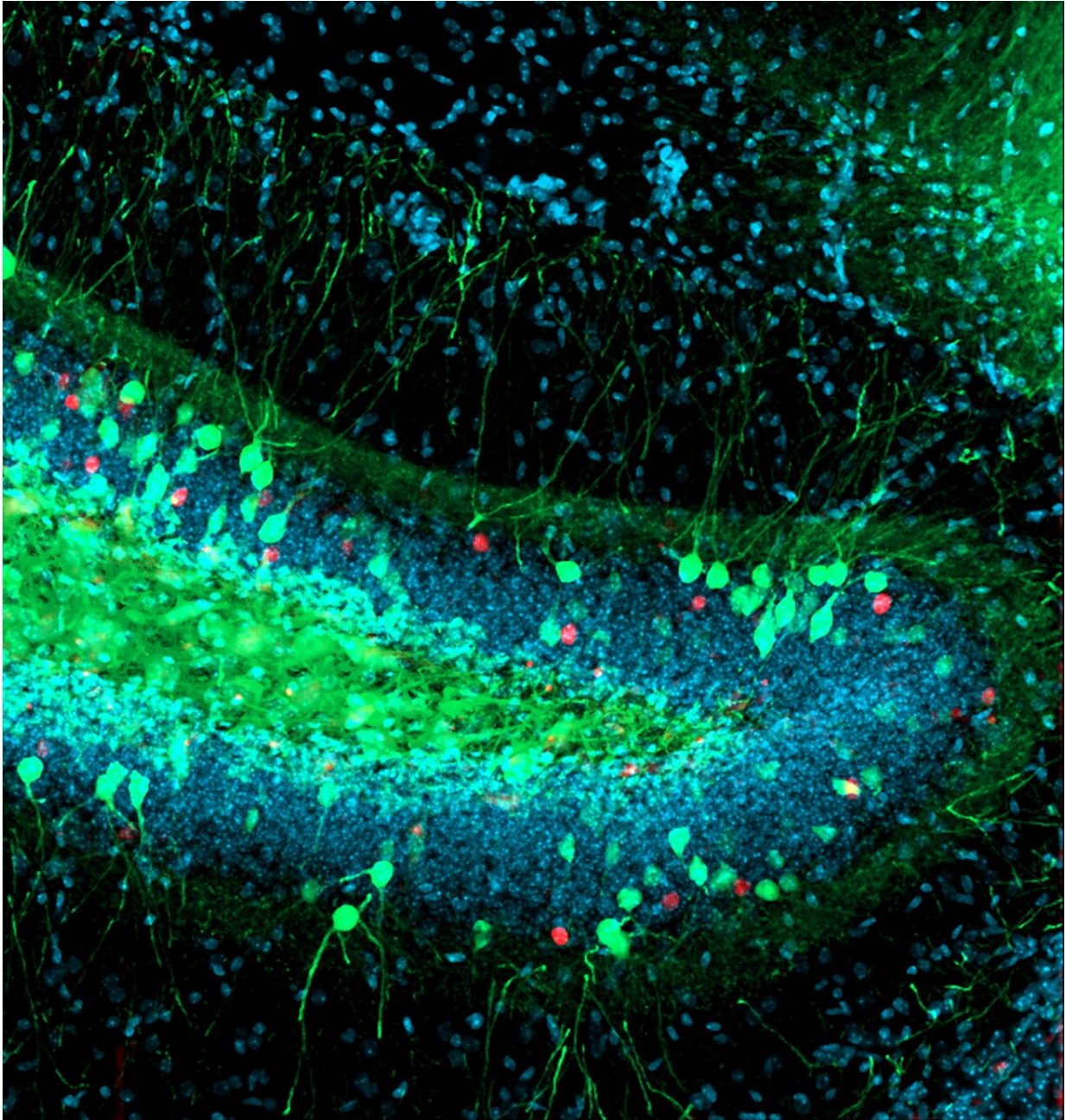


# **Q&A: How do social interactions conjure up memories and emotional responses in the brain?**

March 17 2022, by Molly Gluck

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Social transmission of memory. Credit: The Ramirez Lab

Has a song ever reminded you of the past, and unexpectedly surfaced emotions associated with that specific experience or person from your

memory? Does walking into Staples remind you of back-to-school shopping, even years after graduating? Or, have you ever been introduced to a new employee, and as you exchange names and shake hands, you can't help but think back to your first day on the job?

Experiences can unlock [vivid memories](#)—transporting us back in time and triggering emotional responses. Dr. Steve Ramirez, Assistant Professor of Psychological & Brain Sciences at Boston University, is the principal investigator of The Ramirez Group, where he leads research on how memory works and how to hijack it to treat disorders of the [brain](#).

His latest research, published in *PNAS*, uncovers how memories and [fear](#)-responses can be transmitted through social interactions. How exactly did his team make this discovery, and what are the future implications? Read below for a Q&A with Ramirez and lead author Abby Finkelstein to learn about the motivation behind this work, the findings, and what the team hopes to study next.

## **What did you aim to study with your research? What made you want to examine this issue?**

Our research studies what memory looks like in the brain (i.e. its physical basis) as well as how to artificially manipulate memories to restore the brain. Memory is one of the most fundamental processes of the brain and we can even artificially tinker with the brain to restore memories, enhance positive memories or suppress negative ones. Our work could one day be harnessed for future therapeutic techniques to treat a variety of conditions including depression, anxiety, and post-[traumatic stress disorder](#) (PTSD).

In this study, we specifically wanted to examine how previously acquired memories were modulated when animals socialized. More specifically,

we wanted to study how social interactions can conjure up memories of the past. As humans, we do this all the time—we tell stories (i.e. "remember when..."), we visit some of our most cherished moments of the past, and we learn from some of the hardest experiences through this process of recollection. Rodents also socially interact with one another—and we wanted to study how socialization tapped into and triggered previously acquired memories within their brains as well.

## **Walk us through your experiments. What did the findings reveal?**

Our experiments examined the effect of different social and non-[social experiences](#) on an individual's memory of a past negative event. These social experiences can include having an animal, which we call the "observer" or "stressed familiar individual," interact with its cage mates either directly, behind an opaque wall, or behind a one-way mirror. The non-social experiences can include access to the opaque wall itself without a cage-mate on the other side. The behavioral experiments revealed that two types of socially-transmitted stressors enhanced fear memory, while non-socially transmitted stressors and our control experiences had no effect on fear memory strength.

We hypothesize that this enhancement was due to socially-stimulated stress reactivating neurons encoding the fear memory, and showed that such neuronal ensembles were indeed reactivated only by the social stressors in a brain region called the hippocampus.

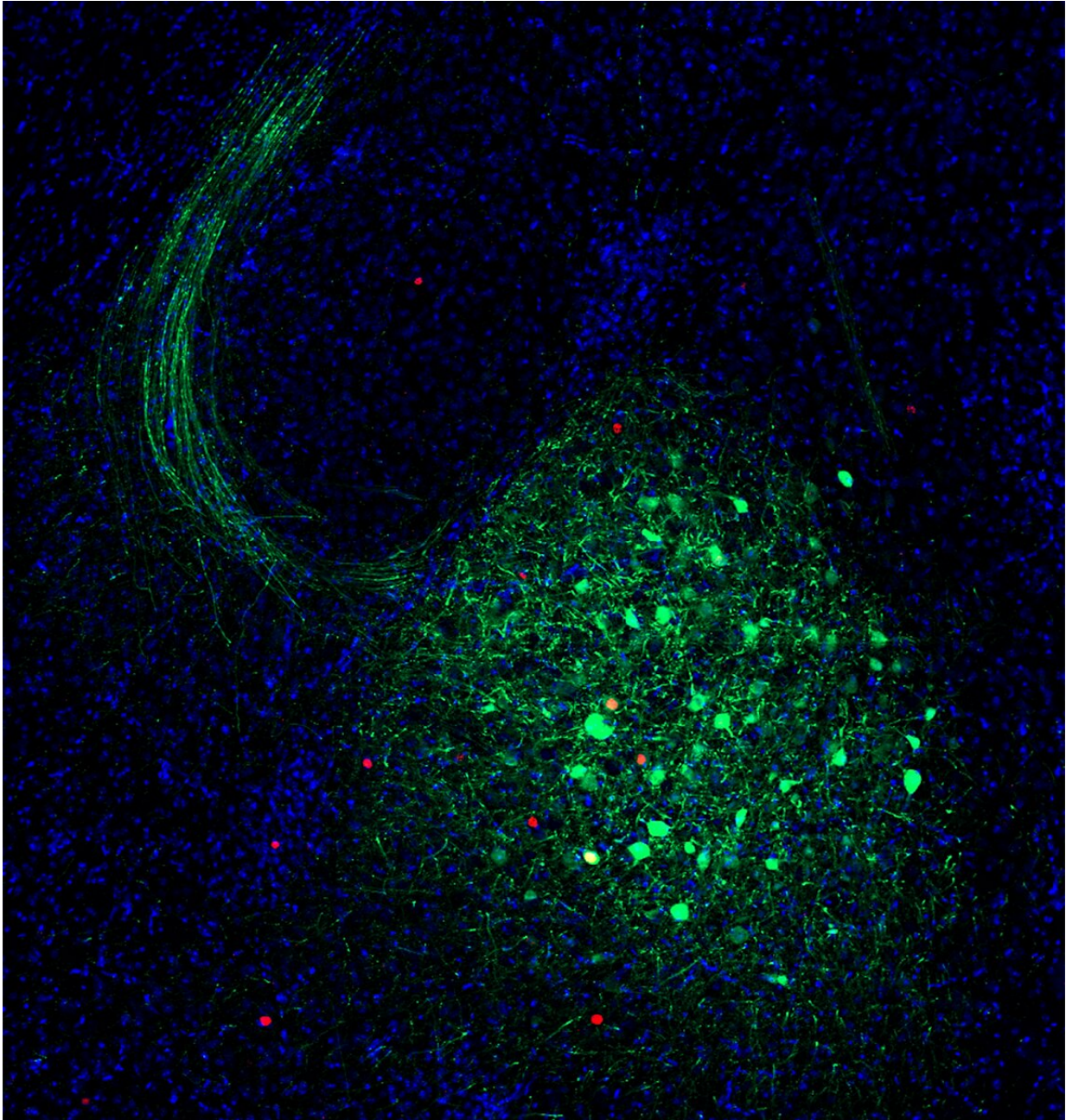
Next, we hypothesized that if fear memory neurons were being reactivated during the social experience, tagging these neurons as active during the social experience and then artificially turning them on in a neutral context would cause fearful behaviors only in mice that also had the fear memory from a past, independently learned experience. In other

words, an animal that had previously acquired a fear memory may have this memory inadvertently activated under certain conditions when a stressed cage mate was present. If so, then reactivating these cells artificially should also produce the fear responses. This is exactly what our optogenetic experiment showed, bolstering our proposal that social stress reactivates hippocampal traces of fear memories and thus amplifies fear recall.

## **What was the most surprising finding?**

We were surprised by the counterintuitive finding that direct physical interaction with a stressed familiar individual did not have a fear recall effect on the mice—while experiencing ambient stress cues indirectly (presumably through their vocalizations and scents, for instance) from the stressed familiar individual had such a strong enhancing effect on fear memory in the mice. The team brainstormed possible explanations, and tested the hypothesis that this phenomenon might be due to the physical interaction impacting not only the cage-mates, but actually reducing the distress signals put out by the stressed familiar individual. We put a "social buffering" mouse on the same side of the wall as the stressed mouse and were able to show that this direct interaction did indeed block the fear memory enhancing signals—and therefore blocked the fear memory recall effect on the entire group.





Social transmission of memory. Credit: The Ramirez Lab

**What is the significance of these findings?**

We show that individually acquired memories can be enhanced by another animal's stress more so than by one's own, revealing a new intersection of individual history and sociality.

The data suggests that socially-transmitted stress signals themselves may more powerfully access particular memories whereas having full on physical interaction with an individual may either leave the memories untouched—or perhaps even buffer their negativity in some instances. Something about the indirect stress cues tilts the scales in favor of fear memory recall and enhancement, but once we add the physical dimension of socialization, we don't see these effects.

These results are exciting to us because they point to the social dimension as a mechanism by which memories can be enhanced among animals.

## **Could this new understanding of socially transmitted fear memories inform treatment approaches for individuals/groups experiencing trauma or post-traumatic stress disorder?**

Our work suggests that in addition to the social transmission of fear memory discovered in recent years, exposure to stressed individuals can amp up one's own, independently learned, fearful memories. This rather surprising finding highlights the importance of focusing on the [social environment](#) of someone recovering from trauma or PTSD, as our work in mice suggests that even mild social stressors can reactivate and strengthen [fear memory](#).

Future work in humans will be necessary to determine the translatability of this newly discovered effect. However, if it carries across social species then it could suggest that spending time with others also

recovering from trauma or dealing with stress could sometimes have a counterproductive effect, with the exception of support groups where a mental health professional is present as fear memories and responses are being socially activated.

Additionally, our work highlights the role of social interaction in strengthening pre-existing memories in ways that are not necessarily pathological—for example, why a rich social environment may be protective for the memories of aging humans.

## **What do you hope to study next?**

We would love to study how memories are socially transmitted among rodents—specifically, which sights and sounds and smells are the most important to trigger and tap into previously held memories? Moreover, a single memory does not exist in a single X-Y-Z coordinate point in a brain; rather, it is distributed throughout the brain in three dimensions (of which the hippocampus is just one key region). With this in mind, we're excited to map out this three-dimensional diagram of memories in the brain as well.

No memory exists in a vacuum, but rather exists among an ocean of memories that are constantly interacting with each other and updating and modulating each other as well. To that end, we're excited to study how multiple memories manifest in the brain and how animals' social interactions and signals can physically influence individual memories.

The long-term possibilities here are endless: How does the presence of a stressed individual affect our previously acquired memories that range from negative to positive? Does our familiarity level with the individual—for instance, a complete stranger compared to a sibling—tilt the scale of whether or not certain memories are recalled, enhanced, or buffered? And, how is this affected as we age or as the brain begins to



deteriorate? We're excited about these future experiments that our work now opens the doors for examining. Ultimately, we would like to measure how the physical basis of memory evolves both over time and into degeneration—which we hope will point to key mechanisms and hints at ways of restoring [memory](#) activity as well.

**More information:** Abby Basya Finkelstein et al, Social reactivation of fear engrams enhances memory recall, *Proceedings of the National Academy of Sciences* (2022). [DOI: 10.1073/pnas.2114230119](https://doi.org/10.1073/pnas.2114230119)

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