Numerical investigation of spinal neuron facilitation with multi-electrode epidural stimulation

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ABSTRACT

Approximately 1,275,000 people in the US have a spinal cord injury severe enough to cause some paralysis of the arms and/or legs. Epidural stimulation using implanted multi-electrode stimulating arrays over the lumbosacral spinal cord has recently shown promise in assisting individuals with severe spinal cord injuries to stand, walk, and even facilitate voluntary movement. Both animal model and human studies have shown that sub-threshold facilitation of motor recovery gives the best results. The underlying neural mechanisms by which sub-threshold epidural stimulation leads to motor recovery are incompletely known.

This thesis uses computational methods to study the *facilitation effect*. A neuron is facilitated if a sub-threshold synaptic input can cause a neuronal output under the influence of a stimulating electric field. The analysis in this thesis is based on a computational model of the epidural spinal stimulation process in the rat spinal cord. This model includes a time-domain finite element simulation (using COMSOL®) of the various tissues in the spinal cord with the appropriate anisotropic and frequency-dependent complex relative permittivities. The voltages obtained from the finite element simulations were used as the extracellular voltage in NEURON simulations.

A population of neurons was simulated under a wide variety of conditions. These simulations highlight the effect of neuron orientation, location, and synaptic timing as key parameters which influence facilitation.

This study indicates that regions of the spinal cord that have previously been ignored may be actively involved in motor recovery. These results may also enable the design of specialized epidural electrode arrays and the design of new stimulation protocols.

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4.14 Membrane voltage (V_m) vs time, for a neuron with axon pointing towards Yp located at GM1_L_r5 exposed to 2.75 V of monophasic stimulation using combination A4pA5n. Each subfigure (a-f) plots V_m on a each segment of a different neurite: (a) $-\hat{x}$ dendrite, (b) $+\hat{x}$ dendrite, (c) $-\hat{y}$ dendrite, (d) $-\hat{z}$ dendrite, (e) $+\hat{z}$ dendrite, and (f) $+\hat{y}$ axon + soma. For each subfigure (a-f): The horizontal axis is the simulation time in ms. Each segment plot is labeled on the right side with (section type, orientation, segment number). The range of the vertical axis for the segment plots is indicated in the lower left corner. The minimum and maximum V_m for each segment is in the middle of each segment plot. Red areas under each segment plot indicate time periods in which V_m at that segment exceeds −10 mV. Subfigure (f) shows an antidromic action potential starting at the axon tip followed by an orthodromic action potential starting at the IS. The second action potential fails to cause neurotransmitter release most likely because of the refractory period of the axon. 109

4.15 (top): Membrane voltage (in mV) at different locations on a simulated neuron as a function of stimulation voltage (in mV, axis shared with bottom plot) for monophasic stimulation with combination A4pA5n, location GM1_L_r5, and axon in the $+\hat{y}$ direction. This is one of the configurations that results in neuron activation with the minimum amount of monophasic stimulation (in this case 2.75 V). The legend labels in the top plot are in the format (section type, orientation, segment number). See Fig. 3.3 for segment number locations by section type. Note that the axon tip (AxonProper, Yp, 16) is most stimulated compared to other probe locations if the stimulation voltage amplitude is less than 2.75 V. (bottom): The time of the maximum membrane voltage (in ms) for each probe vs stimulation voltage (in mV). The time of the maximum membrane voltage helps explain which parts of the neuron reach maximum first. Note that the stimulation pulse starts at 1 ms and peaks at 2.12 ms. 110

4.16 (top): Membrane voltage (in mV) at different locations on a simulated neuron as a function of stimulation voltage (in mV, axis shared with bottom plot) for biphasic stimulation with combination A4pA5n, location GM1_L_r5, and axon in the $+\hat{y}$ direction. This is the same configuration as in Fig. 4.15, except biphasic instead of monophasic stimulation. This is one of the configurations that results in neuron activation with the minimum amount of biphasic stimulation (in this case 3.25 V). The legend labels in the top plot are in the format (section type, orientation, segment number). See Fig. 3.3 for segment number locations by section type. Note that the axon tip (AxonProper, 'Yp' ,16) is most stimulated compared to other probe locations and linear as expected from Fig. 4.7b. (bottom): The time of the maximum membrane voltage (in ms) for each probe vs stimulation voltage (in mV). The time of the maximum membrane voltage helps explain which parts of the neuron reach maximum first. Note that the stimulation pulse starts at 1 ms the middle of the pulse is at 2.66 ms and the maximum amplitudes of the pulse occur at 2.66 ms ± 0.16 ms. The first maximum amplitude occurs at 2.5 ms and the maximum in the axon proper tip, and the $-\hat{x}$ distal dendrite tip occurs very shortly after. 111

4.17 Membrane voltage (V_m) vs time, for a neuron with axon pointing towards Yp located at GM1_L_r5 exposed to 3.25 V of biphasic stimulation using combination A4pA5n. Each subfigure (a-f) plots V_m on a each segment of a different neurite: (a) $-\hat{x}$ dendrite, (b) $+\hat{x}$ dendrite, (c) $-\hat{y}$ dendrite, (d) $-\hat{z}$ dendrite, (e) $+\hat{z}$ dendrite, and (f) $+\hat{y}$ axon + soma. For each subfigure (a-f): The horizontal axis is the simulation time in ms. Each segment plot is labeled on the right side with (section type, orientation, segment number). The range of the vertical axis for the segment plots is indicated in the lower left corner. The minimum and maximum V_m for each segment are in the middle of each segment plot. Red areas under each segment plot indicate time periods in which V_m at that segment exceeds -10 mV. Subfigure (f) shows that no action potential occurs and instead the stimulation pulse causes V_m at the axon tip to exceed -10 mV (and release neurotransmitters) directly. 115

4.18 Membrane voltage (V_m) vs time, for a neuron with axon pointing towards Yn located at GM1_L_r5 exposed to 8.0 V of biphasic stimulation using combination A4pA5n. Each subfigure (a-f) plots V_m on a each segment of a different neurite: (a) $-\hat{x}$ dendrite, (b) $+\hat{x}$ dendrite, (c) $+\hat{y}$ dendrite, (d) $-\hat{z}$ dendrite, (e) $+\hat{z}$ dendrite, and (f) $-\hat{y}$ axon + soma. For each subfigure (a-f): The horizontal axis is the simulation time in ms. Each segment plot is labeled on the right side with (section type, orientation, segment number). The range of the vertical axis for the segment plots is indicated in the lower left corner. The minimum and maximum V_m for each segment is in the middle of each segment plot. Red areas under each segment plot indicate time periods in which V_m at that segment exceeds -10 mV. Subfigure (f) shows an orthodromic action potential starting at the IS and traveling to the axon tip and causing neurotransmitter release. 116

4.19 (top): Membrane voltage (in mV) as a function of stimulation voltage (in mV, axis shared with bottom plot) for biphasic stimulation with combination A4pA5n, location GM1_L_r5, and axon in the $-\hat{y}$ direction. This is the same configuration as in Fig. 4.16 except the axon is in the $-\hat{y}$ direction. This configuration results in an orthodromic action potential starting at the initial segment (IS) with 8 V of stimulation. This is one of the few neurons in Fig. 4.7b with a nonlinear response in the axon tip above 8 V. The legend labels in the top plot are in the format (section type, orientation, segment number). See Fig. 3.3 for segment number locations by section type. (bottom): The time of the maximum membrane voltage (in ms) for each probe vs stimulation voltage (in mV). The time of the maximum membrane voltage helps explain which parts of the neuron reach maximum first. Note that the stimulation pulse starts at 1 ms the middle of the pulse is at 2.66 ms and the maximum amplitudes of the pulse occur at 2.66 ms ± 0.16 ms. The first maximum amplitude occurs at 2.5 ms and the maximum in the $+\hat{y}$ distal dendrite tip occurs very shortly after. 117

4.20 Maximum membrane voltage in mV at the axon distal tip (segment 16) (y-axis) plotted against the second spatial derivative of the static extracellular voltage V_e along a vector pointing towards the soma at the axon distal tip (x-axis) for all neuron locations and all 18 electrode pair combinations using monophasic stimulation (left plot) and biphasic stimulation (right plot). The gray rectangles are a 2d histogram of the number of neurons (see gray colorbar). The colored dots are active neurons (axon tip has a membrane voltage greater than -10 mV) and are colored based on the stimulation voltage (see right colorbar). The red dotted horizontal line indicates the activation threshold (dots and gray rectangles above this line indicate activated neurons). 119

4.21 Maximum membrane voltage in mV at the axon distal tip (segment 16) (y-axis) plotted against the static extracellular voltage at the axon distal tip (x-axis) for all neuron locations and all 18 electrode pair combinations using monophasic stimulation (left plot) and biphasic stimulation (right plot). The gray rectangles are a 2d histogram of the number of neurons (see gray colorbar). The colored dots are active neurons (axon tip has a membrane voltage greater than -10 mV) and are colored based on the stimulation voltage (see right colorbar). The red dotted horizontal line indicates the activation threshold (dots and gray rectangles above this line indicate activated neurons). 120

4.22 Maximum membrane voltage in mV at the axon distal tip (segment 16) (y-axis) plotted against the static extracellular voltage at the axon distal tip minus the static extracellular voltage at the soma (x-axis) for all neuron locations and all 18 electrode pair combinations using monophasic stimulation (top plot) and biphasic stimulation (bottom plot). The gray rectangles are a 2d histogram of the number of neurons (see gray colorbar). The colored dots are active neurons (axon tip has a membrane voltage greater than $-10\,\text{mV}$) and are colored based on the stimulation voltage (see right colorbar). The red dotted horizontal line indicates the activation threshold (dots and gray rectangles above this line indicate activated neurons). 121

4.23 Monophasic stimulation using combination -A4pB4n. Electrode B4 has a positive phase and is labeled red. Electrode A4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\text{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 9.5 V), (GM1_L_r4, Xn, 3.75 V), (GM3_L_r4, Xn, 10.0 V), and (GM1_R_r4, Yn, 7.0 V). . . . 124

4.24 Monophasic stimulation using combination A4pB4n. Electrode A4 has a positive phase and is labeled red. Electrode B4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r4, Yp, 3.75 V), (GM3_R_r4, Yp, 8.75 V), (GM1_L_r4, Xp, 4.25 V), (GM3_L_r4, Xp, 9.0 V), and (GM1_L_r4, Yn, 9.75 V). 125

4.25 Monophasic stimulation using combination -A4pC4n. Electrode C4 has a positive phase and is labeled red. Electrode A4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 3.25 V), (GM3_L_r4, Yp, 7.75 V), (GM1_L_r4, Xn, 4.25 V), (GM1_R_r4, Xn, 3.75 V), (GM3_L_r4, Xn, 8.5 V), (GM3_R_r4, Xn, 6.0 V), and (GM1_R_r4, Yn, 4.75 V). 126

4.26 Monophasic stimulation using combination A4pC4n. Electrode A4 has a positive phase and is labeled red. Electrode C4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r4, Yp, 3.25 V), (GM3_R_r4, Yp, 7.75 V), (GM1_L_r4, Xp, 3.75 V), (GM1_R_r4, Xp, 4.25 V), (GM3_L_r4, Xp, 6.0 V), (GM3_R_r4, Xp, 8.5 V), and (GM1_L_r4, Yn, 4.75 V). 127

4.27 Monophasic stimulation using combination -A4pA5n. Electrode A5 has a positive phase and is labeled red. Electrode A4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r5, Zn, 9.75 V), (GM1_L_r4and5, Zn, 5.75 V), (GM3_L_r4and5, Zn, 8.5 V), (GM1_R_r4and5, Zn, 10.0 V), (GM1_L_r4, Yp, 2.75 V), (GM3_L_r4, Yp, 6.0 V), (GM2_L_r4, Yp, 8.25 V), (GM1_L_r5, Xp, 5.5 V), (GM1_L_r4, Xn, 6.25 V), (GM1_L_r5, Yn, 4.25 V), and (GM3_L_r5, Yn, 9.75 V). 128

4.28 Monophasic stimulation using combination A4pA5n. Electrode A4 has a positive phase and is labeled red. Electrode A5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r5, Yp, 2.75 V), (GM3_L_r5, Yp, 6.0 V), (GM2_L_r5, Yp, 8.25 V), (GM1_L_r4, Xp, 5.75 V), (GM1_L_r5, Xn, 6.25 V), (GM1_L_r4, Yn, 4.25 V), (GM3_L_r4, Yn, 9.75 V), (GM1_L_r4, Zp, 10.0 V), (GM1_L_r4and5, Zp, 5.75 V), (GM3_L_r4and5, Zp, 8.5 V), and (GM1_R_r4and5, Zp, 10.0 V). 129

4.29 Monophasic stimulation using combination -A4pB5n. Electrode B5 has a positive phase and is labeled red. Electrode A4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4and5, Zn, 6.25 V), (GM1_R_r4and5, Zn, 8.25 V), (GM3_L_r4and5, Zn, 9.0 V), (GM1_L_r4, Yp, 2.75 V), (GM3_L_r4, Yp, 6.0 V), (GM2_L_r4, Yp, 8.25 V), (GM1_L_r4, Xn, 6.0 V), (GM1_R_r5, Yn, 6.0 V), and (GM1_L_r5, Yn, 6.0 V). 130

4.30 Monophasic stimulation using combination A4pB5n. Electrode A4 has a positive phase and is labeled red. Electrode B5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r5, Yp, 3.5 V), (GM1_L_r5, Yp, 3.5 V), (GM3_R_r5, Yp, 7.0 V), (GM3_L_r5, Yp, 7.25 V), (GM1_L_r4, Xp, 5.5 V), (GM1_L_r4, Yn, 4.25 V), (GM3_L_r4, Yn, 10.0 V), (GM1_L_r4, Zp, −1.0 V), (GM1_L_r4and5, Zp, 6.5 V), (GM1_R_r4and5, Zp, 7.75 V), and (GM3_L_r4and5, Zp, 9.0 V). 131

4.31 Monophasic stimulation using combination -A4pC5n. Electrode C5 has a positive phase and is labeled red. Electrode A4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than $10\,\mathrm{V}$ of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4and5, Zn, 7.25 V), (GM3_L_r4and5, Zn, 9.75 V), (GM1_R_r4and5, Zn, 7.75 V), (GM3_R_r4and5, Zn, −1.0 V), (GM1_L_r4, Yp, 2.75 V), (GM3_L_r4, Yp, 6.0 V), (GM2_L_r4, Yp, 8.25 V), (GM1_L_r4, Xn, 6.0 V), (GM1_R_r5, Xn, 5.25 V), (GM1_R_r5, Yn, 4.25 V), and (GM3_R_r5, Yn, 9.75 V). 132

4.32 Monophasic stimulation using combination A4pC5n. Electrode A4 has a positive phase and is labeled red. Electrode C5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r5, Yp, 2.75 V), (GM3_R_r5, Yp, 6.0 V), (GM2_R_r5, Yp, 8.25 V), (GM1_L_r4, Xp, 5.25 V), (GM1_R_r5, Xp, 6.0 V), (GM1_L_r4, Yn, 4.25 V), (GM3_L_r4, Yn, 9.75 V), (GM1_L_r4and5, Zp, 7.75 V), (GM3_L_r4and5, Zp, −1.0 V), (GM1_R_r4and5, Zp, 7.0 V), and (GM3_R_r4and5, Zp, 9.75 V). 133

4.33 Monophasic stimulation using combination -B4pB5n. Electrode B5 has a positive phase and is labeled red. Electrode B4 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r4and5, Zn, 6.75 V), (GM1_L_r4and5, Zn, 6.75 V), (GM3_L_r4and5, Zn, 9.25 V), (GM3_R_r4and5, Zn, 9.25 V), (GM1_L_r4, Yp, 3.5 V), (GM1_R_r4, Yp, 3.5 V), (GM3_R_r4, Yp, 7.25 V), (GM3_L_r4, Yp, 7.25 V), (GM1_L_r5, Yn, 6.0 V), and (GM1_R_r5, Yn, 6.0 V). . 134

4.34 Monophasic stimulation using combination B4pB5n. Electrode B4 has a positive phase and is labeled red. Electrode B5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r5, Yp, 3.5 V), (GM1_R_r5, Yp, 3.5 V), (GM3_L_r5, Yp, 7.25 V), (GM3_R_r5, Yp, 7.25 V), (GM1_L_r4, Yn, 6.0 V), (GM1_R_r4, Yn, 6.0 V), (GM1_R_r4and5, Zp, 6.75 V), (GM1_L_r4and5, Zp, 6.75 V), (GM3_L_r4and5, Zp, 9.25 V), and (GM3_R_r4and5, Zp, 9.25 V). 135

4.35 Monophasic stimulation using combination -A3pA5n. Electrode A5 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3and4, Zn, 9.0 V), (GM1_L_r4and5, Zn, 9.75 V), (GM1_L_r3, Yp, 3.0 V), (GM3_L_r3, Yp, 6.25 V), (GM2_L_r3, Yp, 8.25 V), (GM1_L_r5, Xp, 6.0 V), (GM1_L_r3, Xn, 7.0 V), (GM1_L_r5, Yn, 4.5 V), and (GM3_L_r5, Yn, 9.75 V). 136

4.36 Monophasic stimulation using combination A3pA5n. Electrode A3 has a positive phase and is labeled red. Electrode A5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r5, Yp, 3.0 V), (GM3_L_r5, Yp, 6.25 V), (GM2_L_r5, Yp, 8.5 V), (GM1_L_r3, Xp, 6.0 V), (GM1_L_r5, Xn, 7.0 V), (GM1_L_r3, Yn, 4.5 V), (GM3_L_r3, Yn, 9.75 V), (GM1_L_r3and4, Zp, 9.75 V), and (GM1_L_r4and5, Zp, 9.0 V). 137

4.37 Monophasic stimulation using combination -A3pB5n. Electrode B5 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3and4, Zn, 9.0 V), (GM1_L_r3, Yp, 3.0 V), (GM3_L_r3, Yp, 6.25 V), (GM2_L_r3, Yp, 8.25 V), (GM1_L_r3, Xn, 6.75 V), (GM1_R_r5, Yn, 6.25 V), and (GM1_L_r5, Yn, 6.25 V). 138

4.38 Monophasic stimulation using combination A3pB5n. Electrode A3 has a positive phase and is labeled red. Electrode B5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r5, Yp, 3.75 V), (GM1_L_r5, Yp, 3.75 V), (GM3_R_r5, Yp, 7.5 V), (GM3_L_r5, Yp, 7.5 V), (GM1_L_r3, Xp, 6.0 V), (GM1_L_r3, Yn, 4.5 V), (GM3_L_r3, Yn, 9.75 V), (GM1_L_r3and4, Zp, 9.75 V), (GM1_R_r4and5, Zp, −1.0 V), and (GM1_L_r4and5, Zp, −1.0 V). 139

4.39 Monophasic stimulation using combination -A3pC5n. Electrode C5 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3and4, Zn, 9.0 V), (GM1_R_r4and5, Zn, 10.0 V), (GM1_L_r3, Yp, 3.0 V), (GM3_L_r3, Yp, 6.25 V), (GM2_L_r3, Yp, 8.5 V), (GM1_L_r3, Xn, 6.75 V), (GM1_R_r5, Xn, 6.0 V), (GM1_R_r5, Yn, 4.5 V), and (GM3_R_r5, Yn, 9.75 V). 140

4.40 Monophasic stimulation using combination A3pC5n. Electrode A3 has a positive phase and is labeled red. Electrode C5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_R_r5, Yp, 3.0 V), (GM3_R_r5, Yp, 6.25 V), (GM2_R_r5, Yp, 8.25 V), (GM1_L_r3, Xp, 6.0 V), (GM1_R_r5, Xp, 6.75 V), (GM1_L_r3, Yn, 4.5 V), (GM3_L_r3, Yn, 9.75 V), (GM1_L_r3and4, Zp, 10.0 V), and (GM1_R_r4and5, Zp, 9.0 V). 141

4.41 Monophasic stimulation using combination -B3pB5n. Electrode B5 has a positive phase and is labeled red. Electrode B3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r3and4, Zn, 10.0 V), (GM1_R_r3and4, Zn, 10.0 V), (GM1_L_r3, Yp, 3.75 V), (GM1_R_r3, Yp, 3.75 V), (GM3_L_r3, Yp, 7.25 V), (GM3_R_r3, Yp, 7.25 V), (GM1_L_r5, Yn, 6.25 V), and (GM1_R_r5, Yn, 6.25 V). 142

4.42 Monophasic stimulation using combination B3pB5n. Electrode B3 has a positive phase and is labeled red. Electrode B5 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r5, Yp, 3.75 V), (GM1_R_r5, Yp, 3.75 V), (GM3_L_r5, Yp, 7.5 V), (GM3_R_r5, Yp, 7.25 V), (GM1_L_r3, Yn, 6.25 V), (GM1_R_r3, Yn, 6.25 V), (GM1_L_r4and5, Zp, 10.0 V), and (GM1_R_r4and5, Zp, 10.0 V). . . 143

4.43 Monophasic stimulation using combination -A3pA6n. Electrode A6 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.25 V), (GM3_L_r3, Yp, 6.75 V), (GM2_L_r3, Yp, 9.0 V), (GM1_L_r6, Xp, 6.5 V), (GM1_L_r3, Xn, 7.5 V), and (GM1_L_r6, Yn, 4.75 V). 144

4.44 Monophasic stimulation using combination A3pA6n. Electrode A3 has a positive phase and is labeled red. Electrode A6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r6, Yp, 3.25 V), (GM3_L_r6, Yp, 6.75 V), (GM2_L_r6, Yp, 9.0 V), (GM1_L_r3, Xp, 6.5 V), (GM1_L_r6, Xn, 7.5 V), (GM1_L_r3, Yn, 4.75 V), and (GM1_L_r5and6, Zp, −1.0 V). 145

4.45 Monophasic stimulation using combination -A3pB6n. Electrode B6 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.25 V), (GM3_L_r3, Yp, 6.75 V), (GM2_L_r3, Yp, 9.0 V), (GM1_L_r3, Xn, 7.5 V), (GM1_R_r6, Yn, 6.75 V), and (GM1_L_r6, Yn, 6.75 V). . . . 146

4.46 Monophasic stimulation using combination A3pB6n. Electrode A3 has a positive phase and is labeled red. Electrode B6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_R_r6, Yp, 4.0 V), (GM1_L_r6, Yp, 4.0 V), (GM3_L_r6, Yp, 7.75 V), (GM3_R_r6, Yp, 7.75 V), (GM1_L_r3, Xp, 6.5 V), and (GM1_L_r3, Yn, 4.75 V). 147

4.47 Monophasic stimulation using combination -A3pC6n. Electrode C6 has a positive phase and is labeled red. Electrode A3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.25 V), (GM3_L_r3, Yp, 6.75 V), (GM2_L_r3, Yp, 9.0 V), (GM1_L_r3, Xn, 7.5 V), (GM1_R_r6, Xn, 6.5 V), and (GM1_R_r6, Yn, 4.75 V). . . . 148

4.48 Monophasic stimulation using combination A3pC6n. Electrode A3 has a positive phase and is labeled red. Electrode C6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_R_r6, Yp, 3.25 V), (GM3_R_r6, Yp, 6.75 V), (GM2_R_r6, Yp, 9.0 V), (GM1_L_r3, Xp, 6.5 V), (GM1_R_r6, Xp, 7.5 V), (GM1_L_r3, Yn, 4.75 V), and (GM1_R_r5and6, Zp, −1.0 V). 149

4.49 Monophasic stimulation using combination -B3pB6n. Electrode B6 has a positive phase and is labeled red. Electrode B3 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.0 V), (GM1_R_r3, Yp, 4.0 V), (GM3_L_r3, Yp, 7.75 V), (GM3_R_r3, Yp, 7.75 V), (GM1_L_r6, Yn, 6.75 V), and (GM1_R_r6, Yn, 6.75 V). 150

4.50 Monophasic stimulation using combination B3pB6n. Electrode B3 has a positive phase and is labeled red. Electrode B6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r6, Yp, 4.0 V), (GM1_R_r6, Yp, 4.0 V), (GM3_L_r6, Yp, 7.75 V), (GM3_R_r6, Yp, 7.75 V), (GM1_L_r3, Yn, 6.75 V), and (GM1_R_r3, Yn, 6.75 V). 151

4.51 Monophasic stimulation using combination -A2pA6n. Electrode A6 has a positive phase and is labeled red. Electrode A2 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 3.5 V), (GM3_L_r2, Yp, 7.25 V), (GM2_L_r2, Yp, 9.5 V), (GM1_L_r6, Xp, 7.0 V), (GM1_L_r2, Xn, 7.75 V), and (GM1_L_r6, Yn, 5.0 V). 152

4.52 Monophasic stimulation using combination A2pA6n. Electrode A2 has a positive phase and is labeled red. Electrode A6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r6, Yp, 3.5 V), (GM3_L_r6, Yp, 7.25 V), (GM2_L_r6, Yp, 9.5 V), (GM1_L_r2, Xp, 7.0 V), (GM1_L_r6, Xn, 8.0 V), and (GM1_L_r2, Yn, 5.0 V). 153

4.53 Monophasic stimulation using combination -A2pB6n. Electrode B6 has a positive phase and is labeled red. Electrode A2 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 3.5 V), (GM3_L_r2, Yp, 7.25 V), (GM2_L_r2, Yp, 9.5 V), (GM1_L_r2, Xn, 7.75 V), (GM1_L_r6, Yn, 7.25 V), and (GM1_R_r6, Yn, 7.0 V). . . . 154

4.54 Monophasic stimulation using combination A2pB6n. Electrode A2 has a positive phase and is labeled red. Electrode B6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r6, Yp, 4.25 V), (GM1_R_r6, Yp, 4.25 V), (GM3_L_r6, Yp, 8.25 V), (GM3_R_r6, Yp, 8.25 V), (GM1_L_r2, Xp, 7.0 V), and (GM1_L_r2, Yn, 5.0 V). 155

4.55 Monophasic stimulation using combination -A2pC6n. Electrode C6 has a positive phase and is labeled red. Electrode A2 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 3.5 V), (GM3_L_r2, Yp, 7.25 V), (GM2_L_r2, Yp, 9.5 V), (GM1_L_r2, Xn, 7.75 V), (GM1_R_r6, Xn, 7.0 V), and (GM1_R_r6, Yn, 5.0 V). . . . 156

4.56 Monophasic stimulation using combination A2pC6n. Electrode A2 has a positive phase and is labeled red. Electrode C6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_R_r6, Yp, 3.5 V), (GM3_R_r6, Yp, 7.25 V), (GM2_R_r6, Yp, 9.5 V), (GM1_L_r2, Xp, 7.0 V), (GM1_R_r6, Xp, 8.0 V), and (GM1_L_r2, Yn, 5.0 V). . . 157

4.57 Monophasic stimulation using combination -B2pB6n. Electrode B6 has a positive phase and is labeled red. Electrode B2 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 4.25 V), (GM1_R_r2, Yp, 4.25 V), (GM3_L_r2, Yp, 8.25 V), (GM3_R_r2, Yp, 8.25 V), (GM1_L_r6, Yn, 7.0 V), and (GM1_R_r6, Yn, 7.0 V). 158

4.58 Monophasic stimulation using combination B2pB6n. Electrode B2 has a positive phase and is labeled red. Electrode B6 has a negative phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than $10\,\mathrm{V}$ of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r6, Yp, $4.25\,\mathrm{V}$), (GM1_R_r6, Yp, $4.25\,\mathrm{V}$), (GM3_L_r6, Yp, $8.25\,\mathrm{V}$), (GM3_R_r6, Yp, $8.25\,\mathrm{V}$), (GM1_L_r2, Yn, $7.0\,\mathrm{V}$), and (GM1_R_r2, Yn, $7.0\,\mathrm{V}$). 159

4.59 Biphasic stimulation using combination -A4pB4n. Electrode B4 has a positive phase first followed by a negative phase and is labeled red. Electrode A4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than $10\,\mathrm{V}$ of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_R_r4, Yp, $8.0\,\mathrm{V}$), (GM1_L_r4, Xp, $8.75\,\mathrm{V}$), and (GM1_L_r4, Xn, $5.0\,\mathrm{V}$). 160

4.60 Biphasic stimulation using combination A4pB4n. Electrode A4 has a positive phase first followed by a negative phase and is labeled red. Electrode B4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_R_r4, Yp, 4.0 V), (GM3_R_r4, Yp, 9.0 V), (GM1_L_r4, Xp, 6.5 V), and (GM1_L_r4, Xn, 9.0 V). 161

4.61 Biphasic stimulation using combination -A4pC4n. Electrode C4 has a positive phase first followed by a negative phase and is labeled red. Electrode A4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 4.0 V), (GM1_R_r4, Yp, 8.75 V), (GM3_L_r4, Yp, 8.0 V), (GM1_L_r4, Xp, 9.0 V), (GM1_R_r4, Xp, 9.25 V), (GM1_L_r4, Xn, 5.5 V), (GM1_R_r4, Xn, 5.0 V), (GM3_R_r4, Xn, 7.0 V), (GM1_L_r4, Yn, 8.5 V), and (GM1_R_r4, Yn, 7.0 V). 162

4.62 Biphasic stimulation using combination A4pC4n. Electrode A4 has a positive phase first followed by a negative phase and is labeled red. Electrode C4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 8.5 V), (GM1_R_r4, Yp, 4.0 V), (GM3_R_r4, Yp, 8.0 V), (GM1_L_r4, Xp, 5.0 V), (GM1_R_r4, Xp, 5.5 V), (GM3_L_r4, Xp, 7.0 V), (GM1_L_r4, Xn, 9.0 V), (GM1_R_r4, Xn, 9.25 V), (GM1_L_r4, Yn, 7.25 V), and (GM1_R_r4, Yn, 8.75 V). 163

4.63 Biphasic stimulation using combination -A4pA5n. Electrode A5 has a positive phase first followed by a negative phase and is labeled red. Electrode A4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4and5, Zn, 7.0 V), (GM1_L_r4, Yp, 3.25 V), (GM1_L_r5, Yp, 7.5 V), (GM3_L_r4, Yp, 6.75 V), (GM2_L_r4, Yp, 9.25 V), (GM1_L_r5, Xp, 7.25 V), (GM1_L_r4, Xn, 8.0 V), (GM1_L_r4, Yn, 8.0 V), and (GM1_L_r5, Yn, 6.0 V). . . 164

4.64 Biphasic stimulation using combination A4pA5n. Electrode A4 has a positive phase first followed by a negative phase and is labeled red. Electrode A5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 7.5 V), (GM1_L_r5, Yp, 3.25 V), (GM3_L_r5, Yp, 6.75 V), (GM2_L_r5, Yp, 9.25 V), (GM1_L_r4, Xp, 7.25 V), (GM1_L_r5, Xn, 7.75 V), (GM1_L_r4, Yn, 6.0 V), (GM1_L_r5, Yn, 8.0 V), and (GM1_L_r4and5, Zp, 7.25 V). 165

4.65 Biphasic stimulation using combination -A4pB5n. Electrode B5 has a positive phase first followed by a negative phase and is labeled red. Electrode A4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4and5, Zn, 7.5 V), (GM1_L_r4, Yp, 3.5 V), (GM1_R_r5, Yp, 8.0 V), (GM1_L_r5, Yp, 7.75 V), (GM3_L_r4, Yp, 6.75 V), (GM2_L_r4, Yp, 9.5 V), (GM1_L_r4, Xn, 7.75 V), (GM1_L_r4, Yn, 8.0 V), (GM1_R_r5, Yn, 8.5 V), and (GM1_L_r5, Yn, 8.5 V). 166

4.66 Biphasic stimulation using combination A4pB5n. Electrode A4 has a positive phase first followed by a negative phase and is labeled red. Electrode B5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 7.5 V), (GM1_R_r5, Yp, 3.75 V), (GM1_L_r5, Yp, 3.75 V), (GM3_R_r5, Yp, 8.0 V), (GM3_L_r5, Yp, 8.25 V), (GM1_L_r4, Xp, 7.0 V), (GM1_L_r4, Yn, 6.0 V), (GM1_L_r4and5, Zp, 8.0 V), and (GM1_R_r4and5, Zp, 9.5 V). 167

4.67 Biphasic stimulation using combination -A4pC5n. Electrode C5 has a positive phase first followed by a negative phase and is labeled red. Electrode A4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than $10\,\mathrm{V}$ of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4and5, Zn, 8.5 V), (GM1_R_r4and5, Zn, 9.75 V), (GM1_L_r4, Yp, 3.5 V), (GM1_R_r5, Yp, 7.75 V), (GM3_L_r4, Yp, 6.75 V), (GM2_L_r4, Yp, 9.25 V), (GM1_L_r4, Xn, 7.5 V), (GM1_R_r5, Xn, 7.0 V), (GM1_L_r4, Yn, 8.0 V), and (GM1_R_r5, Yn, 6.0 V). 168

4.68 Biphasic stimulation using combination A4pC5n. Electrode A4 has a positive phase first followed by a negative phase and is labeled red. Electrode C5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than $10\,\mathrm{V}$ of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 7.75 V), (GM1_R_r5, Yp, 3.5 V), (GM3_R_r5, Yp, 6.75 V), (GM2_R_r5, Yp, 9.25 V), (GM1_L_r4, Xp, 7.0 V), (GM1_R_r5, Xp, 7.5 V), (GM1_L_r4, Yn, 6.0 V), (GM1_R_r5, Yn, 8.0 V), (GM1_L_r4and5, Zp, 9.75 V), and (GM1_R_r4and5, Zp, 8.5 V). 169

4.69 Biphasic stimulation using combination -B4pB5n. Electrode B5 has a positive phase first followed by a negative phase and is labeled red. Electrode B4 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_R_r4and5, Zn, 8.25 V), (GM1_L_r4and5, Zn, 8.25 V), (GM1_L_r4, Yp, 3.75 V), (GM1_R_r4, Yp, 3.75 V), (GM1_L_r5, Yp, 7.75 V), (GM1_R_r5, Yp, 7.75 V), (GM3_R_r4, Yp, 8.0 V), (GM3_L_r4, Yp, 8.25 V), (GM1_L_r5, Yn, 8.75 V), and (GM1_R_r5, Yn, 8.75 V). 170

4.70 Biphasic stimulation using combination B4pB5n. Electrode B4 has a positive phase first followed by a negative phase and is labeled red. Electrode B5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r4, Yp, 7.75 V), (GM1_R_r4, Yp, 7.75 V), (GM1_L_r5, Yp, 3.75 V), (GM1_R_r5, Yp, 3.75 V), (GM3_L_r5, Yp, 8.25 V), (GM3_R_r5, Yp, 8.25 V), (GM1_L_r4, Yn, 8.75 V), (GM1_R_r4, Yn, 8.75 V), (GM1_R_r4and5, Zp, 8.25 V), and (GM1_L_r4and5, Zp, 8.25 V). 171

4.71 Biphasic stimulation using combination -A3pA5n. Electrode A5 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.75 V), (GM1_L_r5, Yp, 8.25 V), (GM3_L_r3, Yp, 7.0 V), (GM2_L_r3, Yp, 9.5 V), (GM1_L_r5, Xp, 8.0 V), (GM1_L_r3, Xn, 8.75 V), (GM1_L_r3, Yn, 8.75 V), and (GM1_L_r5, Yn, 6.5 V). 172

4.72 Biphasic stimulation using combination A3pA5n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode A5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 8.25 V), (GM1_L_r5, Yp, 3.75 V), (GM3_L_r5, Yp, 7.0 V), (GM2_L_r5, Yp, 9.5 V), (GM1_L_r3, Xp, 8.0 V), (GM1_L_r5, Xn, 8.5 V), (GM1_L_r3, Yn, 6.25 V), and (GM1_L_r5, Yn, 8.75 V). 173

4.73 Biphasic stimulation using combination -A3pB5n. Electrode B5 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.75 V), (GM1_R_r5, Yp, 8.5 V), (GM1_L_r5, Yp, 8.5 V), (GM3_L_r3, Yp, 7.0 V), (GM2_L_r3, Yp, 9.5 V), (GM1_L_r3, Xn, 8.75 V), (GM1_L_r3, Yn, 8.75 V), (GM1_R_r5, Yn, 8.75 V), and (GM1_L_r5, Yn, 8.75 V). 174

4.74 Biphasic stimulation using combination A3pB5n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode B5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 8.25 V), (GM1_R_r5, Yp, 4.0 V), (GM1_L_r5, Yp, 4.0 V), (GM3_R_r5, Yp, 8.25 V), (GM3_L_r5, Yp, 8.5 V), (GM1_L_r3, Xp, 8.0 V), and (GM1_L_r3, Yn, 6.25 V). 175

4.75 Biphasic stimulation using combination -A3pC5n. Electrode C5 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 3.75 V), (GM1_R_r5, Yp, 8.25 V), (GM3_L_r3, Yp, 7.0 V), (GM2_L_r3, Yp, 9.5 V), (GM1_L_r3, Xn, 8.75 V), (GM1_R_r5, Xn, 8.0 V), (GM1_L_r3, Yn, 8.75 V), and (GM1_R_r5, Yn, 6.5 V). 176

4.76 Biphasic stimulation using combination A3pC5n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode C5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 8.25 V), (GM1_R_r5, Yp, 3.75 V), (GM3_R_r5, Yp, 7.0 V), (GM2_R_r5, Yp, 9.5 V), (GM1_L_r3, Xp, 8.0 V), (GM1_R_r5, Xp, 8.75 V), (GM1_L_r3, Yn, 6.25 V), and (GM1_R_r5, Yn, 8.75 V). 177

4.77 Biphasic stimulation using combination -B3pB5n. Electrode B5 has a positive phase first followed by a negative phase and is labeled red. Electrode B3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.0 V), (GM1_R_r3, Yp, 4.0 V), (GM1_L_r5, Yp, 8.5 V), (GM1_R_r5, Yp, 8.5 V), (GM3_L_r3, Yp, 8.25 V), (GM3_R_r3, Yp, 8.25 V), (GM1_L_r5, Yn, 8.75 V), and (GM1_R_r5, Yn, 8.75 V). 178

4.78 Biphasic stimulation using combination B3pB5n. Electrode B3 has a positive phase first followed by a negative phase and is labeled red. Electrode B5 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 8.25 V), (GM1_R_r3, Yp, 8.5 V), (GM1_L_r5, Yp, 4.0 V), (GM1_R_r5, Yp, 4.0 V), (GM3_L_r5, Yp, 8.5 V), (GM3_R_r5, Yp, 8.25 V), (GM1_L_r3, Yn, 8.75 V), and (GM1_R_r3, Yn, 8.75 V). 179

4.79 Biphasic stimulation using combination -A3pA6n. Electrode A6 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.0 V), (GM1_L_r6, Yp, 8.75 V), (GM3_L_r3, Yp, 7.5 V), (GM1_L_r6, Xp, 8.75 V), (GM1_L_r3, Xn, 9.5 V), (GM1_L_r3, Yn, 9.5 V), and (GM1_L_r6, Yn, 6.75 V). 180

4.80 Biphasic stimulation using combination A3pA6n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode A6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 9.0 V), (GM1_L_r6, Yp, 4.0 V), (GM3_L_r6, Yp, 7.5 V), (GM2_L_r6, Yp, 10.0 V), (GM1_L_r3, Xp, 8.75 V), (GM1_L_r6, Xn, 9.25 V), (GM1_L_r3, Yn, 6.75 V), and (GM1_L_r6, Yn, 9.25 V). 181

4.81 Biphasic stimulation using combination -A3pB6n. Electrode B6 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.0 V), (GM1_R_r6, Yp, 9.25 V), (GM1_L_r6, Yp, 9.25 V), (GM3_L_r3, Yp, 7.5 V), (GM1_L_r3, Xn, 9.5 V), (GM1_L_r3, Yn, 9.5 V), (GM1_R_r6, Yn, 9.25 V), and (GM1_L_r6, Yn, 9.5 V). 182

4.82 Biphasic stimulation using combination A3pB6n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode B6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 9.0 V), (GM1_R_r6, Yp, 4.5 V), (GM1_L_r6, Yp, 4.5 V), (GM3_L_r6, Yp, 9.0 V), (GM3_R_r6, Yp, 9.0 V), (GM1_L_r3, Xp, 8.75 V), and (GM1_L_r3, Yn, 6.75 V). 183

4.83 Biphasic stimulation using combination -A3pC6n. Electrode C6 has a positive phase first followed by a negative phase and is labeled red. Electrode A3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.0 V), (GM1_R_r6, Yp, 8.75 V), (GM3_L_r3, Yp, 7.5 V), (GM1_L_r3, Xn, 9.5 V), (GM1_R_r6, Xn, 8.5 V), (GM1_L_r3, Yn, 9.5 V), and (GM1_R_r6, Yn, 6.75 V). 184

4.84 Biphasic stimulation using combination A3pC6n. Electrode A3 has a positive phase first followed by a negative phase and is labeled red. Electrode C6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 9.0 V), (GM1_R_r6, Yp, 4.0 V), (GM3_R_r6, Yp, 7.5 V), (GM2_R_r6, Yp, 10.0 V), (GM1_L_r3, Xp, 8.75 V), (GM1_R_r6, Xp, 9.5 V), (GM1_L_r3, Yn, 6.75 V), and (GM1_R_r6, Yn, 9.25 V). 185

4.85 Biphasic stimulation using combination -B3pB6n. Electrode B6 has a positive phase first followed by a negative phase and is labeled red. Electrode B3 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 4.25 V), (GM1_R_r3, Yp, 4.5 V), (GM1_L_r6, Yp, 9.25 V), (GM1_R_r6, Yp, 9.25 V), (GM3_L_r3, Yp, 9.0 V), (GM3_R_r3, Yp, 9.0 V), (GM1_L_r6, Yn, 9.25 V), and (GM1_R_r6, Yn, 9.25 V). 186

4.86 Biphasic stimulation using combination B3pB6n. Electrode B3 has a positive phase first followed by a negative phase and is labeled red. Electrode B6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r3, Yp, 9.0 V), (GM1_R_r3, Yp, 9.0 V), (GM1_L_r6, Yp, 4.5 V), (GM1_R_r6, Yp, 4.5 V), (GM3_L_r6, Yp, 9.0 V), (GM3_R_r6, Yp, 9.0 V), (GM1_L_r3, Yn, 9.5 V), and (GM1_R_r3, Yn, 9.5 V). 187

4.87 Biphasic stimulation using combination -A2pA6n. Electrode A6 has a positive phase first followed by a negative phase and is labeled red. Electrode A2 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 4.25 V), (GM1_L_r6, Yp, 9.5 V), (GM3_L_r2, Yp, 8.0 V), (GM1_L_r6, Xp, 9.25 V), (GM1_L_r2, Xn, 10.0 V), (GM1_L_r2, Yn, 9.75 V), and (GM1_L_r6, Yn, 7.25 V). 188

4.88 Biphasic stimulation using combination A2pA6n. Electrode A2 has a positive phase first followed by a negative phase and is labeled red. Electrode A6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 9.5 V), (GM1_L_r6, Yp, 4.25 V), (GM3_L_r6, Yp, 8.0 V), (GM1_L_r2, Xp, 9.25 V), (GM1_L_r6, Xn, 10.0 V), (GM1_L_r2, Yn, 7.25 V), and (GM1_L_r6, Yn, 10.0 V). 189

4.89 Biphasic stimulation using combination -A2pB6n. Electrode B6 has a positive phase first followed by a negative phase and is labeled red. Electrode A2 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 4.25 V), (GM1_L_r6, Yp, 9.75 V), (GM1_R_r6, Yp, 10.0 V), (GM3_L_r2, Yp, 8.0 V), (GM1_L_r2, Xn, 10.0 V), (GM1_L_r2, Yn, 9.75 V), (GM1_L_r6, Yn, 10.0 V), and (GM1_R_r6, Yn, 10.0 V). 190

4.90 Biphasic stimulation using combination A2pB6n. Electrode A2 has a positive phase first followed by a negative phase and is labeled red. Electrode B6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 9.5 V), (GM1_L_r6, Yp, 4.75 V), (GM1_R_r6, Yp, 4.75 V), (GM3_L_r6, Yp, 9.5 V), (GM3_R_r6, Yp, 9.5 V), (GM1_L_r2, Xp, 9.25 V), and (GM1_L_r2, Yn, 7.25 V). 191

4.91 Biphasic stimulation using combination -A2pC6n. Electrode C6 has a positive phase first followed by a negative phase and is labeled red. Electrode A2 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\text{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 4.25 V), (GM1_R_r6, Yp, 9.25 V), (GM3_L_r2, Yp, 8.0 V), (GM1_L_r2, Xn, 10.0 V), (GM1_R_r6, Xn, 9.0 V), (GM1_L_r2, Yn, 9.75 V), and (GM1_R_r6, Yn, 7.25 V). 192

4.92 Biphasic stimulation using combination A2pC6n. Electrode A2 has a positive phase first followed by a negative phase and is labeled red. Electrode C6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 9.5 V), (GM1_R_r6, Yp, 4.25 V), (GM3_R_r6, Yp, 8.0 V), (GM1_L_r2, Xp, 9.25 V), (GM1_L_r2, Yn, 7.25 V), and (GM1_R_r6, Yn, 10.0 V). 193

4.93 Biphasic stimulation using combination -B2pB6n. Electrode B6 has a positive phase first followed by a negative phase and is labeled red. Electrode B2 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds −10 mV with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10$ mV. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 4.5 V), (GM1_R_r2, Yp, 4.75 V), (GM1_L_r6, Yp, 9.75 V), (GM1_R_r6, Yp, 10.0 V), (GM3_L_r2, Yp, 9.75 V), (GM3_R_r2, Yp, 9.5 V), (GM1_L_r6, Yn, 10.0 V), and (GM1_R_r6, Yn, 10.0 V). 194

4.94 Biphasic stimulation using combination B2pB6n. Electrode B2 has a positive phase first followed by a negative phase and is labeled red. Electrode B6 has a negative phase first followed by a positive phase and is labeled blue. All other electrodes are floating and labeled purple. Soma, AH, IS, and AP are displayed as red lines for those neurons whose axon tip membrane voltage exceeds $-10\,\mathrm{mV}$ with no more than 10 V of stimulation. Dendrites are not displayed. The color of the cube at each axon tip indicates stimulation voltages required for axon tip to reach $V_m > -10\,\mathrm{mV}$. List of location, axon direction, and threshold: (GM1_L_r2, Yp, 9.5 V), (GM1_R_r2, Yp, 10.0 V), (GM1_L_r6, Yp, 4.75 V), (GM1_R_r6, Yp, 4.75 V), (GM3_L_r6, Yp, 9.5 V), (GM3_R_r6, Yp, 9.5 V), (GM1_L_r2, Yn, 10.0 V), and (GM1_R_r2, Yn, 10.0 V). 195

5.1 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron's synapse is at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to biphasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum pulse amplitudes occur at t=77.66ms ± 0.16ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$), where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (-5.0V, 4.783nS, 10, 6), (-5.0V, 4.776nS, 9, 5), (-5.0V, 4.769nS, 9, 5), (-4.0V, 4.783nS, 8, 5), (-4.0V, 4.776nS, 8, 5), (-4.0V, 4.769nS, 8, 5), (-3.0V, 4.783nS, 8, 5), (-3.0V, 4.776nS, 8, 5), (-3.0V, 4.769nS, 7, 4), (-2.0V, 4.783nS, 8, 5), (-2.0V, 4.776nS, 7, 4), (-2.0V, 4.769nS, 7, 3), (-1.0V, 4.783nS, 6, 5), (-1.0V, 4.776nS, 5, 1), (-1.0V, 4.769nS, 5, 0), (-0.5V, 4.783nS, 6, 2), and (-0.5V, 4.776nS, 3, 0). 206

5.2 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=4.783nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 16. The electrical stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. Synapse trigger times that have a dark yellow to orange color above them are a part of the "facilitation window." 207

5.3 Stimulation only: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). All data measured using neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. 208

5.4 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to $-2.0\,\text{V}$ of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=66.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 209

5.5 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to monophasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. This neuron is active without any EPSPs if exposed to -5.0V of stimulation. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (-4.0V, 4.783nS, 8, 7), (-4.0V, 4.776nS, 8, 7), (-4.0V, 4.769nS, 7, 7), (-3.0V, 4.783nS, 8, 3), (-3.0V, 4.776nS, 8, 3), (-3.0V, 4.769nS, 8, 3), (-2.0V, 4.783nS, 7, 0), (-2.0V, 4.776nS, 6, 0), (-2.0V, 4.769nS, 6, 0), (-1.0V, 4.783nS, 7, 0), (-1.0V, 4.776nS, 6, 0), (-1.0V, 4.769nS, 6, 0), (-0.5V, 4.783nS, 6, 0), (-0.5V, 4.776nS, 6, 0), and (-0.5V, 4.769nS, 5, 0). 212

5.6 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=4.783nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 16. The electrical stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 213

5.7 Stimulation only: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). All data measured using neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. 214

5.8 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to $-2.0\,\text{V}$ of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=71.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 215

5.9 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to monophasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (5.0V, 4.783nS, 7, 9), (5.0V, 4.776nS, 7, 9), (5.0V, 4.769nS, 6, 9), (4.0V, 4.783nS, 6, 10), (4.0V, 4.776nS, 6, 10), (4.0V, 4.769nS, 6, 10), (3.0V, 4.783nS, 5, 14), (3.0V, 4.776nS, 5, 13), (3.0V, 4.769nS, 5, 12), (2.0V, 4.783nS, 2, 14), (2.0V, 4.776nS, 2, 14), (2.0V, 4.769nS, 2, 13), (1.0V, 4.783nS, 1, 14), (1.0V, 4.776nS, 1, 14), (1.0V, 4.769nS, 1, 10), (0.5V, 4.783nS, 1, 14), (0.5V, 4.776nS, 1, 9), and (0.5V, 4.769nS, 1, 3). 216

5.10 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=4.783nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 16. The electrical stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 217

5.11 Stimulation only: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). All data measured using neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. 218

5.12 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=76.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 219

5.13 2d histogram of the number of facilitated neurons with synapses in the middle (segment 8) of the distal dendrite for: (a) monophasic and (b) biphasic stimulation. The y-axis of each 2d histogram shows the number of synapse trigger times which result in facilitation (or stimOnly if no EPSP is required to activate the neuron at that value of V_s). Understanding the x-axis of each 2d histogram requires looking at the background columns behind the histogram. The magnitude of stimulation voltage ($|V_s|$) is represented by the color of each column (see right color bar to the right of each plot). The synapse weight of each column is indicated by the hatching of each column (see legend to the far right of each histogram). The number of neurons in each square is indicated by the gray-scale colorbar just to the right of the histogram. Each column consists of the results from simulating 71280 neurons under 18 electrode combinations (described in Section 5.3). 223

5.14 2d histogram of the number of facilitated neurons with synapses at the distal tip (segment 16) of the distal dendrite for: (a) monophasic and (b) biphasic stimulation. The y-axis of each 2d histogram shows the number of synapse trigger times which result in facilitation (or stimOnly if no EPSP is required to activate the neuron at that value of V_s). Understanding the x-axis of each 2d histogram requires looking at the background columns behind the histogram. The magnitude of stimulation voltage ($|V_s|$) is represented by the color of each column (see right color bar to the right of each plot). The synapse weight of each column is indicated by the hatching of each column (see legend to the far right of each histogram). The number of neurons in each square is indicated by the gray-scale colorbar just to the right of the histogram. Each column consists of the results from simulating 71280 neurons under 18 electrode combinations (described in Section 5.3). 224

5.15 Stacked bar charts showing the number of active neurons (from facilitation or stimulation-only) where each column corresponds to a different pair of stimulation voltage ($|V_s|$) and synapse weight. These charts are for neurons with synapses in the middle (segment 8) of the distal dendrite and (a) monophasic and (b) biphasic stimulation. Each column consists of the results from simulating 71280 neurons under 18 electrode combinations (described in Section 5.3). Understanding the x-axis of each 2d histogram requires looking at the background columns behind the histogram. The magnitude of stimulation voltage ($|V_s|$) is represented by the color of each column (see virdis (yellow-green-blue color map) color bar to the right of each plot). The synapse weight of each column is indicated by the hatching of each column (see legend to the far right of each histogram). The color of each bar in the stacks (see legend to the right of the colorbar) indicates the number of synapse trigger times which result in facilitation (or stimOnly if the stimulation by itself causes activation). The maximum of the y-axis is the total number of simulated neurons (71280) indicated by a red horizontal line. 225

5.16 Stacked bar charts showing the number of active neurons (from facilitation or stimulation-only) where each column corresponds to a different pair of stimulation voltage ($|V_s|$) and synapse weight. These charts are for neurons with synapses at the distal tip (segment 16) of the distal dendrite and (a) monophasic and (b) biphasic stimulation. Each column consists of the results from simulating 71280 neurons under 18 electrode combinations (described in Section 5.3). Understanding the x-axis of each 2d histogram requires looking at the background columns behind the histogram. The magnitude of stimulation voltage ($|V_s|$) is represented by the color of each column (see virdis (yellow-green-blue color map) color bar to the right of each plot). The synapse weight of each column is indicated by the hatching of each column (see legend to the far right of each histogram). The color of each bar in the stacks (see legend to the right of the colorbar) indicates the number of synapse trigger times which result in facilitation (or stimOnly if the stimulation by itself causes activation). The maximum of the y-axis is the total number of simulated neurons (71280) indicated by a red horizontal line. 226

5.17 These two figures show (a) the largest 3 synapse weights from Fig. 5.15a and (b) Fig. 5.16a. See those figures for detailed description. The y-axis is a $\log_{10}$ scale with the total number of simulated neurons (71280) indicated by a red horizontal line. A greater number of neurons with synapses triggered on the distal tips of the distal dendrites have facilitation windows larger than 2 trigger time samples compared with synapses in the middle of the dendrite for synapse weights that are subthreshold by the same amount. 227

5.18 These two figures show (a) the largest 3 synapse weights from Fig. 5.15b and (b) Fig. 5.16b. See those figures for detailed description. The y-axis is a $\log_{10}$ scale with the total number of simulated neurons (71280) indicated by a red horizontal line. A greater number of neurons with synapses triggered on the distal tips of the distal dendrites have facilitation windows larger than 2 trigger time samples compared with synapses in the middle of the dendrite for synapse weights that are subthreshold by the same amount. 228

5.19 Example histogram plot showing the regions of example feature x that can be used for prediction of facilitation. The y-axis is the number of trigger points facilitated above threshold (−10 mV). Each trigger corresponds with about 5 ms of time during which a triggered synapse would cause facilitation. For each feature, active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below for feature value f_0, where T=1 and T=0 indicates that the neuron is active and non-active respectively. 230

5.20 Stimulation type: Biphasic, combination: A3pC5n, stimulation magnitude: V_s =2 V. Synapses are on segment 8 of each dendrite with a synapse weight of 3.436 nS. See Section 5.A for more description. Colormap indicating facilitation width can be found in Table 5.4. Darker colors indicate wider facilitation windows. 242

5.21 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to biphasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (5.0V, 4.783nS, 9, 6), (5.0V, 4.776nS, 8, 6), (5.0V, 4.769nS, 8, 6), (4.0V, 4.783nS, 8, 6), (4.0V, 4.776nS, 8, 6), (4.0V, 4.769nS, 8, 6), (3.0V, 4.783nS, 8, 6), (3.0V, 4.776nS, 7, 6), (3.0V, 4.769nS, 7, 5), (2.0V, 4.783nS, 8, 6), (2.0V, 4.776nS, 7, 5), (2.0V, 4.769nS, 6, 4), (1.0V, 4.783nS, 7, 5), (1.0V, 4.776nS, 6, 0), (1.0V, 4.769nS, 5, 0), (0.5V, 4.783nS, 5, 0), (0.5V, 4.776nS, 4, 0), and (0.5V, 4.769nS, 1, 0). 249

5.22 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=4.783nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 16. The electrical stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 250

5.23 Stimulation only: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). All data measured using neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. . 251

5.24 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=41.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 252

5.25 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=66.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 253

5.26 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=106.0 ms with a synaptic weight of 4.783nS. The synapse was located at segment 16 on the distal dendrite that points in the $+\hat{x}$ direction. 254

5.27 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to biphasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (-5.0V, 3.45nS, 9, 6), (-5.0V, 3.443nS, 8, 6), (-5.0V, 3.436nS, 8, 6), (-5.0V, 3.422nS, 7, 5), (-5.0V, 3.394nS, 7, 4), (-5.0V, 3.337nS, 7, 3), (-5.0V, 3.225nS, 6, 1), (-5.0V, 3.0nS, 4, 0), (-4.0V, 3.45nS, 8, 6), (-4.0V, 3.443nS, 7, 5), (-4.0V, 3.436nS, 7, 5), (-4.0V, 3.422nS, 7, 4), (-4.0V, 3.394nS, 6, 2), (-4.0V, 3.337nS, 6, 1), (-4.0V, 3.225nS, 4, 0), (-4.0V, 3.0nS, 2, 0), (-3.0V, 3.45nS, 8, 6), (-3.0V, 3.443nS, 7, 4), (-3.0V, 3.436nS, 7, 3), (-3.0V, 3.422nS, 6, 2), (-3.0V, 3.394nS, 5, 0), (-3.0V, 3.337nS, 4, 0), (-3.0V, 3.225nS, 1, 0), (-2.0V, 3.45nS, 6, 5), (-2.0V, 3.443nS, 5, 2), (-2.0V, 3.436nS, 5, 1), (-2.0V, 3.422nS, 4, 0), (-2.0V, 3.394nS, 3, 0), (-1.0V, 3.45nS, 6, 3), (-1.0V, 3.443nS, 4, 0), (-1.0V, 3.436nS, 3, 0), and (-0.5V, 3.45nS, 5, 0). 257

5.28 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=3.45nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 8. The electrical stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 258

5.29 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=46.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 259

5.30 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=66.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 260

5.31 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=101.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 261

5.32 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to biphasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (5.0V, 3.45nS, 8, 7), (5.0V, 3.443nS, 8, 6), (5.0V, 3.436nS, 8, 6), (5.0V, 3.422nS, 7, 5), (5.0V, 3.394nS, 7, 4), (5.0V, 3.337nS, 7, 3), (5.0V, 3.225nS, 6, 1), (5.0V, 3.0nS, 5, 0), (4.0V, 3.45nS, 8, 7), (4.0V, 3.443nS, 7, 6), (4.0V, 3.436nS, 7, 5), (4.0V, 3.422nS, 7, 4), (4.0V, 3.394nS, 6, 3), (4.0V, 3.337nS, 6, 1), (4.0V, 3.225nS, 5, 0), (4.0V, 3.0nS, 1, 0), (3.0V, 3.45nS, 7, 6), (3.0V, 3.443nS, 7, 5), (3.0V, 3.436nS, 6, 4), (3.0V, 3.422nS, 6, 2), (3.0V, 3.394nS, 5, 0), (3.0V, 3.337nS, 4, 0), (3.0V, 3.225nS, 1, 0), (2.0V, 3.45nS, 7, 6), (2.0V, 3.443nS, 6, 3), (2.0V, 3.436nS, 5, 1), (2.0V, 3.422nS, 5, 0), (2.0V, 3.394nS, 4, 0), (1.0V, 3.45nS, 6, 3), (1.0V, 3.443nS, 4, 0), (1.0V, 3.436nS, 2, 0), (0.5V, 3.45nS, 4, 0), and (0.5V, 3.443nS, 1, 0). 264

5.33 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=3.45nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 8. The electrical stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 265

5.34 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=46.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 266

5.35 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=66.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 267

5.36 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of biphasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and the maximum amplitudes of the pulse occur at t=77.66ms ± 0.16ms. An Exp2Syn synapse was triggered at t=106.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 268

5.37 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to monophasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. This neuron is active without any EPSPs if exposed to -5.0V of stimulation. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (-4.0V, 3.45nS, 8, 8), (-4.0V, 3.443nS, 8, 7), (-4.0V, 3.436nS, 8, 7), (-4.0V, 3.422nS, 7, 7), (-4.0V, 3.394nS, 8, 7), (-4.0V, 3.337nS, 8, 7), (-4.0V, 3.225nS, 8, 6), (-4.0V, 3.0nS, 8, 5), (-3.0V, 3.45nS, 8, 4), (-3.0V, 3.443nS, 8, 4), (-3.0V, 3.436nS, 7, 3), (-3.0V, 3.422nS, 7, 3), (-3.0V, 3.394nS, 7, 2), (-3.0V, 3.337nS, 7, 0), (-3.0V, 3.225nS, 6, 0), (-3.0V, 3.0nS, 4, 0), (-2.0V, 3.45nS, 7, 2), (-2.0V, 3.443nS, 7, 1), (-2.0V, 3.436nS, 6, 1), (-2.0V, 3.422nS, 6, 0), (-2.0V, 3.394nS, 5, 0), (-2.0V, 3.337nS, 5, 0), (-2.0V, 3.225nS, 3, 0), (-1.0V, 3.45nS, 7, 0), (-1.0V, 3.443nS, 6, 0), (-1.0V, 3.436nS, 6, 0), (-1.0V, 3.422nS, 5, 0), (-1.0V, 3.394nS, 4, 0), (-0.5V, 3.45nS, 7, 0), (-0.5V, 3.443nS, 6, 0), (-0.5V, 3.436nS, 5, 0), and (-0.5V, 3.422nS, 3, 0). 270

5.38 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=3.45nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 8. The electrical stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 271

5.39 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=46.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 272

5.40 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=76.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 273

5.41 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to −2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=86.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 274

5.42 Membrane voltage at the axon tip (V_m^{axontip}) vs synapse trigger time for a neuron whose axon points in the $-\hat{y}$ direction located at GM1_L_r5. This neuron has a synapse triggered at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction and is exposed to monophasic epidural stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The following list contains tuples of the form (V_s, w, $\#T_B$, $\#T_A$) where V_s is the stimulation voltage, w is the synapse weight, and ($\#T_B$, $\#T_A$) is the number of synapse trigger time samples (x-axis samples in the above graph) before or after the stimulation pulse, respectively, given the values of V_s and w that result in neuron activation (a value of V_m^{axontip} above $-10\,\text{mV}$) : (5.0V, 3.45nS, 6, 9), (5.0V, 3.443nS, 6, 9), (5.0V, 3.436nS, 6, 9), (5.0V, 3.422nS, 6, 8), (5.0V, 3.394nS, 5, 7), (5.0V, 3.337nS, 5, 6), (5.0V, 3.225nS, 4, 4), (5.0V, 3.0nS, 3, 2), (4.0V, 3.45nS, 6, 10), (4.0V, 3.443nS, 6, 10), (4.0V, 3.436nS, 5, 9), (4.0V, 3.422nS, 5, 8), (4.0V, 3.394nS, 5, 7), (4.0V, 3.337nS, 4, 5), (4.0V, 3.225nS, 4, 2), (3.0V, 3.45nS, 4, 13), (3.0V, 3.443nS, 4, 11), (3.0V, 3.436nS, 4, 9), (3.0V, 3.422nS, 4, 7), (3.0V, 3.394nS, 3, 4), (3.0V, 3.337nS, 0, 1), (2.0V, 3.45nS, 0, 14), (2.0V, 3.443nS, 0, 11), (2.0V, 3.436nS, 0, 7), (2.0V, 3.422nS, 0, 3), (1.0V, 3.45nS, 0, 14), (1.0V, 3.443nS, 0, 6), and (0.5V, 3.45nS, 0, 14). 276

5.43 Membrane voltage (V_m) (see colormap) at the axon tip (top figure) and at the synapse location (bottom figure) as a function of synapse trigger time (x-axis) and simulation time (y-axis). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic epidural stimulation using stimulating electrode combination A4pA5n while a synaptic input with synapse weight=3.45nS is triggered at varying times on the distal dendrite that points in the $+\hat{x}$ direction at segment 8. The electrical stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. The colormap is white when $V_m = -68.31$ mV (the resting membrane voltage for the distal axon tip) and changes from dark yellow to orange at $V_m = -10$ mV to indicate neuron activation. 277

5.44 Stimulation only: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). All data measured using neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. 278

5.45 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=81.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 279

5.46 Stimulation + EPSP: Each subplot plots a different variable ((a) V_m, (b) m_{IKdrSM}, (c) m_{IKaSM}, (d) h_{IKaSM}, (e) m_{INaSM}, and (f) h_{INaSM}) against simulation time (ms) for probes on axon-soma (sub-top) and dendrites (sub-bottom). Measured on neuron GM1_L_r5_Yn exposed to 2.0 V of monophasic stimulation using stimulating electrode combination A4pA5n. The stimulation pulse starts at t=76.0ms and has a maximum amplitude at t=77.13ms. An Exp2Syn synapse was triggered at t=146.0 ms with a synaptic weight of 3.45nS. The synapse was located at segment 8 on the distal dendrite that points in the $+\hat{x}$ direction. 280

5.47 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.0 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 537 are facilitated, and 426743 are non-active. 282

5.48 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.225 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 1647 are facilitated, and 425633 are non-active. 283

5.49 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.338 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 4248 are facilitated, and 423032 are non-active. 284

5.50 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.394 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 9670 are facilitated, and 417610 are non-active. 285

5.51 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.422 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 24532 are facilitated, and 402748 are non-active. 286

5.52 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.436 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 62471 are facilitated, and 364809 are non-active. 287

5.53 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.443 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 110804 are facilitated, and 316476 are non-active. 288

5.54 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.45 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 257472 are facilitated, and 169808 are non-active. 289

5.55 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.769 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 82986 are facilitated, and 344294 are non-active. 290

5.56 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.776 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 120616 are facilitated, and 306664 are non-active. 291

5.57 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.783 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 256925 are facilitated, and 170355 are non-active. 292

5.58 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.0 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 2562 are facilitated, and 424473 are non-active. 293

5.59 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.225 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 6522 are facilitated, and 420513 are non-active. 294

5.60 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.338 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 16246 are facilitated, and 410789 are non-active. 295

5.61 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.394 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 46322 are facilitated, and 380713 are non-active. 296

5.62 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.422 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 87686 are facilitated, and 339349 are non-active. 297

5.63 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.436 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall\text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 133965 are facilitated, and 293070 are non-active. 298

5.64 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.443 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 185287 are facilitated, and 241748 are non-active. 299

5.65 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.45 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall\text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (-10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 319226 are facilitated, and 107809 are non-active. 300

5.66 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.769 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall \text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 176092 are facilitated, and 250943 are non-active. 301

5.67 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.776 nS using features $f_0 = V^{\text{IS}}_{static} - V^{\text{Soma}}_{static}$, $f_1 = V^{\text{Synapse}}_{static} - V^{\text{Soma}}_{static}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$, and $f_3 = \min_{\forall \text{dendrites}}(V^{\text{DistalDendriteMiddle}}_{static}) - V^{\text{Soma}}_{static}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 209901 are facilitated, and 217134 are non-active. 302

5.68 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 16 with weight 4.783 nS using features $f_0 = V_{static}^{\text{IS}} - V_{static}^{\text{Soma}}$, $f_1 = V_{static}^{\text{Synapse}} - V_{static}^{\text{Soma}}$, $f_2 = \text{avg}_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$, and $f_3 = \min_{\forall \text{dendrites}}(V_{static}^{\text{DistalDendriteMiddle}}) - V_{static}^{\text{Soma}}$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 278554 are facilitated, and 148481 are non-active. 303

5.69 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.0 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 537 are facilitated, and 426743 are non-active. 305

5.70 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.225 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 1647 are facilitated, and 425633 are non-active. 306

5.71 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.338 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 4248 are facilitated, and 423032 are non-active. 307

5.72 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.394 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 9670 are facilitated, and 417610 are non-active. 308

5.73 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.422 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 24532 are facilitated, and 402748 are non-active. 309

5.74 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.436 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 62471 are facilitated, and 364809 are non-active. 310

5.75 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.443 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 110804 are facilitated, and 316476 are non-active. 311

5.76 Predicting facilitation for all combinations using biphasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.45 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 400 are active without the EPSP, 257472 are facilitated, and 169808 are non-active. 312

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5.83 Predicting facilitation for all combinations using monophasic epidural stimulation with a synapse triggered on a distal dendrite at segment 8 with weight 3.394 nS using features $f_0 = \max_t(V_m^{\text{AH}}(t))$, $f_1 = \min_t(V_m^{\text{Synapse}}(t))$, $f_2 = \max_t(V_m^{\text{Synapse}}(t))$, and $f_3 = \max_{\forall \text{dendrites}} \max_t(V_m^{\text{DistalDendriteMiddle}}(t))$. Each feature is on the x-axis in a separate subplot above with the number of trigger points facilitated above threshold (−10 mV) as the y-axis. Each subplot consists of three 2D histograms (showing the number of neuron simulations in each square), shades of grey (unclassified), shades of red (classified as active), and shades of blue (classified as non-active). For each feature active and non-active classification regions of unclassified samples are drawn with a yellow and cyan background respectively. These classification regions are also written as rules below, where T=1 and T=0 indicates that the neuron is active and non-active respectively. The number of samples of neurons caught by each rule is specified in the comment after each rule. Using the decision regions in that subplot and those above, the percent of all samples classified (id), active samples classified (id+), and non-active samples classified (id-) are labeled in each subplot. There are a total of 427680 samples of which 645 are active without the EPSP, 46322 are facilitated, and 380713 are non-active. 319

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NOMENCLATURE

neurite. Any projection from the neuron cell body; a dendrite or an axon.

sub-threshold. In this thesis sub-threshold indicates that the electrical stimulation or the synaptic input does not cause neurotransmitter release from the neuron(s) simulated.