1 STRUCTURAL ASPECTS

Connectivity in local cortical circuits displays a distinctive feature: Bidirectionally connected pairs of neurons appear much more frequent than one would expect from the overall connection probability. This aspect of local networks has been reported repeatedly,

Here we investigate whether anisotropy in connectivity can be at cause for this overrepresentation of reciprocally connected pairs. In random networks, the chance to encounter a specific mode of connection in a random pair of neurons be can easily be computed from the overall connection probability p. For this let X be the random variable of the number of edges between two different vertices in a Gilbert graph $G(n,p)$ with $n \geq 2$. As the edges are independently realized resulting in a simple directed graph, we have

$$\begin{aligned} \mathbf{P}(X=0) &= (1-p)^2 && \text{unconnected pair,} \\ \mathbf{P}(X=1) &= 2p(1-p) && \text{single connection,} \\ \mathbf{P}(X=2) &= p^2 && \text{reciprocal connection;} \end{aligned} \tag{1.1}$$

in short $\mathbf{P}(X=k) = \mathcal{B}_{2,p}(k)$ for $k \in \{0,1,2\}$ and $P(X=k) = 0$ otherwise. This probability distribution reflects the expectation for connectivity of neuron pairs in anisotropic networks. A numeric analysis of the anisotropic sample graphs reveals that bidirectionally connected pairs appear almost twice as often as expected from the overall connection probability($p = 0.116$) and equations 1.1, similarly as reported by Song et al. (Figure 1.1 A). However, comparing pair probabilties in anisotropic networks with the probabilities in their rewired counterparts we find that anisotropy is does not influence the occurrence of two-neuron motifs (Figure 1.1 B) In fact, expected connections in neuron pairs are identical in distance-dependent and rewired anisotropic networks (**??**).

We can further support this observation by computing the probability distribution for the expected number of edges between to random vertices in the anisotropic graph model. Explicitly assuming that only the distance-dependent connection probability $C(x)$ as calculated in Theorem **??** is decisive in determining the distribution for connections in neuron pairs, we can from $C(X)$ and the probability distribution

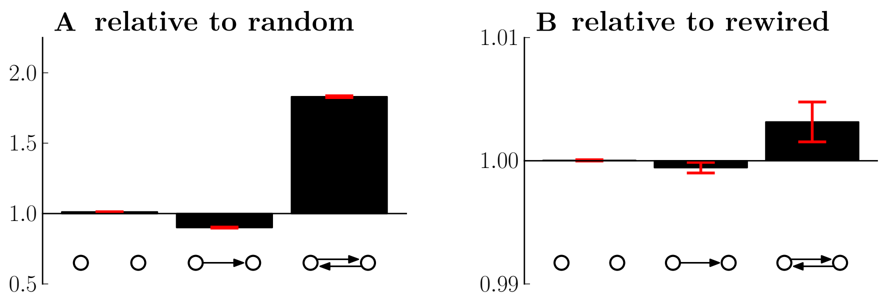

Figure 1.1: Overrepresentation of reciprocal connections in anisotropic networks due to distance-dependent connectivity Extracting the counts of unconnected, one-directionally and bidirectionally connected neuron pairs in the anisotropic sample graphs, overrepresentation of reciprocally connected pairs is identified as a feature of the network's distance dependency as opposed to anisotropy in connectivity. **A)** Showing the quotient of the counts for the three pair types, extracted from the set of sample graphs, with the number of expected pairs in Gilbert random graphs $G(n, p)$, where $n = 1000$ and $p = 0.116$ were matched to the sample graph parameters. While single connections appear less often than in Gilbert random graphs, reciprocal connections are significantly overrepresented. Errorbars SEM. **B)** Comparing appearance of connection pairs in the anisotropic sample graphs with their respective appearance in the rewired sample graphs, we find that eliminating anisotropy does not significantly change the counts for the connection types, indicating that anisotropy does not influence two neuron connection probabilities. Errorbars SEM. (`c5f1462b`)

$f(x)$ for the a random neuron pair to be at distance x (Theorem **??**), determine **P**.

$$\mathbf{P}(X=0) = \int_0^{\sqrt{2}} (1-C(x))^2 f(x)\,dx,$$
$$\mathbf{P}(X=1) = \int_0^{\sqrt{2}} 2C(x)(1-C(x))f(x)\,dx \quad \text{and}$$
$$\mathbf{P}(X=2) = \int_0^{\sqrt{2}} C(x)^2 f(x)\,dx$$

which yields, using the and

$$\mathbf{P}(X=0) = 0.791336 \qquad 0.7907 \pm 0.0008$$
$$\mathbf{P}(X=1) = 0.184151 \qquad 0.1846 \pm 0.0007$$
$$\mathbf{P}(X=2) = 0.024513 \qquad 0.02462 \pm 0.00009$$

Maybe simplicity of the model makes stuff wrong. Tune to Perin distance profile.

Let

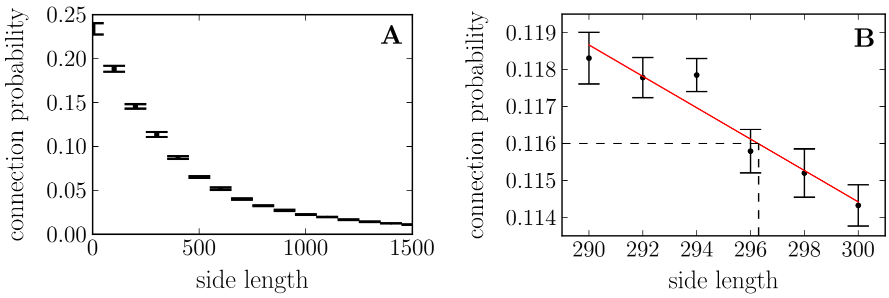

Figure 1.2: (6154302f, ef0e785d)

With side length 296:

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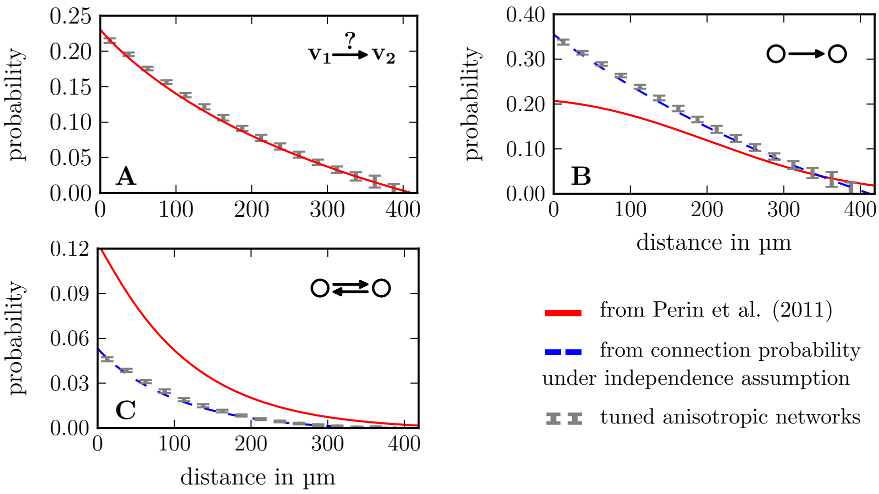

Figure 1.3: Overrepresentation of reciprocal connections independent of Comparison of occurrences of one- and bidirectionally connected neuron pairs in (gray) with profiles found by Perin et al. (2011) (red), shows that overrepresentation of bidirectional pairs is distance-independent and not connected to anisotropy. **A)** Overall connection probability in the adapted anisotropic networks was successfully tuned to reflect connection probability found by Perin et al. **B)-C)** Probabilities for a random neuron pair to display , (875505b0)