



DISCOVER PROBLEM

Attention is a limited resource. The Nielsen Norman Group states that the global economy has shifted from material-based to attention-based. In response to this, apps and services are designed to be more and more addictive so that they can “hook” users to the service^[1]. According to Loh and Kanai ^[2], the Internet has reshaped human cognition to prefer a shallow mode of engagement with information. This mode of information processing is characterized by increased distractability, rapid lateral attention shifts and reduced contemplation. This, in-turn, leads to a disruption in the acquisition of deep-reading skills and the formation of corresponding neural networks.

Linda Stone, a technology consultant who has worked at Apple and Microsoft coined the term “Continuous Partial Attention” to describe the fragmented allocation of our limited attentional resources.

In people with adult ADHD, the inherent difficulties in paying attention are further worsened by the “attention economy”.



Adults in the UK spent an average of 25.3 hours online per week.



13.4 GBP were generated in advertising revenues in 2018, up 15% from 2017



OPPORTUNITY

In his book Deep Work ^[3], Cal Newport states that our current economy rewards those who can spend their time in undistracted “deep” work to learn advanced concepts efficiently and produce work of value. This idea is backed up by Psychologist Csikszentmihalyi’s concept of Flow ^[4], which is characterized by deep engagement in autotelic (intrinsically motivated) work. Csikszentmihalyi further says a good life consists of the regular experience of Flow. One of the necessary preconditions of flow is the absence of distractions.

DISCOVER

INITIAL RESEARCH

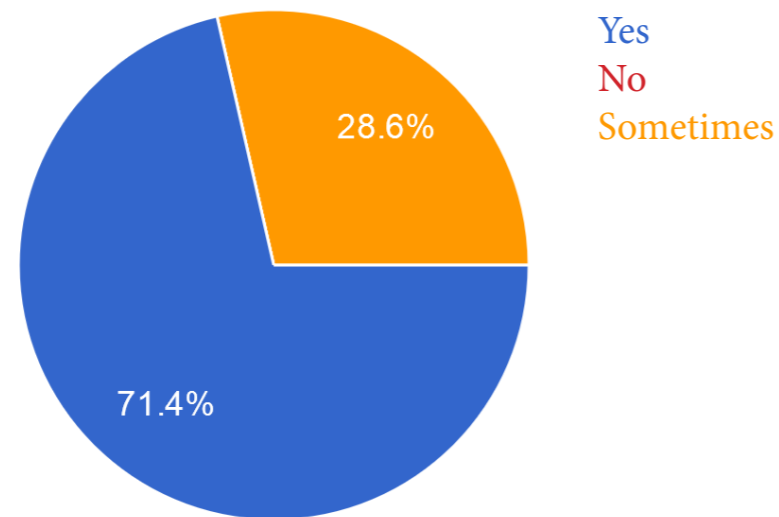
Ethnographic research was done in the form of interviews and questionnaires. The questionnaire had 21 respondents and 5 people were interviewed. Everyone that participated is currently a student. The research in this stage also included watching day-in-the-life vlogs of students. The research indicated that problems with attention were exacerbated by the covid-19 lockdown. At this time, the target group was changed from adults with ADHD to college students in lockdown.

INSIGHTS

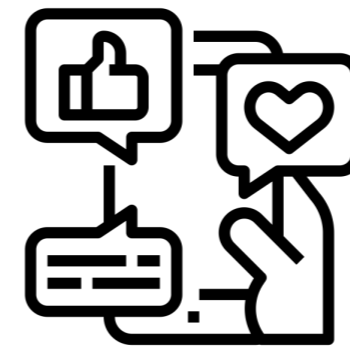
The interviews and vlogs generated meaningful insights:

- Most homes/flats are not built with Work From Home in mind
- Not having a rigid routine that comes from being in the campus/workplace results in a drop in productivity
- Lack of social contact leads to poor mental health and unwillingness to work/study
- Liminal spaces are far and few in between while working from home

Do you feel that distraction is a big problem for you?



What are the most common distractions?



Social Media



No Interest in Work



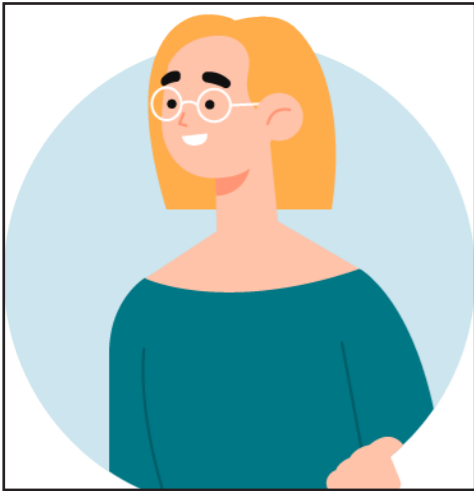
Mental States such as Anxiety

Desk research led to the discovery of the following solutions for minimizing distractions and establishing flow:

- Work in the library/dedicated workspace.
- Master internal triggers of distraction.
- Work with intention by deciding on a specific task and defining goals.
- Do not multitask.
- Pomodoro technique.
- Use app/website blocker.
- Create a ritual before working to trigger flow.
- Sleep & Exercise.

DEFINE

USER PERSONA



- Emily, age 22.
- 2nd Year University Student.
- Moved back to her parents’ due to covid-19.
- Has online classes for her current and next semesters.

GOALS

- Wants to achieve Flow.
- Wants to get better grades.
- Wants to be more productive at home.





FRUSTRATIONS

- Procrastinator.
- No dedicated workspace.
- Fear of Missing Out on social media.

BEFORE LOCKDOWN

07:00	14:00	14:30	17:00
			
Puts on makeup and gets ready for college.	“gets in the zone” during her walk to the library.	Group study with friends balances focus and unfocus.	Commute home ensures she leaves “work mode”.

AFTER LOCKDOWN

10:00	11:00	15:30	23:00
			
Sleeps late and wakes up late.	Puts on “work” pajamas and works from her bed.	Is more prone to long periods of distraction.	Works late into the night. Always in “work mode”.

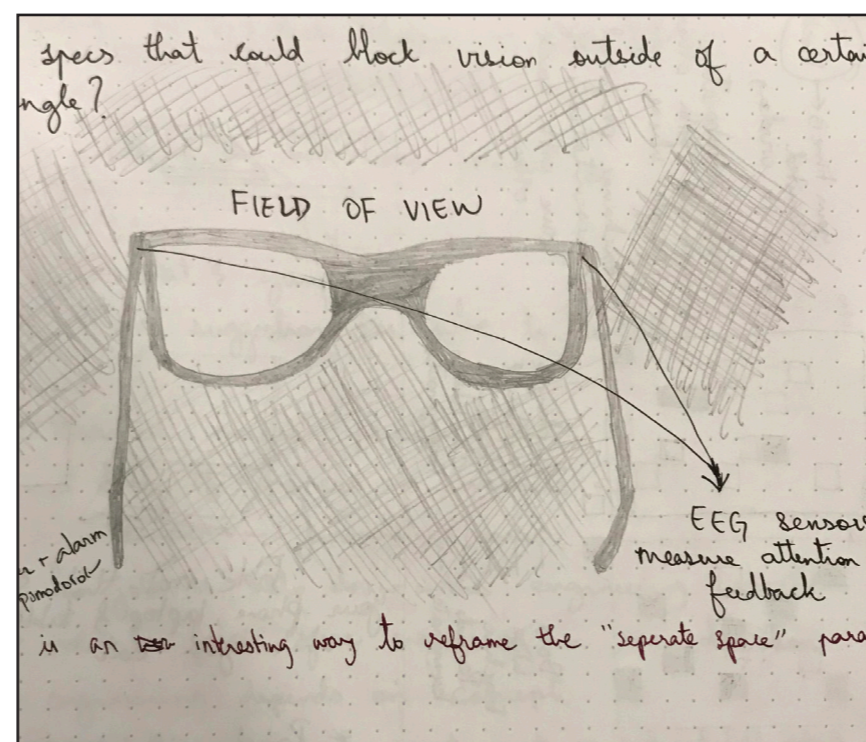
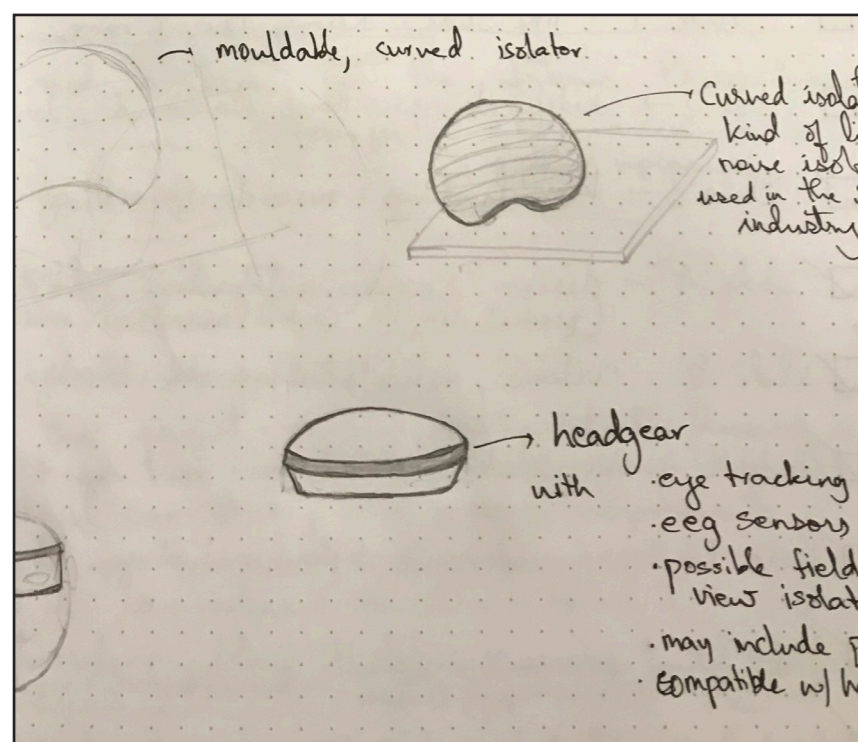
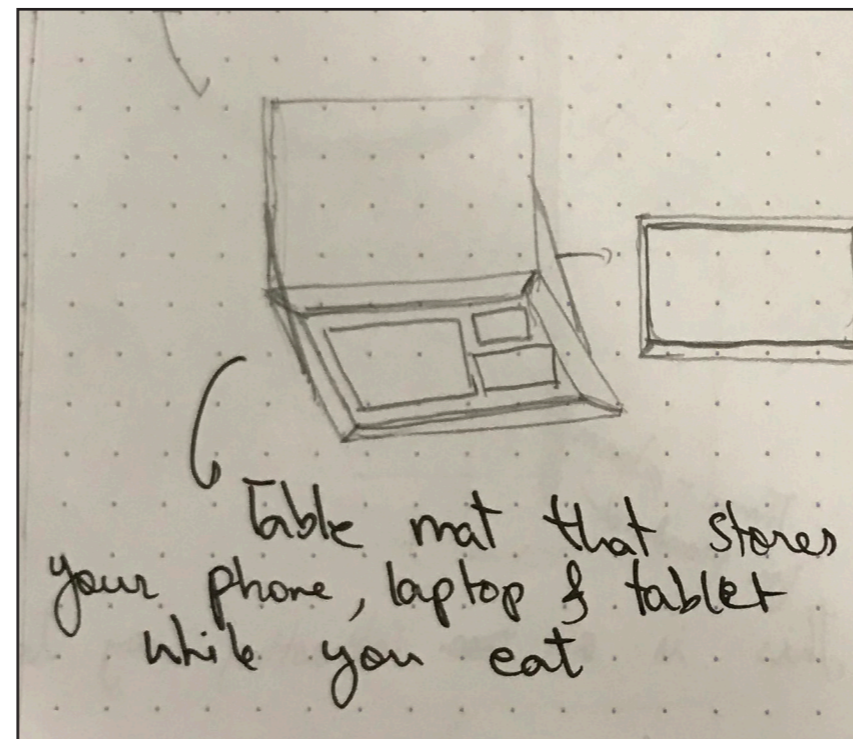
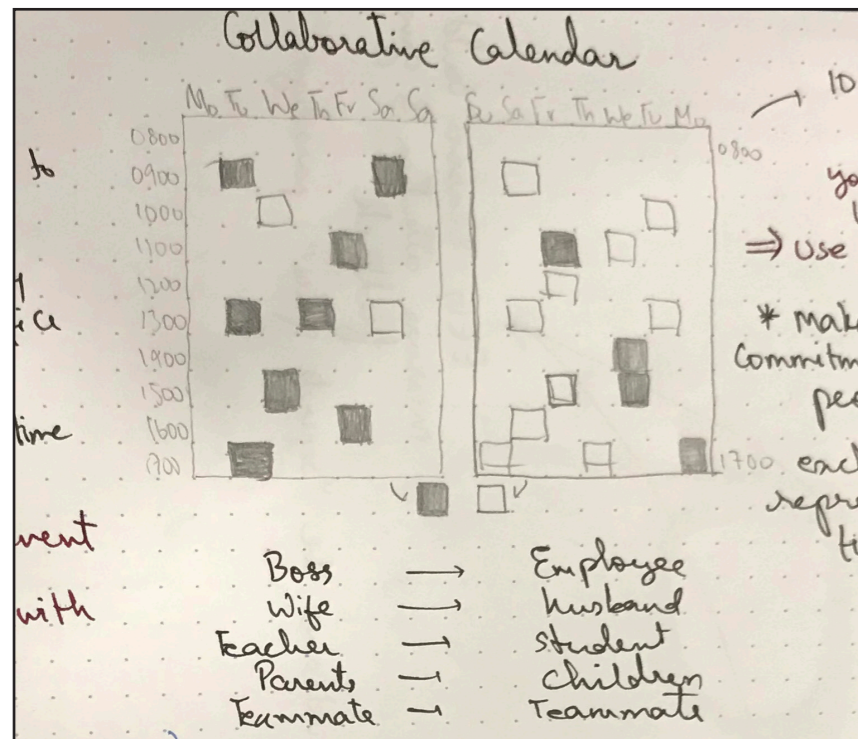
DESIGN REQUIREMENTS

- Create separate space for the user to work/study in.
- Enable user to achieve flow.
- Improve attention of the user in the long-term.
- Direct liminal moments towards focus.

DEFINE

CONCEPT GENERATION

Upon definition of the user requirements, design concepts were generated. The most salient were a tactile calendar, a pair of glasses that limited field of view, a physical barrier to delineate a workspace, a table mat that stored the users' devices for the duration of their meal and a headband that tracked user attention using the technologies of EEG and eye tracking.



CONCEPT SELECTION

The concept chosen for further development is a combination of the eyeglasses that limit field of view and the headband that tracks the users' level of attentiveness. By choosing this direction:

- a separate space is created for the user by virtue of the glasses that limit field of view. This has the added advantage of a small physical footprint, thereby enabling easier adoption small homes/flats
- EEG could be used to provide instantaneous feedback to the user
- A corresponding app can be used to provide the user with motivational statistics about the improvement in their focus. The app could use machine learning to learn the user's focus habits and nudge them towards work/study when they're least prone to distractions

DEVELOP TECHNOLOGY WHAT IS EEG?



EEG is a technology that measures the small electrical charges ($\sim\mu\text{V}$) that are created as a result of neural activity in a person's brain (reference). Electrodes are used to record the charges.

Electrodes are conductors that are used in making contact with the non-metallic components of a circuit.

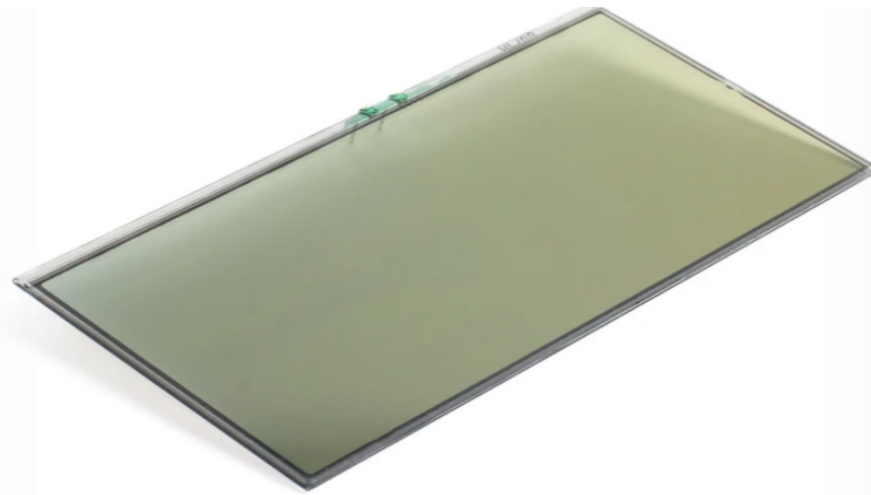


The EEG chip chosen for further development is the NeuroSky TGAM. This off-the-shelf chip comes with a proprietary software and algorithms that can measure user attention levels. Due to this functionality, eye-tracking was dropped and only EEG is used. The chip requires electrodes, a communication protocol and a battery to implement. Bluetooth Low-Energy was chosen as the

communication protocol. By calculating the power consumption of the EEG and BLE module, a battery was chosen. The electrodes employed are dry electrodes. These are easy to set up and comfortable to wear over long periods of time as opposed to wet electrodes which are generally considered to have better signal quality. However, researchers have shown that dry electrodes are comparable in efficacy to wet electrodes for most applications^[5].

LCD SHUTTER

To help create a separate space and also provide feedback to the user, an LCD shutter placed on the outer edges of the users' eyes is used. The opacity of the shutter can be varied by putting a voltage across it. The intention behind this decision is that the opacity of the LCD shutter would increase as the users' attention dropped. This would act as feedback for the user while also limiting their field of view to what is in front of them. It is believed that this feedback is subtle enough for the user to register subconsciously. This is to ensure that the user isn't distracted to tell them that they're distracted. An LCD shutter was chosen because other technologies that vary the opacity of glass (EC glass, SPD) require Mains voltage (230V) and are not meant to be implemented at such a small size.



ENGINEERING REQUIREMENTS

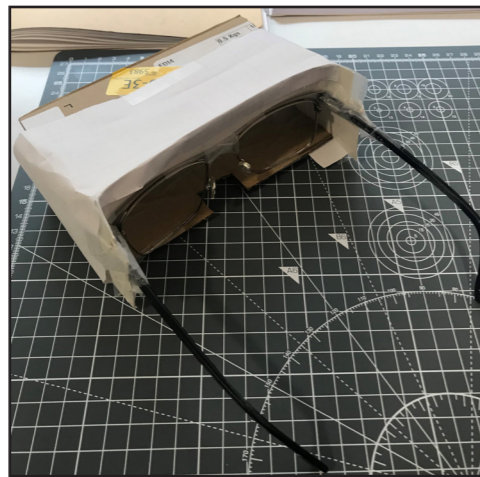
- Implement EEG.
- Limit user field of view.
- Provide user with feedback.
- Interface with users' phone.
- Battery life of minimum four hours.
- Lightweight ($< 800\text{g}$).

CONCEPT VALIDATION

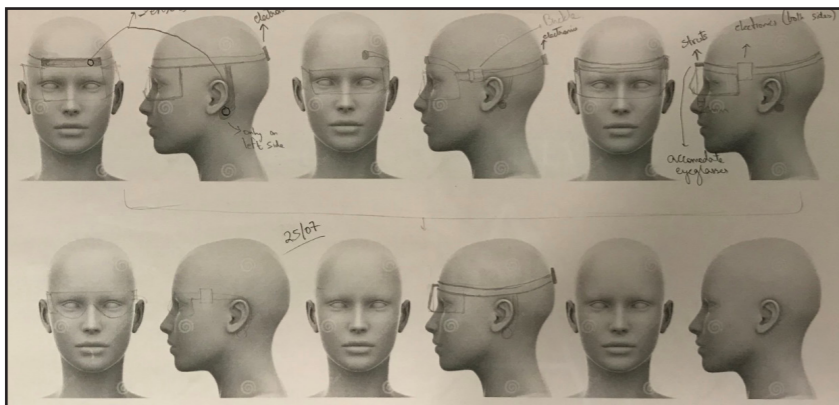
Researchers at the MIT Media Lab have used a similar concept that pairs EEG & EOG (electrooculography) with haptic feedback and have concluded that EEG feedback does help the user redirect attention towards the task at hand and also leads to higher scores in subsequent comprehension tests as compared with random or no feedback^[6].

DEVELOP PROTOTYPING AND EVALUATION

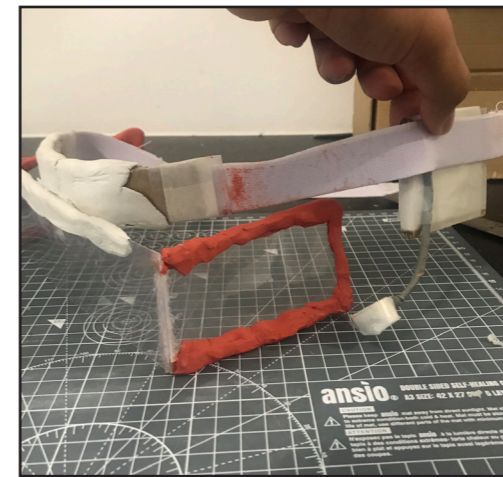
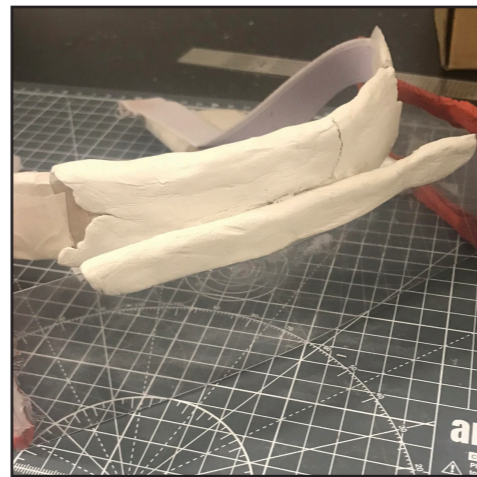
Concepts were generated based on the requirements of electrode placement and battery size. The selected EEG chip requires that at least two electrodes be placed on the user's head: one on the forehead above either of the eyes and one behind either ear. The most promising concepts were prototyped and evaluated. The variations among the concepts was primarily the placement of the electronics. Prototyping was limited to physical prototypes since a working functional prototype would require a considerable time investment to build the necessary skills.



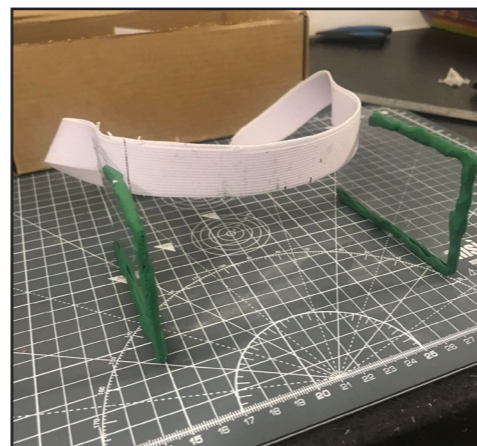
Initial prototypes revealed that blocking field of view for extended periods of time causes eye strain. This was the reason why the concept of side shutters with variable opacity was chosen.



Two different configurations of the electronics housing were considered. The choice was made to have one larger case at the back of the head as opposed to two smaller ones on either side.



Evaluating usability of headset with eyeglasses and headphones.



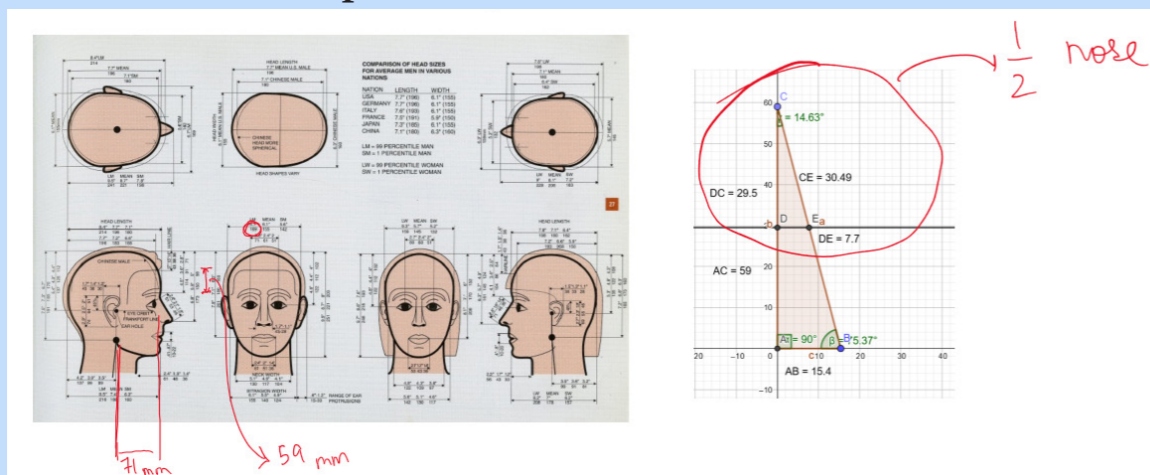
Tutorial feedback raised into question the necessity of the front visor. A prototypes was made without the front visor. This was used for A/B testing along with the previous prototype.

DEVELOP

ANTHROPOMETRICS AND USER TESTING

Anthropometric data was consulted for dimensioning the headband [7]. The headband was designed for the 5th dimension female to the 95th dimension male. The strap is designed with three holes to provide adjustability for the widest range of users. The material chosen has been optimized for softness and flexibility to enhance comfort and maintain the minimum pressure required to hold the electrode in place.

Calculations were done to decide the length of the front band and thickness of the side straps.



The user test had six participants. Two were men and four were women. The participants were of different heights and ethnicities (both influential factors for head circumference). The test consisted of two parts: a usability test and an A/B test.

The usability test was used to validate the dimensions derived from anthropometric data. Users were asked about their experience of subjective comfort while wearing the headband. Five out of six users found it comfortable to wear, and it stayed in place when they moved their heads. One user felt pain on their forehead as a result of a bump on their skull that was unique to them. A common complaint was the weight of the item, however, this was due to the materials used in

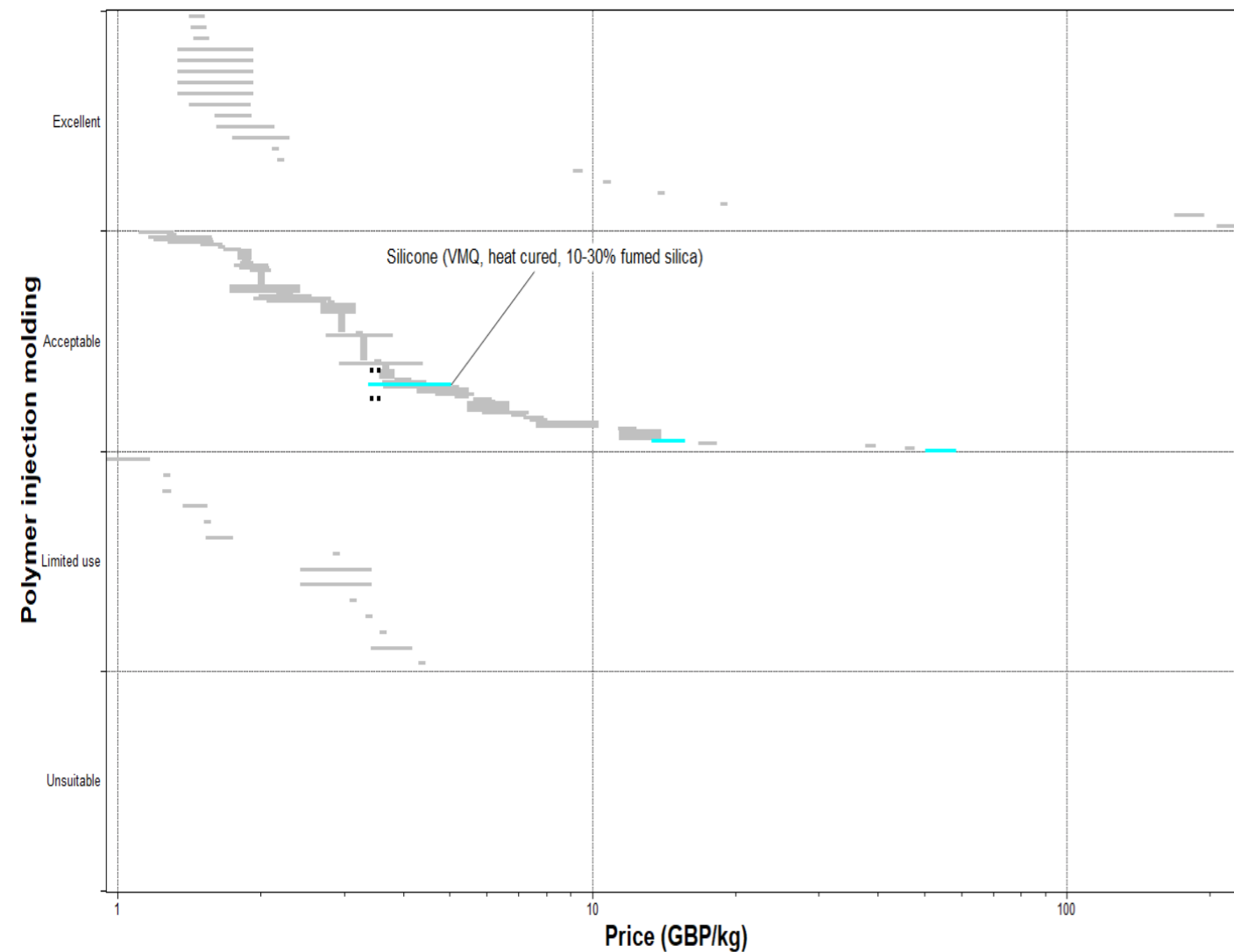


modelling. The final device is going to be lighter than the model. The final product is also designed with a flexible headband and will therefore conform to the unique shape of users' foreheads.

The A/B testing was used to decide if the front visor should be included in the device. Users first wore the headband with the visor and read some text from a book. Next, the users wore the headband with only the shutters and no visor and read some text from a book. Due to the inability to create a high-fidelity prototype, users were asked to press down on the shutters on the second model to ensure that they don't converge towards their nose. The users were asked to state their preference based on an explanation of the device function. Five users preferred the second version, without the front visor, and it was therefore dropped from the design. None of the users made the association that the shutters might look like horse blinders and didn't mind once it was pointed out.

DELIVER MATERIAL SELECTION

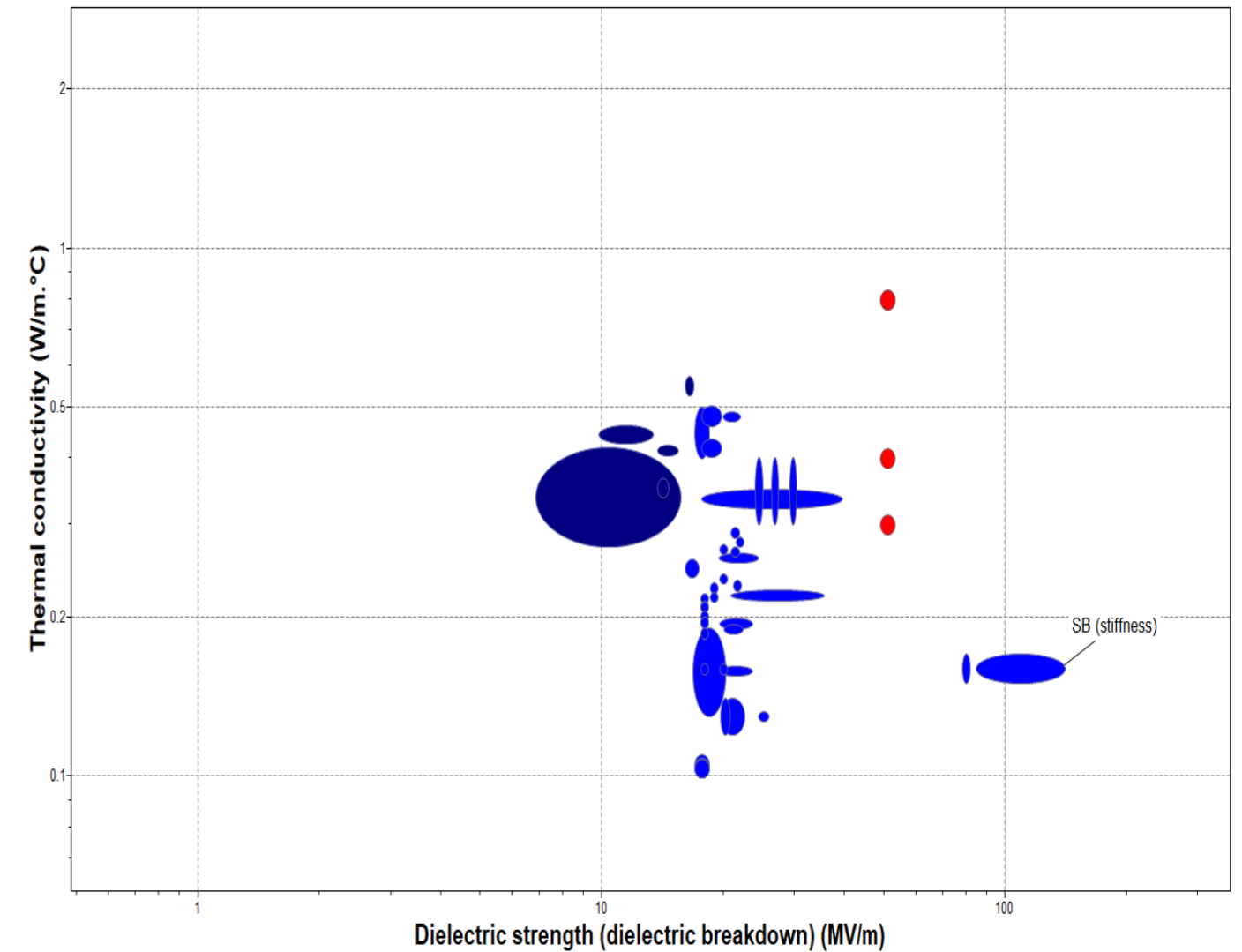
CES EduPack was used to select the materials for the design.



ELASTOMER COMPONENTS

The elastomer components are: the front band, side straps and reference electrode. ISO 10933 biocompatibility standards were used as limits in the material selection process, since these materials are in prolonged contact with the skin. Materials were then plotted with the aim to minimize price while maximizing manufacturability.

The chosen material was Silicone VMQ. The hardness and flexibility are to be varied by changing the composition. The front band and reference electrode will use harder silicone than the side straps.

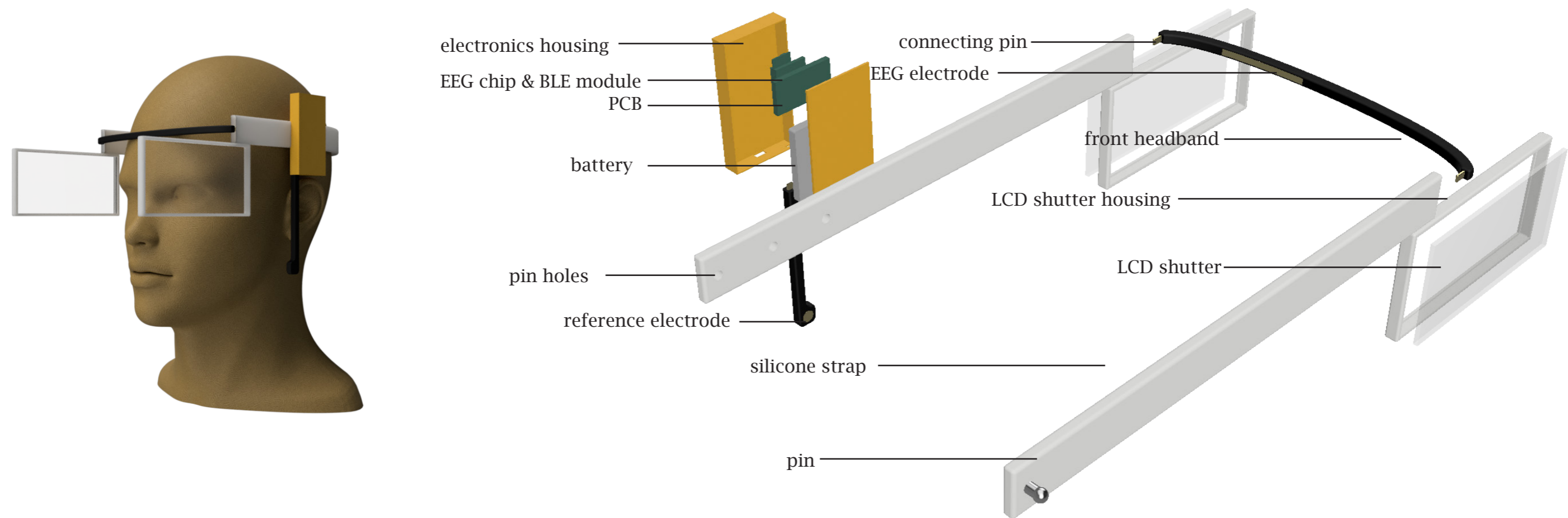


ELECTRONICS HOUSING

The electronics housing requires a hard plastic that can be adhered to the silicone band. Since the material houses electronics, it must be electrically insulating and non heat-conducting. Materials were plotted with the aim of selecting a material with high dielectric strength and low thermal conductivity.

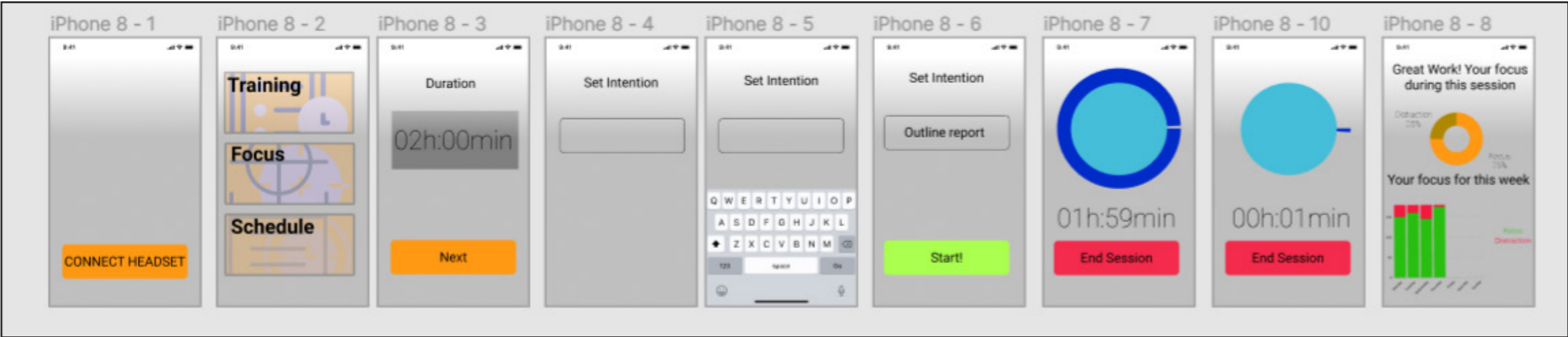
The chosen material was SB (Styrene Butadiene) plastic.

DELIVER FINAL PRODUCT

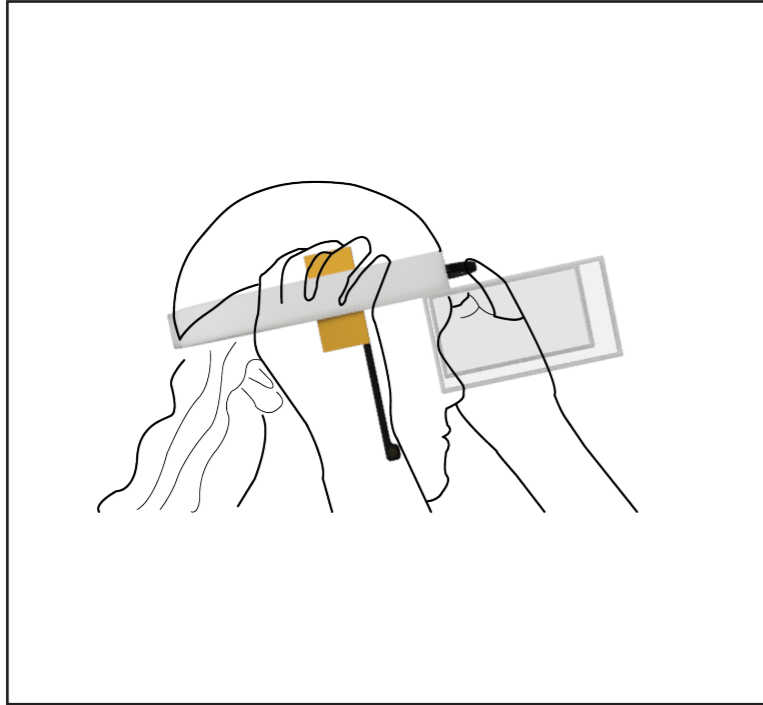


APP INTERFACE

The function of the corresponding app is to help the user set an intention at the star of their work session, and to provide them with meaningful statistics on their level of focus in the short and long term.



DELIVER SOLUTION IN CONTEXT



Put on the headset.



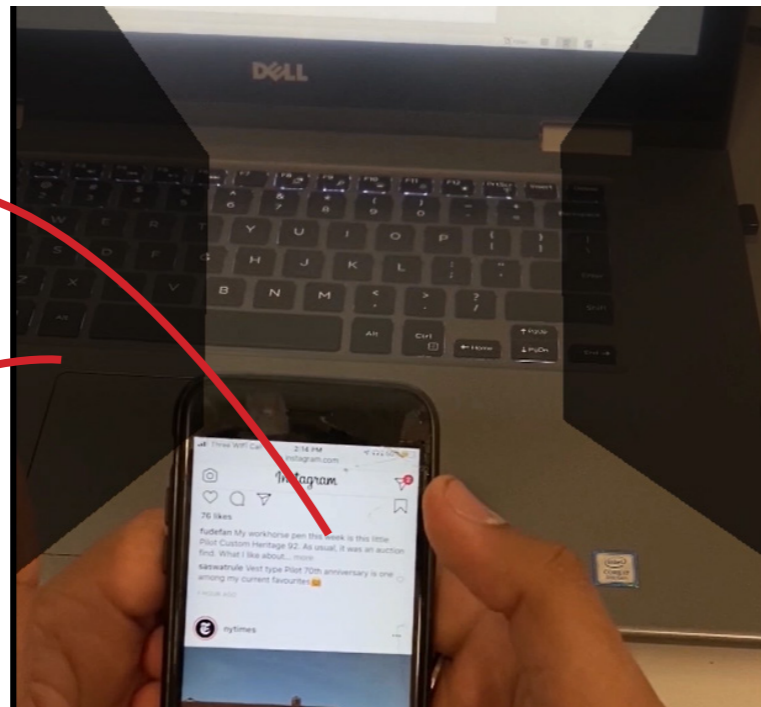
Set intention on the app



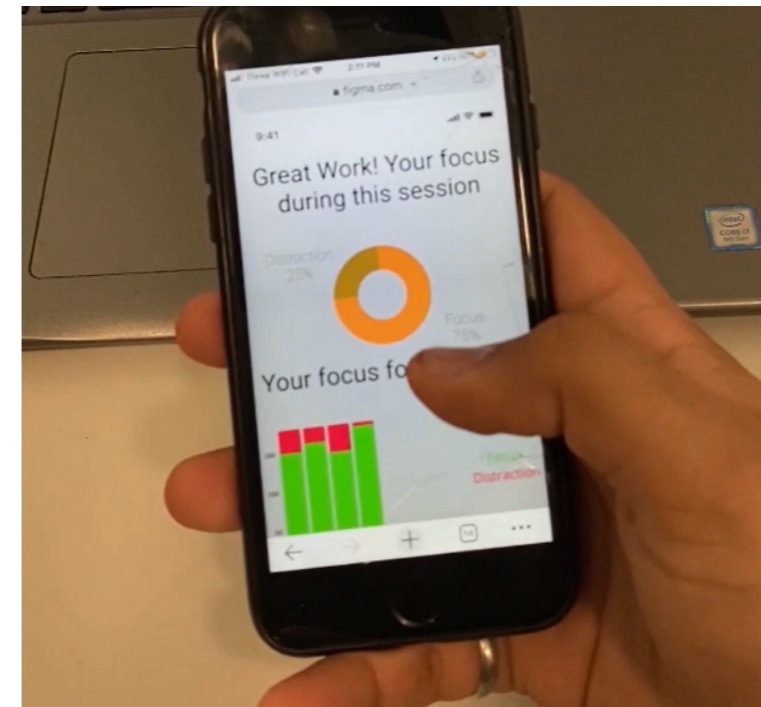
Work/Study. EEG measures attentiveness

Distracted

Feedback



Receive subtle feedback to refocus your attention, if distracted.



Receive feedback on attention level for the current session and in the long-term.

REFERENCES

- [1]Kane, L., 2019. The Attention Economy. URL <https://www.nngroup.com/articles/attention-economy/>
- [2]Loh, K.K., Kanai, R., 2016. How Has the Internet Reshaped Human Cognition? *Neuroscientist* 22, 506–520. <https://doi.org/10.1177/1073858415595005>
- [3]Newport, C., 2016. Deep work: rules for focused success in a distracted world. Piatkus, London.
- [4]Nakamura, J., Csikszentmihalyi, M., 2014. The Concept of Flow, in: Csikszentmihalyi, M. (Ed.), *Flow and the Foundations of Positive Psychology: The Collected Works of Mihaly Csikszentmihalyi*. Springer Netherlands, Dordrecht, pp. 239–263. https://doi.org/10.1007/978-94-017-9088-8_16
- [5]Di Flumeri, G., Aricò, P., Borghini, G., Sciaraffa, N., Di Florio, A., Babiloni, F., 2019. The Dry Revolution: Evaluation of Three Different EEG Dry Electrode Types in Terms of Signal Spectral Features, Mental States Classification and Usability. *Sensors* 19, 1365. <https://doi.org/10.3390/s19061365>
- [6]Kosmyna, N., Maes, P., 2019. AttentivU: An EEG-Based Closed-Loop Biofeedback System for Real-Time Monitoring and Improvement of Engagement for Personalized Learning. *Sensors* 19, 5200. <https://doi.org/10.3390/s19235200>
- [7]ANTHROPOMETRY AND BIOMECHANICS [WWW Document], n.d. . National Aeronautics And Space Administration. URL <https://msis.jsc.nasa.gov/sections/section03.htm>