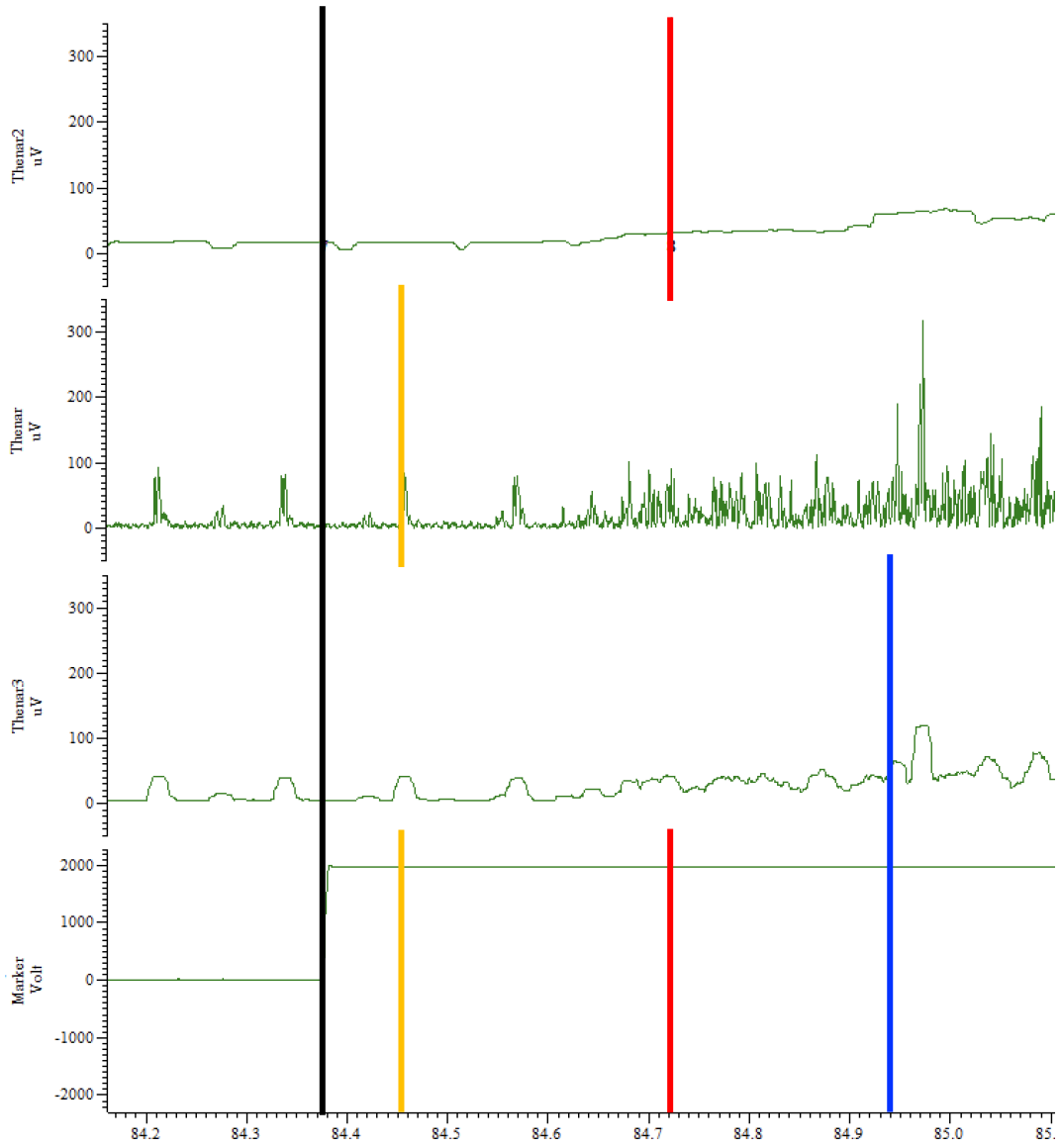
No tonic EMG, minimal response



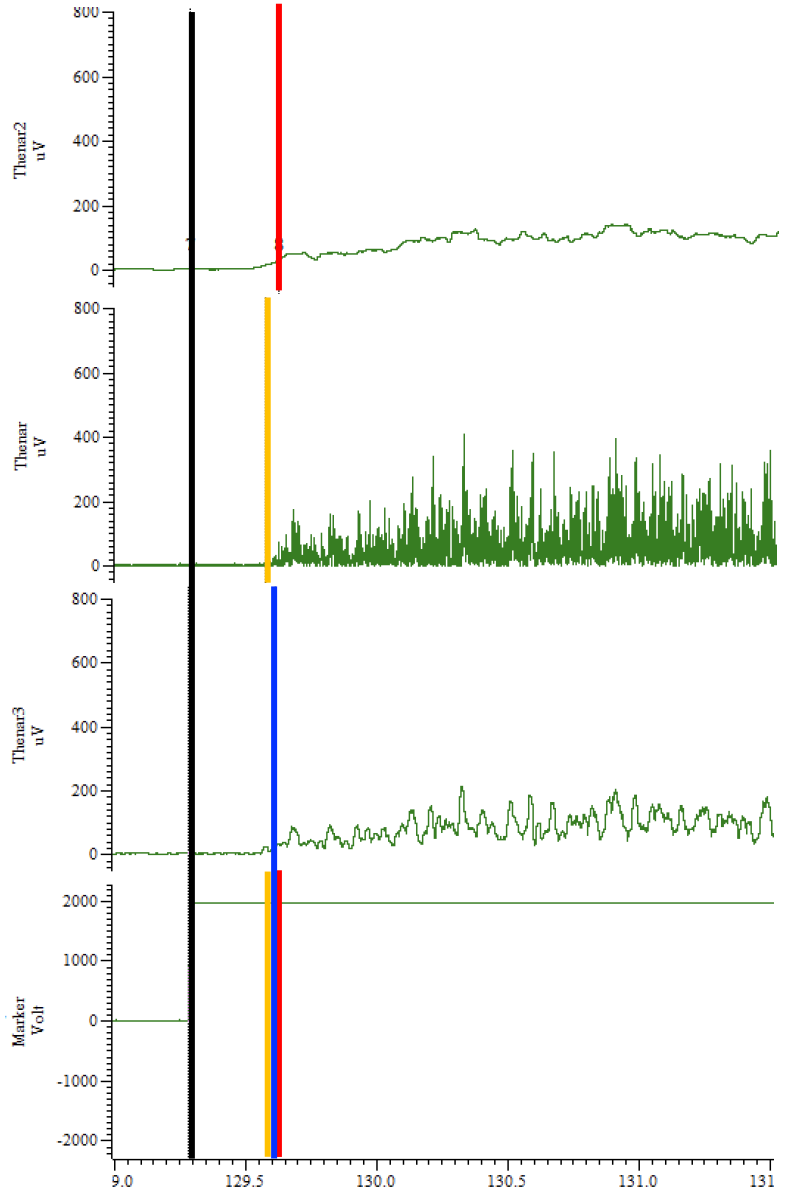
Method 5: 4 SD, no duration criteria

trial start
rectified EMG onset
8 ms RMS EMG onset
50 ms RMS EMG onset

Tonic EMG, clear response



No tonic EMG, clear response



Literature Review Summary

Reference	Findings
Hodges_Bui96	• 3 SD/25 ms • 1 SD/50 ms • 1 SD/10 ms • Authors recommend selecting criteria that align most closely with visually derived onset for data set being analyzed
Federico_Perez17	• 4 SD/no duration criteria reported (presumably first point at which rectified data surpasses 4 SD of baseline since SD criteria is so high)
Kobelt18	• 1.5 SD/25 ms (duration not listed in text; derived from figure key) • selected onset criteria based on which most closely match visual onset identification (based on the recommendations of Hodges_Bui paper)
Hofstoetter_McKay_Tansey_Minassian14	• Agonist muscle activity during each movement phase was normalized to the total activity recorded across all ipsilateral muscles. Thus, the amount of TA activity (RMSTA) relative to the total magnitude of ipsilateral muscle activation (RMStotal) during dorsiflexion was individually calculated as RMSTA/TMStotalR