Neuro 120 Homework 2: Data Analysis

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1 Question 1: Auditory Neuroplasticity

1.1 Raster Plot of Single-Unit Activity

To plot the raster plot, we wrote the following code:

```
stimulus_start_times = 0:1/6:(60); % In seconds
%% Part A
% Make raster plot
figure(1);
hold on
for i = 1:(length(stimulus_start_times)-1)
    spikes_in_window = spikes_single_unit((spikes_single_unit > ...
        stimulus_start_times(i)) & (spikes_single_unit < ...
        stimulus_start_times(i + 1)));
    spikes_normalized = (spikes_in_window - stimulus_start_times(i))';
    trial_num = ones(1, length(spikes_normalized))*i;
    plot([spikes_normalized; spikes_normalized], [trial_num; trial_num-1],'k',
        'LineWidth',3)
end
xlim([0,0.167])
ylim([0,360])
yticks(0:30:360)
xlabel('Time (s)');
ylabel('Trial Number');
title('Response of a Single-Unit to the Exposure Stimulus');
```

This produces the raster plot shown in Figure 1, which clearly shows that the neuron responds consistently to the stimulus about 0.03 seconds into the start of the trial.

1.2 Gaussian Kernel Firing Rate Estimate

We calculate the estimate of the firing rate of this single-unit neuron by writing the following code:

```
%% Part B
% Create gaussian filter
figure(2);
```

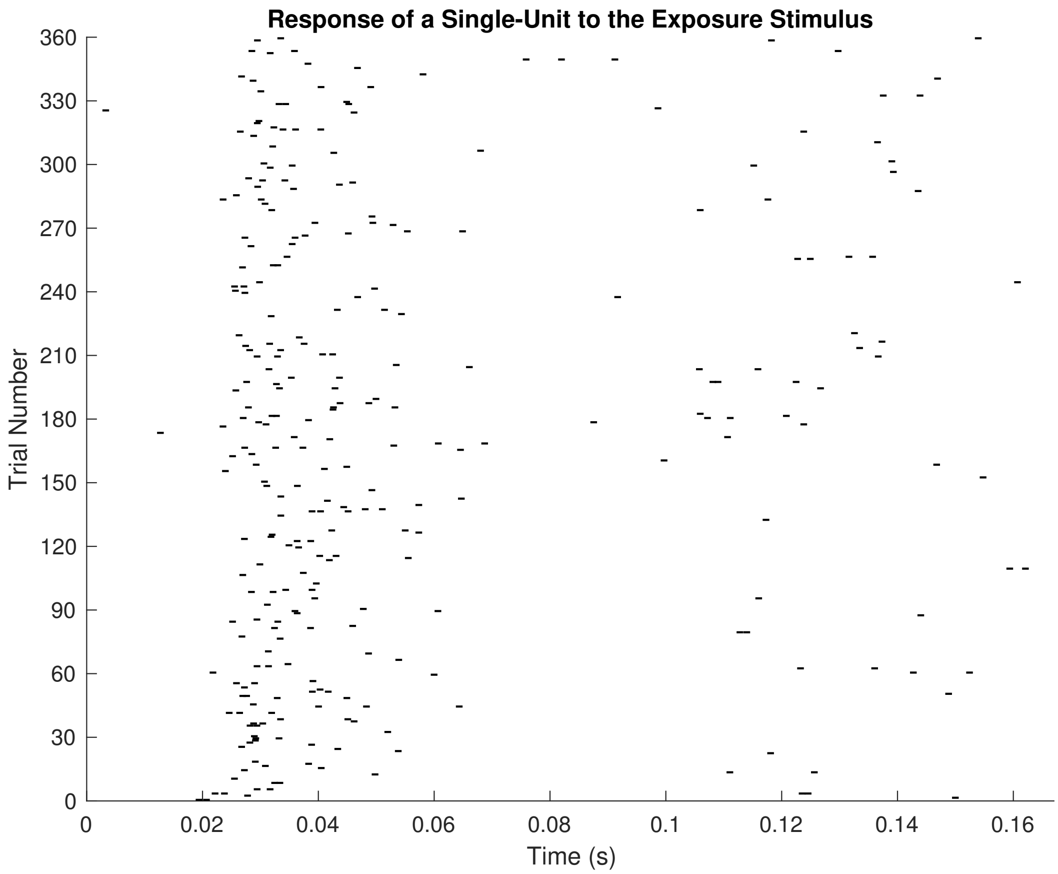

Figure 1: Raster Plot of Single-Unit Activity.

```
x=[0:0.0001:1/6];
avg_dist = zeros(1,length(x));
for i = 1:(length(stimulus_start_times)-1)
    spikes_in_window = spikes_single_unit((spikes_single_unit > ...
        stimulus_start_times(i)) & (spikes_single_unit < ...
        stimulus_start_times(i + 1)));
    spikes_normalized = (spikes_in_window - stimulus_start_times(i))';
    trial_num = ones(1, length(spikes_normalized))*i;
    norm = zeros(1,length(x));
    for j=1:length(spikes_normalized)

        norm = norm + normpdf(x,spikes_normalized(j),0.005);
    end
    avg_dist = avg_dist+norm;
end
plot(x,avg_dist./360)
xlabel('Time (s)');
ylabel('Firing Rate (Hz)');
```

This code simply places a Gaussian distribution with a standard deviation of 0.005s centered at the location of each spike and averages these distributions over all stimulus trials. This work produces Figure 2, which shows that the firing rate increases dramatically around 0.03s into the trial, going from a baseline firing rate of about 5 Hz to a peak of just over 25 Hz.

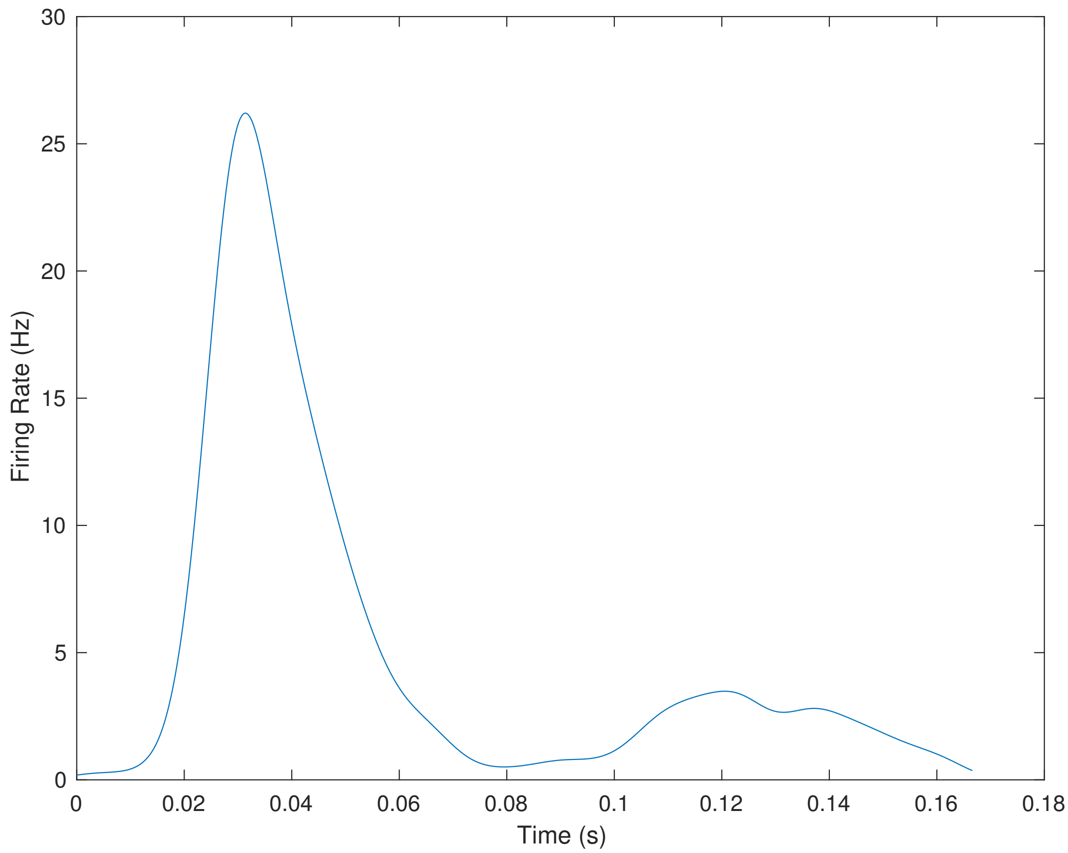

Figure 2: Gaussian Estimation of Firing Rate Using $\sigma = 0.005s$.

1.3 Gaussian Kernel Parameter Variation

We next alter the σ parameter of the Gaussian kernel from above and generate Figures 3 and 4 which shows the effect of this change. We used the following code to make these figures.

```
%% Part C
% sigma = 50ms, 0.5ms
sigma = [0.05,0.0005]
for k = 1:2
    figure(k+2);
    x=[0:0.0001:1/6];
    avg_dist = zeros(1,length(x));
    for i = 1:(length(stimulus_start_times)-1)
        spikes_in_window = spikes_single_unit((spikes_single_unit > ...
            stimulus_start_times(i)) & (spikes_single_unit < ...
            stimulus_start_times(i + 1)));
```

```
        spikes_normalized = (spikes_in_window - stimulus_start_times(i))';
        trial_num = ones(1, length(spikes_normalized))*i;
        norm = zeros(1,length(x));
        for j=1:length(spikes_normalized)
            norm = norm + normpdf(x,spikes_normalized(j),sigma(k));
        end
        avg_dist = avg_dist+norm;
    end
    plot(x,avg_dist./360)
    xlabel('Time (s)');
    ylabel('Firing Rate (Hz)');
end
```

We can see from these figures that a very small standard deviation results in a

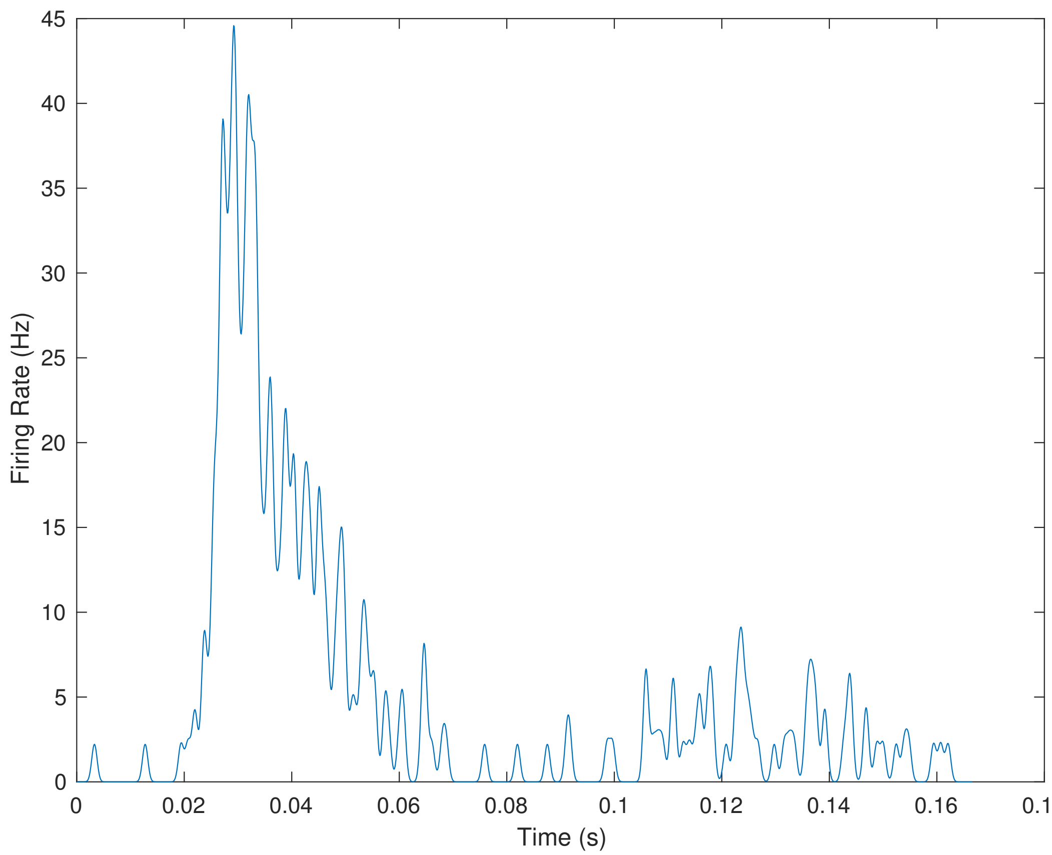

Figure 3: Gaussian Estimation of Firing Rate Using $\sigma = 0.0005s$.

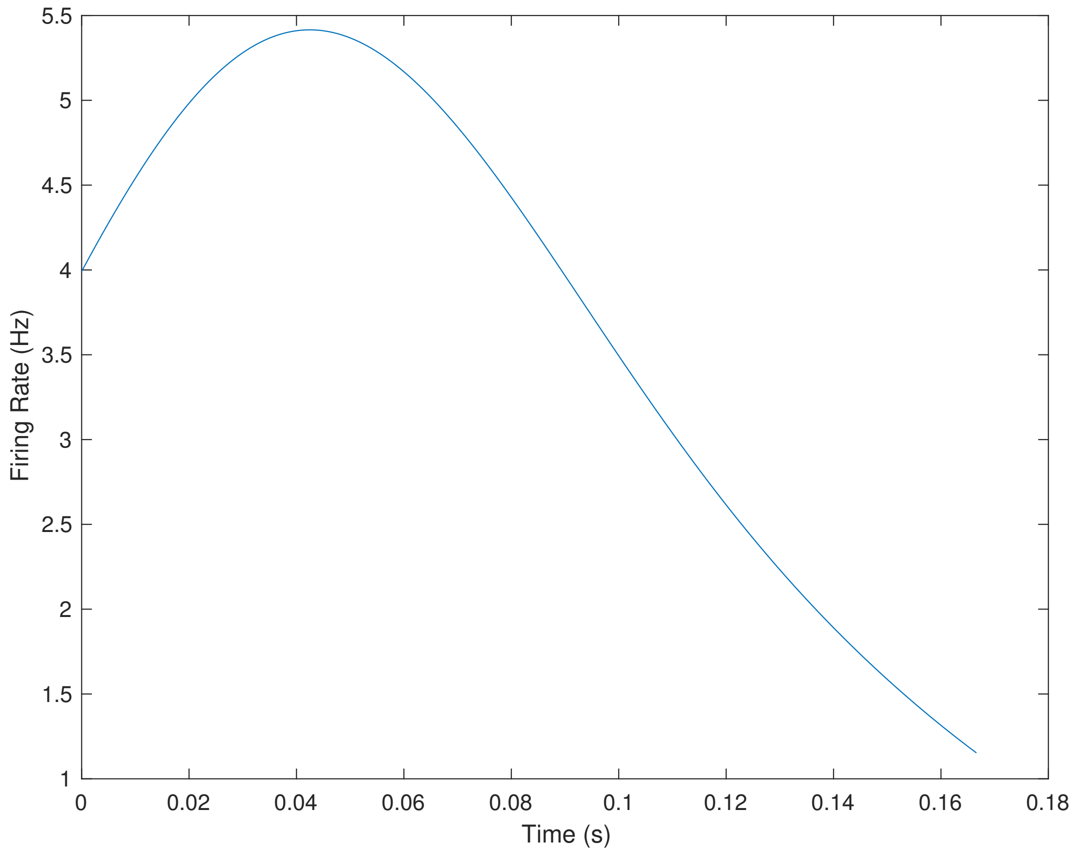

Figure 4: Gaussian Estimation of Firing Rate Using $\sigma = 0.05s$.