I. Abstract

The International Dyslexia Association estimates 15-20% of the population has a language-based learning disability. Our future technology device will support dyslexic people with reading and writing. Our vision for D^2 (Dyslexia Device) is to design a device that will be small and unnoticeable but will allow children or adults to have a technology device that will compensate for areas of the brain that have challenges with processing language.

The device combines a variety of key technologies such as electroencephalography (EEG, reading brain waves), optical character recognition, auditory bone conduction, artificial intelligence, and lasers to provide a complete support device for a child or adult with dyslexia.

Dyslexia Device (D^2)

II. Description

1. Present Technology

Dyslexia is a language learning problem that many people struggle with. “In the US 14.5 to 43.5 million children and adults suffer from dyslexia.”[1] Dyslexia is a brain-based condition that impacts reading, spelling, and writing. It's not a problem with basic vision, it's a problem with understanding and working with written or auditory language. A dyslexic person often has a differently structured brain. You can see signs of dyslexia even before the child starts to read, they can have a hard time recognizing individual sounds in words. Dyslexic children may have a hard time with phonemic awareness. They also might see words that are backward, upside down, letters jumping around the page, and smushed together.

It’s hard for people with dyslexia to match words with sounds. The Pareto-Temporal Area (brain) helps understand new words, and the Occipital-Temporal Area (brain) helps with spelling, pronouncing, and figure out what a word means, but these areas are not being activated in a dyslexic brain.

Currently, there is no real cure for dyslexia, but there are tools that help. Many tools are limited, only focused on a specific type of problem. For example, colored and tinted dyslexia glasses only help with clearing vision problems. There are tools that help

[1]“Dyslexia: What Brain Research Reveals About Reading.” *Dyslexia: What Brain Research Reveals About Reading | LD Topics | LD OnLine*, www.ldonline.org/article/10784/.

with writing such as Livescribe Smartpen, and Speech-to-text (Dragon Dictation, Google's VoiceNote), but there is nothing that helps with vision, writing, and learning in one tool. Today, students and adults do not have a technology tool to provide all the support to ensure they don't feel anxiety, lack of confidence, and lose interest in learning because their brains work differently.

2. History

Dyslexia was discovered 130 years ago. Rudolf Berlin gave the name dyslexia in 1887 to an adult who lost the ability to read. In 1877, Kussmaul identified reading difficulties he called Wortblindheit, which meant word-blindness. James Hinshelwood, James Kerr, and William Pringle Morgan focused on including children with difficulties learning to read. At the 1868 annual meeting of the American Neurological Association in Washington, DC, Samuel T. Orton, a neuropathologist, presented his first paper on word-blindness which was due to a lack of cerebral dominance. Through the years, many have researched and published findings. For example, Clement Launay in 1949, conducted research that explained mirror reading.

Most significant advancements came in the 1980s and 1990s in understanding dyslexia due to technology advancement with brain imaging using positron emission tomography (PET) and magnetic resonance imaging (MRI).

3. Future Technology

The device will include a computer that will read the person's brain waves and several key technologies such as optical character recognition (OCR), bone conduction, artificial intelligence and lasers to provide a complete tool for a child or adult with dyslexia.

Figure 1: D^2 being used for reading and writing.

"Brainwaves are electrical impulses in the brain."[2] Brain waves work through the synaptic transmission, which is used to transmit signals between cells. Brain waves are detected using a technique called electroencephalography (EEG).

Our device can use brain waves to turn the device on and off, because it will be hard for the person to have to talk to the product every time they want it to function. Brain waves is one of the most important things in our project because they transfer information from the brain to the CPU without having to press a button.

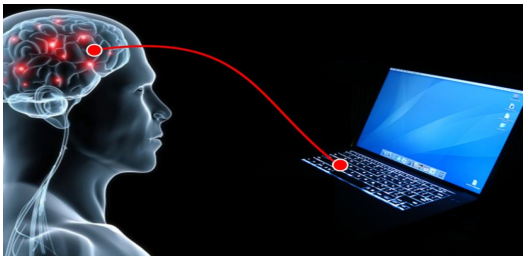


Figure 2: Brain Computer Interfacing

The brain waves will work with our computer which is called brain computer interfacing (BCI). We will place nano-size electrodes placed on the scalp or you could place them inside as an implant. This allows us to capture the electrical signal that passes from neuron to neuron in your brain. The difference in electric potential are the signals that will be analyzed and translated into commands. These commands will be sent to our device.

[2] "What Are Brainwaves?: Improve Brain Health with Neurofeedback." *Sinha Clinic*, www.sinhaclinic.com/what-are-brainwaves/.

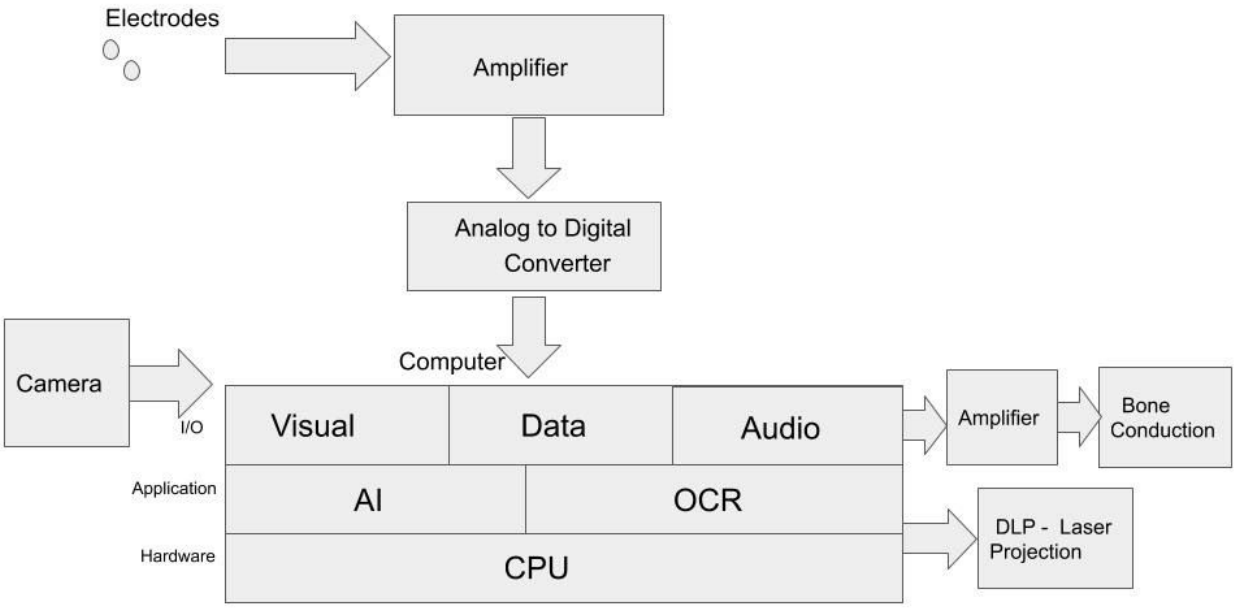


Figure 3: D^2 Technology

The upper part of Figure 3 shows how the electrodes sense the electrical signals of your brain waves. The signals are extremely weak so an amplifier improves the signals before sending to analog to digital converter. The converter changes the signals to binary ones and zeros that can be used by the computer. In addition to the EEG, the I/O bus accepts information from a camera which is looking at the text. The outputs from the computer are the audio for the auditory bone conduction and text for the DLP laser projection.

A camera feeds a video image of a printed page for the optical character recognition (OCR). We can use OCR to scan words and transfer them into text. *"OCR technology is used to convert virtually any kind of images containing written text (typed,*

handwritten or printed) into machine-readable text data."[3] The computer will store the written text and wait for the brain waves to instruct next steps.

Figure 3: OCR example

The D^2 will be able to scan the paper using OCR and read it using an audio amplifier to the dyslexic user through bone conduction. "Bone conduction is the conveyance of sound through bones to the skull of the inner ear."[4] Some benefits of using bone conduction is that they can help you hear in really loud places and there is no loss of auditory input due to earbuds or headphones. This audio portion of the device can help improve reading and understanding.

With our device, we will also assist with writing. Our brain computer interfacing will use a laser and projection lens to project the word onto a piece of paper so that a person could write over the letters. Also, if a person has a tablet, phone, or computer, the brain waves would be able to communicate so that they could write directly from the brain into the device.

[3]Harris, Joshua, and michael Edmisten. "What Is OCR And What Is It Used For?" *Document Data Capture And Workflow Automation*, 17 Jan. 2020, docparser.com/blog/what-is-ocr/.

[4] Bruning, K.C., and John Allen. "What Is Bone Conduction?" *WiseGEEK*, Conjecture Corporation, 29 Jan. 2020, www.wisegeek.com/what-is-bone-conduction.htm

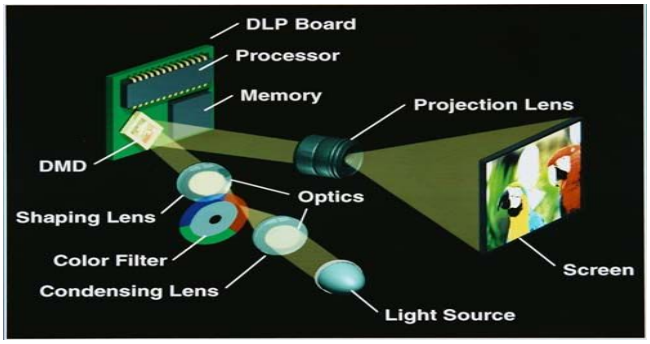


Figure 4: Laser Projection Design

Figure 4 shows the design for our device to project text. *"A laser is created when the electrons in atoms in special glasses, crystals, or gases absorb energy from an electrical current or another laser and become "excited."*[5] those electrons move from a lower to higher energy orbit, around the atom's nucleus. When they return to their normal state, the electrons produce photons (particles of light).

Laser lights reflect off a set of micro mirrors in the DLP chips (Digital Light Processing Chips). Lasers get to the final projection lens which helps figure out how much space you need between the projector and where the words will be projected.

"Artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks."[6] We will have to add AI to this device because AI will be needed to translate distorted text the dyslexic brain would write, into the correct words and text. For our device, the AI program will learn the

[5] *How Lasers Work*, lasers.llnl.gov/education/how_lasers_work.

[6] "Artificial Intelligence – What It Is and Why It Matters." *SAS*, www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html.

words that the reader will want to write down, so the AI program will correct the words and project them visually.

The D^2 is flexible, it can be installed on glasses, earrings, headbands, and even hair clips. We didn't want it to be noticeable because we didn't want to make the dyslexic person feel uncomfortable with our device.

4. Breakthroughs

For our invention we need the device to be small. We would need to use brain waves to connect to the computer and artificial intelligence, and the area of brain computer interfacing including AI still has many technical challenges. We also don't want a person wearing a giant cap of EEG electrodes. We would want a breakthrough so we would have a small electrode implanted or on a headband/cap.

The OCR, bone conduction, and laser technologies exist and have already been tested. We would need to focus on two areas, brain computer interacting with the device and using AI to learn and correctly project the writing. For instance, if you were Dyslexic and writing the sentence, "I love STEAM.", the brain would possibly, and probably not process the sentence correctly. We would like to run our tests on both Dyslexic children, and Dyslexic adult brains. We would have to conduct several different tests, such as how the brain waves work with the child and adult brain. We would do testing to ensure that the camera and the OCR are picking up what the eyes and the brain want to read.

5. Design Process

In the design process, we rejected a few things. When we started we wanted our device to be a type of high-tech glasses, but we decided that not all people wanted to wear glasses, we wanted it to be small and aesthetically unnoticeable. With our design process we want to build an everyday accessory.

As we were designing our device, we thought it would be hard for a person to listen to other people and sounds if something was always talking in their ear. We learned about bone conduction and added that technology to our device. Bone conduction doesn't use the eardrum but allows the Cochlea to directly receive vibrations from sound waves. This allows other sound vibrations to pass through the eardrum. It was a better approach for a person to hear using the D^2 .

We decided to research how to best instruct the device for when a person would want it to read or when they would want it to project text or send text to a device. We researched brain computer interfacing and thought the use of a person's own brain waves would be the best way to decide when and what they would want to read or write. We decided not to use voice activated devices because we would not want the D^2 to be disturbing, and noticeable in the classroom.

We also learned that we will have to use AI in our device, because a dyslexic brain works differently, so it will project the words incorrectly. To fix this will have to add AI to translate and project the words correctly.

We interviewed a neuroscientist, and we learned our design needed to be adjusted. Our initial vision was to have all in compact devices as shown in the figure below, and after interviewing with the neurologist, we placed the electrodes on the scalp. We would not be able to put the EEG next to bone conduction earphones because the EEG would pick up the bone conduction vibrations.

6. Consequences

Our device can have both positive and negative impacts on society. One negative is that it can not cure dyslexia, it is a support device and we wouldn't want people to stop researching for a cure because there is already a D^2. It's possible our device will not completely help a person with all of their symptoms that come with their dyslexia.

Our device will make reading and writing easier. One positive is that the device can help many adults and children with their dyslexia. It can help them read words clearly, and writing will be easier. This is a positive because it will help people with dyslexia have an easier time in school and out of school. We hope that the D^2 will help people feel comfortable being themselves, but not become too attached to the device, because if the device stopped working, the dyslexic person might not know how to read or write without the device. Another positive is that this device can help people with dyslexia boost their self-esteem, and confidence in their everyday lives. With the D^2 we hope people will feel more confident with their reading and writing abilities.

IV. Bibliography

Figures:

Figure 1: Created by Team

Figure 2: Mitra, Supriya Ranjan. “Neuroscience Have Allowed Us to Interface Directly with the Human Brain.” *Schneider Electric Blog*, 11 Apr. 2018, blog.se.com/sustainability/2018/04/03/brainwave-a-media-of-universal-language/.

Figure 3: Woodford, Chris. “Ocr-Feature-Detection.” How Does OCR Document Scanning Work?, 2010, www.explainthatstuff.com/how-ocr-works.html.

Figure 4:“DLP Projectors.” *Pctechguide.com*, 24 May 2013, www.pctechguide.com/projectors/dlp-projectors.

Online Articles:

"Dyslexia." *Mayo Clinic*, Mayo Foundation for Medical Education and Research, 22 July 2017, www.mayoclinic.org/diseases-conditions/dyslexia/symptoms-causes/syc-20353552.

"Five Ways Not to Treat Dyslexia, Part 2." *Lexercise*, 17 May 2018, www.lexercise.com/blog/five-ways-not-to-treat-dyslexia-part-2.

Bruning, K.C., and John Allen. "What Is Bone Conduction?" WiseGEEK, Conjecture Corporation, 29 Jan. 2020, www.wisegeek.com/what-is-bone-conduction.htm.

"Bone Conduction." Wikipedia, Wikimedia Foundation, 24 Jan. 2020, en.wikipedia.org/wiki/Bone_conduction.

"What Are Brainwaves?: Improve Brain Health with Neurofeedback." *Sinha Clinic*, www.sinhaclinic.com/what-are-brainwaves/.

Bates, Kristyn. “Brain-to-Brain Interfaces: the Science of Telepathy.” The Conversation, 4 Feb. 2020, theconversation.com/brain-to-brain-interfaces-the-science-of-telepathy-37926.

“Does an Autistic Brain and a Dyslexic Look the Same - Google Search: Dyslexia, Sight Word Flashcards, Dyslexia Teaching.” *Pinterest*, www.pinterest.com/pin/449937819021479203/.

Korbey, Holly. “Tech Tools That Have Transformed Learning With Dyslexia.” KQED, 4 Nov. 2015, www.kqed.org/mindshift/42036/tech-tools-that-transformed-learning-with-dyslexia.

“How Does OCR Document Scanning Work?” Explain That Stuff, 11 Dec. 2018, www.explainthatstuff.com/how-ocr-works.html.

Harris, Joshua, and Michael Edmisten. “What Is OCR And What Is It Used For?” Document Data Capture And Workflow Automation, 17 Jan. 2020, docparser.com/blog/what-is-ocr/.

"Artificial Intelligence – What It Is and Why It Matters." *SAS*, www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html.

How Lasers Work, lasers.llnl.gov/education/how_lasers_work.

"Digital Light Processing." Wikipedia, Wikimedia Foundation, 21 Jan. 2020, en.wikipedia.org/wiki/Digital_Light_Processing.

"Dyslexia." *Mayo Clinic*, Mayo Foundation for Medical Education and Research, 22 July 2017, www.mayoclinic.org/diseases-conditions/dyslexia/symptoms-causes/syc-20353552.

https://cdn4.explainthatstuff.com/ocr-feature-detection.png

Team, Understood. "Video: Dyslexia and the Brain." *And the Brain*, Understood, 16 Oct. 2019, www.understood.org/en/learning-thinking-differences/child-learning-disabilities/dyslexia/video-dyslexia-and-the-brain.

Submitted by Anonymous (not verified) on April 13, et al. “Dyslexia and the Brain: What Does Current Research Tell Us?” *Reading Rockets*, 12 Dec. 2013, www.readingrockets.org/article/dyslexia-and-brain-what-does-current-research-tell-us.

“EEG (Electroencephalogram).” *Mayo Clinic*, Mayo Foundation for Medical Education and Research, 7 Dec. 2018, www.mayoclinic.org/tests-procedures/eeg/about/pac-20393875.

“History of Dyslexia Research.” Wikipedia, Wikimedia Foundation, 4 Jan. 2020, en.wikipedia.org/wiki/History_of_dyslexia_research.

“How to Support a Dyslexic Employee.” *Kelly Services Search and Selection Recruitment Consultancy Offering Bespoke Workforce Solutions*, www.kellyservices.ca/ca/business-services/business-resource-centre/managing-employees/how-to-support-a-dyslexic-employee/.

"Frequently Asked Questions." International Dyslexia Association, dyslexiaida.org/frequently-asked-questions-2/.

Mitra, Supriya Ranjan. "Neuroscience Have Allowed Us to Interface Directly with the Human Brain." *Schneider Electric Blog*, 11 Apr. 2018, blog.se.com/sustainability/2018/04/03/brainwave-a-media-of-universal-language/.

Web Page Images

https://www.brainfacts.org/-/media/Brainfacts2/Archives/Article-Images/Dyslexia-Today.jpg

https://www.google.com/imgres?imgurl=https%3A%2F%2Fimages-na.ssl-images-amazon.com%2Fimages%2FI%2F31IJW0FRC6L._SL500_AC_SS350_.jpg&imgrefurl=https%3A%2F%2Fwww.amazon.com%2FLivescribe-APX-00008-2GB-Echo-Smartpen%2Fdp%2FB00524DLZ0&tbnid=TaLsbe5YIfdvYM&vet=12ahUKEwibsbnG9MXnAhWTkp4KHd2LBFYQMygBegUIARChAw..i&docid=7JiXWjc0eaU0UM&w=350&h=350&q=smart%20pen%20generic&ved=2ahUKEwibsbnG9MXnAhWTkp4KHd2LBFYQMygBegUIARChAw

https://www.quantib.com/hs-fs/hubfs/assets/pillar%20pages/The%20ultimate%20guide%20to%20AI%20in%20radiology/images/Pillar%20page%20-%20figure%201-7.png?width=1908&name=Pillar%20page%20-%20figure%201-7.png

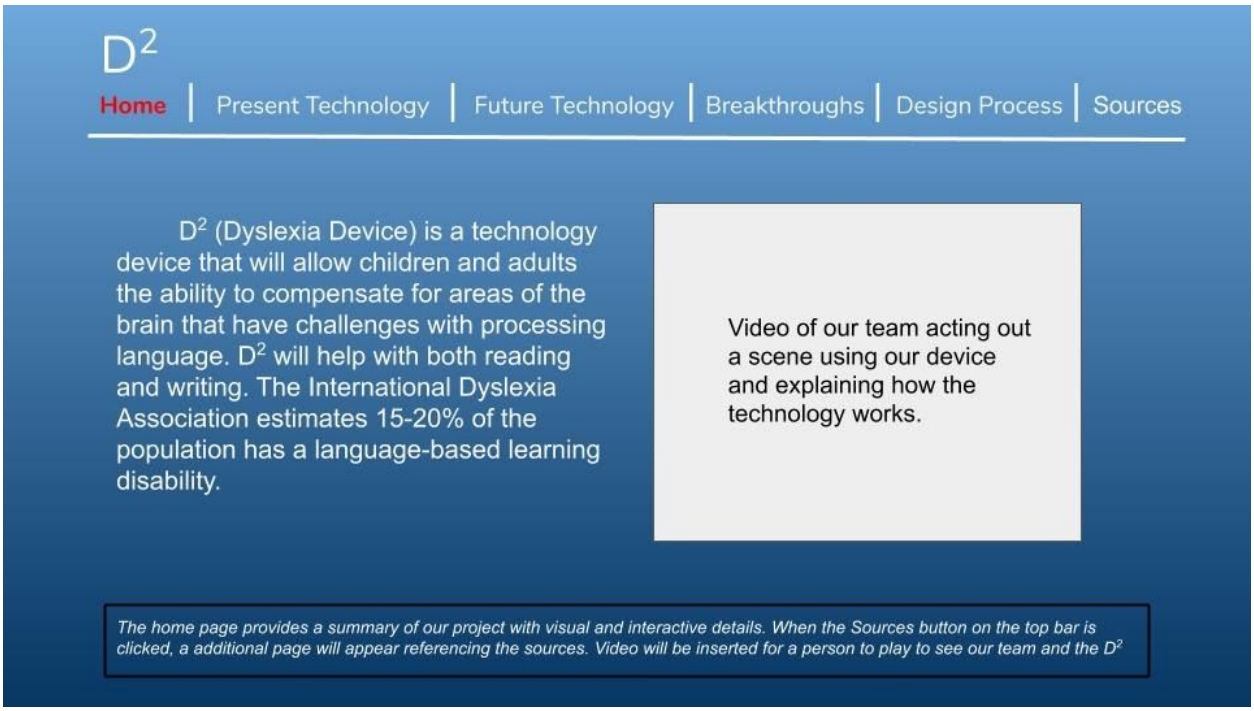
http://ibgwww.colorado.edu/~gayan/ch1.pdf

https://www.gadgetgram.com/2017/07/20/android-smartwatch-for-offline-speech-to-text-part-1/

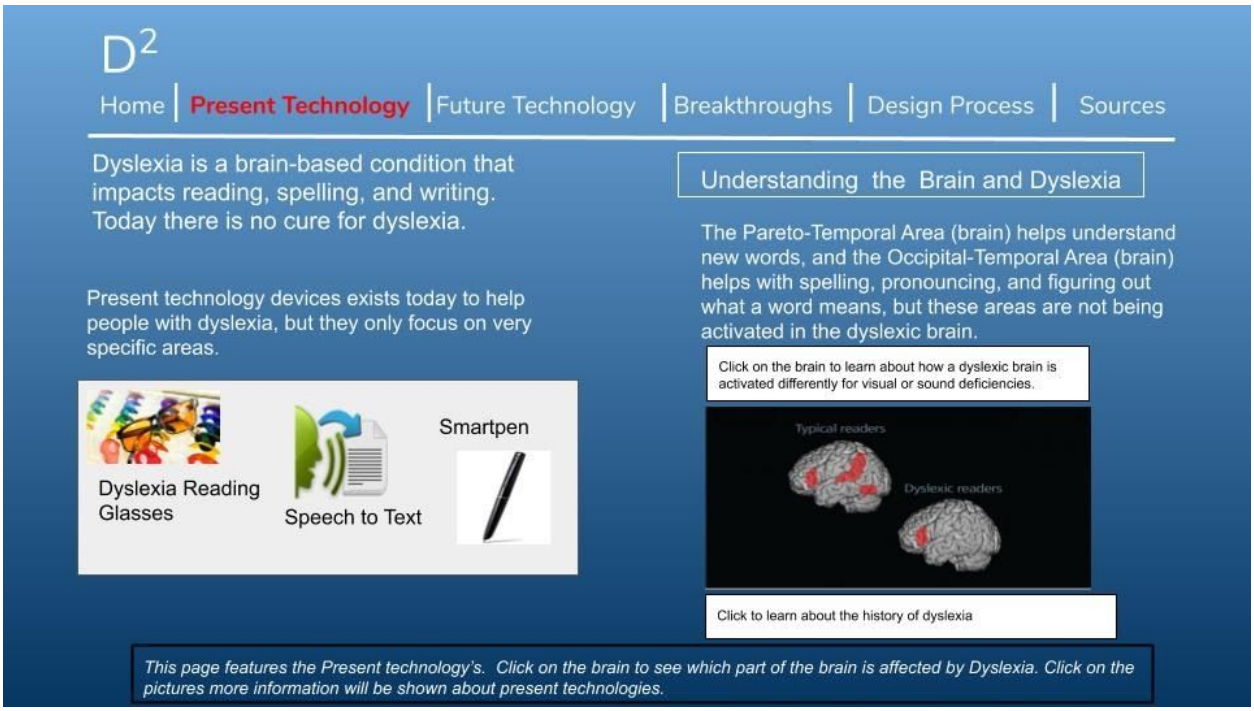
"History of Dyslexia Research." *Wikipedia*, Wikimedia Foundation, 4 Jan. 2020, en.wikipedia.org/wiki/History_of_dyslexia_research.

IV. Web Design

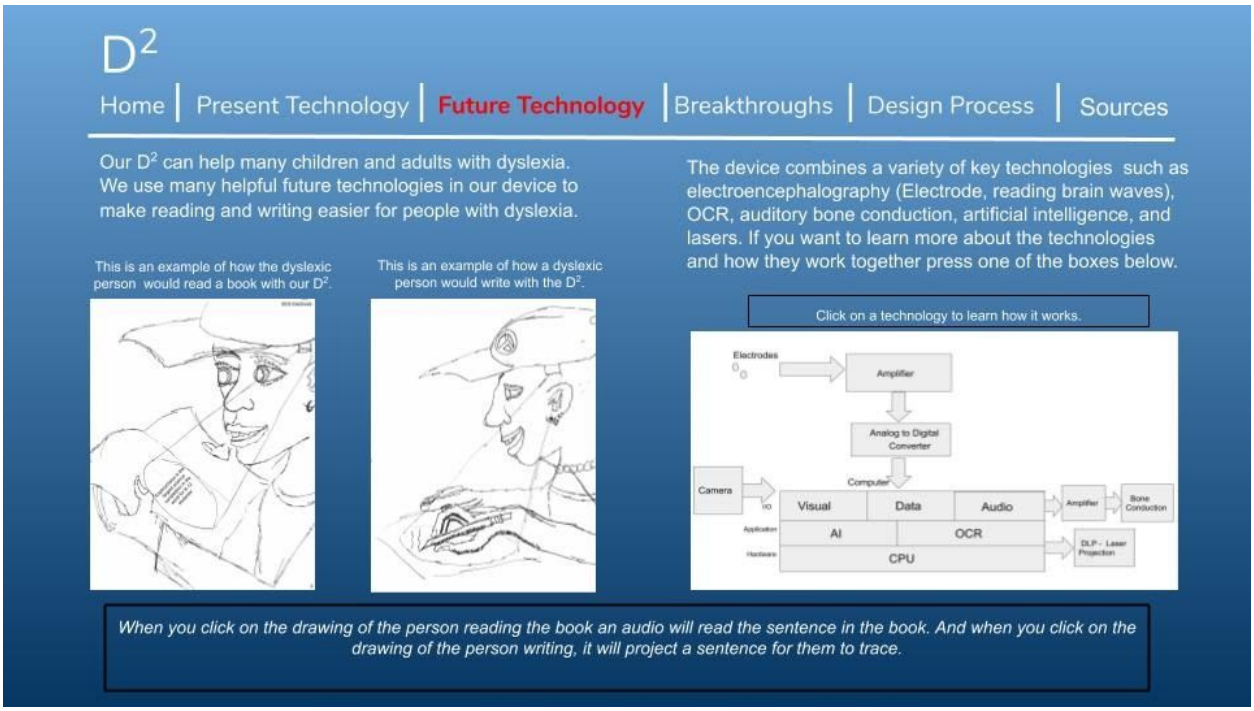
Page 1.



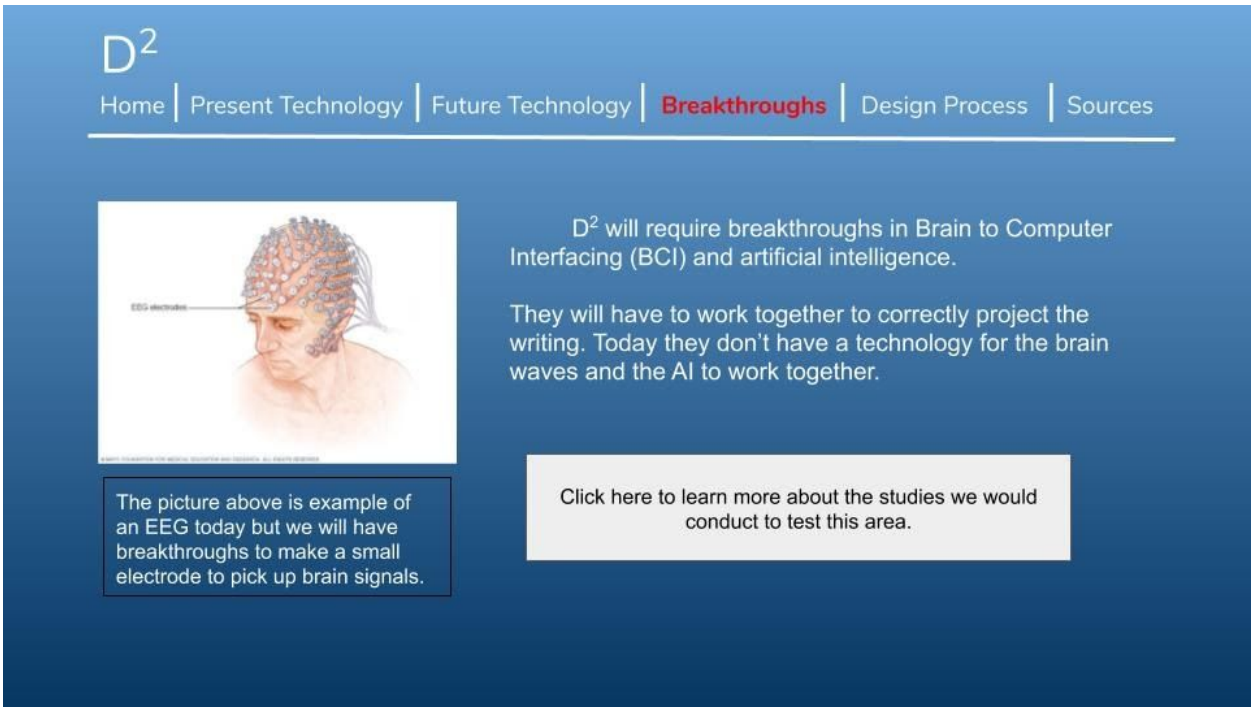
Page 2.


D2
Home
Present Technology
Future Technology
Breakthroughs
Design Process
Sources
Dyslexia is a brain-based condition that impacts reading, spelling, and writing. Today there is no cure for dyslexia.
Present technology devices exists today to help people with dyslexia, but they only focus on very specific areas.
Dyslexia Reading Glasses
Speech to Text
Smartpen
Understanding the Brain and Dyslexia
The Pareto-Temporal Area (brain) helps understand new words, and the Occipital-Temporal Area (brain) helps with spelling, pronouncing, and figuring out what a word means, but these areas are not being activated in the dyslexic brain.
Click on the brain to learn about how a dyslexic brain is activated differently for visual or sound deficiencies.
Typical readers
Dyslexic readers
Click to learn about the history of dyslexia
This page features the Present technology's. Click on the brain to see which part of the brain is affected by Dyslexia. Click on the pictures more information will be shown about present technologies.

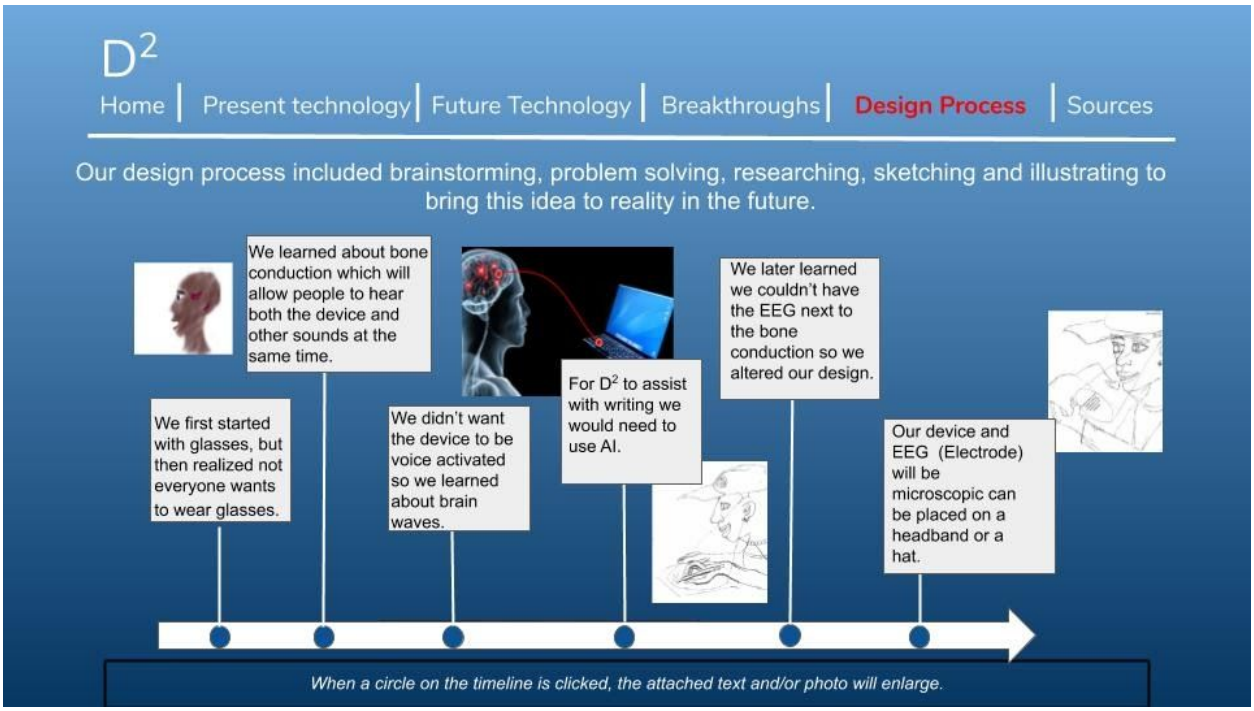
Page 3.


D2
Home | Present Technology | Future Technology | Breakthroughs | Design Process | Sources
Our D2 can help many children and adults with dyslexia. We use many helpful future technologies in our device to make reading and writing easier for people with dyslexia.
This is an example of how the dyslexic person would read a book with our D2.
This is an example of how a dyslexic person would write with the D2.
The device combines a variety of key technologies such as electroencephalography (Electrode, reading brain waves), OCR, auditory bone conduction, artificial intelligence, and lasers. If you want to learn more about the technologies and how they work together press one of the boxes below.
Click on a technology to learn how it works.
Electrodes
Amplifier
Analog to Digital Converter
Computer
Camera
Visual
Data
Audio
AI
OCR
CPU
Amplifier
Bone Conduction
DLP - Laser Projection
When you click on the drawing of the person reading the book an audio will read the sentence in the book. And when you click on the drawing of the person writing, it will project a sentence for them to trace.

Page 4.


D2
Home | Present Technology | Future Technology | Breakthroughs | Design Process | Sources
D2 will require breakthroughs in Brain to Computer Interfacing (BCI) and artificial intelligence.
They will have to work together to correctly project the writing. Today they don't have a technology for the brain waves and the AI to work together.
The picture above is example of an EEG today but we will have breakthroughs to make a small electrode to pick up brain signals.
Click here to learn more about the studies we would conduct to test this area.

Page 5.


D2
Home | Present technology | Future Technology | Breakthroughs | Design Process | Sources
Our design process included brainstorming, problem solving, researching, sketching and illustrating to bring this idea to reality in the future.
We first started with glasses, but then realized not everyone wants to wear glasses.
We learned about bone conduction which will allow people to hear both the device and other sounds at the same time.
We didn't want the device to be voice activated so we learned about brain waves.
For D2 to assist with writing we would need to use AI.
We later learned we couldn't have the EEG next to the bone conduction so we altered our design.
Our device and EEG (Electrode) will be microscopic can be placed on a headband or a hat.
When a circle on the timeline is clicked, the attached text and/or photo will enlarge.