(a) Spectrogram Distance vs. Neurogram Distance

(b) Spectrogram Distance vs. Neurogram Distance

(c) Spectrogram-normalized Distance vs. Spectrogram-normalized linear neurogram

Legend:
- **Song**
- **MLd**
- **L**
- **CM**
Tuning for Spectro-temporal Modulations as a Mechanism for Auditory Discrimination of Natural Sounds

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Supplementary Figure 2. Correlation between spectrogram distance and neurogram distance.

Could differences in the neurogram distances reported here be explained by simpler differences in the acoustics between songs and ml-noise other than those shown in the MPS and in the CV? Because the modulation power between song and ml-noise was matched and because ml-noise was a random stimulus, ml-noise stimuli were more variable (had higher entropy) than song stimuli. However because of the strong correlations found in song, it turned out the intensity level differences across frequency bands between two random segments of song were on average greater than the intensity level differences between two segments of ml-noise. This effect is shown in (a) where the spectrographic distance between two segments of sound was calculated with:

\[ D_s = 2 \cdot \sqrt{\frac{1}{N_{Bonds} N_{TBin}} \sum_{t=1}^{N_{TBin}} \sum_{b=1}^{N_{Bonds}} (S_{b,t}(A) - S_{b,t}(B))^2} \]

where \( S(A) \) and \( S(B) \) are 100 ms segments of sound in their spectrographic representation: the spectrogram segments are vectors over time (index \( t \)) and frequency bands (index \( b \)). As for the neurogram distance, the average spectrogram distance was obtained by repeating this calculation for 136,800 random pairs of sound segments for song and 32,400 random pairs of ml-noise stimuli. In this analysis, the spectrographic distance for song is statistically larger than that for ml-noise. Could these larger spectrogram distances in song explain the larger neurogram distances that we reported in the main section of the paper? To address this potential confound, we performed two additional analyses: we correlated the measures of neurogram distance with spectrogram distance and we repeated the neural discrimination comparisons after normalizing the neurogram distance by the spectrogram distance. (b) Scatter plots show the pair wise relationship between neurogram distance and spectrogram distance. The linear relationship is weak, with small correlation coefficients. This effect can be in part explained by the fact that a majority of neurons in our data set were tuned to particular changes in spectro-temporal modulations. We calculated an alternative measure of neural discrimination by normalizing the neurogram distance for each pair of sound segments by the corresponding distance between the spectrograms. As shown in the bar plots shown in (c), the normalized neurogram distances for song responses remained higher than for ml-noise in all three areas and the linear normalized neurogram distance remained higher in MLd and Field L. As a result of these two analyses, we conclude that the greater neurogram distances for song cannot be explained by the greater power level fluctuations in song stimuli. Error bars are s.e.m. \( P < 0.0001 \)