In collaboration with Joshua Shaevitz (Physics, Princeton), this device consists of three cameras and three power LEDs. The cameras are synced in time and images from all cameras are stored to disk. LED-based backlit illumination is created by directed light at each camera and the cameras are synced to a translation stage. The LEDs are mounted at the top of an X-Y stage directed at each camera and the cameras are aligned to image the same 3D voxel in space and the magnification is set using custom optics such that a single fly takes up about 10% of the view of the camera. This position is used to calculate the position of the fly from the centroid of each frame within the frame of the overhead camera. This position is used to track the fly in the field of view of the camera. The area in each camera frame is contained in a 100mm Petri dish mounted on a fixed pillar cantilevered into the filming region. We have been able to record hundreds of thousands of images in this setup–a throughput acquisition mode, we will likely have to further restrict the flies' vertical motion using techniques such as those developed by Simon (2010).

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Wavelet Transform

GJB et al, Interface (2014)
Time

van der Maaten & Hinton, 2008

GJB et al, Interface (2014)
\[ p_{ij} = \frac{\exp(-\|x_i - x_j\|^2/2\sigma_i^2)}{\sum_{k \neq i} \exp(-\|x_i - x_k\|^2/2\sigma_i^2)} \]

\[ q_{ij} = \frac{(1 + \|y_i - y_j\|^2)^{-1}}{\sum_{k \neq l} (1 + \|y_k - y_l\|^2)^{-1}} \]

\[ C = KL(P||Q) = \sum_i \sum_j p_{ij} \log \frac{p_{ij}}{q_{ij}} \]

van der Maaten & Hinton, 2008
Lab Coordinates  Real Time  Behavioral Space

Fast Leg Movement #4
2D vs. 3D

Error = 2.9 bits

Error = 3.3 bits

Entropy = 20.6 bits
Transitions Between Periodic Orbits

Figure 10: Orbits in posture space for head grooming (blue orbit) and anterior leg motion (green orbit) behaviors, with the transition from grooming to leg motions in red. The orbits are obtained using the Phaser algorithm, and the transition trajectory is averaged across all instances of the transition with a given duration. Leaving and entering orbit occurs near the point of highest orbital velocity.

Figure 11: Visualization of consistency in exit and entry phase for the transition in figure 10. Color represents probability of exit/entry at a given point in orbit, obtained by fitting a gaussian to the phase distribution. Grey circles indicate peak exit/entry points.
Male

N = 59
~21 x 10^6 data points

Female

N = 51
~18 x 10^6 data points
Female PDF - Male PDF

Wilcoxon rank sum test (p < .01)

Region-Normalised PDF

Female PDF - Male PDF

Mode #1 Mode #2

Mode #6 Mode #7

Projection

Phase 00 2π

male

female

male-preferred

female-preferred
Non-Negative Matrix Factorization

\[ X = WH \]

\[ X, W, H > 0 \]

\[ X \in \mathbb{R}^{N \times d} \]

\[ W \in \mathbb{R}^{N \times r} \]

\[ H \in \mathbb{R}^{r \times d} \]
Cande et al, eLife, 2018
Cande et al, eLife, 2018
Density before Transitioning to Yellow Region
\( p(\rho_{-2 < t < 0}(\vec{x}) | \text{Yellow}) \)

Density before Transitioning to White Region
\( p(\rho_{-2 < t < 0}(\vec{x}) | \text{White}) \)

\[ I(\rho_{-2 < t < 0}(\vec{x}); R) = 0.5 \pm 0.1 \text{ bits} \]

with Jirui Qiu
~85% of lines show statistically significant information
Head Movements
Turning Movements
Locomotion
Rear Grooming
Body Extensions
Doing the Hokey Pokey
Arm/Leg In/Out
1) A transform is applied to a Gaussian-smoothed density over these each postural mode separately. After normalization, each point in time subsequently applied to these time series, creating a spectrogram for analysis, we applied a behavioral mapping technique previously applied to fruit.”

2) “Stranger” voles had not been cohabitated with, and were not associated with each other for 48 hours in a home cage prior to video recording. “Stranger” female or “stranger” female voles were video recorded for 10 minutes in an open field cage with 3-4 cm substrate and one water bottle.

3) In order to quantify the social interaction, a pair of dyadic interactions between socially interacting prairie voles, a premier rodent model for studying pair bonding behavior (Berman et al., 2014; Young and Wang, 2004).

4) Much of systems-level neuroscience has focused on studying the neural circuit mechanisms that enable an individual organism to predict the underlying neural dynamics driving animals’ movement. The black lines are the boundaries found from a water movement. The graph represents the calculation of Jensen-Shannon (J-S) Divergence, a measure of distance between two distribution, where J-S Divergence is an unsupervised learning technique introduced by (Berman et al., 2014) for evaluating the behavioral space of a subject with its partner versus a subject with the stranger.

5) Here, we employed a behavioral mapping technique previously applied to fruit behavior of freely moving fruit. The differences between them. This quantitative measure provides a map of Subject, with Stranger (Figures 6, 7 & 8).

6) Figure 6 and 7. Comparison between the pair of dyadic interactions for two groups of 3 voles. The subjects in both cases show different stereotyped behavior when interacting with their partners as to when they interact with the strangers.

7) The graph represents the calculation of Jensen-Shannon (J-S) Divergence, which quantitatively and qualitatively, we see that regions within maps of each subject correspond to distinct stereotyped behaviors, and in the map for the same animal, different regions correspond to different stereotyped behaviors.

8) From this work, we infer that the behavioral space of an individual animal is highly dependent on the social context it is in. This implies that the behavior of an animal is not only determined by its internal state, but also by its interaction with other animals.

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