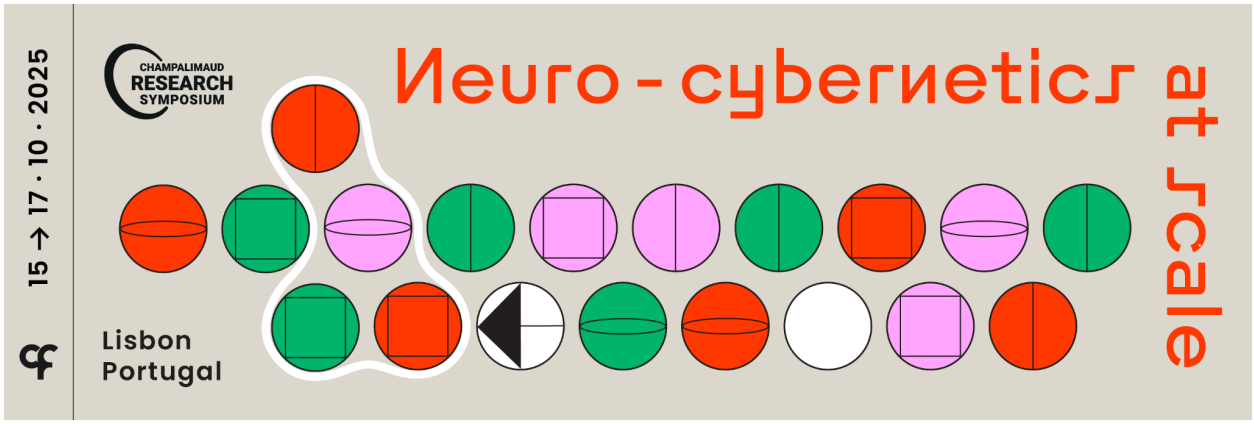

Bridging scales between chemical space and behavioral phenotype

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A core challenge in neuroscience is to model organism-level behavior without abstracting away relevant low-level biological processes. Foundational models in neuroscience learn to relate neuronal activity with behavior [1], while parallel models in pharmacology aim to map chemical structure to cellular effects [2]. Connecting these fields, we developed a multiscale model of how animal behavior can be manipulated at the chemical level.

We mapped molecular structure to behavioral phenotypes using a dataset of over 18,000 compounds screened in zebrafish larvae across three experimental paradigms: visuomotor behavior [3], sensory habituation [4], and circadian rhythm activity [5]. Using a pre-trained molecular embedding network and contrastive learning, we created a joint embedding space that aligns chemical structures with their corresponding behavioral fingerprints.

The resulting model generalizes, predicting learned features of the behavior for unseen compounds. The learned joint embedding space is structured, clustering compounds by mechanism of action and revealing relationships within chemical space. We also study the model's scaling properties as a function of both the chemical library and the behavioral readouts.

animal behavior, drug discovery, foundation model