Losing Focus: The Brain Speaks

Damian Baraty, **Faculty Advisor**: Dr. Erin Solovey

Leah Friedman, Ruixue Liu, Reza Moradinezhad, Anush Niranjan, Denisa Qori, Gloria Houseman, Pat Rahmlow

DREXEL UNIVERSITY College of Computing & Informatics

RETHink at DREXEL UNIVERSITY

Research Objective

To develop personal adaptive learning environments based on real time brain data that allows people to learn most effectively.

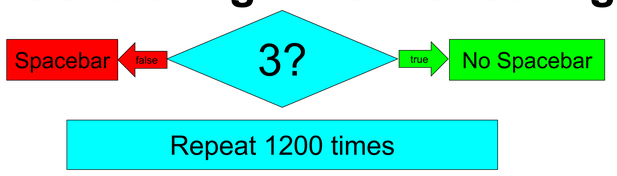
Overview

To understand cognition and brain states, and to advance development of adaptive learning environments, a study participant:

- wears a noninvasive fNIRS neuroimaging headband,
- performs a controlled task to induce a particular cognitive state (e.g. mind wandering).

The participants' behavioral data (e.g. computer activity) and brain activity are analyzed to find brain patterns associated with particular cognitive states.

Generating Mind Wandering



The SART protocol prompts participants to enter a mind-wandering state that fNIRS can detect:

1. A number between 1-9 appears on the computer screen.
2. The participant hits the space bar for all numbers but 3.
3. Repeat every 2.5 seconds with 1200 numbers over 30 minutes, with a 3 occurring 5% of the time.

Eventually, mistakes happen, but what can that tell us about what is going on in the brain?

Common Abbreviations

AIR—Advanced Interaction Research Lab
fNIRS—functional near-infrared spectroscopy
MW—Mind Wandering
SART—Sustained Attention to Response Task

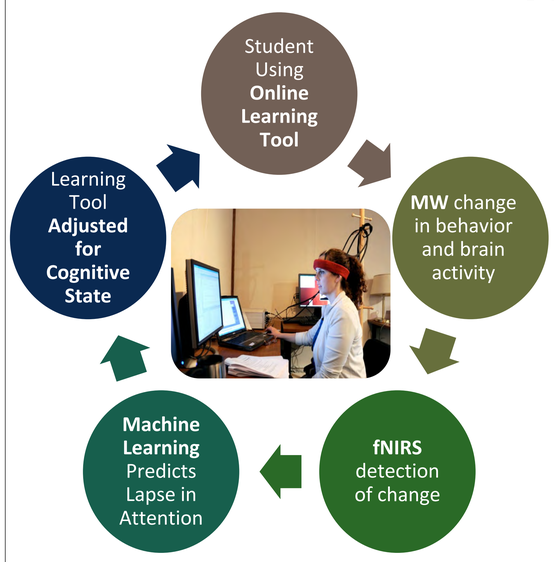


Diagram depicting the Online Learning Tool → MW → fNIRS detection → ML → Adaptive Learning Environment cycle, featuring Dr. Solovey using the fNIRS device. Used with permission from *Towards Neuroadaptive Personal Learning Environments: Using Direct Brain Assessment to Detect Changes in Attentional State,* by Leah Friedman and Erin Solovey.

Activities

The SART protocol requires a sustained attention to a task over time. Mistakes during this test have been associated with mind wandering states that fNIRS can analyze to show what happens physiologically in the brain. But before we can try to deduce the cognitive state of the brain, we need to understand how participants perform generally in the SART protocol. Hopefully, that will help us answer basic questions, such as do participants:

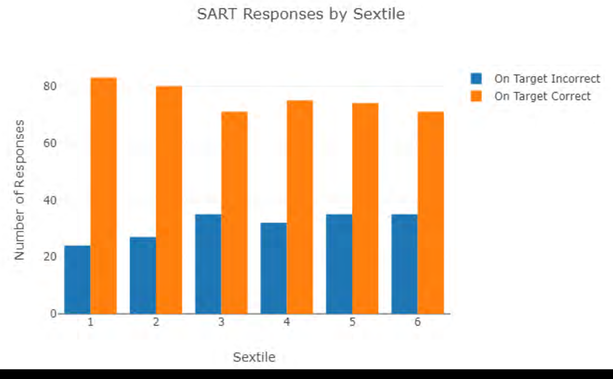
- Get better at the task with practice, or
- Make more mistakes as time passes;
- Respond incorrectly randomly, or
- Have "streaks" of solid correct or incorrect answers to the prompts.

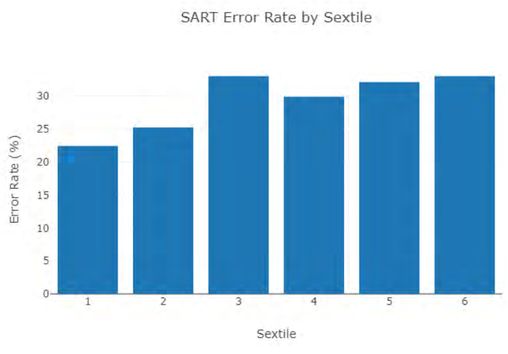
This will help us validate the SART protocol as a tool to induce mind wandering.

Hypothesis:

Participants will make errors in the beginning of the session, but as the session proceeds, will become more prone to mind-wandering states, leading to an increase in error rates on the SART tests.

Results:





Conclusions:

Our hypothesis was confirmed, mostly. Error rates for the first and second sixth of the time period (roughly 5 minutes each) were around 20% and 25%, but after 10 minutes of testing, the error rate shot up to 30%, a significant increase, but error rates hover around 30% from that point forward. This data may indicate that fNIRS data regarding Mind-Wandering states may be more interesting after the 10' mark.

Course Materials

- *The Art of Data Massage: Recovering from Impractical Database Decisions*. This Lesson Plan, designed for intro CS and CSP classes, will go over basic algorithmic solutions to data storage problems, starting with Excel and moving on with Python.

Future Work

- Combine work on understanding SART results with analysis of fNIRS data and MW states.
- Build Machine Learning analysis tools to automatically detect mind wandering brain states in online learning environments.
- Explore the streak problem in the SART data using advanced computer techniques.
- At places like Drexel, researchers have already explored producing functional fNIRS devices based on simpler microcontrollers such as the Arduino or BBC's micro:bit. This would bring brain research and adaptive learning systems closer to classrooms.

More Info:

For more info and classroom lesson plans, use the QR code to jump to the Google Site for this REThink project.

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Research Experiences for Teachers Site for Machine Learning to Enhance Human-Centered Computing

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