Today

- hypothesis testing (how many * do I get to use?)
- resampling
- introduction to photon detection
Hypothesis testing recipe

1. decide how often you are willing to be wrong (i.e. what level of significance are you testing for; p < 0.05, p < 0.01, p < 0.xx)
2. calculate a ‘test statistic’ from your data (e.g. the mean value, the variance, the 10th centered moment …)
3. pick a ‘null hypothesis’ to be tested (e.g. that the data comes from a distribution with mean = 0)
4. predict the distribution of your test statistic under the null hypothesis
5. determine the probability of observing a value of the test statistic as large or larger than that you observed and compare to desired significance level
Hypothesis testing example

Does cocaine increase the number of spines on dopaminergic neurons in VTA?

Sarti et al., 2007
Kauer and Malenka, 2007
Hypothesis testing example

Does cocaine increase the number of spines on dopaminergic neurons in VTA?

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Hypothesis testing example

Does cocaine increase the number of spines on dopaminergic neurons in VTA?

1. decide how often you are willing to be wrong
   \[ p < 0.05 \]
2. calculate a ‘test statistic’ from your data
   **sign of difference in spine count**
3. pick a ‘null hypothesis’ to be tested (e.g. that the data comes from a distribution with mean = 0)
4. predict the distribution of your test statistic under the null hypothesis
5. determine the probability of observing a value of the test statistic as large or larger than that you observed and compare to desired significance level

<table>
<thead>
<tr>
<th>saline</th>
<th>cocaine</th>
<th>sign of diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>18</td>
<td>+</td>
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<tr>
<td>7</td>
<td>21</td>
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<td>23</td>
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<tr>
<td>9</td>
<td>19</td>
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Hypothesis testing example

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1. decide how often you are willing to be wrong
   \[ p < 0.05 \]
2. calculate a ‘test statistic’ from your data
   sign of difference in spine count
3. pick a ‘null hypothesis’ to be tested
   \textbf{cocaine has no effect on spine count}
4. predict the distribution of your test statistic under the null hypothesis
5. determine the probability of observing a value of the test statistic as large or larger than that you observed and compare to desired significance level

\begin{tabular}{|c|c|}
\hline
  + & - \\
\hline
  62 & 51 \\
\hline
\end{tabular}
Hypothesis testing example

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4. predict the distribution of your test statistic under the null hypothesis
   **binomial distribution** \( p_+ = 0.5, N=113 \)
5. determine the probability of observing a value of the test statistic as large or larger than that you observed and compare to desired significance level

\[ \begin{array}{cc}
+ & - \\
62 & 51 \\
\end{array} \]

\[ \text{probability density} \]

\[ \text{number +} \]
Hypothesis testing example

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3. pick a ‘null hypothesis’ to be tested
   cocaine has no effect on spine count
4. predict the distribution of your test statistic under the null hypothesis
   binomial distribution \( p_+ = 0.5, \) \( N = 113 \)
5. determine the probability of observing a value of the test statistic as large or larger than that you observed and compare to desired significance level
   \[ p = 0.18 \] that we would observe at least 62 + comparisons by chance
Interpreting your results

1. You can never completely reject the null hypothesis - you can just reject it at a specified level of confidence

2. You cannot prove the null hypothesis to be correct
Parametric and nonparametric tests

parametric tests: data is assumed to be described by a specific underlying probability distribution, and test uses this distribution to evaluate significance

non-parametric tests: do not assume a distribution (e.g. sign test in example we just discussed)
Resampling and model validation

How do we estimate the variance?
Figure 5, A and B, shows the dependence of spike count variability on mean pooled across all ON and OFF cells in five retinas. To quantify the deviations of the data from the Poisson prediction, the Fano factor (ratio of variance to mean) was estimated by linear regression of the variance against the mean for the pooled data. The Fano factor was 0.277 ± 0.002 (SE) for ON cells and 0.369 ± 0.003 for OFF cells. This difference could reflect higher firing rates in ON cells combined with the fact that the mean-variance relation is not linear or could reflect a difference in the mean-variance relation. This was examined by computing:

FIG. 1. Primate retinal ganglion cell firing patterns. Rasters and firing rates over time are shown for representative ON and OFF parasol cells from each of 4 retinas (A, B, C, and D, respectively). The stimulus was spatially uniform binary noise with time course shown above the rasters in A. The root mean square (RMS) stimulus contrast was 96, 80, 96, and 96%, respectively. The stimulus refresh interval was 8.33 ms. The dots on the time axis represent identified times of firing onset; periods with unreliable firing were excluded (see RESULTS). Beneath each raster, the time-varying firing rate is shown, calculated in 0.1-ms bins and smoothed by a Gaussian filter with a SD of 2 ms.

Resampling and model validation