**What New Memory Research Can Tell Us About Second-Language Learning**

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Tell me if this sounds familiar: You just turned the light off, your head is on the pillow, your eyes are closed, and yet instead of drifting off to dreamland, you find yourself thinking about something that happened earlier in the day. Frustrating as rehashing those memories may be, not only is it normal, it may improve your memory.

Well, maybe not the obsessive replay at a conscious level…

But at an unconscious level, memory reactivation is critically important. At a recent symposium on the topic at the CNS annual meeting, I was struck by not only the wide range of tools being used to study memory reactivation — from behavioral work during sleep to neuroimaging using EEG and fMRI — but also by the potential applications for research in my own field, second-language acquisition.

Before I get into that, though, let’s review how researchers are studying memory reactivation. The critical technique in neuroimaging studies of memory reactivation is a play on simple correlation. Researchers such as Lila Davachi (NYU) have used fMRI to observe activation patterns specific to a particular experience, like looking at faces. They then observe activation patterns at rest or during other tasks and see to what extent these are similar to the earlier patterns.

Perhaps surprisingly, Davachi’s lab has found that these activation patterns persist both into rest and into other tasks, even if they occur 10 to 20 minutes later. So even though the participants were supposed to be doing math problems, vestiges of the activation pattern related to faces was still there. These persisting brain states are positively correlated with memory performance, suggesting that our initial attempt at remembering information is only the start of a larger process.

The findings from Davachi’s lab have been corroborated on the other side of the Atlantic by Lluis Fuentemilla (University of Barcelona) and colleagues, who have also found that memory reactivation was related to better memory. He, however, arrived at that conclusion using EEG, allowing him to measure changes at a much smaller timescale: milliseconds rather than minutes. His group’s work shows that less than a second after encountering a new context, we replay the information from the previous context. This, he argued, allows us to better discriminate between events that happen within a particular context, rather than those that cross contextual boundaries. Remember that — it will be important later.

For now, let’s cross our own little contextual boundary and talk about sleep, because memory reactivation during sleep has significant effects on our waking lives, as Ken Paller (Northwestern) presented. Specifically, slow-wave sleep includes periods of heightened neural synchrony — that is, lots of our neurons activating together — causing memory reactivation.

The part that might sound like a too-good-to-be-true late-night TV advertisement is the fact that Paller’s lab has found that memory reactivation during slow-wave sleep can be manipulated to improve specific memories. For example, they found that if you pair a sound with a picture, and then play the sound during slow-wave sleep, this improves recall of that picture (although the effect depends on how well you had encoded the picture the first time). In addition, the effect appears to occur regardless of the type of information cued: spatial skills, music skill, even counter-stereotype training all benefit from reactivation during sleep!

Now is where we get into the good stuff. As a language researcher, I was intrigued by the idea that memory reactivation could be used as a tool to improve second-language acquisition. I think the most obvious application would be in vocabulary acquisition; pairing translation equivalents with foreign language words is analogous to the work his lab has already done with sound-picture pairings. Perhaps more interesting, however, is the potential for memory reactivation to be one of the mechanisms behind the effects of language immersion.

Now before you get excited (or is that just me?), let’s check the facts. While the folk wisdom has become that language immersion is a panacea that can cure all your language learning ills, it is simply not true. Study abroad experiences are only more effective than domestic learning when learners take advantage of the extra opportunities they have to use the second language.

As someone who went abroad specifically to try and improve her language skills, this is more difficult than you may think. Popular tourist destinations are used to English-speaking visitors, and the well-meaning people there will often return your attempts to speak the local language with English. That being said, if you are persistent and really do attempt to immerse yourself in local culture, you are rewarded with a multitude of cues and information that you wouldn’t be exposed to in a typical classroom setting.

These stimuli alone would be of value, but combined with the memory reactivation we experience during sleep and when encountering new contexts (see, I told you it would be important), language immersion may allow us to stack the deck in terms of which items are reactivated and consequently better learned. Obviously this would require some testing—such as correlating gains in second-language proficiency with amount of slow-wave sleep during immersion—but I’m going to throw the idea out there. That’s what conferences are for, right?

At the symposium, I was also inspired by the work Daphna Shohamy (Columbia) presented looking at the interplay of memory reactivation and decision-making. Her [lab finds](http://shohamylab.psych.columbia.edu/content/papers/sd15.pdf) that when we associate two items (let’s say a brand name with a pair of pants), and then one of those items is rewarded (someone gives you a compliment on the pants), that has an effect even on the unrewarded paired item (e.g., you are more likely to buy that brand the next time you are out shopping, even if you weren’t complimented because of the brand). Your hippocampus has paired not only the brand and the pants, but also second-order information about both of those, like the compliment (with help from your ventromedial cortex). All of that is reactivated when you go to buy your next pair of pants.

How does this tie into language immersion? Motivation. You need motivation to repeatedly seek out new language learning experiences, and motivation has been consistently tied to language learning success (in immersion contexts and otherwise). If we imagine that motivation is based on past experiences, then you can see the beginnings of a potential positive spiral: motivated learners have positive language experiences, which are more likely to be reactivated due to the positive associations and consequently improves their language skills, which then allows them to have more experiences, and so on.

Even if you aren’t currently learning another language, there is plenty to take away from this research. Memory reactivation, whether triggered while you are asleep or entering new contexts, appears to improve our recall and guide our decisions. Excitingly, we may be able to manipulate this process to our benefit by (a) sleeping more so that we increase our slow-wave sleep; and (b) selectively stimulating memories during slow-wave sleep, whether they are for second-language vocabulary or guitar melodies. In the interest of sleeping more, maybe next year the poster sessions could start at 9am instead of 8am. You know, for science.

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