**We all do it - mistaking makes :-)**

There are quite a few colloquial expressions about the value of mistakes:

"Making mistakes is better than faking perfection."

"If I had to live my life again, I'd make the same mistakes, only sooner."

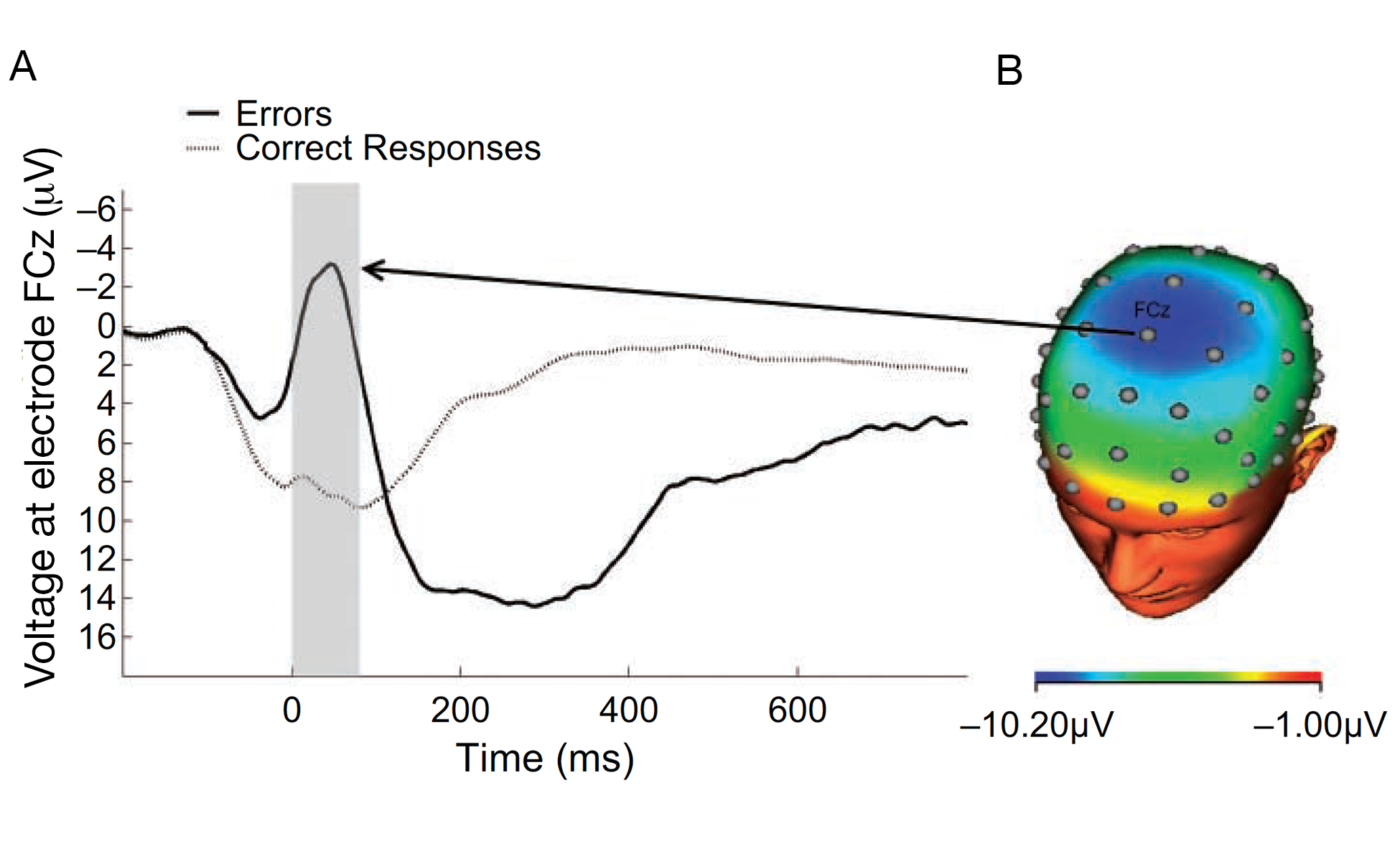
"The only people that never make mistakes are the people that never try anything."

"Your best teacher is your last mistake."

Now, there is danger in taking old sayings at face value, but the frequency that we hear this kind of logic begs the question: Is there evidence that we learn best from mistakes?

**The physiology of mistakes**

Your body reacts to making errors, and for good reason. Evolutionarily speaking, making an error could mean missing an opportunity to mate or to forage, or *not* avoiding a predator. Some errors are not so bad, like mistaking blackberries for raspberries, but other errors, like mistaking a grizzly bear for a black bear, might be really important! It makes sense that organisms should possess error recognition systems, and that they might be sensitive to the magnitude of the consequences that stem from their errors. Recognizing an error, whether consciously or unconsciously, is necessary to avoid making the same mistake again



*Figure 1. There is a striking pattern in brain activity just after we make a mistake, called error-related negativity or ERN. A) There is a spike in negative voltage at an electrode placed on the scalp 50 milliseconds after someone makes a mistake that is not present when we are correct. B) The difference between electrode voltage at the scalp for correct and incorrect answers is displayed as a color map.*

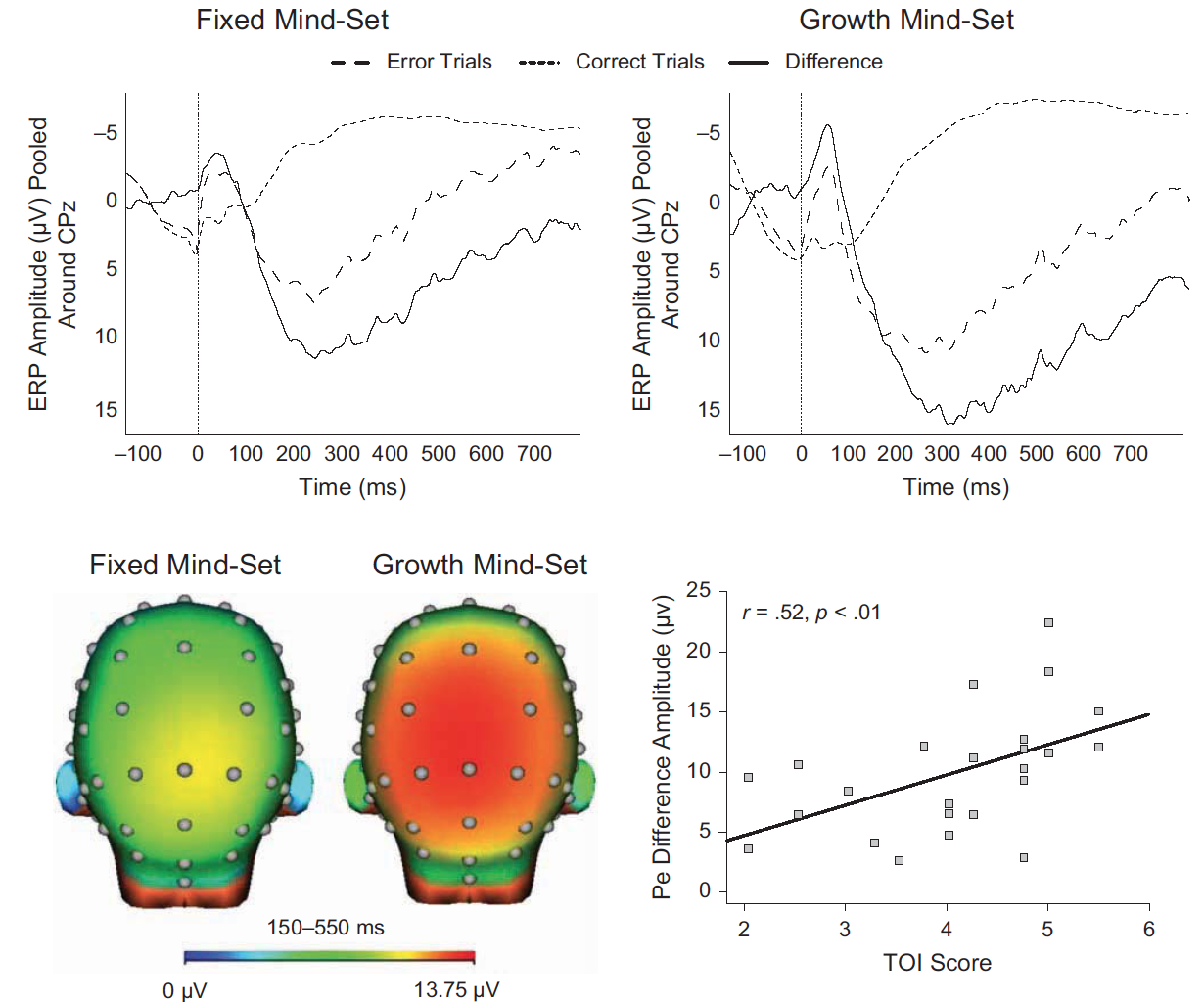
Researchers have found out a lot of really interesting things about the ERN described in Figure 1 above. First, people seem to differ innately in how strong their brains respond to making an error. Some people are just more reactive and sensitive than others. Second, people have stronger brain responses to making errors they feel are more consequential. For example, if people are punished for errors, the magnitude of their ERN's can increase. Third, the mental reaction to errors coincides with a more general physiological response - people will often have slowed heart rates and changes in skin conductance (due to sweating) after making mistakes.

**Mistakes and mindset**

You may have heard about people having a "**fixed mindset**" or a "**growth mindset**". Someone with a **fixed mindset** believes their ability and intelligence are largely innate, and are not easily changed. What does an error mean to a fixed mindset student? It must mean they aren't intelligent enough to handle the task at hand, which is a terrible thing to hear or accept. Fixed mindset people don't like making mistakes because it is a reminder of their own limitations.

In contrast, someone with a **growth mindset** believes intelligence and ability are malleable, changeable, and respond to training and effort. What does an error mean to a growth mindset student? It means that the student was trying to learn something new, to improve their ability, to become more intelligent. That is a great, rewarding feeling. People with a growth mindset welcome mistakes as proof they are pushing forward.

So, the question you should be asking is which is "correct" - a fixed or growth mindset? There is more good news here. All the evidence, from brain science to educational research to everyday experiences, suggests that ability and intelligence are malleable. Old dogs can learn new tricks. Your mistakes, and even the anxiety you might feel when you get something wrong in class, are proof that you are learning. Strange, but true!

**Back to the brain**

We started talking about the brain's response to mistakes. And above we reviewed these fuzzy concepts "fixed" and "growth" mindset. The amazing thing is that people with fixed and growth mindsets actually differ in how their brains react to mistakes.

*Figure 2. Maps of electric activity in the brains of fixed and growth mindset individuals, 150-550 milliseconds after an error is made, where warm colors indicate greater positive voltage. Positive voltage during this timeframe ("error positivity") is known to be related to awareness and allocation of attention to mistakes. Simply put, growth mindset individuals may have better post-error correction mechanisms. From Moser et al. 2011.*

Think about this for a second - your mindset affects your brain physiologically, and how your brain processes and learns from mistakes. That is a powerful result.

**What does this brain research mean for you?**

Whether you knew it or not, your body has been responding to errors you make. And, if you've had teachers or parents that punished you for making mistakes, as almost everyone has had, you've probably become more and more sensitive. The feelings of stress or anxiety you might feel in the classroom are very real, both physiologically and mentally. There is some good news, however.

1. Your body is trying to help you. The error recognition process is essential for learning - that is, you have to recognize an error in order to do something different next time. We need this system in order to learn.
2. Being aware of a physiological response, putting a name on it, and understanding it can help reduce its severity. This might sound fluffy and new-age, but it is completely true. For example, people that want to dive underwater for long periods of time first learn how their bodies respond to breath-holding and physical exertion, and then can consciously alter their heart rates and physiological response to CO2 build-up.
3. Consciously defining the consequences of making a mistake can help you reduce your reactivity to mistakes. What is the *worst* that can happen if you make a mistake on a biology quiz? That single mistake won't make you fail the class, fail out of school, and become destitute. Most often when we ask ourselves the "what is the worst that can happen" question, the answer is "well, really, not very much." You will be less worried about making mistakes if you recognize they don't matter much.

**Journal Assignment**

Look back at your notes/ journal entries while working with R over the past week. Reflect on the different kinds of mistakes you made. Summarize the mistakes and areas of struggle as you leaning to use this new tool. What would have made this process easier? What do you think you have gained through making these mistakes and correcting them?

To report these findings, you may choose any of the following formats:

* Write a substantial paragraph answering these questions and presenting the requested information.
* Record and create a video that presents your answers to the questions and presents all of the requested information. This could include a verbal description or visual representations.

**References**

Hajcak G. 2012. What we've learned from mistakes: insights from error-related brain activity. Current Directions in Psychological Science 21:101-106.

Moser JS, et al. 2011. Mind your errors: evidence for a neural mechanism linking growth mindset to adaptive posterror adjustments. Psychological Science 22: 1484-1489.