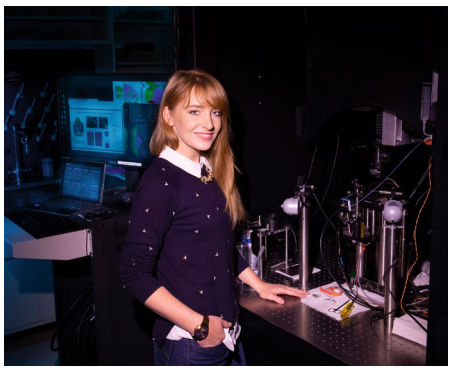
THE AUTHOR FILE

Mackenzie Weygandt Mathis

Building a sustainable open source toolbox to track social behavior and how to get in the zone.

She did a little self-experiment, says Mackenzie Weygandt Mathis, laughing. Her data confirm it's harder to start a lab during COVID-19. She launched her integrative neuroscience lab at EPFL's Geneva campus in the fall of 2020. Some members of her previous lab at the Rowland Institute at Harvard moved with her to Switzerland. The EPFL lab is at Campus Biotech, home to EPFL researchers like Mathis and others from places like the University of Geneva and the Wyss Center. "It's a cool place and I like Geneva — it's super international and a nice place to live," she says. It's far from her native Central Valley of California, where she spent her youth surrounded by orange trees, peach orchards, cows, dogs and horses. "I actually grew up showing horses competitively," she says and considered it as a profession. But she also liked science. She became a pre-med student at University of Oregon, which might have led to a career as a physician. "I had never met a scientist growing up," she says.

As an athlete, she had always been fascinated by the motor nervous system. This interest deepened as she encountered physicians who treated patients with amyotrophic lateral sclerosis (ALS), a brain disease that targets motor neurons. "It's heartbreaking," she says. This led Mathis to a summer stint at Columbia University, where scientists used funding from the non-profit Project ALS to develop drug screens with stem-cell-derived motor neurons. This was during the Bush administration, when federal funding for such work had been prohibited. Mathis fell in love with science and says, "it just was so fun to be at the forefront of unknowns." She stayed in the Columbia lab as a technician, became lab manager and did independent research on motor neurons. Her interest in cellular mechanisms and behavior led her to do her PhD research with Harvard's Nao Uchida to link motor behavior and computational approaches to reinforcement learning. Her mentors encouraged her to apply for an internally funded position at the university's Rowland Institute. "It's really a cool place where you can just come in and engineer, do experiments, think about big questions," she says. In between her PhD defense and her Rowland job start, she squeezed in a short postdoctoral fellowship at University of Tübingen with computational neuroscientist



Mackenzie Weygandt Mathis. Credit: A. Olivella

Matthias Bethge to, as she says, "sharpen my teeth on deep learning."

In her latest work, she and her colleagues present multi-animal DeepLabCut, open-source software for tracking how animals move and identifying individual animals in a group. Animals may leave the scene and then return, and "you want to know who's who," she says. That's especially useful when studying social behavior, she says, and can be used in conjunction with optogenetics to better understand the brain circuits that drive behaviors. She is happy the team found a way to have the software 'learn' how to localize the geometric configuration of so-called keypoints of behaving animals in the image frames of videos. Statistical estimation helps to track, say, a marmoset's tail movements, the directions a mouse points his or her nose, or movements of a fish's rear fin. At its core, multi-animal DeepLabCut applies deep learning with an architecture involving a convolutional neural network and transformers. With training, it can be used for studying any type of animal movement. The paper also presents benchmarking datasets for studying groups of mice, fish and marmosets. It's a way to help the computer science's benchmarking culture "permeate into life science a bit more."

Mathis and her husband, Alexander Mathis, a former Marie Curie fellow in computational neuroscience at Harvard University and now also at EPFL, share senior authorship of multi-animal DeepLabCut, which builds on DeepLabCut (DLC), which the Mathises co-developed. DeepLabCut originated as both scientists hunted to solve experimental challenges they individually faced. They turned to computer vision, deep learning and human pose estimation. DLC is built on DeeperCut, from which it differs by about 200,000 lines of code. DeeperCut is built on DeepCut, both of which were developed for human pose estimation by Eldar Insafutdinov, a postdoctoral fellow in computer vision at the University of Oxford. The name DeepLabCut is a nod to his work, she says. Around 70 people have contributed to the DLC code base. DLC has around 14,000 monthly downloads and 350,000 downloads to date. It's been used for analyses of many types of behaving animals: ants, crayfish and bats, to name a few. "I'm super proud and humbled," she says. "And at the same time, it's a huge responsibility." The team is careful about changes and updates. With Chan Zuckerberg Initiative support they hired Jessy Lauer, a full-time software developer who is first author of the multi-animal DLC paper.

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Mathis's work gives neuroscientists a precise way to track and quantify behavior, says Silvia Arber, a neuroscientist at the Biozentrum and Friedrich Miescher Institute for Biomedical Research in Basel, Switzerland, who collaborates with Mathis. "Her incredibly interactive and highly competent approach to science works like one of her efficient closed-loop systems, taking on board suggestions from the community to continuously improve and further develop the method," says Arber. "Her energy and scientific breadth are just simply phenomenal." When Mathis has time, she enjoys cooking, which might harken back to her days in the chemistry lab, she says. She also enjoys skiing and the deep focus it brings. She gets the same sense when diving deeply into a scientific question or into coding. It's what athletes call "being in the zone." ❐

Vivien Marx

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Reference
Lauer, J. et al. Multi-animal pose estimation, identification and tracking with DeepLabCut. *Nat. Methods* https://doi.org/10.1038/s41592-022-01443-0 (2022).