This is a handout with notes on every slide along with image and source citations for the benefit of the viewer.

Thank you, first of all, for giving me a few minutes of your time and consideration. This presentation is geared towards those who not only dream of the future, but are interested in embracing a better present.

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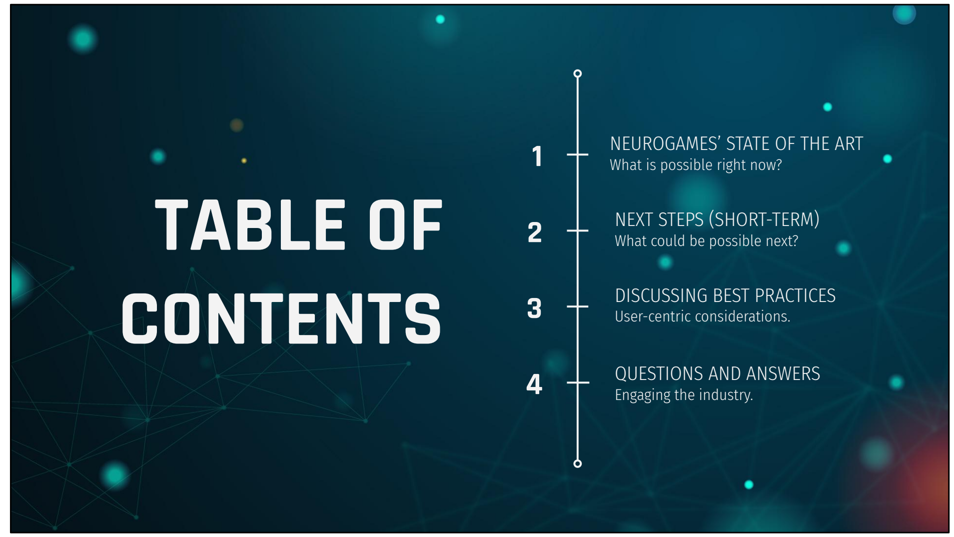


This presentation was made for the Technically Games Conference 2020. For the next 15 minutes, we'll see what's possible in the realm of neurogames.

For the purposes of this presentation, ‘neurogame’ is defined as a digital game that interfaces directly with the brain as a form of game mechanic.
Also, to keep this presentation short, I will only be giving a brief chronological overview of non-invasive devices that interface directly with the brain.
Very few hardcore gamers would undergo surgery every year to get the latest neurogadget, right?

What I am about to present is not mere concept art, but actual devices. The illustrations showcase these devices in use.

ElectroEncephaloGraphic (EEG) devices are not a specially new thing. But it is only recently that commercially available, wieldy devices have been available to the wider public. They usually have 2-8 electrodes that measure the brain’s alpha, beta and theta waves. They usually register general states of mind such as stress and attention. Research-gradee EEG caps have 64-128 wet electrodes that give more accurate information about what region of the brain is firing and to what level of excitability.

In this example, we see MindLight, a mental health game teaching children how to cope with anxiety. EEG controllers are commonly used for meditation and mental health mechanics.

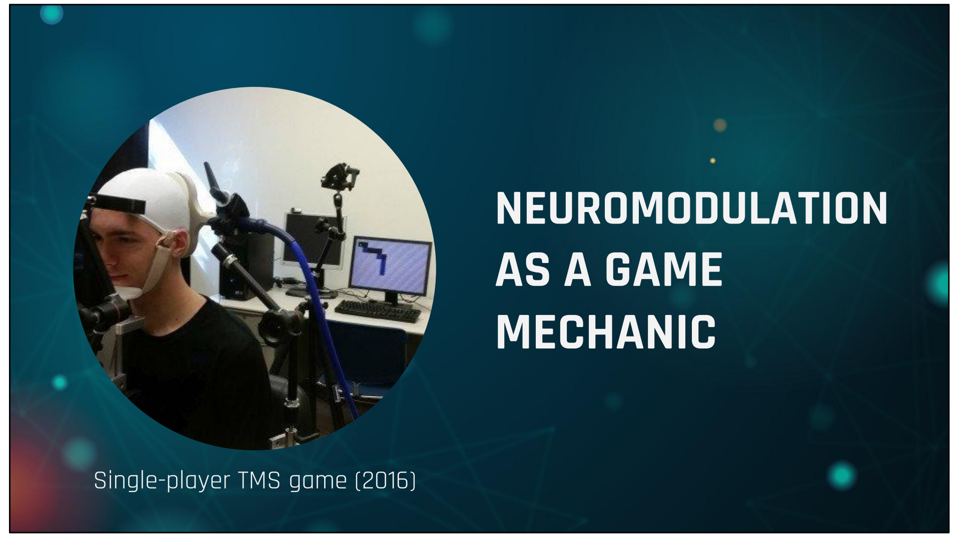
Schoneveld, Elke, Malmberg, Monique, et al. (2016), ‘A neurofeedback video game (*Mindlight*) to prevent anxiety in children: A randomized controlled trial’, *Computers in Human Behavior*, 63, pp. 321-333.

Scientists at the University of Washington have been developing for the past 6-7 years a non-invasive system to interface with the brain using Transcranial Magnetic Stimulation (TMS). It is basically a couple of magnetic coils changing polarity really fast to excite or inhibit an area of the brain.

In this example, one player is looking at the game but has no controller (P1), whereas a second player in another building cannot see the game but has a controller (P2). When P1 has an intention to fire a rocket, an impulse is sent to P2's motor cortex to make his wrist twitch and press the rocket launching button.

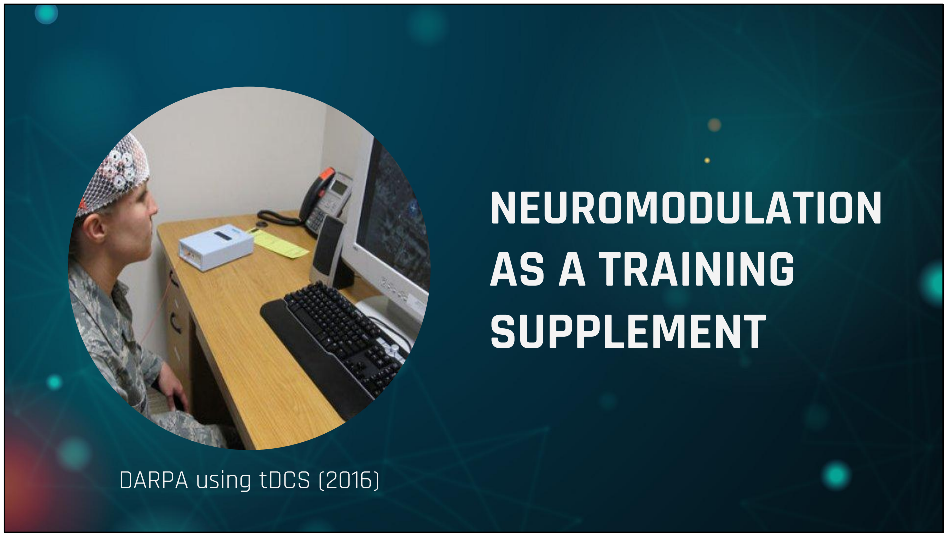
They have continued their work to this day, further expanding the BrainNet to have two senders and one receiver. They always use games as a proof of concept. Their level of accuracy is above 90%.

Rao, Rajesh, Stocco, Andrea, et al. (2014), 'A Direct Brain-to-Brain Interface in Humans', *PLoS ONE*, 9:11, p. e111332.



Following a similar principle, scientists in the same lab at the University of Washington made a game where the single player cannot see the screen but their visual cortex is stimulated to perceive a phosphene, a sort of flash of light. When the player sees the phosphene, they know they have to press a button to go down a ladder in the maze, else, they move forwards.

Losey, Darby, Stocco, Andrea, et al. (2016), 'Navigating a 2D Virtual World Using Direct Brain Stimulation', *Frontiers in Robotics and AI*, 3, p. 72.



Experiments at the United States' Defense Advanced Research Projects Agency (DARPA) have proven that Transcranial Direct Current Stimulation (tDCS) can enhance learning of virtual pilotin exercises. Basically, they send a current through the prefrontal cortex to enhance concentration. We'll talk about nootropics later on.

Gamers have tried replicating the same benefits to very little success (foc.us). The general consensus is that they lack a team of scientists placing and regulating the impulses in the correct place. Further tDCS can potentially irritate facial muscles and even burn skin if conditions are not closely monitored.

Nelson, Justin, McKinley, Richard, et al. (2016) 'The Effects of Transcranial Direct Current Stimulation (tDCS) on Multitasking Throughput Capacity', *Frontiers in Human Neuroscience*, 10, p. 589.

Scientists at the MIT Media Lab have come up with a way to "read" silent speech, by translating the nervous impulses that arrive to the facial muscles into words that would be articulated with that muscle placement.

The picture shows Dr. Kapur actively using the AlterEgo device in a 60 minutes interview. He has recently developed a new version which is less obtrusive and translucid, but I personally liked the look of this one.

Kapur, Arnav, Kapur, Shreyas and Maes, Pattie (2018), 'AlterEgo: A Personalized, Wearable Silent Speech Interface', in *23rd International Conference on Intelligent User Interfaces (IUI '18)*, New York, NY, USA, March, New York: Association for Computing Machinery, pp. 43-53.

CTRL-Labs, in partnership with Facebook Reality Labs has developed a Neural Interface Technology that, similarly to the previous one, catches nervous impulses arriving into the wrist to decode the way in which the fingers are supposed to be moving in the hand. No more cameras guessing where those fingers are!

The newer version looks more elegant and can be sponsored to labs researching VR locomotion and hand tracking.

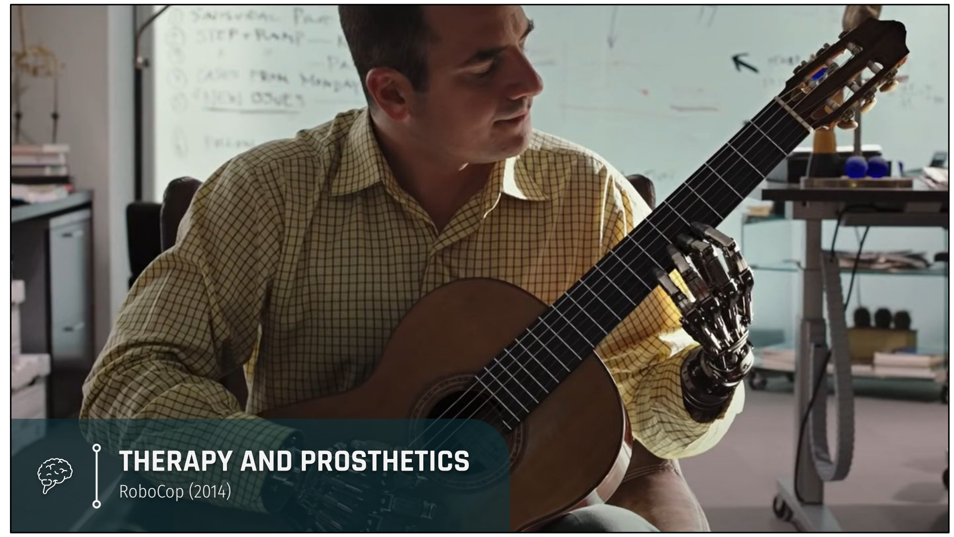
CTRL-labs (2018), 'Thomas Reardon Introduces CTRL-kit at Slush 2018', YouTube, 6 February, https://www.youtube.com/watch?v=D8pB8sNBGlE. Accessed 1 November 2020.

EMOTIV was one of the first pioneers in EEG controllers. Some of you may have heard of them. Well, pay close attention to the picture in the slide. What is the only electronic device being worn by the people at work?

That's right, their latest development, the MN8, is a pair of earphones with two dry electrodes that track people's alpha, beta and theta brain-waves. It is only available under a business licence for businesses wanting to research whether their workers are paying attention during the workday. The concept is to maximize productivity and safety. We'll come back to neuroethics and privacy later on.

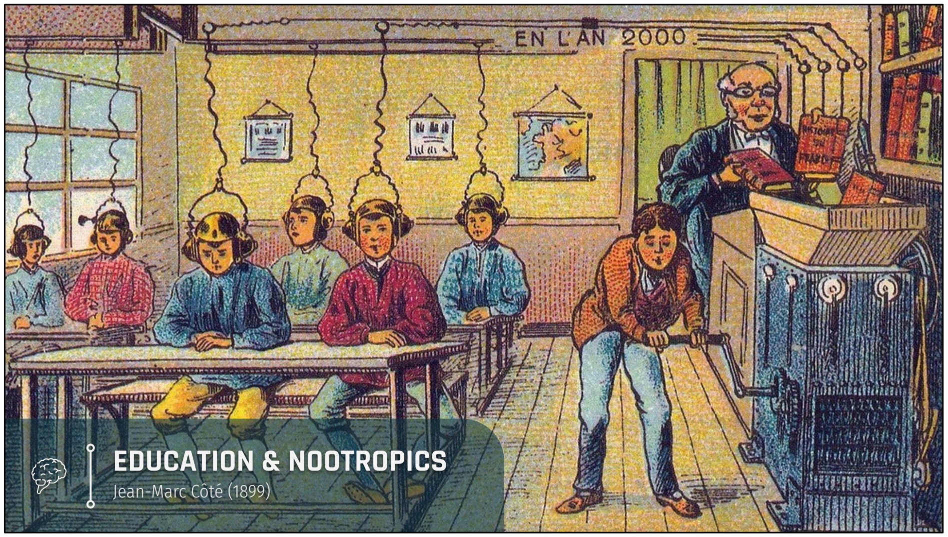
EMOTIV (2020), 'Workplace Wellness, Safety and Productivity: MN8', EMOTIV, https://www.emotiv.com/workplace-wellness-safety-and-productivity-mn8/. Accessed 1 November 2020.

Now that we have seen some possible doors for commercially-available neurogames, let's try to imagine what could be behind those doors!



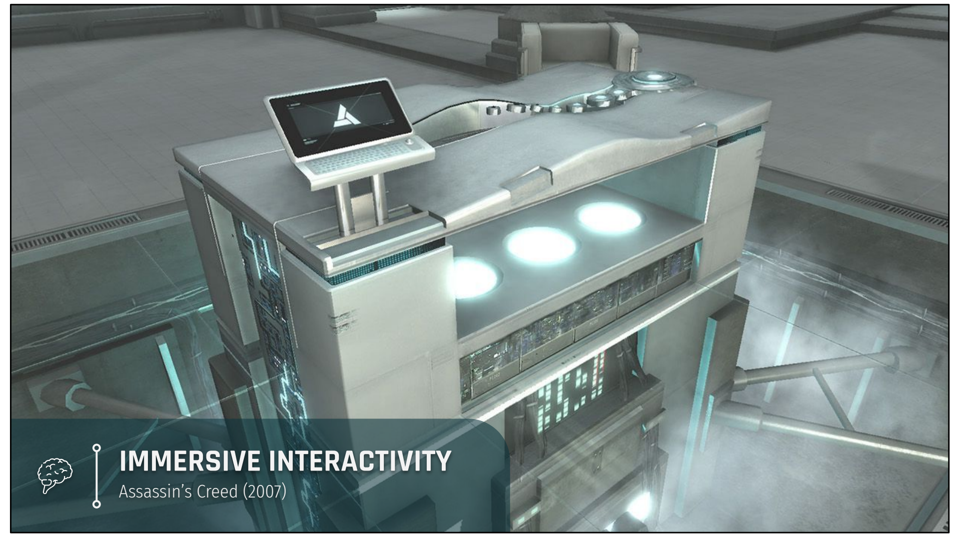
The first one is obvious to anyone who has searched for these technologies. Research on this front usually sells the idea of enhancing prosthetic control and helping develop novel therapies. In fact, there's many companies today that get government subsidies for this kind of research. It is very probable that the first applications will be medical.

Padilha, José (2014) *RoboCop*, United States: Metro-Goldwyn-Mayer Pictures.



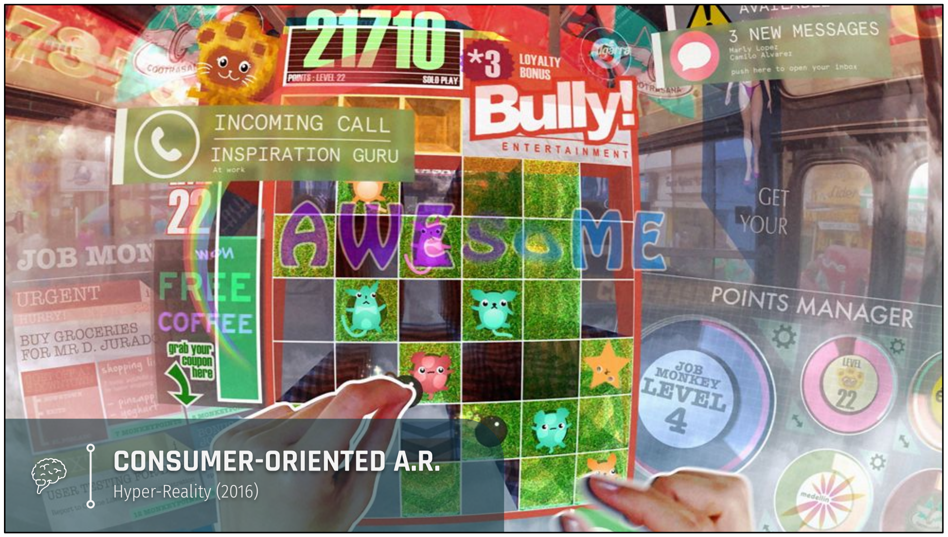
The next usual application is enhancing education. Some classical thinkers believe these technologies could help cram information into passive students. Yes, even today. Contemporary researchers hope that these technologies will empower the student into actively exploring new knowledge. Nootropics (cognitive-enhancers) could open a world to a new era of learning *and* cheating.

Jean-Marc Côté, *En l'An 2000*, 1899. Ink on cigar box. France.



Of course, Technically Games would not be complete without the hope for expanding the realm of gaming. These technologies could make games more immersive, more exciting, more powerful… if more expensive.

Gameloft and Ubisoft (2007), *Assassin's Creed*, Montréal: Ubisoft and Gameloft.

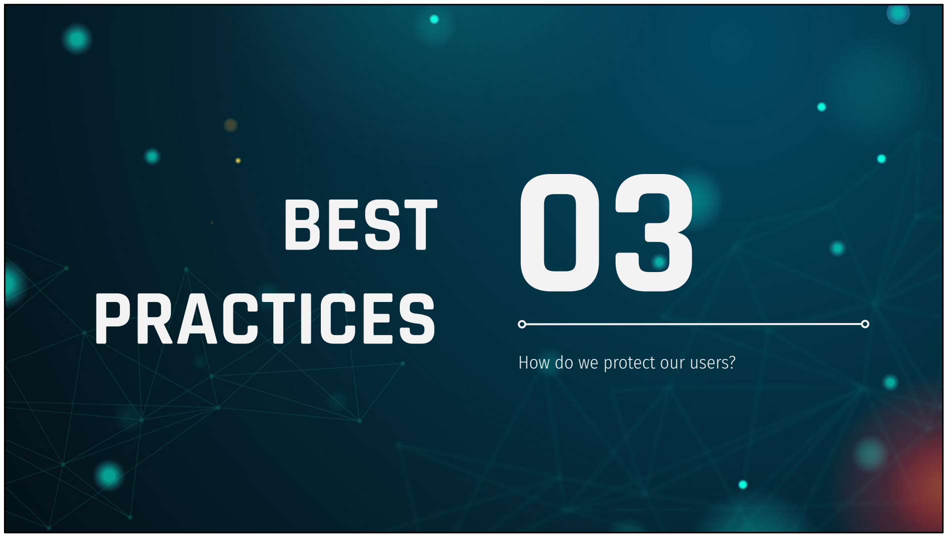


No new technology is safe from consumerism. We can most likely expect our telecommunications and publicity to adapt to new devices being readily available to the consumer. For good and bad.

Matsuda, Keiichi (2016), *Hyper-Reality*, Colombia: Fractal.

...for the very, very, very bad, indeed. New devices open a door to a new intimacy, which can be violated and exploited for someone else's profit. Legally *and* illegally, of course. Which brings me to...

Dontnod Entertainment (2013), *Remember Me*, Paris: Capcom.



Now that we know what is possible today and have quickly fantasized about the tip of the neurogames iceberg, it is time that we come back to Earth with a plan of action. For neurogames *are* nigh and we are woefully prepared.

As of today, only Chile and Spain have enshrined neurorights in law.
While the rest of the governments follow suit and complement human rights with neurorights, it has fallen to the providers of neuroservices to self-regulate, which some have started to do, as is the case of Facebook Reality Labs, pictured.

But, it won't be long before private parties start misusing the technology for profit. So, what can we do as an industry to foster a culture of respect for our users' most intimate information?

Facebook Reality Labs (2020), 'Responsible Innovation Principles', Facebook, https://about.fb.com/realitylabs/responsible-innovation-principles/. Accessed 1 November 2020.

Neuroethicists have themselves taken steps to guide the neuroscience industry in general.

Yuste, Rafael, Goering, Sara, et al. (2017), 'Four ethical priorities for neurotechnologies and AI', *Nature*, 551:7679, pp. 159-163.

In my own Master thesis, I proposed a few best practices and potential safeguards for the games industry regarding neurogames.
The general ideas are in the slide, the specifics can be seen in the conclusion chapter cited below. But the general concepts should be enough to guide any aspiring neurogames designer.

Saldivar, Diego (2019), 'Design Guidelines for Transcranial Magnetic Stimulation as a Game Mechanic', Master thesis, Cologne: Technische Hochschule Köln.

The medical establishment is also rich in neuroethics resources which we should take into account when designing our gaming platforms.

Zuk, Peter, Torgerson, Laura, et al. (2018), 'Neuroethics of Neuromodulation: An Update', *Current Opinion in Biomedical Engineering*, 8, pp. 45-50.

Above all, we must make sure that our most precious asset it protected at all times, from design to end use.
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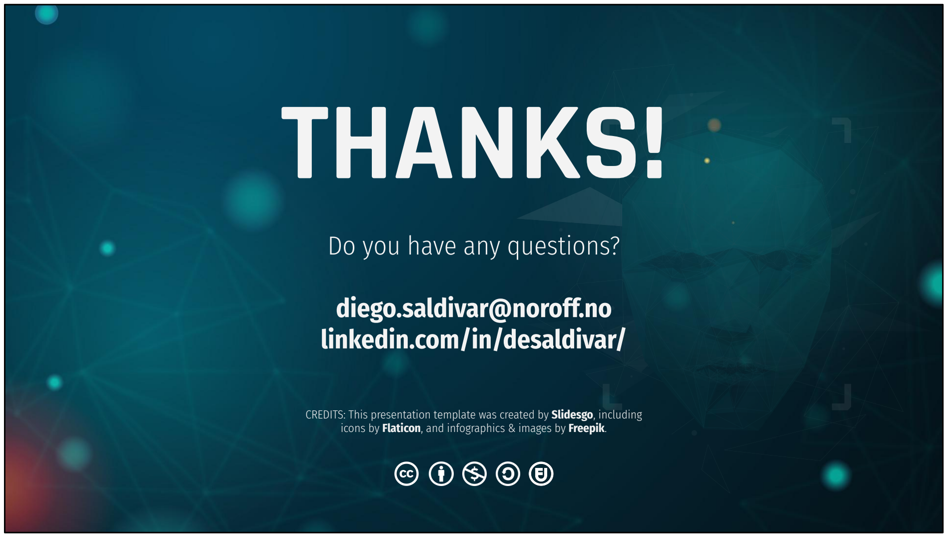

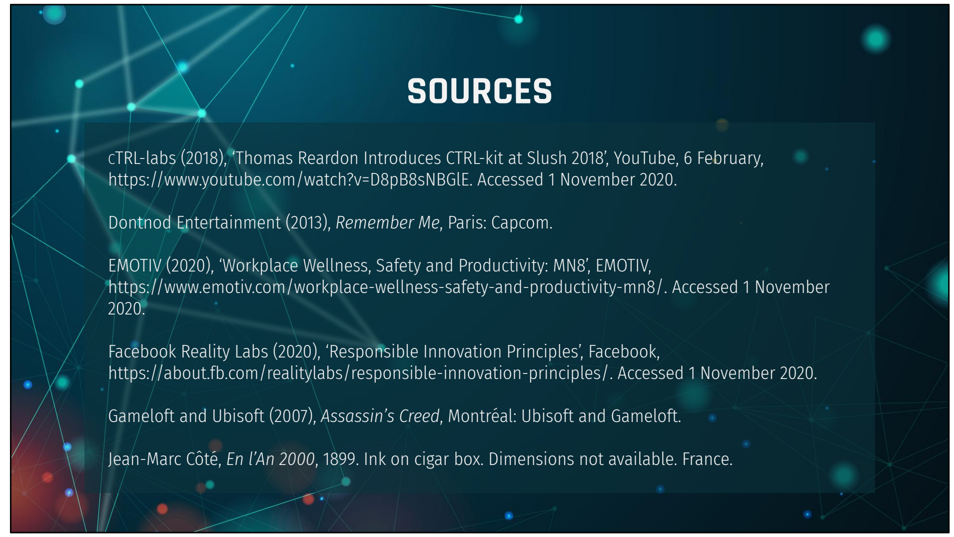

Thank you for your time! If you'd like to reach out, check the contact information on the slide.

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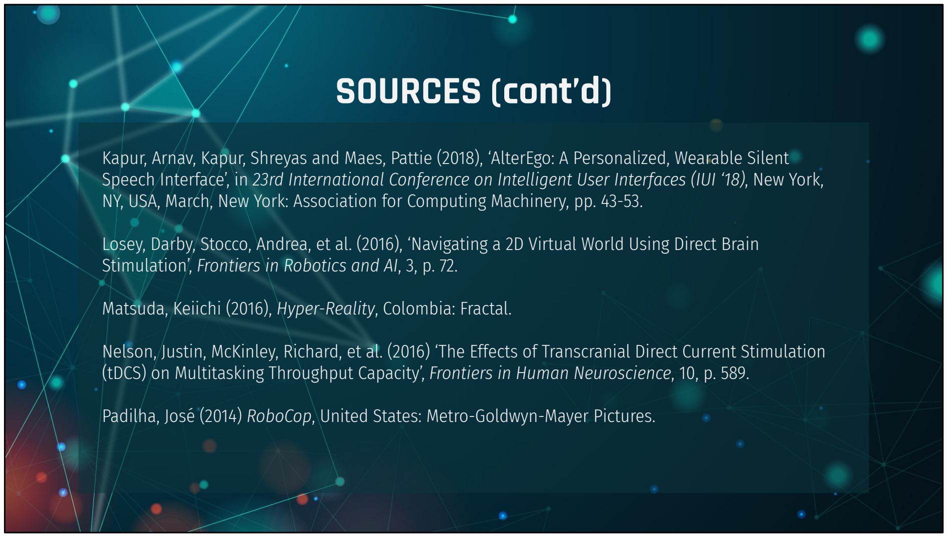

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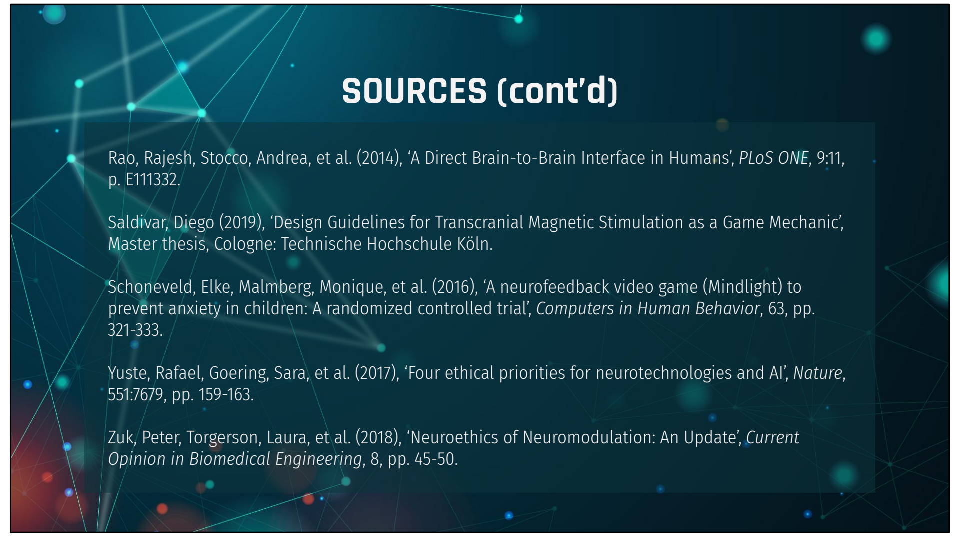

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