

P3
Project
report
June 2023

NavigAble

A computer input device for ALS patients

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Approval Form

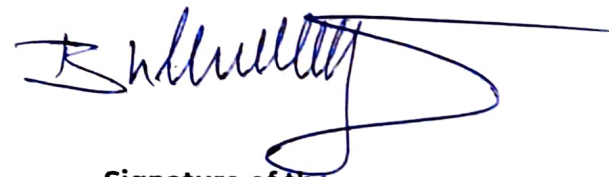
The Design Project III titled "NavigABLE" by Parth Rathod,
Roll Number - 216130001 is approved in partial fulfillment of the Master
of Design degree in Industrial Design at the IDC School of Design, Indian
Institute of Technology Bombay.



Prof . Purba Joshi
[Project Guide]



**Signature of the
Chair Person**



**Signature of the
Internal Examiner**



**Signature of the
External Examiner**

Declaration Form

I, declare that this written report represents my ideas in my own words, and where others' ideas or words have been included I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.

I understand that any violation of the above will be caused for disciplinary action by the Institute and can also evoke penal action from the source, from which proper permission has not been taken or improperly been cited.



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November 2022

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Abstract

This report presents the design and development of a computer input device aimed at improving cursor navigation and control for patients suffering from Amyotrophic Lateral Sclerosis (ALS). ALS is a debilitating neurodegenerative disease that gradually impairs motor functions, making conventional input devices challenging to use. The primary objective of this research was to create an intuitive and effective cursor control device that would enable ALS patients to navigate computer interfaces with greater ease, fostering improved independence and access to digital resources.

A comprehensive approach was employed, combining principles of assistive technology, and user-centered design. The design process encompassed an in-depth analysis of the specific challenges faced by ALS patients in cursor navigation and an exploration of existing assistive technologies.

The proposed cursor control device utilizes innovative technologies tailored to the varying degrees of motor impairment observed among ALS patients. The device's ergonomic design and customizable settings further contribute to a personalized and comfortable user experience.

Iterative prototyping and extensive user testing were conducted in collaboration with ALS patients and healthcare professionals. Their feedback played a crucial role in refining the device's functionality, usability, and ergonomics.

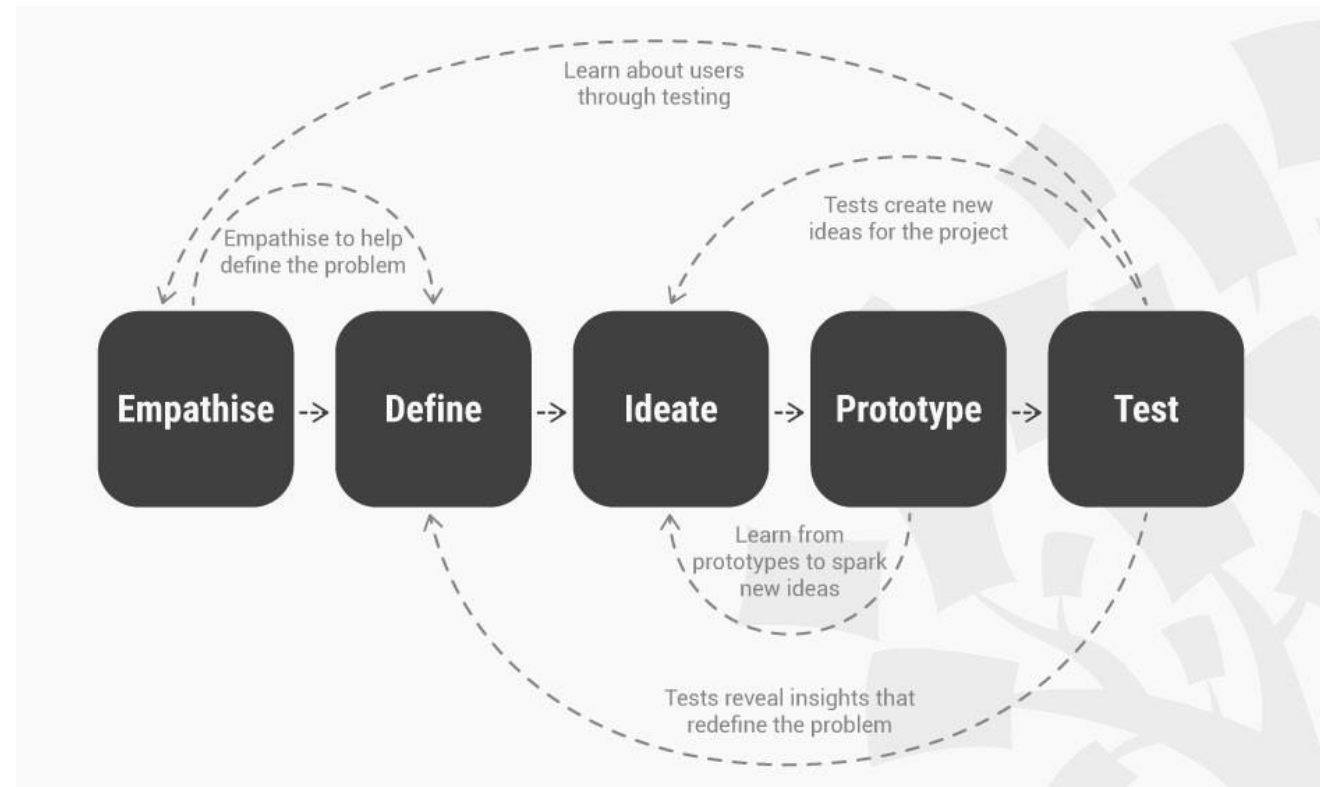
The technical aspects of the cursor control device, including hardware components, sensor integration, connectivity options, and compatibility with standard computer systems, were addressed. Considerations of affordability, portability, and ease of use were prioritized to ensure widespread accessibility and adoption.

Evaluation of the device showcased promising outcomes, including enhanced cursor navigation, improved control, and increased user satisfaction among ALS patients. The device's impact extends beyond basic computer interaction, empowering individuals to engage in educational, professional, and social activities.

Personalized technology offers new avenues for independence and access to digital resources, thereby enhancing the overall quality of life for individuals with ALS. Ongoing research and continued refinement of such devices hold great potential in revolutionizing the daily experiences of ALS patients and empowering them in their digital interactions.

Methodology

Throughout the design process for my computer input device for ALS patients, I followed a systematic approach that encompassed several key stages: empathizing, defining, ideation, prototyping, and testing.



<https://www.interaction-design.org/>

I engaged with ALS patients, caregivers, and medical professionals to gain a deep understanding of their unique needs and challenges. This allowed me to empathize with their experiences and establish a clear problem statement for my design. During the ideation stage,

I generated numerous creative ideas and sketched out potential solutions that aligned with the defined problem. From there, I progressed to the prototyping stage, transforming my chosen concept into a tangible device that combined hardware and software components. Iterative testing and

refinement were crucial in ensuring the device's usability and effectiveness in facilitating cursor control.

I conducted evaluations at various stages and gathered feedback from ALS patients and stakeholders to fine-tune the device's performance and user experience. This design methodology enabled me to create a computer input device that empowers ALS patients to control the cursor using their gross motor skills.

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Primary Research

Introduction

What is a MND?

In MND, the motor neurons start dying causing muscle weakness in various parts of the body. Thus the affected nerves stop sending messages to the muscles gradually leading to weakness and thinning (atrophy/ wasting) of those muscles. This is known as neurodegeneration.

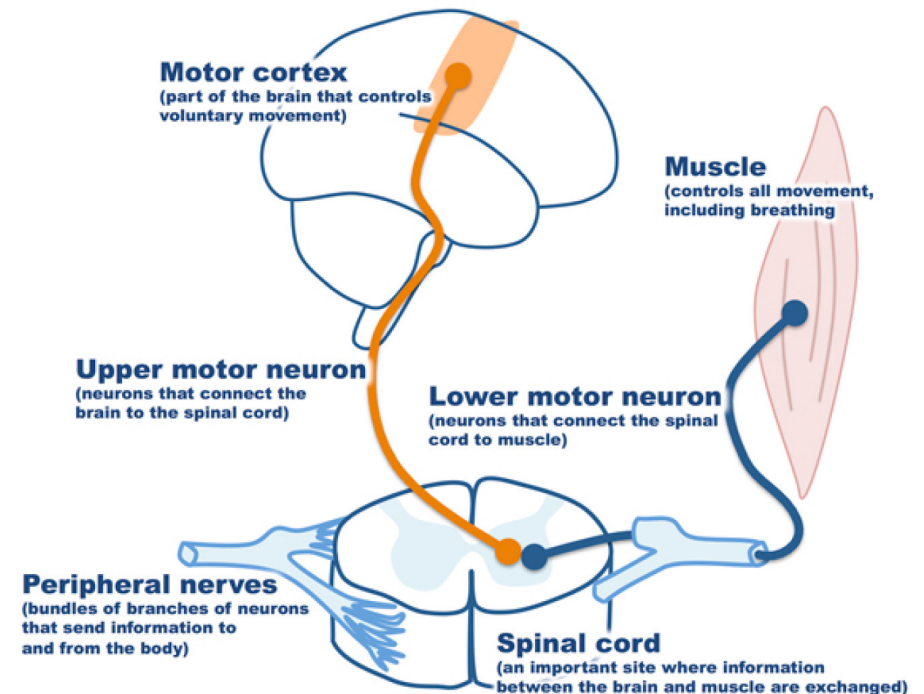
MND has a significant effect on people and their families. Patients may have trouble moving around, speaking, swallowing, and breathing as the condition worsens. Maintaining independence and a high standard of living is extremely difficult due to MND's persistent nature. Furthermore, it is impossible to emphasise the emotional and psychological toll on patients, carers, and loved ones.

MND affects a diverse range of individuals worldwide, regardless of age, gender, or ethnic background. It is estimated that around 2-5 individuals per 100,000 are diagnosed with MND each year. Although the exact cause of MND remains largely unknown, a combination of genetic and environmental factors is believed to contribute to its development.

While there is currently no cure for MND, significant advancements have been made in understanding the disease and developing supportive care strategies to manage symptoms, enhance comfort, and prolong survival. These include assistive technologies, multidisciplinary care teams, respiratory support, and palliative care services that aim to improve the overall well-being of individuals living with MND.

MND has also been presumed to have a genetic origin where in the disease may be transmitted from one generation to the other. Some of the genes have been identified that may cause MND. When there is a gene involvement it is called as familial MND. However MND may be present without any family history (sporadic). But 90% of the times MND is sporadic and only 10% is of the times a definite genetic cause is identified.

Incidence of ALS in USA is 2 per 100000, in Canada it is 2.4 per 100000, in UK it is 2.16 per 100000 however the incidence rate in India has not been identified. [1]



In MND, connections from the brain to the spinal chord (upper motor neurons) and from the spinal chord to the muscle (lower motor neurons) may die. As these neurons die, control of muscles are lost.

Source: <https://www.mndandme.com.au/what-is-mnd/what-is-mnd/>

Types of MND

MND leads to the degeneration of these motor neurons. It can affect:

- Upper motor neurons (UMN) in the brain that descend to the spinal cord or,
- Lower motor neurons (LMN) that exit the spinal cord to activate muscles or,
- Both upper and lower motor neurons.

These motor neurons are the vital communication links between the brain and the voluntary muscles, controlling their movement.

The UMN & LMN diseases can further be divided into the following categories as per the type of progression and the symptoms. They are further classified as per whether the disease is onset via the limbs or via the “bulbar” region (speech, swallowing and chewing) They are also different in terms of rate of progression, severity & life expectancies.

1. UMN disorders

- in which the neuron originating from the brain and ending in the spinal cord are damaged.

a. Primary Lateral Sclerosis(PLS)

- This is a rare form of MND and where mainly the legs undergo weakness and, in some cases, the arms. In most cases, speech, breathing, and swallowing remain unaffected till the advanced stage is reached.

b. Pseudobulbar palsy - In this, there is the progressive weakness of facial muscles, mastication muscles, and laryngeal muscles, causing facial expression, difficulty to chew and swallow, and progressive difficulty of speech.

2. LMN disorders

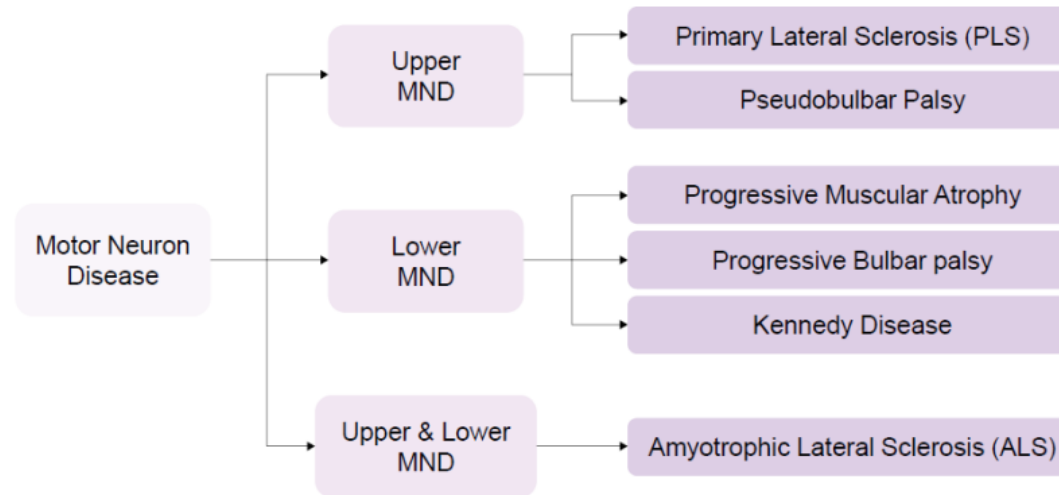
- in this, the nerve originating from the spinal cord and spreading through the body are damaged.

a. Progressive muscular atrophy(PMA) - Common symptoms in this disease are weakness in legs and arms. Speech, breathing, and swallowing are rarely affected and found only at an advanced stage.

b. Progressive bulbar palsy(PBP) - There is progressive difficulty in swallowing, chewing, and talking. The average life expectancy is between 6 months to 3 years from the point of symptoms.

c. Spinal muscular atrophy(SMA)

- This is a genetic disorder, and the severity of the condition is different for every patient. There is progressive wasting of hip and shoulder muscles.
d. Kennedy disease - This disease runs in the family and is an inherited disorder that has been seen more in males than females. It causes weakness in the upper and lower extremities[2].



Types of MND

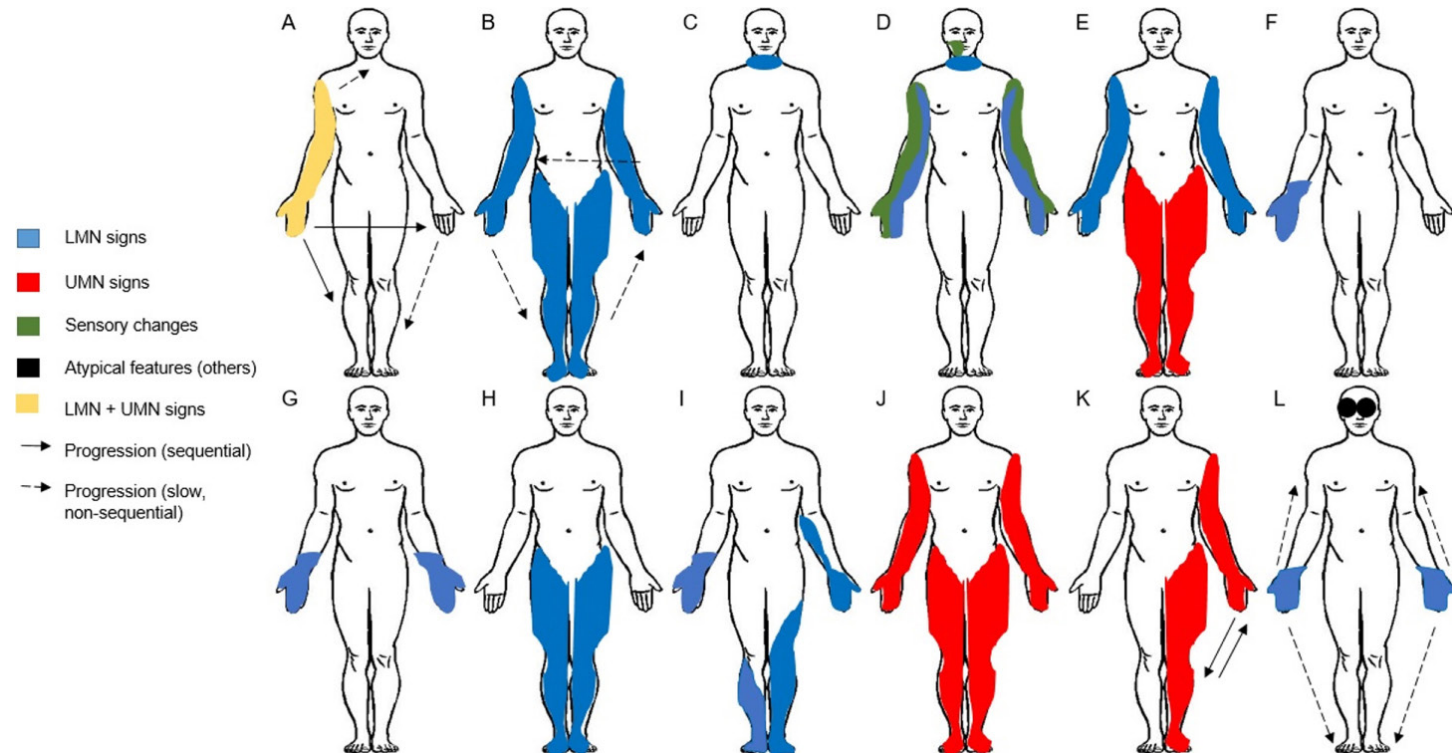
Types of MND

	UMN Syndrome	LMN Syndrome
Type of Paralysis	Spastic Paresis (Partially paralysed rigid muscular tone)	Flaccid Paralysis (loose muscle tone)
Atrophy	No – Disuse Atrophy	Severe Atrophy
Fasciculation (involuntary muscle contraction & Relaxation) & Fibrillation (irregular heartbeats)	Absent	Could be present
Deep Tendon Reflex (reflex when tendons are struck)	increase	Absent
Pathological Reflex (Pathologic reflexes are reversions to primitive responses and indicate loss of cortical inhibition)	Positive Babinski Sign (Flexion of foot when palm of foot is stroked)	Absent
Superficial Reflex (Superficial reflexes are motor responses to scraping of the skin)	Absent	Present

Source : <https://boneandspine.com/upper-motor-neuron-and-lower-motor-neuron-syndromes/>

Further classifications

As seen in the image, ALS most commonly affects both upper and lower limbs of the patients, hence restricting upper and lower body mobility.



Atypical Motor Neuron Disease variants

Source : <https://pubmed.ncbi.nlm.nih.gov/30846210/>

Amyotrophic Lateral Sclerosis - ALS

ALS, or amyotrophic lateral sclerosis, is a progressive neural disease that affects the motor neurons in the brain and the spinal cord. A-myo-trophic comes from the Greek language. "A" means no. "Myo" refers to muscle, and "Trophic" means nourishment – literally translating to "No muscle nourishment." When a muscle has no neural stimulus, it "atrophies" i.e., it wastes away. "Lateral" identifies the areas in a person's spinal cord where these motor neurons are located. As they degenerate, the muscles attached to them start hardening ("sclerosis") in the region.

FACTS ABOUT ALS



ALS Facts & Figures

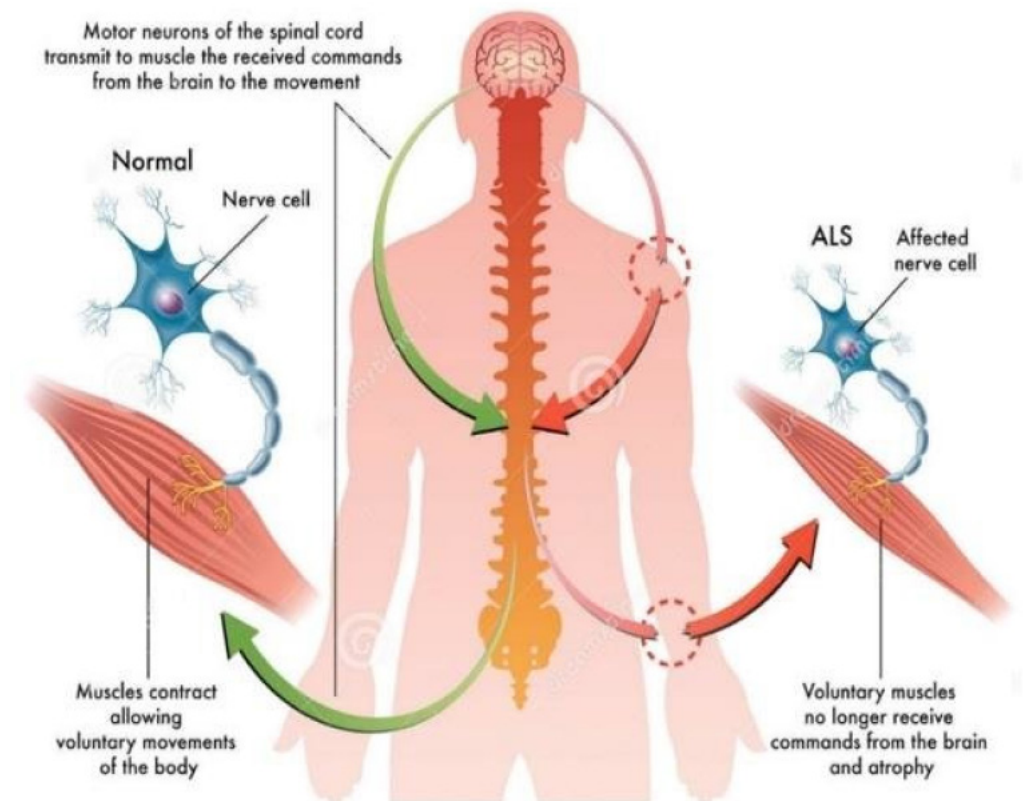
Source : <https://www.dell.com/en-us/perspectives/how-ai-helps-give-als-patients-a-voice/>

Age of onset

ALS can be classified based on the age of onset. The peak age of onset is said to be 58 to 63 for sporadic ALS (non hereditary) and 47 to 52 for familial ALS (hereditary). Also about 10% of all ALS cases begin before age of 45 (young onset ALS), and about 1% begin before age of 25 (juvenile ALS) [3].

Survival rate

Half of all patients affected with ALSMND have a life expectancy of least three or more years after diagnosis. 20% of the patients live five years or more and up to 10% of them live more than 10 years [4]



Motor neuron degeneration

Source : https://www.researchgate.net/figure/Amyotrophic-LateralSclerosis-ALS_fig1_320285827

Causes

The exact causes of Amyotrophic Lateral Sclerosis (ALS), also known as Motor Neuron Disease (MND), are not fully understood. However, research suggests that a combination of genetic and environmental factors may contribute to the development of ALS. Here are some key factors associated with ALS:

Genetic Factors: A small percentage of ALS cases, approximately 5-10%, are inherited or familial ALS (fALS), resulting from specific gene mutations. Mutations in genes such as SOD1, C9orf72, TARDBP, FUS, and others have been identified as associated with fALS. These genetic mutations can lead to abnormal functioning of motor neurons and their subsequent degeneration.

Sporadic ALS: The majority of ALS cases, around 90-95%, are classified as sporadic ALS (sALS). Sporadic ALS occurs without a clear family history of the disease and is thought to result from a complex interplay of genetic and environmental factors.

Environmental Factors: Various environmental factors have been studied for their potential association with ALS. These include exposure to certain toxins or chemicals, such as lead, mercury, pesticides, and heavy metals. However, the specific causal relationship between these factors and ALS development requires further research.

Excitotoxicity and Oxidative Stress: Excitotoxicity, a process in which excessive stimulation of neurons leads to their damage or death, and oxidative stress, an imbalance between free radicals and antioxidants, are believed to contribute to the degeneration of motor neurons in ALS. These processes may be influenced by both genetic and environmental factors.

It is important to note that ALS is a complex and multifactorial disease, and the interplay between genetic predisposition and environmental triggers is still being explored. Ongoing research aims to uncover additional factors that may contribute to the development of ALS, providing a better understanding of the disease and potential targets for therapeutic interventions.

• Gene Mutation

Various types of genetic mutations can result in inherited ALS

• Protein Mishandling

Mishandled proteins by the nerve cells can lead to a gradual accumulation of abnormal forms of these proteins in the cells, seriously affecting or killing them

• Chemical Imbalance

People with ALS often have higher levels of glutamate

Only a small percentage of ALS is clearly attributable to genetics, which leaves a room for the possible involvement of environmental risk factors.

Research has found some links between ALS and the following environmental factors:



Causes and risk factors associated with Amyotrophic Lateral Sclerosis
Source: <https://alstreatment.com/amyotrophic-lateral-sclerosis-causes/>

Symptoms

General Symptoms

Motor neuron disease (MND), including amyotrophic lateral sclerosis (ALS), presents a wide range of signs and symptoms, which can make diagnosis challenging and often delayed. One distinguishing feature of MND is that it primarily affects muscle weakness while leaving sensations unaffected. The disease can initially manifest in the limbs or the mouth. If any of the following symptoms are observed, it is crucial to seek immediate medical attention:

Muscle weakness: Gradual loss of muscle strength and control.

Muscle wasting: Progressive muscle atrophy and shrinking.

Muscle fatigue: Easily becoming tired and experiencing muscle exhaustion.

Muscle spasticity: Stiffness and tightness in muscles, leading to reduced range of motion.

Muscle cramps: Involuntary muscle contractions causing pain and discomfort.

Muscle twitches: Uncontrolled, spontaneous muscle contractions, also known as fasciculations.

Dysphagia: Difficulty in swallowing due to weakened throat and tongue muscles.

Dysarthria: Impaired speech and articulation due to muscle weakness.

Respiratory failure: Weakening of the respiratory muscles, leading to breathing difficulties.

Cognitive and mood changes: In some cases, ALS can be associated with cognitive impairments, such as changes in memory, thinking, and behavior, as well as mood disturbances.

Due to the progressive nature of MND, there is currently no known cure. However, supportive care and symptom management play a critical role in the treatment of people with ALS (PALS). The focus of care is on addressing the various symptoms and providing necessary support to enhance quality of life. Multidisciplinary approaches involving healthcare professionals such as neurologists, occupational therapists, physiotherapists, speech therapists, and palliative care specialists are essential in managing the complex needs of individuals with ALS.

Head and neck symptoms^{7,8} (bulbar)

- Impaired speech
- Excess saliva
- Difficulty swallowing

Upper body symptoms⁷⁻⁹

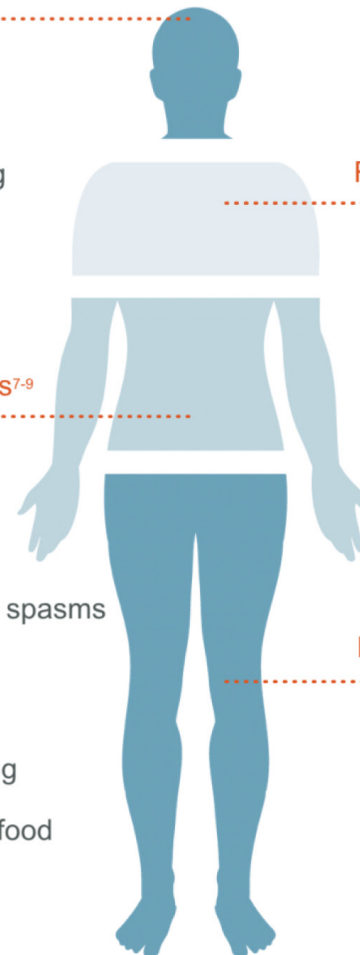
- Hand weakness
- Limited range of motion
- Upper body muscle spasms
- Trouble with dressing/hygiene
- Impaired handwriting
- Difficulty preparing food

Respiratory symptoms^{7,10}

- Shortness of breath
- Restricted breathing
- Difficulty sleeping

Lower body symptoms^{8,9}

- Frequent tripping
- Difficulty on stairs
- Weak feet



Symptoms of ALS classified by region

Source: <https://www.alspathways.com/als-overview/>

Common Secondary Complications

Some of the common complications of MND are:

Motor neuron disease (MND), including amyotrophic lateral sclerosis (ALS), can give rise to various complications that impact multiple systems in the body. Some of the common complications associated with MND include:

Breathing problems (respiratory complications): As the disease progresses, weakened respiratory muscles can lead to difficulties in breathing, reduced lung capacity, and the need for respiratory support or mechanical ventilation.

Cognitive and Behavioral changes: Some individuals with MND may experience changes in cognitive function, such as difficulties with memory, thinking, and decision-making. Additionally, behavioral changes, including emotional lability, apathy, and depression, can also occur.

Thrombophlebitis/Deep vein thrombosis (DVT): Immobility, muscle weakness, and decreased mobility associated with MND can increase the risk of developing blood clots, particularly in the

deep veins of the legs, leading to thrombophlebitis or DVT.

Contractures: Progressive muscle weakness and immobility can result in the development of contractures, which are permanent shortening and tightening of muscles, causing joint stiffness and limited range of motion.

Joint pain: Joint pain can occur due to abnormal stress and strain on joints caused by muscle weakness and imbalances.

Joint subluxation/Dislocation: Weakening of the supporting muscles and ligaments around joints can increase the risk of joint subluxation (partial dislocation) or dislocation, leading to pain and functional impairment.

Fractures: Fragile bones, reduced muscle support, and increased risk of falls can predispose individuals with MND to fractures, particularly in weight-bearing bones.

Constipation: Decreased muscle tone in the digestive tract can result in slowed bowel movement and constipation.

Anxiety related to difficulty of breathing: Breathing difficulties and the fear of respiratory failure can contribute to anxiety and emotional distress in individuals with MND.

The management of these complications involves a multidisciplinary approach.

Healthcare professionals such as neurologists, respiratory therapists, physiotherapists, occupational therapists, and palliative care specialists collaborate to address and alleviate these challenges, enhance quality of life, and provide optimal support to individuals living with MND.

Progression of Symptoms

The symptoms and progression of ALS can vary among individuals, but there are general patterns observed in the course of the disease.



Progression of Symptoms of ALS

Source: <https://www.startstemcells.com/the-stages-of-als-understanding-the-progression-of-the-disease.html>

Early stage: The initial symptoms often involve muscle weakness, twitching (fasciculations), cramping, or stiffness. Weakness may first be noticed in one limb or one side of the body, and tasks requiring fine motor skills may become more challenging. However, individuals in the early stage typically maintain their independence in daily activities

Middle stage: As the disease progresses, muscle weakness spreads to other parts of the body, and mobility becomes increasingly affected. This stage is characterized by difficulty walking, tripping or stumbling, and muscle fatigue. Daily activities such as dressing, bathing, and eating may require assistance or adaptive equipment. Speech and swallowing difficulties can also arise.

Late stage: In the advanced stages of ALS, individuals experience severe muscle weakness and may become completely paralyzed. They may be confined to a wheelchair or bed and require extensive assistance for all activities of daily living. Breathing difficulties become prominent as the respiratory muscles weaken.

Many individuals with ALS ultimately succumb to respiratory failure, which is the most common cause of death in ALS patients.

However, ALS progresses differently for each person. Average life expectancy after diagnosis is 2 to 5 years, but varies widely.

Management and Treatment

ALS is a complex and progressive disease that presents with a wide range of symptoms. To provide effective care, it is crucial to approach and manage all the symptoms comprehensively. Due to the progressive nature of ALS and the continuous changes in an individual's condition, a multidisciplinary approach to care is highly beneficial.

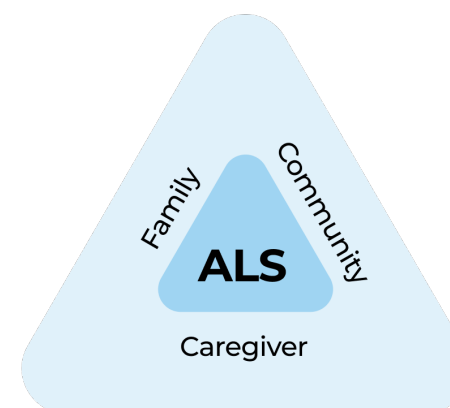
At the initial stages of ALS, individuals may have different needs compared to later stages when mobility is significantly impaired. Therefore, a tailored approach is necessary to address the evolving requirements and challenges faced by the individual.

It is important for individuals with ALS to understand that goals and plans may need to be adjusted as the disease progresses. The dynamic nature of ALS necessitates regular reassessment and modification of care strategies to meet the changing needs of the person. This includes adapting assistive devices, implementing new techniques to support mobility and communication, and addressing respiratory needs.

The primary objective at all stages of ALS is to optimize health and enhance the overall quality of life for the individual. This involves managing symptoms such as muscle weakness, fatigue, spasticity, breathing difficulties, and swallowing impairments. Palliative care may also be integrated to address pain, provide emotional support, and assist with end-of-life planning.

By employing a comprehensive and multidisciplinary approach, healthcare professionals can work collaboratively to address the diverse needs of individuals with ALS. This approach ensures that care is tailored to the individual's specific requirements and provides the best possible support to optimize their health and quality of life throughout the course of the disease.

- Day Care Center / Hospice
- Associations / Organisations
- Medical Social Worker



- | | |
|-------------------------------|-------------------------------|
| • Intensivist | • Physical Therapist |
| • Physician | • Occupational Therapist |
| • Neurologist | • Speech Language Pathologist |
| • Orthotist | • Nutritionist |
| • Psychologist / Psychiatrist | • Nurse |
| | • Physiatrist |

Stakeholders in the ALS Patient Community

Types of Treatment

Mainstream Medication



Mainstream Medication

Source: <https://unsplash.com/s/photos/pills>

The Mainstream medications include :

- Vitamin & Protein Supplements
- Symptom Management drugs
- FDA approved drugs
- Pain Management drugs
- Drugs for muscle spasms, cramps & spasticity
- Drugs for fatigue, depression , sleep

Physiotherapy



Physiotherapy

Source: <https://runwayhealth.ca/physiotherapy-for-the-knee/>

This includes a wide range of ROM, Strengthening, Aerobic & Cardio Exercises along with other types of unconventional techniques such as Yoga, Aqua-Therapy. Etc.

It leads to the increase in Muscle Endurance, Strength and helps in pain management and prevention of fasciculations and cramps.

Occupational Therapy



Occupational Therapy

Source: <https://familycarehha.com/blog/what-can-an-occupational...>

Occupational Therapy can help you accomplish your activities of daily living (eating, bathing, dressing, writing, shopping, etc.), your work, and your leisure through the use of compensatory strategies, adaptive devices, home and work modifications, and community resources.

Speech Therapy



Speech Therapy

Source: <https://alsworldwide.org/podcasts/category/39>

This is usually done for patients with respiratory insufficiency, symptoms of dysphagia or dysarthria. The following main criterion are taken care of :

- Energy conservation while speaking
- Slowing speech
- Exaggerated enunciation

Types of Treatment

Nutritionist



Nutritionist aids for ALS

Source: <https://unsplash.com/s/photos/pills>

Amyotrophic lateral sclerosis(ALS) is a progressive neurological disease with a high risk of malnutrition. Due to changing disease status, diet modification may need to be done frequently. They also need to meet the patients swallowing requirements & have specialized liquid diets as well.

Respiratory Therapy



Respiratory Therapy

Source: <https://runwayhealth.ca/physiotherapy-for-the-knee/>

In ALS, breathing difficulties can start early or much later. Because of this patients prognosis will be poor. So the non-invasive and invasive mechanical ventilation have been used for patient's care. Following are the alternative approaches to treat respiratory problems. Some devices that are used as respiratory devices are cough assist devices, diaphragmatic pacing .Etc.

Stem Cell Therapy



Stem Cell Therapy

Source: <https://johnandrachukmd.com>

Stem cell therapy is being explored extensively for MND- /ALS. Stem cells are unique, specialized cells that help to repair, regenerate and replace damaged cells. Stem cell therapy (also called cell therapy/ regenerative medicine) works on the principle of using healthy cells to repair damaged cells. Stem cells are considered to be “blank slates”, which means they are programmable.

Gene Therapy



Gene Therapy

Source: <https://www.livescience.com/>

It involves the genetic repair of the damaged brain cell to deliver a beneficial cell protein, which will stop the disease progression and repair dying nerve cells. It is Currently under clinical trials.

Muscle Wasting and Wrist Drop

Muscle Wasting

Muscle wasting, a common symptom in various conditions including ALS, occurs due to the damage and loss of motor neurons that control muscle movement. The progressive degeneration of these neurons leads to shrinking, weakening, and eventual loss of muscle mass.

As the muscles waste away, their strength and ability to generate movement decrease. This results in difficulties with various movements, such as abduction (spreading apart), adduction (bringing together), and opposition (thumb-to-finger movement) among the fingers. The muscles responsible for these actions become progressively weaker and less responsive.

One noticeable effect of muscle wasting is the change in the appearance of the hand. With the loss of muscle bulk, the palm may appear flatter and lacking a defined shape. The natural curves and contours of the hand may be less pronounced due to the muscle atrophy.

While muscle wasting is a challenging aspect of conditions like ALS, occupational therapy interventions can help individuals maintain functional abilities and improve their ability to engage in daily activities despite the changes in muscle structure and function.

Wrist Drop

As the disease progresses, the muscles responsible for wrist extension and finger movement weaken and lose their function. This makes it challenging for individuals to perform essential daily activities that involve grasping, holding, and manipulating objects. Tasks such as holding things, picking up and positioning objects, using utensils to eat, combing hair, and brushing teeth become difficult due to the limited mobility and weakness of the wrist and fingers.

Wrist drop and associated difficulties in hand and finger movements are not exclusive to MND. Similar conditions can occur in other conditions, such as radial nerve palsy and hand paralysis, where the nerves or muscles controlling wrist and finger movements are affected.



Muscle Wasting

Source: <https://onlinelibrary.wiley.com/doi/full/10.1002/jgf2.213>



Wrist Drop

Source: <https://casereports.bmj.com/content/2018/bcr-2017-221302>

Inferences

From the above studies, The key inferences are as follows :

1. ALS and MND are neurological diseases which affect the physical and mental stature of the patient
2. Excessive care must be taken while designing for such patients by thoroughly understanding the extent of limitations their body can take while performing actions
3. The stages of the disease are very short-lived in nature - which means that the same design cannot be used from one stage to another as the condition of the patient gets more and more complex and difficult to treat. Hence, while designing for such patients, one must either look to create a range of products for every stage or adaptable products that can be used through stages.
4. The nature of the disease itself makes it highly variable (as seen in the types of MND). Hence, while looking at it from a physiotherapy perspective, the progression is variable too. We can either look to solving the problems of a niche area of the disease or map out the commonalities between stages and solve for them through standardization.
5. A possible complication while solving could be the difference in aides for UMN & LMN symptoms due to the difference in muscle qualities.
6. The balance must be maintained while giving them physiotherapy due to Complications mentioned – Joint pain, Fractures, Respiratory problems. Etc
7. A possible area of intervention could be assistive devices for patients with ALS to compensate for the progressive loss of motor function, enabling them to maintain independence and enhance their quality of life. These devices could assist with daily activities, communication, mobility, and breathing support as the disease progresses.

Secondary research

Interview with Doctors

Dr Hemangi Sane



Consultant Physician,
Deputy Director at NeuroGen

Observations and comments

For legs we have many equipment	For hand not much has been done yet	Collaborating between different departments	Maybe an Exoskeleton	Limited rotation in elbow	Poor Grip, Wrist not good	Google home had made life easy	Deltoids becomes weak not the shoulder joint.
Comb my hair	Wash my face	Wipe my mouth	Needs helper all the time when at home	Hands don't work is the biggest problem	Hands falls down on the side can't pick up needs to call help	Typing is bit hard	"Theory of Everything" Gives impact on his desire and how life is
Apple as a system has helped	Connectivity Because my whole phone can be accessed from laptop	Can't turn ON the laptop	Floating keyboard is not on during startup	Eye tracking on Mobile/Laptop We have it but not commercially available			

MND condition:

Arm weakness & Gait.

Has MND from last 11 years.

There is progressive weakness in hands and legs with difficulty in getting in and out of the chair and climbing stairs.

-Dependent on caretaker for mobility.

-Has a difficulty in speaking, swallowing and coughing.

-After stem cell therapy, the condition is stable.

Inferences

There is a need for assistive equipment for upper body mobility	due to limited upper limb movement, need of assistive exoskeleton to perform gross motor skills	Most help always required for tasks that need hands	Makes use of virtual keyboard, phone always on auto pickup, uses Apple ecosystem	Can add features to mouse like SOS button, bell and a button to change devices
	Mouse kept on lap over a board, can lead to slipping of hand	Need for affordable tech for communication like eye tracker, muscle twitch, pressure sensor	Need for easy cursor navigation to use virtual keyboard, excel, etc	

Interview with Doctors

Dr Hima Biju



Department in Charge of
Operational Therapy,

Experienced doctor heading the
occupational therapy department.
Came across various cases
of neurological diseases in
rehabilitation.

Dr. Hima Biju provided information
on two patients who had visited the
clinic in the past for diagnosis and
treatment.

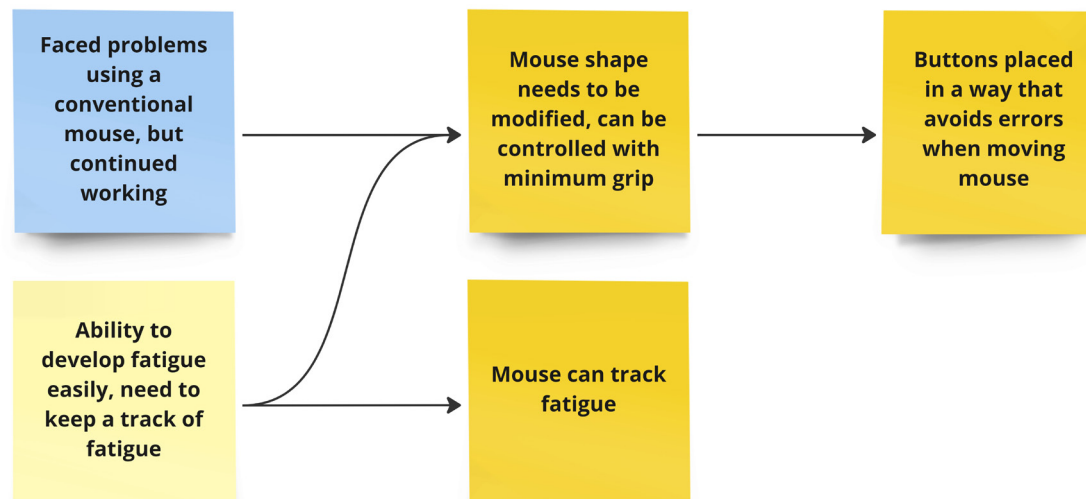
Patient 1 ●

Patient 2 ●

Observations and comments

Easy Fatigue Ability, need to keep a track of fatigue	Need to take frequent rest	Fasciculations (Jumping of Muscles)	Support of Assistive devices to maintain range of motion and support the muscles.	Muscle Wasting	What we value in life is different for different people and that is why the motivation factors differ.	OT is important to continue performing daily tasks since muscles are constantly being used
Homemaker, Teacher and a Mom	She values being able to teach the children	Wants to be able to make chapatis.	Upset about losing the ability to move and work around the house	Positive attitude towards therapy sessions	Last day for PT and OT in hospital, will continue at home	Knows muscles are deteriorating day by day
Software Engineer in IBM	She valued work over other things	She said I hire a maid to do bathing and everything but she just wants to work.	Faced problems using a conventional mouse, but continued working	Stopped taking therapy after a point.		

Inferences



Interview with patients

Patient 1



Female (Age - 59)
Profession - Primary school teacher

Health condition -
Disease is progressing slowly. There is weakness and pain in arms but still manages to do lots of daily things within her capability. She is also able to drive her automatic car. But with MND, she felt disappointment and frustration at not being able to do things she used to take granted.

Patient 2



Male (Age - 40)
Profession - Business manager in motor sales

Health condition -
Diagnosis at 39 yrs of the age. Still working in his profession. He has arm weakness. He mentioned he feels frustrated for not being able to do normal things properly, like holding a pen and spoon or brushing teeth.

Patient 3



Male (Age - 24)
Profession - Former building worker

Health condition -
Diagnosed with MND a year ago. Fingers started being weak at age 20. Now, has very limited usage of hand unable to work. Lives on his own as he likes to be independent of family. He finds difficulty in dressing, washing, and eating.

Patient 4

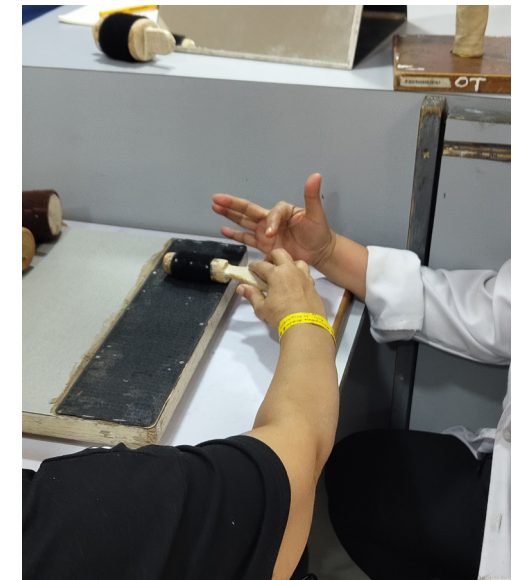
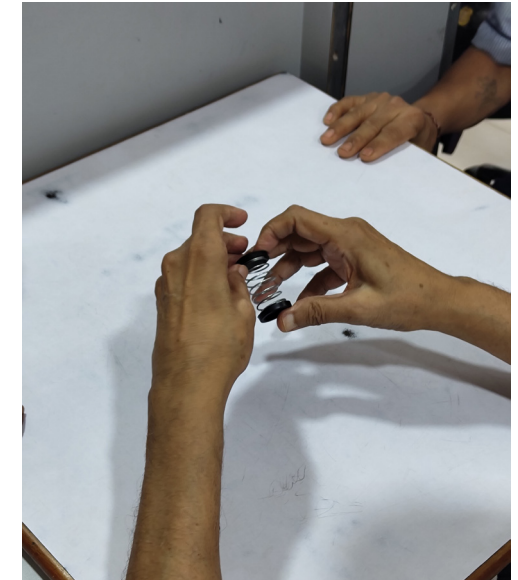


Male (Age - 48)
Kenya, Currently in Hyderabad

Health condition -
Weakness in grip, can't hold small things. Due to weakness in the wrist joint, the wrist drop condition is there, which makes it difficult to perform daily activities. Small sets of experiments were performed with him to understand the abilities and the movements of the body parts. The experiments included picking up the small things, bigger things, using a spoon, eating with it, lifting a glass of water and drinking, etc.

Shadowing patient therapy

We shadowed four patients at Neurogen clinic. We observed their Physiotherapy sessions and Operational therapy sessions. This provided us with valuable information about their symptoms, behaviors, and interactions. It also enhanced learning, empathy, and the patient-provider relationship, providing insights for quality improvement and process optimization, thus helping us create patient-centered products.



User journey

Mapping activity in the office

Of Dr. Sane to identify which activities require assistance and which activities can be achieved by the patient independently.



The **Patient** enters the office on a wheelchair. She uses an electric wheelchair that uses a **joystick** for navigation. Alternatively, in certain situations, a **Caretaker** can also bring the patient in on a wheelchair.

Observation: The patient finds it difficult to use the **joystick** due to lack of fine motor skills to grip it



The **Caretaker** positions the **Patient** in front of the Desktop and sets up the table turning the devices on.

Assistance needed with :



Input of password



Placing a writing pad on the lap



Placing a mouse on the pad and positioning the hand on it

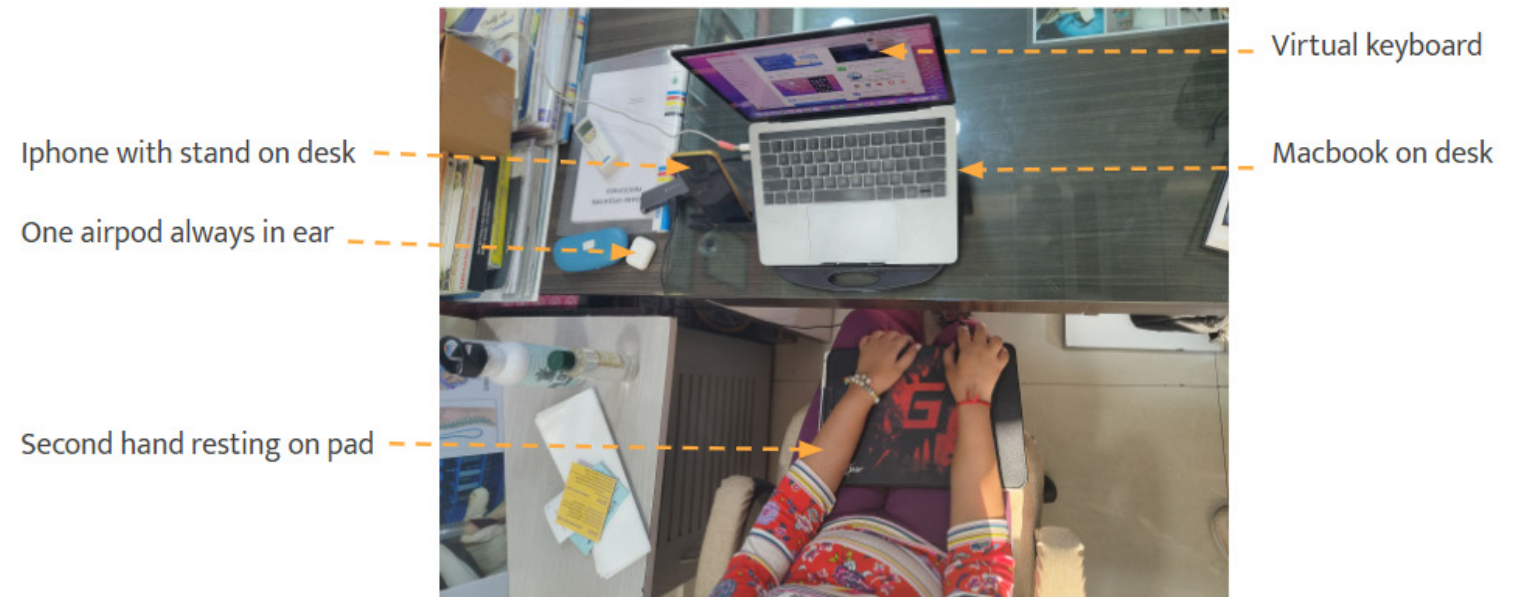


At the end of the day, the caretaker wraps everything up and shuts the devices.

Context study

This primary research was conducted to see and understand the problems from the first hand experiences of the users. This was done through contextual interviews, shadowing treatment sessions and discussions. The process was documented using a few images and audio with the consent of the stakeholders.

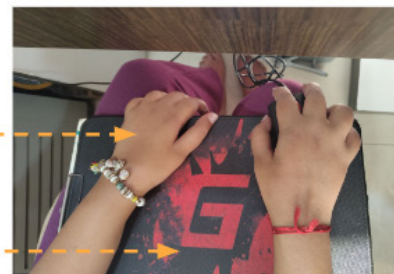
The working environment of Dr. Hemangi Sane was observed and inferences were derived. Types of devices used, how they were used, how they were positioned, were some of the aspects that were observed.



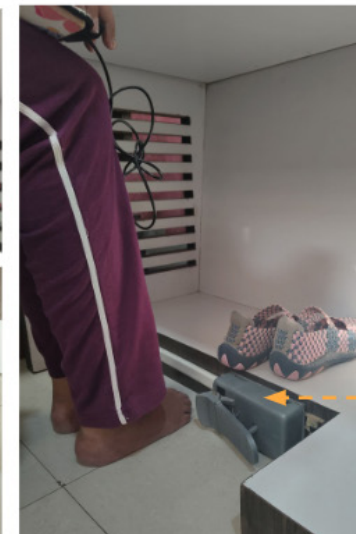
Fingers not gripping around the mouse adequately



Second hand can be used for other switches

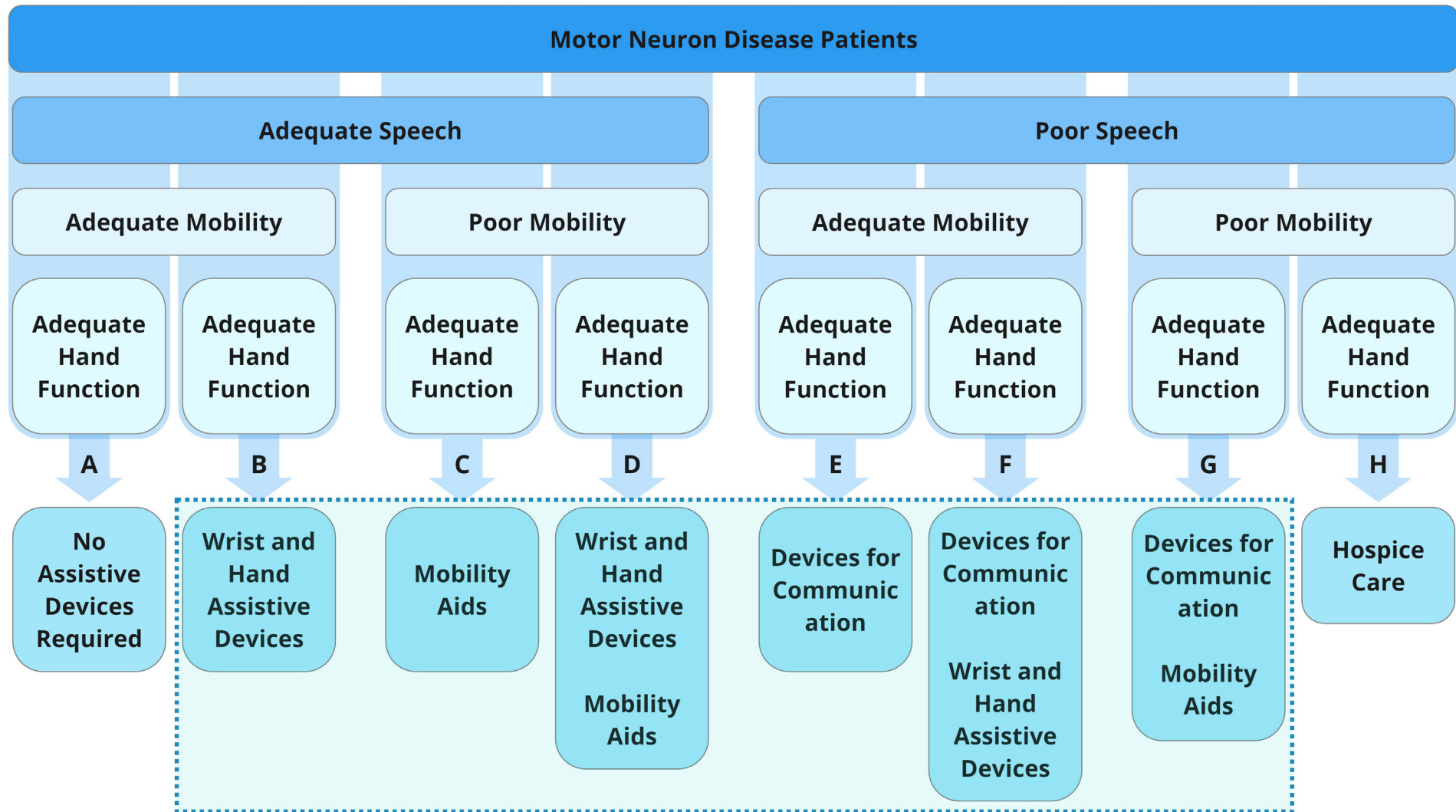


Hard board used for mouse pad



Foot switch to call for assistance

Area of intervention



The highlighted zone demarcates the range of patients that define the area of intervention

Design objective

To design a computer input device for patients suffering from ALS

Design Considerations:

Accessibility: The device should be accessible to people with different levels of mobility and hand dexterity.

Ergonomics: The device should be designed with ergonomics in mind to minimize discomfort and strain on the user.

Ease of maintenance: The device should be easy to maintain and clean, with replacement parts readily available.

Cost: The device should be cost-effective and affordable for the target user group.



Assistive technology

Significance

Assistive technology plays a crucial role in enhancing the quality of life and independence of ALS (Amyotrophic Lateral Sclerosis) patients. Some of the benefits and significance of assistive technology for ALS patients area as follows:

Communication and Expression:

ALS often impairs the ability to speak and communicate effectively. Assistive technology provides alternative communication methods such as eye-tracking systems, speech synthesizers, and voice recognition software, enabling patients to express their thoughts, needs, and emotions.

Access to Information and Resources:

Assistive technology allows ALS patients to access digital resources, including the internet, educational materials, and entertainment. It empowers them to stay informed, engaged, and connected with the world, enhancing their intellectual stimulation and social interactions.

Independence and Autonomy:

ALS patients may experience increasing dependence on caregivers for daily activities. Assistive technology enables greater independence by offering tools for mobility, environmental control, and personal care. Devices like wheelchair-mounted controls, home automation systems, and adaptive tools enable patients to perform tasks autonomously.

Employment and Productivity:

ALS patients often face challenges in maintaining employment due to physical limitations. Assistive technology provides solutions like voice recognition software, adaptive keyboards, and specialized computer input devices, enabling individuals to continue working, engaging in meaningful activities, and contributing to the workforce.

Psychological and Emotional Well-being:

ALS can lead to feelings of isolation, frustration, and loss of identity. Assistive technology promotes psychological well-being by enabling social connectivity through video communication, social media, and online support networks. It also allows individuals to pursue hobbies, creative outlets, and recreational activities, boosting their overall emotional well-being.

Safety and Caregiver Support:

Assistive technology enhances safety by monitoring vital signs, providing fall detection systems, and alerting caregivers in emergencies. It reduces the physical strain on caregivers by automating certain tasks, providing remote monitoring capabilities, and facilitating better care coordination.

<https://business.scope.org.uk/article/assistive-technology-devices-definitions-how-disabled-people-use-the-web>



Computer input devices

Computer input devices are hardware devices that allow users to interact with a computer system by providing input, such as commands, data, or instructions. These devices enable users to control and navigate computer interfaces, enter information, and perform various tasks. Here are some commonly used computer input devices:

Keyboard: The keyboard is a primary input device consisting of a set of keys, including alphanumeric keys, function keys, and special keys. Users input text, commands, and other data by pressing keys on the keyboard.

Mouse: The mouse is a handheld device that enables users to control the cursor on the computer screen. It typically includes buttons for clicking and scrolling, allowing users to select and interact with graphical elements and navigate through applications and documents.

Touchscreen: A touchscreen allows users to interact directly with the computer display by touching the screen with their fingers or a stylus. Touchscreens are commonly used in smartphones, tablets, and certain laptop or desktop computers.

Trackpad: A trackpad is a touch-sensitive surface located on laptops or standalone input devices. It enables users to control the cursor by moving their fingers across the surface, similar to the functionality of a mouse.

Joystick: Joysticks are primarily used in gaming and simulation applications. They provide precise control over movement and direction, allowing users to manipulate objects or navigate virtual environments.

Gamepad: Gamepads are specialized input devices designed for gaming purposes. They typically feature multiple buttons, directional pads, and analog sticks to control characters or interact with game elements.

Scanners: Scanners capture images or documents and convert them into digital format. They allow users to input physical documents, photos, or drawings into a computer system for storage, editing, or sharing.

Microphones: Microphones capture audio input and convert it into digital format. They are commonly used for voice recognition, recording, communication, and multimedia applications.

Webcams: Webcams capture video input, allowing users to participate in video calls, conferences, or live streaming. They are integrated into laptops or available as external devices.

Biometric Devices: Biometric devices, such as fingerprint scanners or facial recognition cameras, provide secure and convenient authentication methods by recognizing unique physical characteristics of individuals.

The selection and use of specific input devices depend on the user's preferences, application requirements, and the tasks they need to perform on the computer.



The mouse

Why?

Amongst the variety of computer input devices, the mouse was as chosen as my area of intervention for the following reasons:

- Most used device when using a PC
- Navigate across the screen
- Use virtual keyboard
- Use multiple devices on the desk
- Affordable computer input device

Problem identification

Loss of fine motor control:

As the disease progresses, patients can experience a loss of fine motor control, making it difficult to perform precise movements required for using a mouse.

Hand and arm weakness:

Patients with ALS can experience weakness and atrophy in their hands and arms, making it difficult to hold and operate a mouse for an extended period.

Fatigue:

Using a computer mouse can require significant effort and concentration, leading to increased fatigue and muscle weakness.

Difficulty clicking and double-clicking:

Clicking and double-clicking a mouse can be challenging for patients with ALS due to the loss of strength and coordination in their fingers.

Involuntary movements:

ALS can cause involuntary muscle movements, making it challenging to use a mouse with accuracy.

Lack of support to prevent arm from slipping and falling



Alternatives used to control computer cursor

Some assistive devices that can be used to control a computer cursor are shown here:



Trackballs



Joystick



Touchpad



Eye tracking



Head mounted pointing devices

Assistive mice

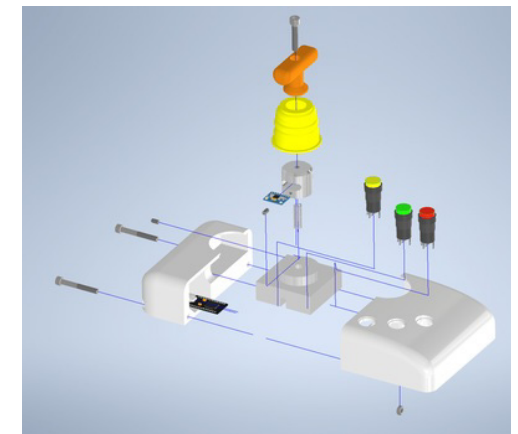
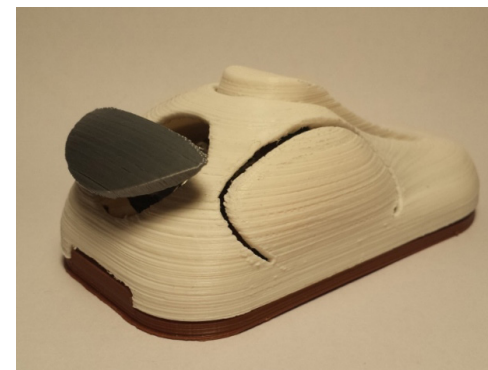
Commercially available

Assistive mice commercially available in the market were studied to understand the price range, features and current trends.

 Evoluent VerticalMouse 4 Wireless The patented shape of the VerticalMouse Wireless supports the hand in an upright neutral posture to avoid forearm twisting without the cord. VIEW PRODUCT	 Evoluent VerticalMouse 4 The patented shape of the VerticalMouse supports the hand in an upright neutral posture to avoid forearm twisting. VIEW PRODUCT	 Goldtouch Wireless Comfort Mouse The unique shape of this ergonomic mouse will ensure you keep your wrist at a natural 24 degree angle to alleviate pressure on tendons and joints. VIEW PRODUCT	 Goldtouch USB Comfort Mouse The Goldtouch USB Comfort Mouse supports the hand in a naturally sloping angle that places the wrist in a neutral position. VIEW PRODUCT
 Adesso iMouse E10 Wireless Mouse The Adesso iMouse E10 provides a vertical orientation with wireless convenience and the freedom of a smooth connection up to 30'. VIEW PRODUCT	 DXT Ergonomic Mouse 2 The DXT 2 Mouse enables the hand to work from a relaxed position reducing the tension on the soft tissues. VIEW PRODUCT	 TinyMouse Optical Half the size of a standard computer mouse and just right for your child's small hands. VIEW PRODUCT	 Mini Mice Sized for younger students, the Mini Mice are ideal for beginning computer users. VIEW PRODUCT

Open source kits

Open-source 3D printable assistive technology is vital as it promotes accessibility, affordability, and customization. By providing open designs that can be downloaded and 3D printed, it eliminates barriers and allows individuals with disabilities to access and create their own assistive devices. This reduces costs, encourages customization based on specific needs, fosters innovation through collaboration, enables rapid prototyping and iteration, and empowers users to be independent and self-sufficient. Overall, open-source 3D printable assistive tech plays a crucial role in creating inclusive and equitable solutions for people with disabilities.



Features of assistive mice

Based on the market study, a list of features was generated that can be considered to be added in the final design in order to create a quality product as per market standards.

Ergonomic Design: The assistive mouse should have an ergonomic design that promotes comfort and minimizes strain on the user's hand and arm. It should be shaped and sized to accommodate various grip styles and hand sizes, allowing for prolonged use without causing discomfort or fatigue.

Customizable Sensitivity: Providing adjustable sensitivity settings allows users to modify the mouse's tracking speed and responsiveness according to their motor capabilities. This feature is important as it enables users to fine-tune the mouse's sensitivity to their comfort and control levels, facilitating precise cursor movements.

Alternative Control Mechanisms: Incorporating alternative control mechanisms beyond traditional hand movement is essential. This may include options such as joystick-like controls, head-tracking systems, or eye-tracking technology.

Offering alternative control methods allows users to operate the mouse using their remaining motor abilities, ensuring accessibility for individuals with diverse needs.

Programmable Buttons: Having programmable buttons on the assistive mouse provides users with the ability to assign custom functions or macros to specific buttons. This feature allows for easier access to frequently used commands or actions, reducing the need for repetitive and complex movements.

Assistive Technology Integration: The assistive mouse should be compatible with various assistive technologies, such as switch scanning devices or sip-and-puff systems. Integration with these technologies enables users with specific motor impairments to control the mouse using alternative input methods that suit their abilities.

Tactile and Auditory Feedback: Incorporating tactile feedback, such as haptic vibrations or textured surfaces, provides users with sensory cues and enhances their interaction with the mouse. Additionally, auditory feedback, such as click sounds or spoken feedback for cursor movements, can be beneficial for individuals with visual impairments or to provide confirmation during interaction.

Wireless Connectivity: Offering wireless connectivity options, such as Bluetooth or RF, eliminates the constraints of cables and allows users to position the mouse more freely. This feature enhances flexibility and ease of use, particularly for individuals with limited mobility.

Battery Life and Power Saving Features: Considering battery life and implementing power-saving features is crucial to ensure that the assistive mouse remains operational for extended periods. Long battery life and features like automatic sleep mode or low-power consumption contribute to the convenience and uninterrupted usage of the device.

Durability and Easy Maintenance: The assistive mouse should be designed to withstand frequent use and potential physical impacts. It should be made of durable materials and have a robust construction to ensure longevity. Additionally, easy maintenance features, such as removable and washable covers, can enhance cleanliness and hygiene.

UI and keyboards

A brief study was done on virtual keyboards and their features in order to get insights on human computer interaction and how the assistive device can be integrated with them.

Large and Well-Spaced Keys:

Virtual keyboards often feature larger keys that are well-spaced, making it easier for ALS patients with limited motor control and dexterity to target and press the desired keys accurately. The increased size and spacing reduce the risk of unintentional key presses and improve typing accuracy.

Customizable Layouts:

Virtual keyboards typically offer customizable layouts, allowing ALS patients to adjust the key arrangement based on their specific needs and preferences. They can modify the size, position, and grouping of keys to accommodate their remaining motor abilities and optimize comfort during typing.

Word Prediction and

Autocomplete: Virtual keyboards often incorporate word prediction and autocomplete functionalities. These features suggest or complete words based on the user's input and context, reducing the number of keystrokes required.

ALS patients can select the desired word or phrase from the suggestions, minimizing the effort and time needed for typing.

Gestures and Swiping: Some virtual keyboards support gesture-based input, where ALS patients can perform swiping or sliding motions across the keyboard to input characters or complete words. This feature allows for faster and more fluid input, especially for individuals with limited finger or hand movements.

Voice Input: Virtual keyboards may integrate voice input capabilities, enabling ALS patients to dictate their text instead of manually typing. Voice recognition technology translates spoken words into text, allowing individuals with ALS to compose messages or documents using their voice, reducing the physical demands of typing.

Adjustable Sensitivity: Virtual keyboards often provide adjustable sensitivity settings, allowing ALS patients to fine-tune the responsiveness of the keyboard to their motor control capabilities. This feature enables individuals to set the keyboard to be more or less sensitive to their touch, accommodating variations in muscle strength and coordination.

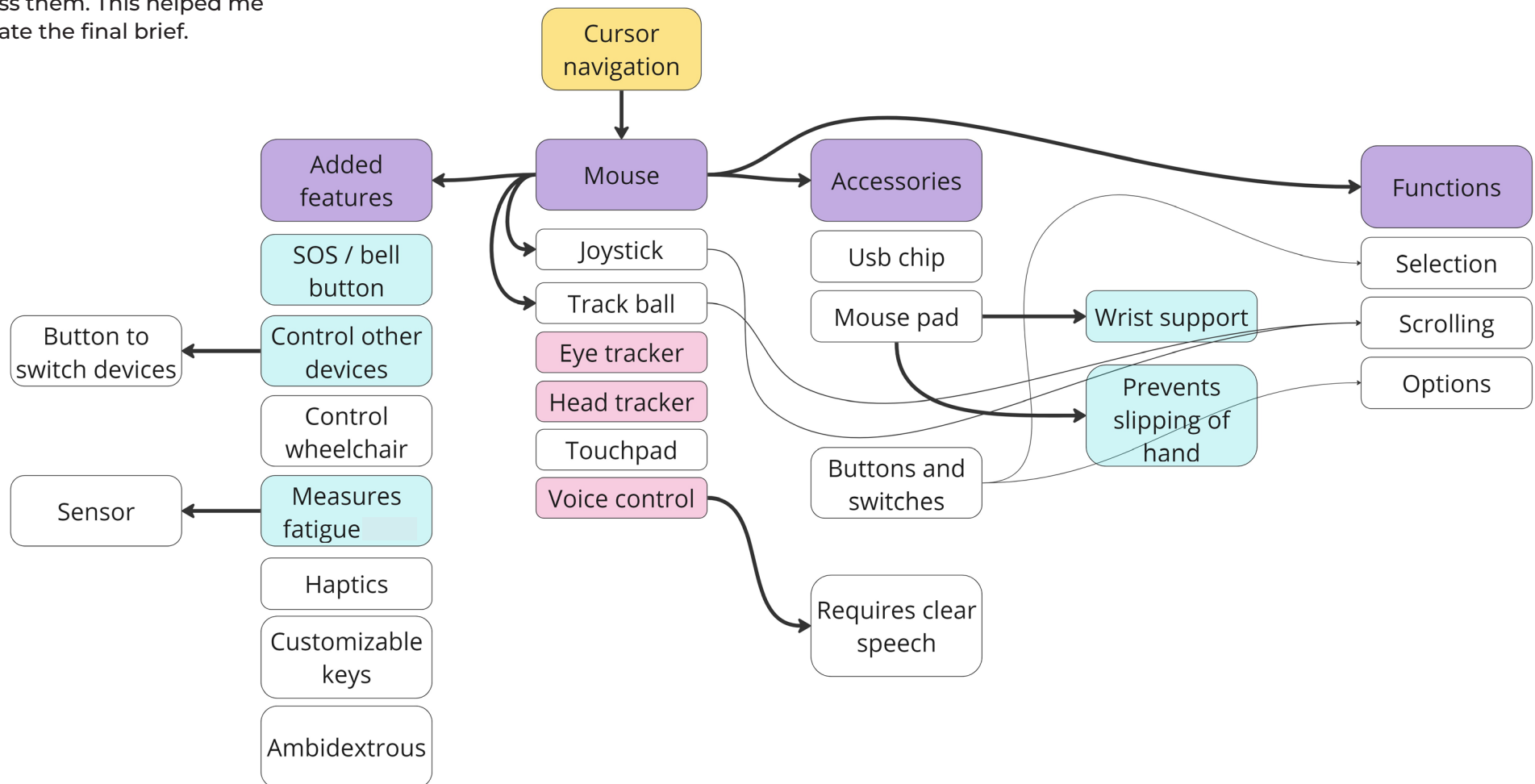
Visual and Auditory Feedback:

Virtual keyboards offer visual and auditory feedback to aid ALS patients in their typing. Visual cues such as highlighting the selected key or displaying the typed characters assist individuals with visual guidance. Auditory feedback, such as key clicks or spoken feedback for entered characters, provides additional confirmation and enhances the user experience.

Integration with Assistive Technologies: Virtual keyboards can integrate with various assistive technologies, such as eye-tracking systems or switch scanning devices. ALS patients can control the virtual keyboard using alternative input methods, leveraging their remaining physical abilities and assistive devices to interact with the keyboard effectively.

Functions of mouse and design opportunities

Based on the above study a mind map was created around cursor navigation that helped me identify problems and combine features from different accessories to address them. This helped me generate the final brief.



Brief

To design a computer input device for patients suffering from ALS. The device should ease cursor navigation for the patients by engaging gross motor skills. It should make use of the most easily achievable movements to trigger the control elements.

Target Users: Individuals with ALS (Amyotrophic lateral sclerosis) who have limited mobility in their hands and limbs, but have intact cognitive abilities.

Key Requirements:

Easy to use - better grip, intuitive to use

Durable - fall proof, low maintenance

Compatibility - easy to connect to multiple range of devices

Customizable - can assign features to buttons as per user needs

Portable - non bulky, easy to move and carry

Additional features

Easy switch from one device to another

Bell, call button

Finger print sensor to unlock devices

Devices and stages of ALS

To define the area of intervention

The complexity of technology adopted by assistive devices increases as the disease progresses. This diagram tracks the type to devices used by patients at different stages of ALS.

Since the area of intervention lies between the initial stage and last stage, my intervention focuses on resolving problems and improving the user experience of products like assistive mice, joysticks, trackball, switches, trackpads and maybe other head controlled devices.



Key guards



Trackball and assistive mouse



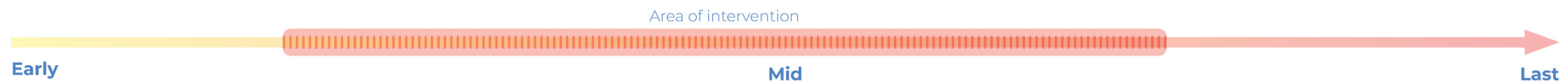
Joysticks



Head operated mouse



Brain computer interface



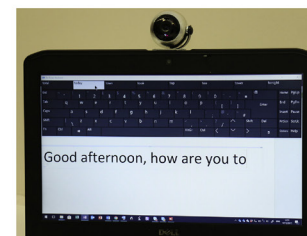
Communication boards



Switches



Trackpads



Head tracker



Eye tracker

Access technology

The model

Access technology cannot be considered in isolation; it is part of a bigger system that includes the user, the access technology, the device that is being used and the activity and environment in which it is being used. All these aspects must be taken into account when considering access to assistive technologies.

Device

The device refers to the electronic assistive technology device itself: the computer, voice output communication aid, environmental control system or powered wheelchair.

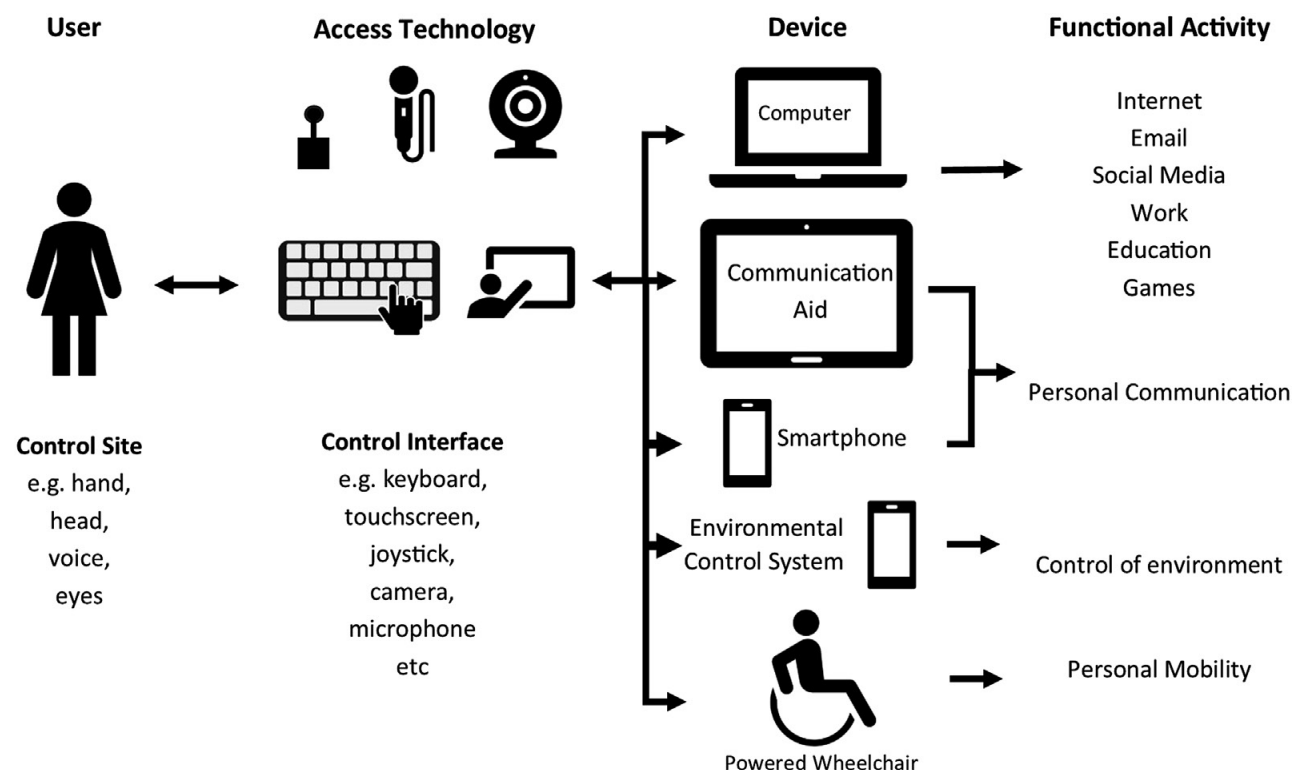
Control Site

The control site is the body part or physical action that the user employs to operate the technology; this can be a finger and/or a hand, foot, knee, elbow, voice, mouth, head or eyes, and more. The most common control sites are finger/thumb/hand, as used to access touchscreen, keyboard, mouse or trackpad.

Control Interface

The control interface refers to the input device and interface, such as the touchscreen, keyboard, mouse, joystick or eye-gaze camera. The control interface is bidirectional and processes information both to and from the user – it presents options and provides a means for the user

to choose between them and to interact with the device. The control interface is usually visual, but can also be tactile (e.g., a Braille display) or audible (e.g., screen reader software or auditory scanning).



Latest tech and research

Tap strap 2 _ Wearable Keyboard, Mouse & Air Gesture Controller



Rs. 26,800
Can be connected to multiple devices
Compatible with multiple operating systems
Customizable gestures

Soft robot glove _ Wyss Institute at Harvard University



Clinical tests_2022
Restores hand motor function to handle objects independently at home
Detects the residual muscle signals fired by motor neurons when the patient attempts to perform a grasping motion

Latest tech and research

Wearable Skin-like Device, MIT



Clinical tests_2022

Ultrathin semiconductor film made of a piezoelectric substance that adheres to the skin, sensing the vibrations of the body.

The sensor does not require any power source.

Microsoft adaptive accessories



Rs.1200 to Rs.15,000

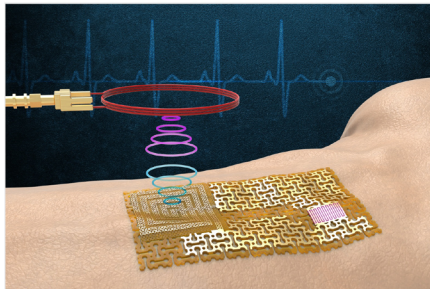
Connects multiple tech to create an ecosystem

Attachments that can connect to existing devices

Modular

Latest tech and research

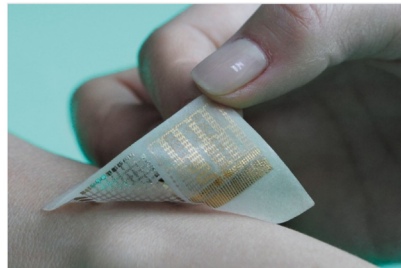
There are several technological advancements made in wearable 'skin' technology that can be used to design an assistive device.



news.mit.edu

Engineers fabricate a chip-free, wireless electronic "skin"

MIT engineers fabricated a chip-free, wireless electronic "skin." The device senses and wirelessly transmits signals related to pulse, sweat, and ultraviolet exposure, without bulky chips or batteries.



www.nature.com

Stick-on skin sensor measures motion - Nature

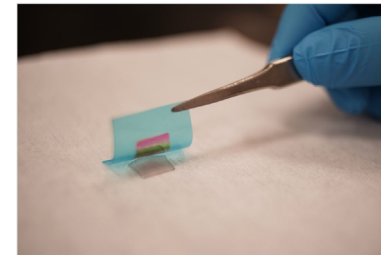
A wearable device as thin as a temporary tattoo can measure, store and transmit data on muscle activity, and release embedded drugs into the wearer's skin. Dae-Hyeong Kim at Seoul National University in South Korea and his colleagues built their device ...



news.mit.edu

Sweat-proof "smart skin" takes reliable vitals, even during workouts and spicy meals

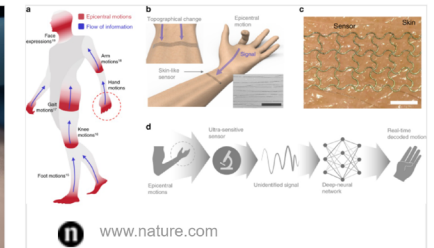
Engineers have developed a sweat-proof "electronic skin" - a conformable, sensor-embedded sticky patch that reliably monitors a person's health, even when a wearer is perspiring. The patch contains artificial sweat ducts through the material's ultrathin...



news.mit.edu

Study opens route to flexible electronics made from exotic materials

MIT engineers have developed a technique to fabricate ultrathin semiconducting films made from a host of exotic materials other than silicon. To demonstrate their technique, the researchers fabricated flexible films made from gallium arsenide, gallium n...



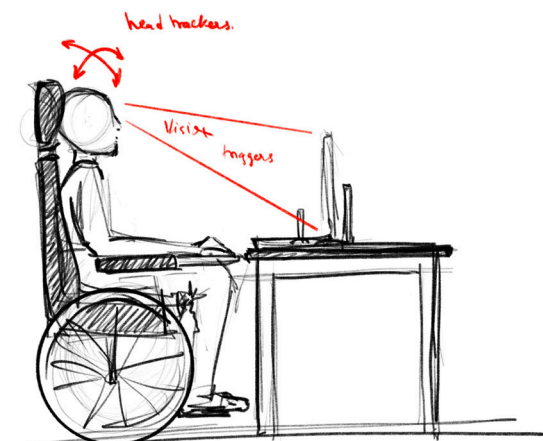
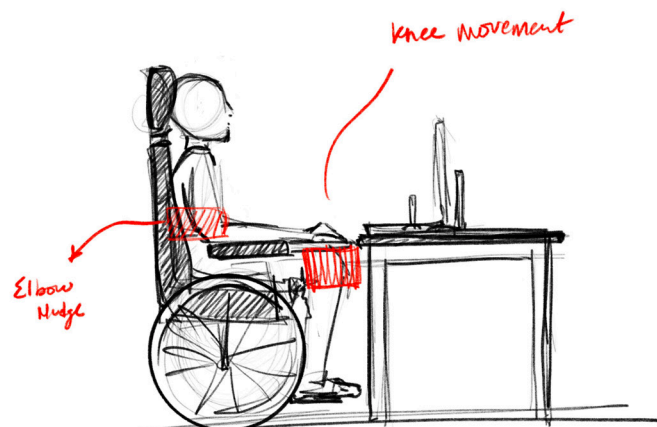
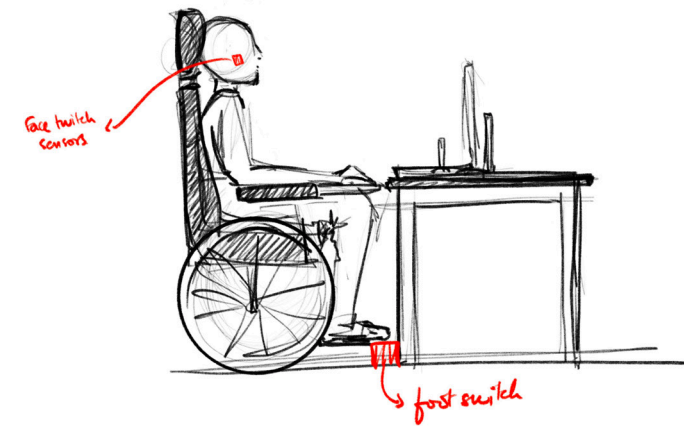
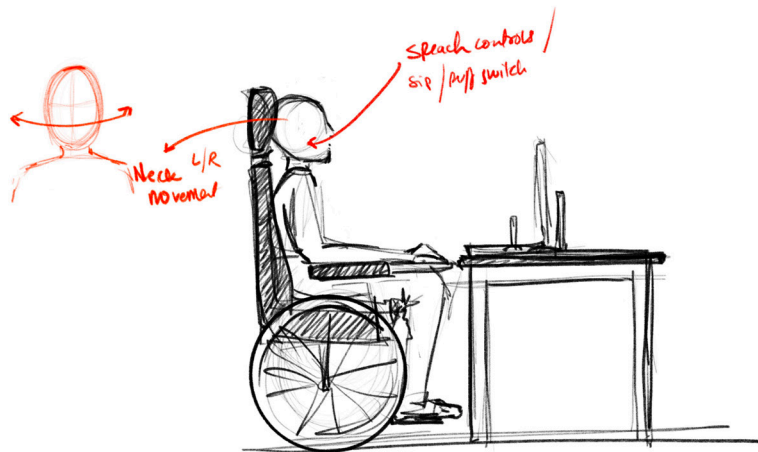
www.nature.com

A deep-learned skin sensor decoding the epicentral human motions - Nature Communications

Real-time monitoring human motions normally demands connecting a large number of sensors in a complicated network. To make it simpler, Kim et al. decode the motion of fingers using a flexible sensor attached on wrist that measures skin deformation with ...

Sites of intervention

Apart from hands as a possible site of intervention, there were other potential sites explored to make ideations.



[illegible][illegible]

Face and head

The sketches include:

- A side profile of a head wearing a VR headset with labels: "re / phone / tablet screen assembly" and "in small hand brackets".
- A top-down view of a circular device with three segments and a central button.
- A side profile of a head wearing a device with a large rectangular screen and a small rectangular sensor on the side, with labels: "Bottom / switch" and "eye movement".
- A front view of a head wearing a device with two large rectangular sensors on the cheeks, with labels: "eye" and "Signal transmission".
- A front view of a head wearing a device with a large rectangular sensor on the cheek and a small rectangular sensor on the temple, with labels: "Temple sensor", "cheek", and "touch sensor".

Legs

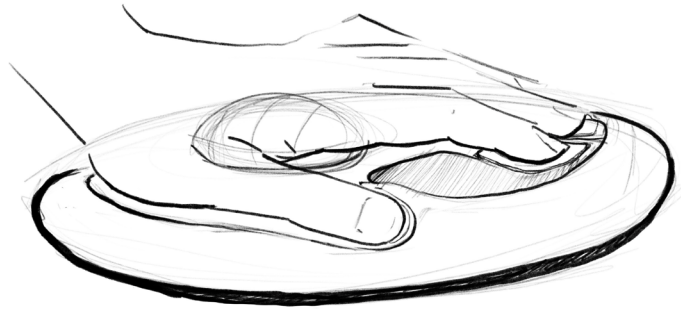
A diagram showing the legs of a chair. Two red arrows point to the front and back legs, labeled "Ball Joint".

+ Legs

The diagram illustrates a custom wheelchair seat designed for a person with legs. On the left, a person is shown sitting in a wheelchair. A red outline highlights the custom seat, which is labeled 'seats' and 'by manual'. On the right, a 3D perspective view of the seat is shown, labeled 'Tubshell' and 'seats'. A red arrow points to the base of the seat, labeled 'Seats controlled by legs'.

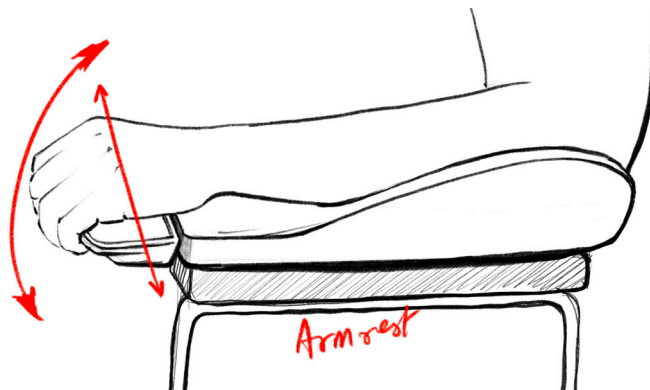
Ideations

Flat palm trackball



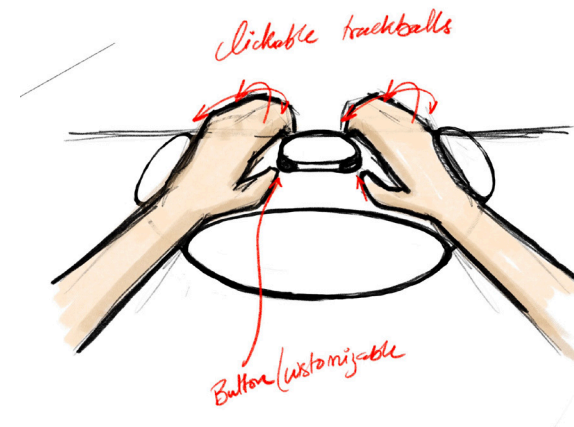
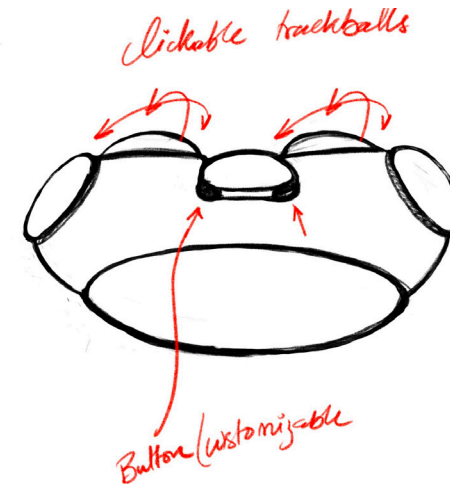
Uses a trackball below the palm, buttons under the fingers. Palm in resting position.

Arm rest controller



Uses a joystick integrated with the wheelchair, can be used to navigate the wheelchair alternatively.

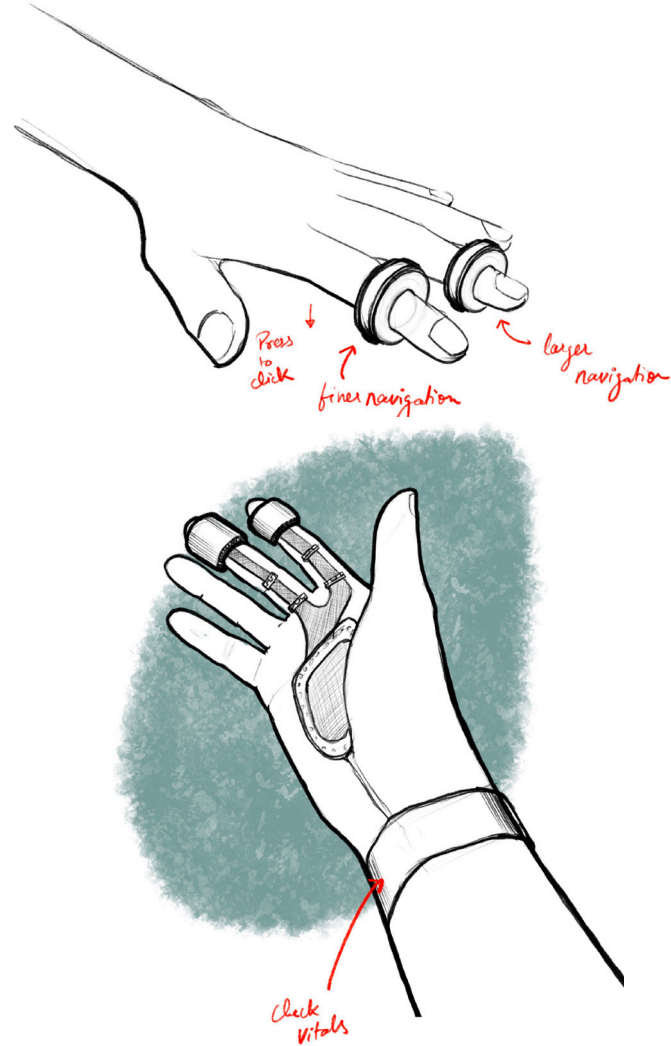
Dual hand controller



Uses trackballs in both hands to navigate, Thumb operated switches, Rests on the lap with hands in neutral position

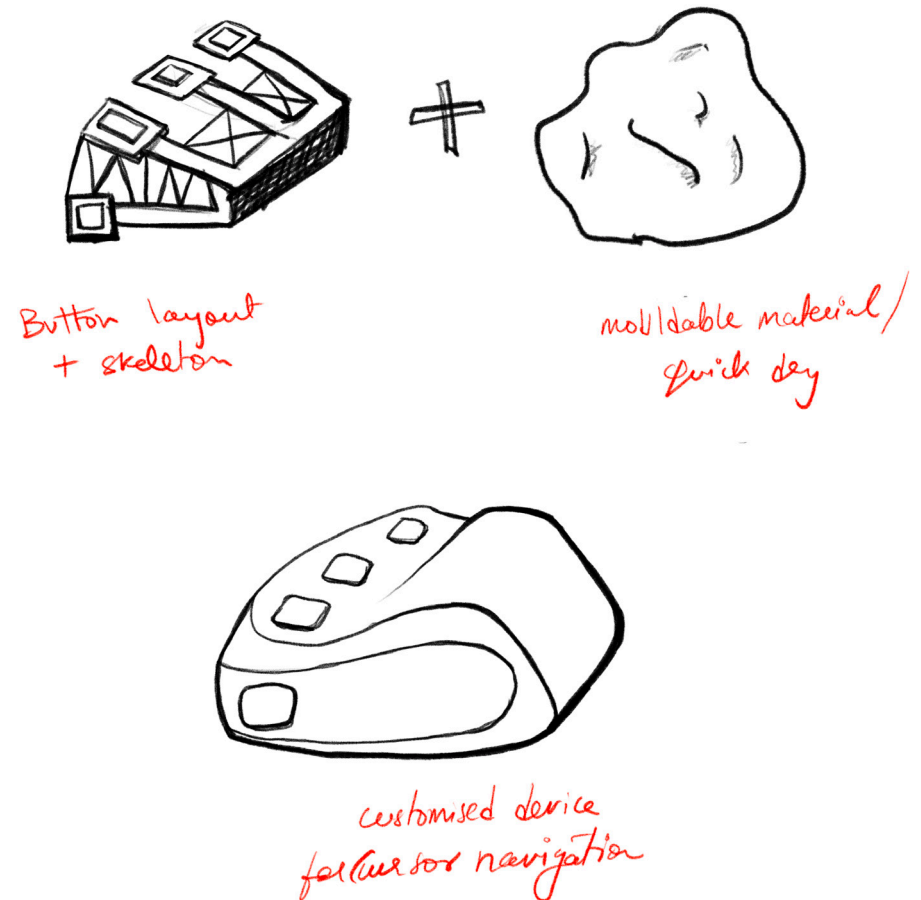
Ideations

Ring controller



A rotating ring worn on the finger, additional controls given on the face of palm.

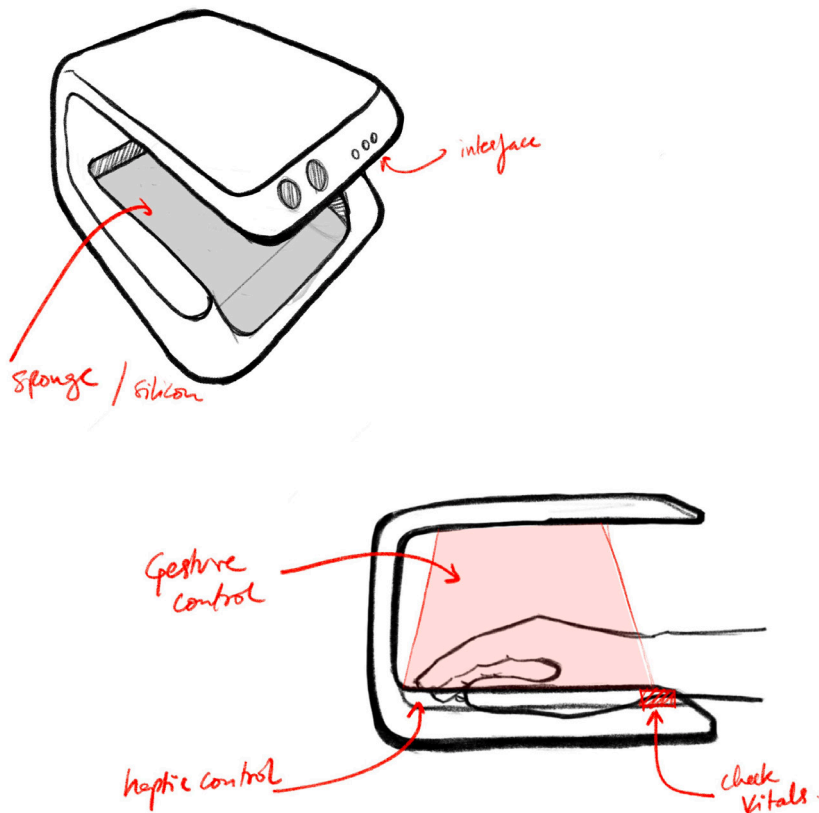
Customized ergonomics with mouldable material



Device uses a modular exoskeleton with quick dry mouldable material that takes the shape of the users palm.

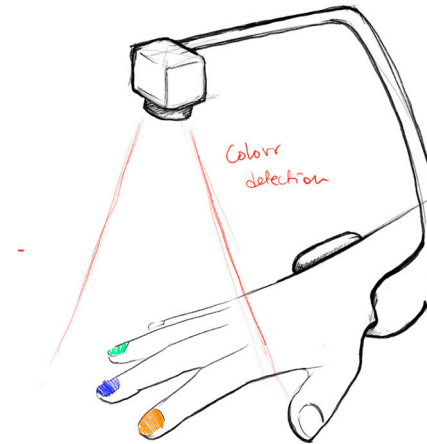
Ideations

Gesture sensing pads

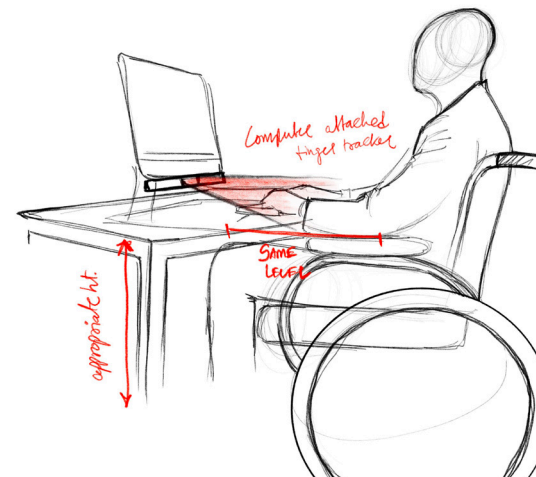


A soft material at the base tracks hands movements and sensors on the top track gestures

Gesture sensing cameras

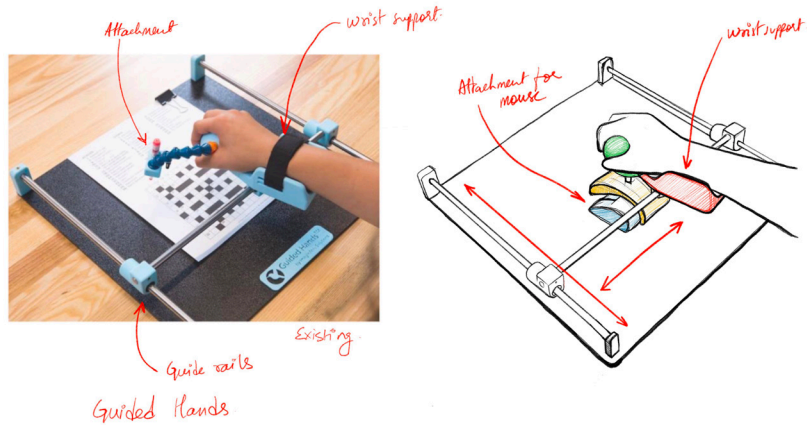


Screen mounted sensors



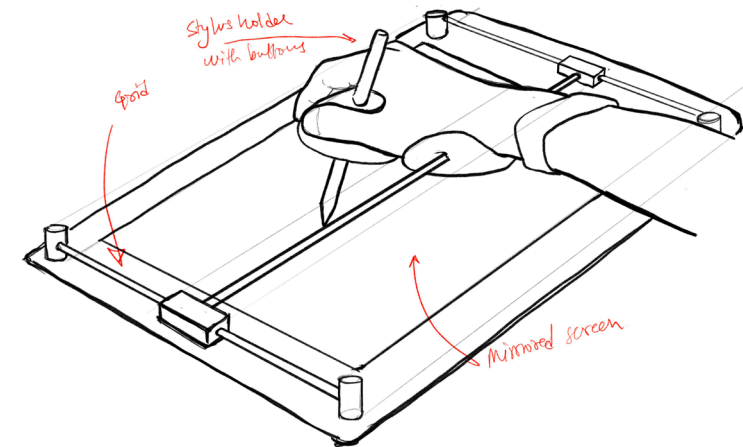
Ideations

Guided hands attachment



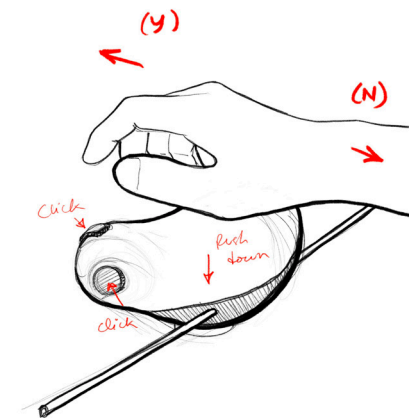
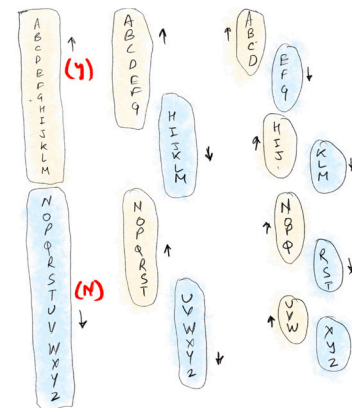
Inspired from the existing product Guided Hands, Can be used to navigate the mouse on x and y axis with the help of guides

Mirrored screen pad



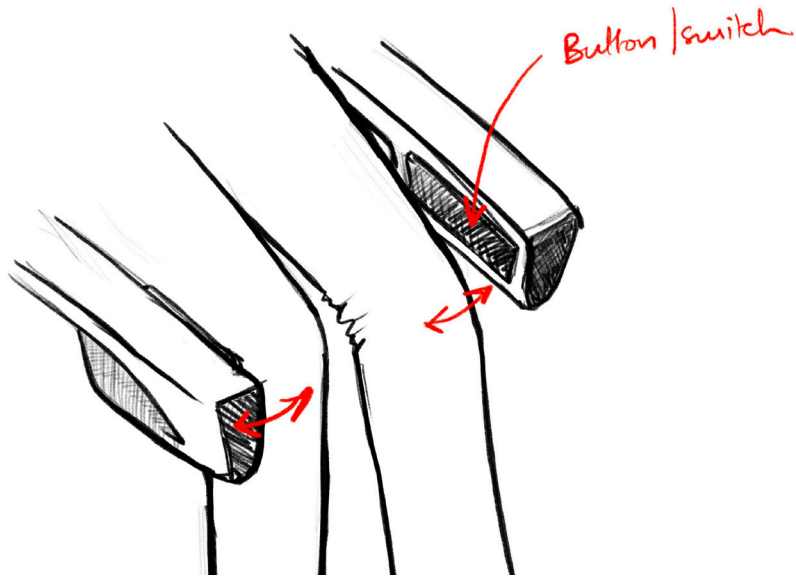
Uses a combination of screen mirroring on a touch pad and Guided Hands

Inbuilt keyboard



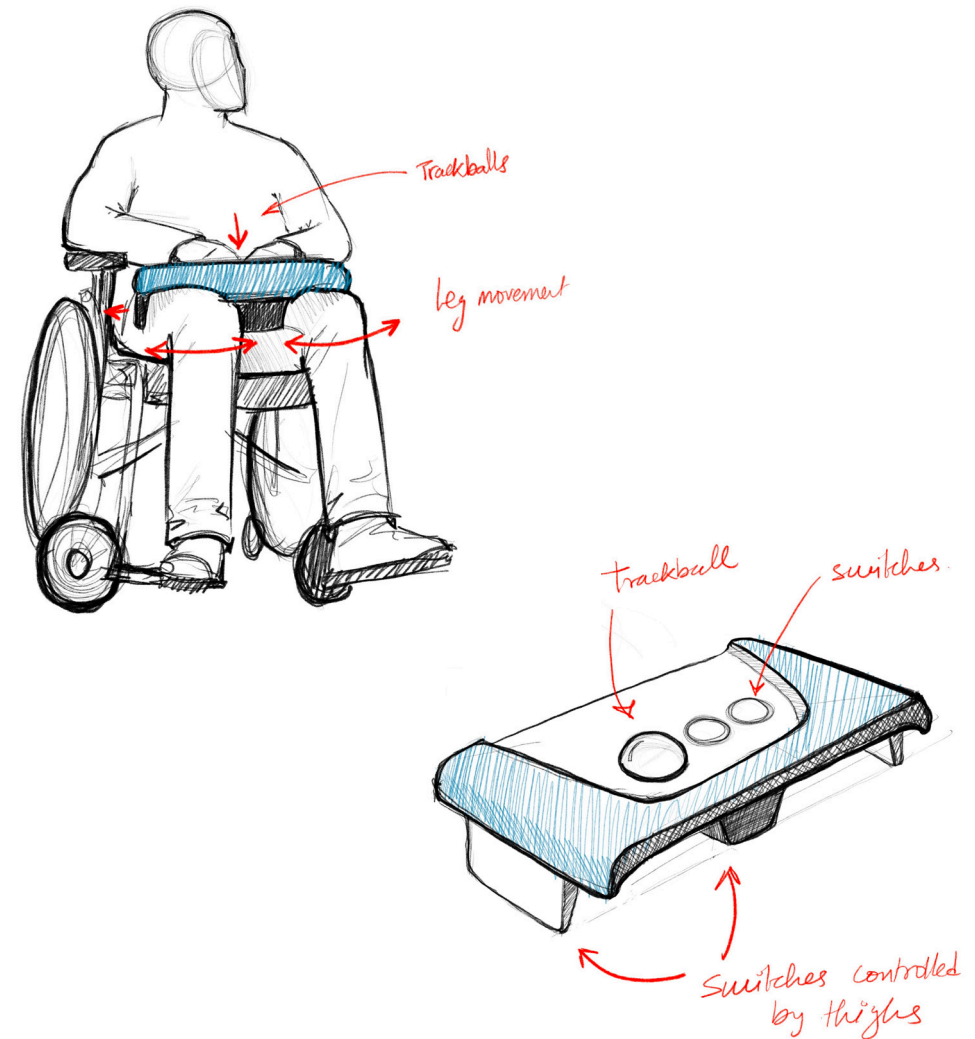
Ideations

Thigh switch



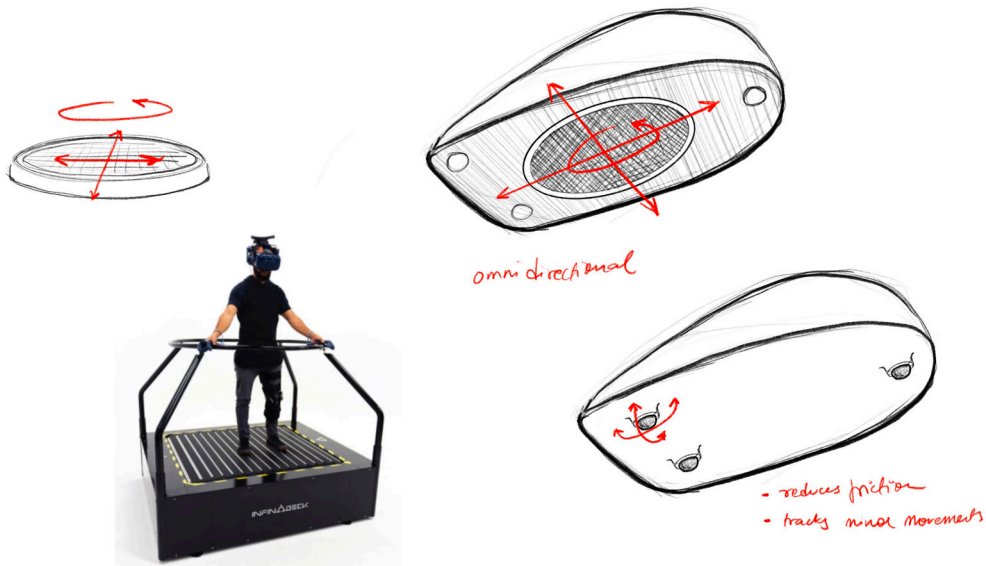
There were some ideations made that used leg movement to give a command

Tray with leg and hand switches



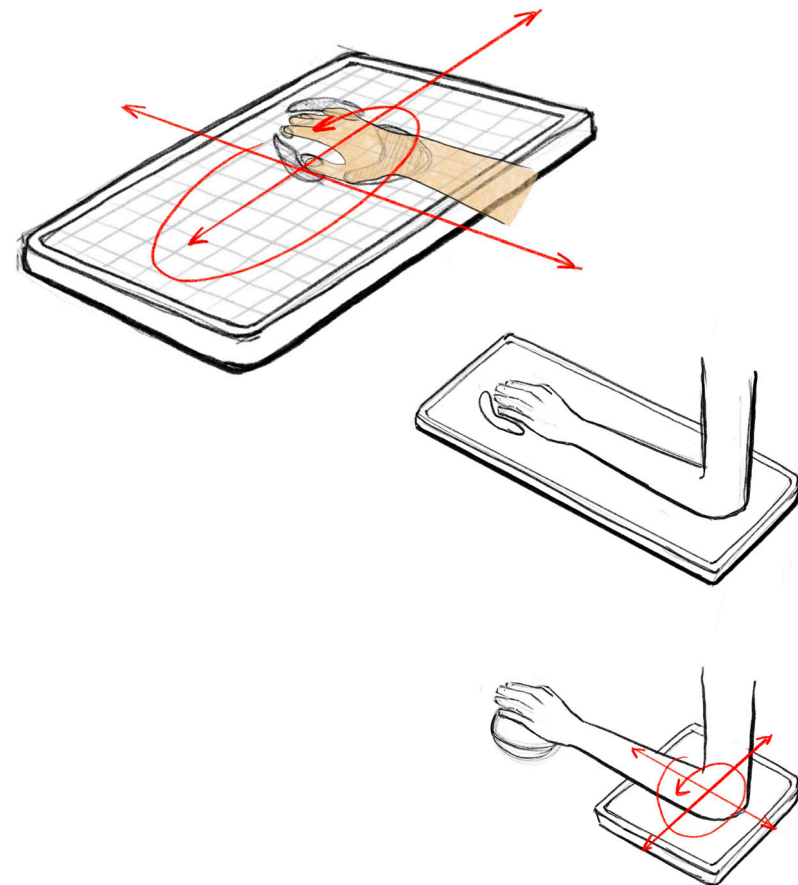
Ideations

Omnidirectional treadmill



Uses the concept of omnidirectional treadmills below the mouse to reduce friction

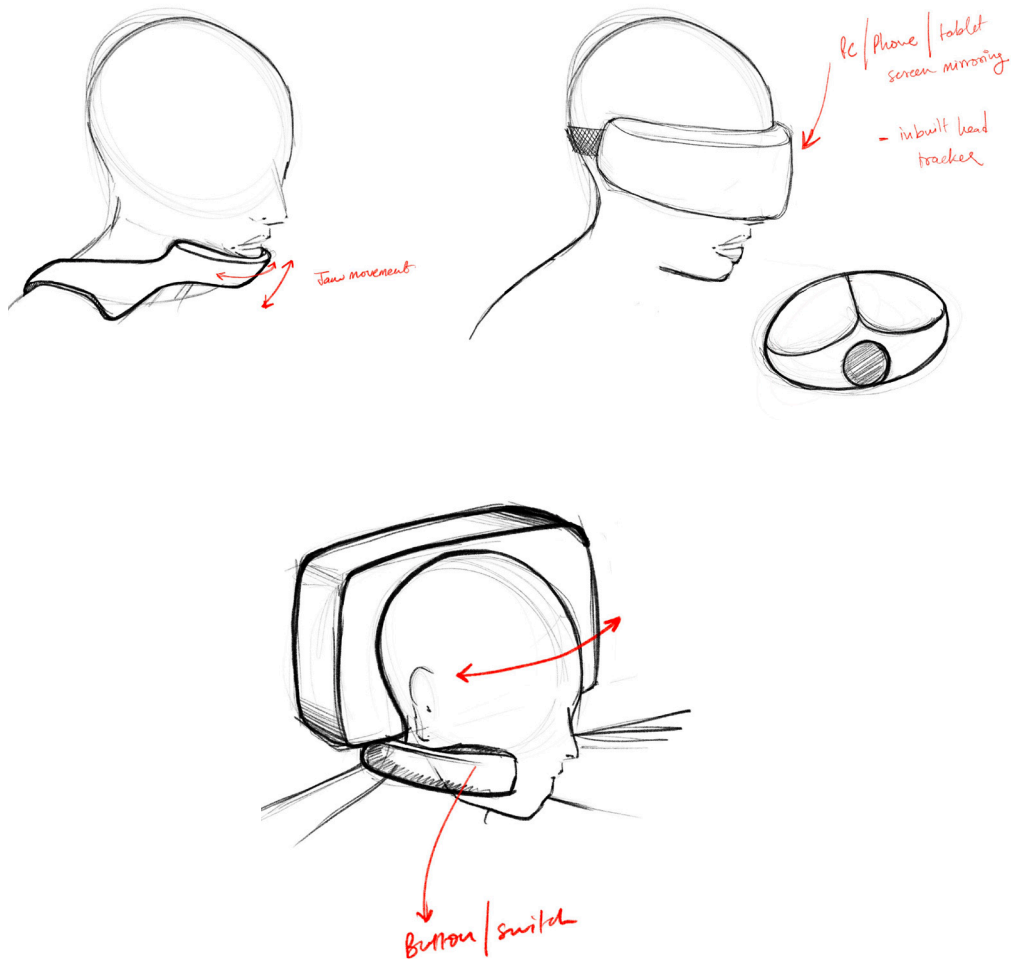
Omnidirectional treadmill + tray / mousepad



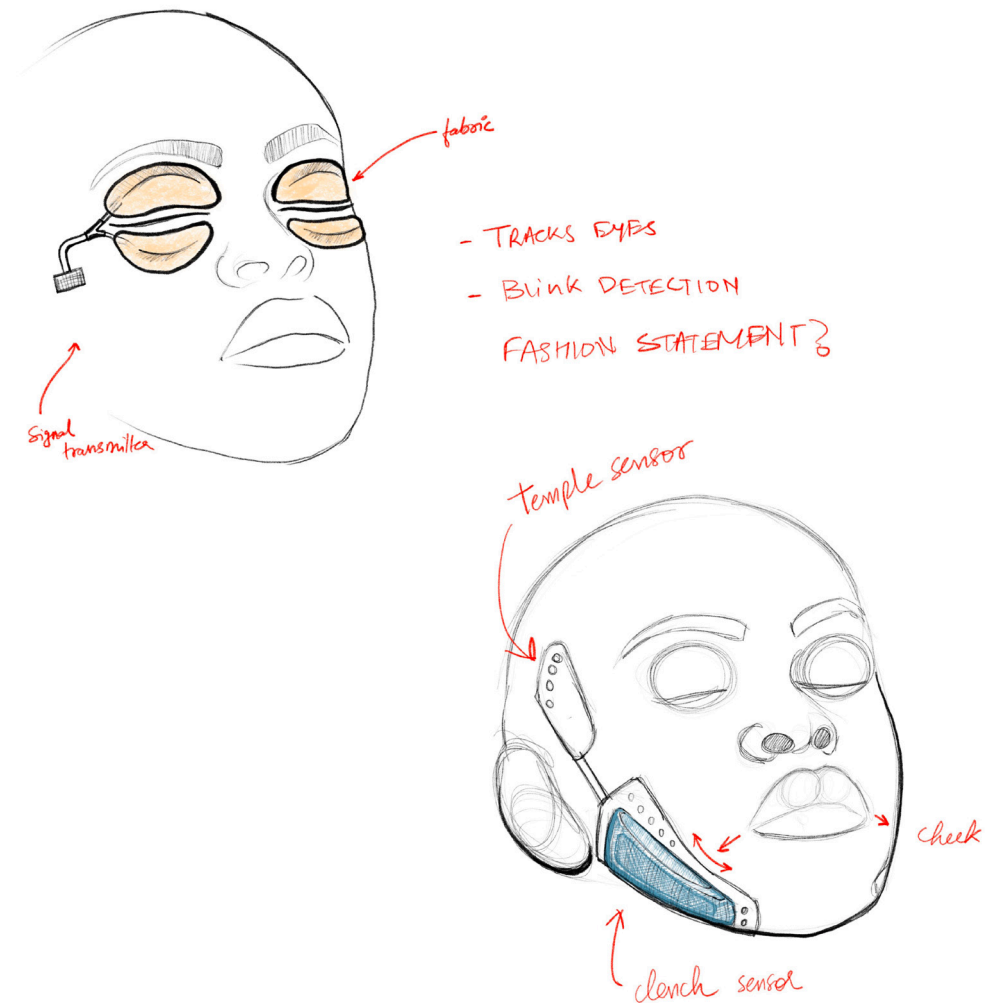
Combination of omnidirectional treadmill and touch pad

Ideations

Head and jaw controlled switches

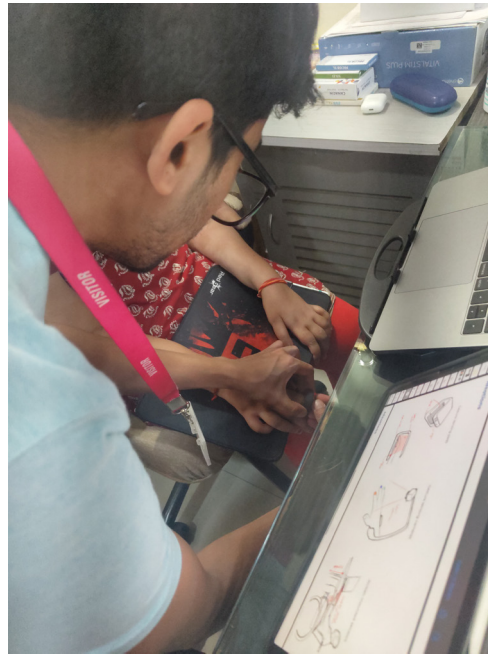


Eye and clench sensors_ Customizable



Ideation evaluation and critique

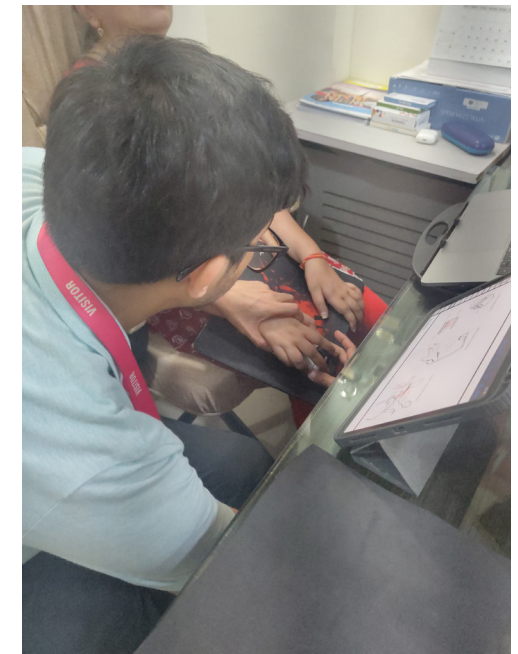
The ideations were tested and critiqued by doctors at Neurogen clinic and Dr. Hemangi Sane, who could give us valuable feedback and a usability perspective of patients at various stages of ALS.



Dr. Hemangi Sane trying out Ring mouse mockup at her clinic



Dr. Hemangi Sane trying out Ring mouse mockup at her clinic



Dr. Hemangi Sane trying out a 3D printed joystick

Ideation evaluation and critique

Assuming that durability, compatibility, accuracy and customization are constant, the ideations were evaluated on the following parameters -

Number of control sites

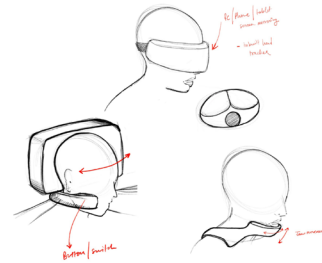
Stages

Efficiency / ease of use

Comfort

Inferences were derived, not to eliminate, but to further refine, improvise and merge ideations together to generate concepts.

Head control devices



Parameters

Number of control sites

1-2

Stages

1 2 3

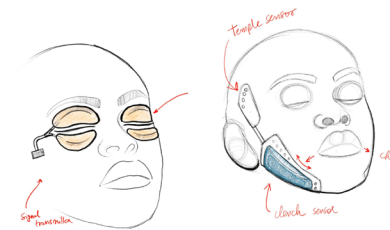
Efficiency / ease of use

1 2 3

Comfort

1 2 3

Skin sensors



Parameters

Number of control sites

1-2

Stages

1 2 3

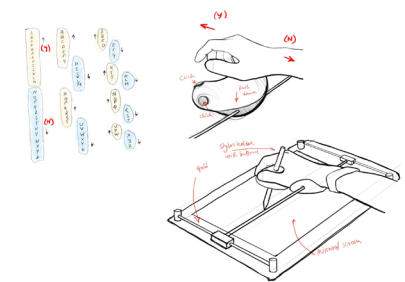
Efficiency / ease of use

1 2 3

Comfort

1 2 3

Hand glide devices



Parameters

Number of control sites

1

Stages

1 2 3

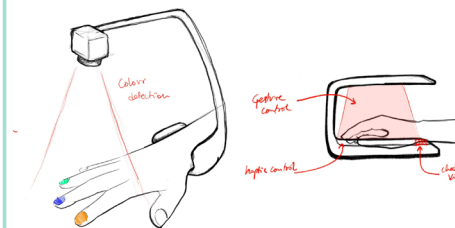
Efficiency / ease of use

1 2 3

Comfort

1 2 3

Gesture control devices



Parameters

Number of control sites

1

Stages

1 2 3

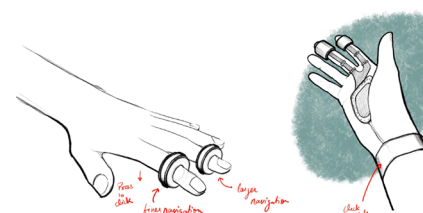
Efficiency / ease of use

1 2 3

Comfort

1 2 3

Ring mouse



Parameters

Number of control sites

1

Stages

1 2 3

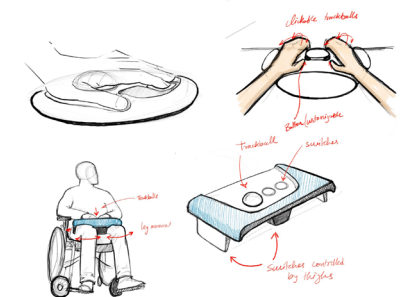
Efficiency / ease of use

1 2 3

Comfort

1 2 3

Hand held devices



Parameters

Number of control sites

2

Stages

1 2 3

Efficiency / ease of use

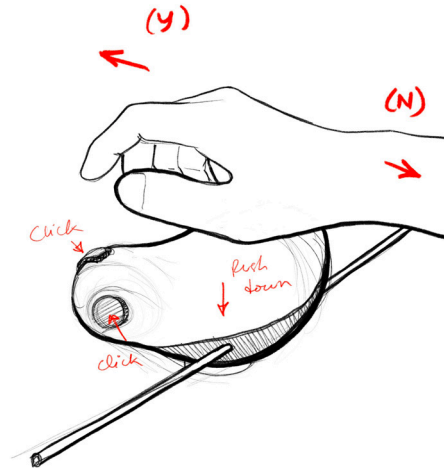
1 2 3

Comfort

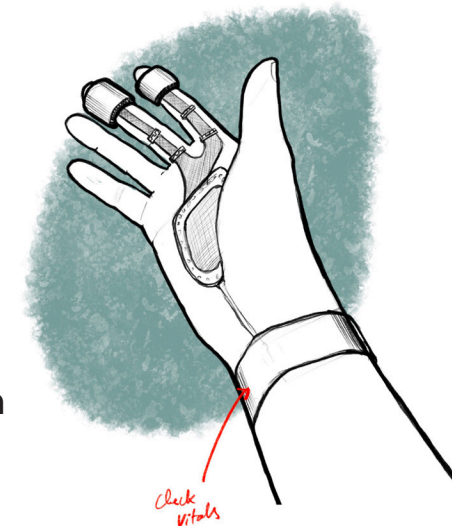
1 2 3

Inferences

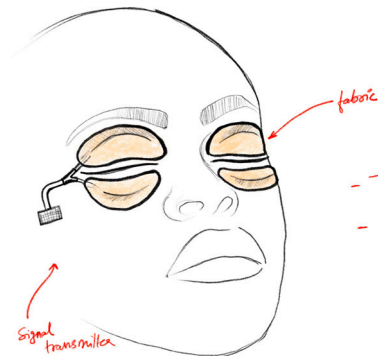
Hand glide and gesture control devices, although efficient, might require some fine motor movement



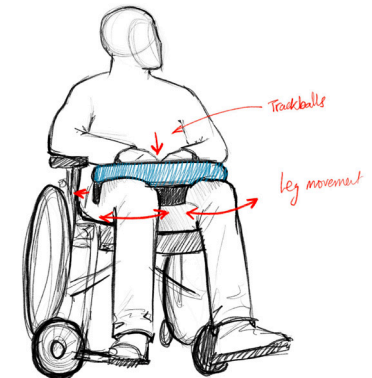
Ring mouse can be improved by incorporating multi directional navigation



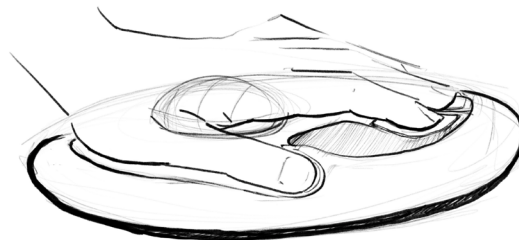
Wearable head mounted and skin devices are efficient but require getting used to and can be intrusive



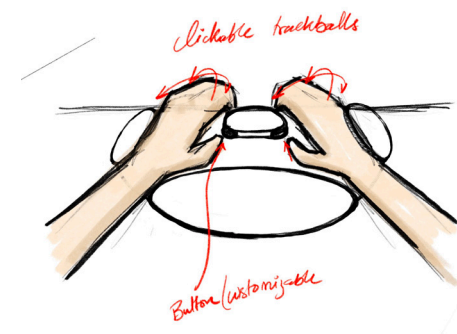
Thigh switches require more effort to operate and can be avoided



Skin sensing devices can be paired with a hand held controller for additional inputs instead of blinking



Hand held devices that require least amount of gripping are preferred



Grip and movement study

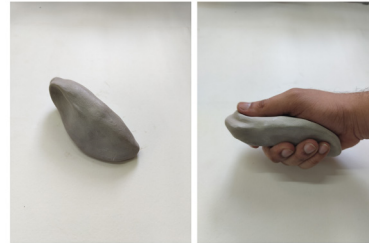
To understand how patients grip and move objects, they were asked to hold various clay models and apply pressure using different parts of their hand.

This also enabled to identify potential movements that can be used to navigate the cursor.

The patients were also asked to operate 3D printed devices and switches to understand their operation and identify scope of improvement.

It also helped to identify the shape, pressure requirements and location of Control elements.

Clay grip 1



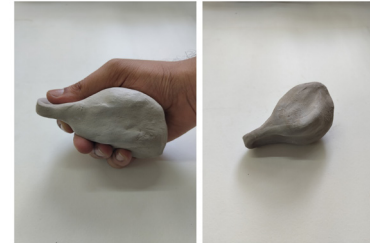
Observation

Does not require mouse pad or support

Difficult to grip

Focuses only on thumb

Clay grip 2

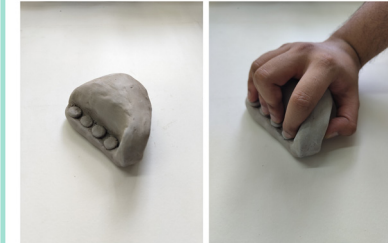


Observation

Difficult to grip

Finer movement with fingers is difficult to achieve

Clay grip 3

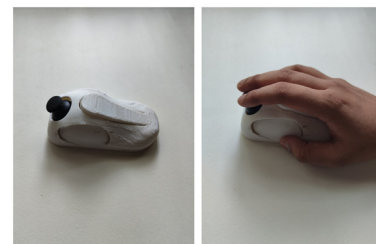


Observation

Difficult to press buttons with fingers

Thumb button difficult to use

Joystick



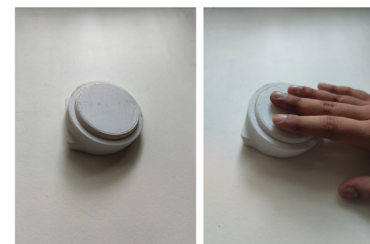
Observation

Difficult to move with fingers

Needs to be fixed to desk / mousepad

Side buttons difficult to access

Big switch



Observation

Easy to press with wrist

Needs to be fixed to avoid movement when being used

Grip and movement study

The exercise allowed me to observe and discover other movements that the patients can execute with ease and can be performed repeatedly without causing fatigue. Some of the potential movements that were identified and can be considered while designing are as follows:



Position: Palm facing down supported by a flat surface, fingers pointing towards the ground, resting out of the edge of the flat surface.

Action: Pressing a button using all fingers

Movement: gross motor skill



Position: Palm facing down resting on a big switch

Action: Pressing a button base of the palm and wrist

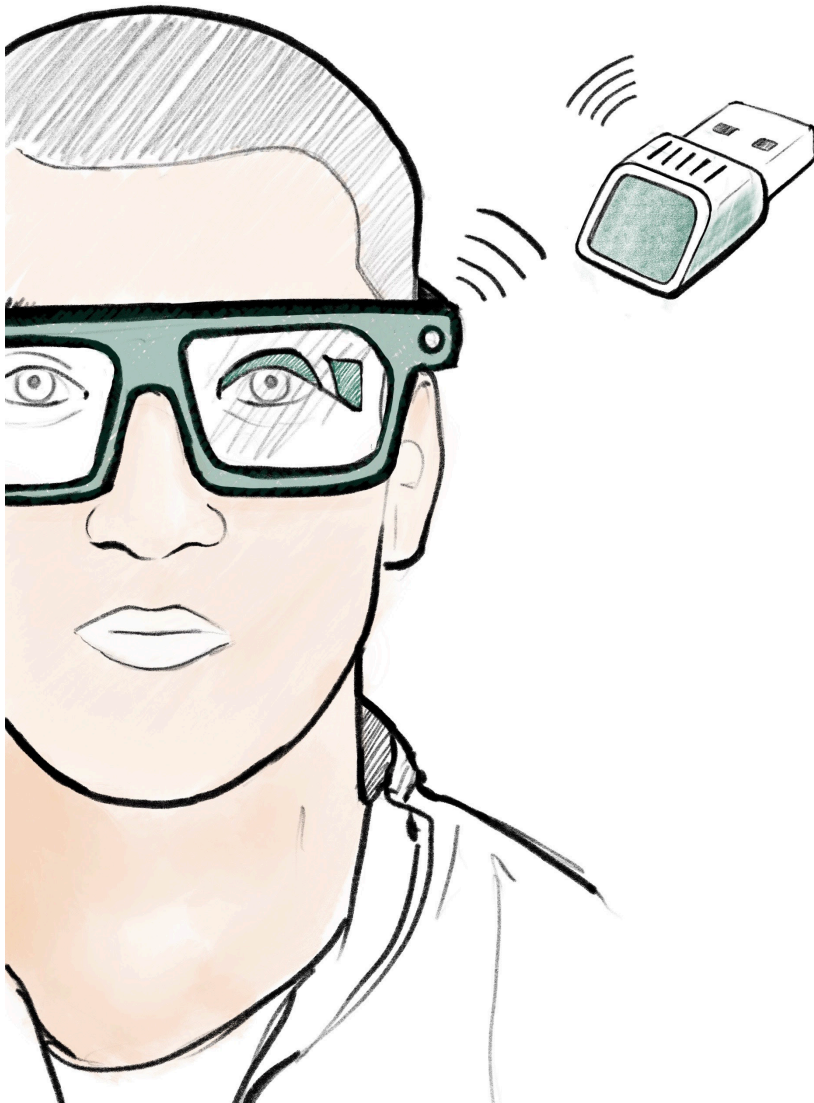
Movement: gross motor skill, use of body movement to exert pressure

Concepts

Based on the above study, three concepts were derived that aimed at reducing the movement required, being intuitive to use and reduced fatigue by repetitive motion.

Concept 1

Uses wearable skin technology and an additional hand held device.



Features:

Can be connected to PC using usb

Eye movement controls cursor navigation and other commands are given by hand held/wearable device

Wireless transmission of commands through frame of glasses

Wrist band displays battery percentage and also monitors fatigue and vitals

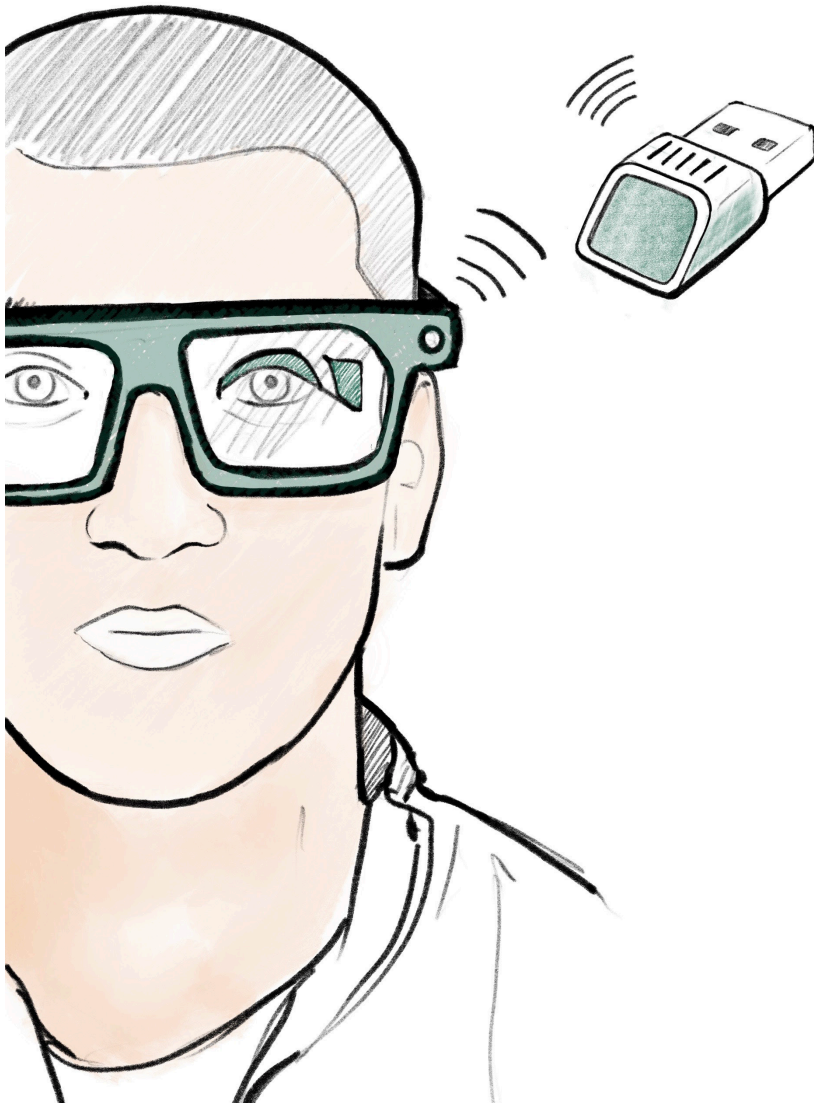
Wearable glove with control elements and wrist button

Additional buttons, fingerprint scanner provided where they are easily accessible



Concept 1

Evaluation



Pros

- Fine motor skills not required for cursor movement
- Combination of sensors and hand control elements provides more accuracy and reduces stress on hands

Cons

- Tedious and time consuming when applying on skin/eyelids
- Needs reconfiguration every-time devices are switched
- Tech needs to be developed
- The skin feels uncomfortable when performing expressions
- Feels intrusive
- Sweat / tears might affect its performance



Concept 2

A wearable device for fingers that uses a small trackball



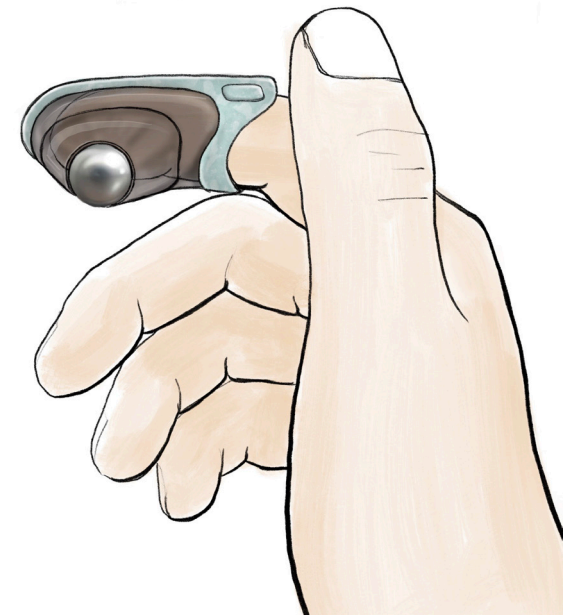
Features:

Multi-directional clickable trackball that can be controlled by fingers

Controls to change DPI and trigger SOS

Screen shows battery and time. Can be used to change settings

Can be worn on both hands to reduce stress on one hand



Concept 2

Evaluation

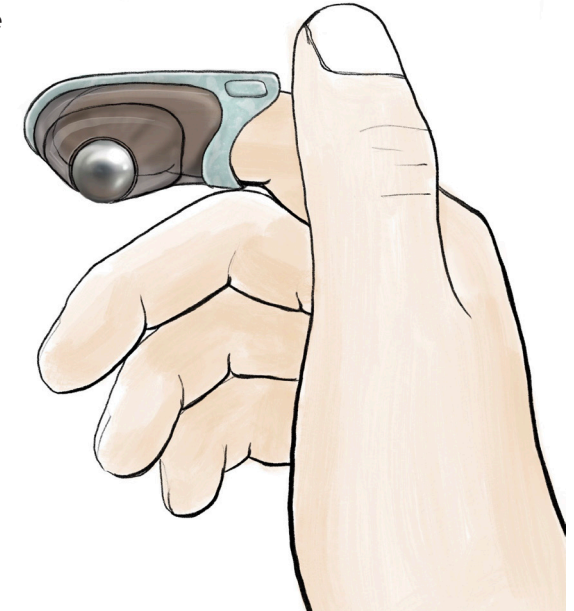


Pros:

- Minimal and un-intrusive
- Larger screen area covered with lesser movement
- Can be worn on any finger, as per patients ability
- Ambidextrous

Cons:

- Needs additional surface or mouse pad
- Some control elements might require fine motor skills
- Patients with tremors may find difficulty in using
- Less scope of adding more control elements and functions



Concept 3

A device that rests on the lap and supports hands in resting position.



Features:

Uses wrist pressure buttons

Clickable touch pad to navigate the cursor

Uses both hands to reduce stress on one hand

Can use memory foam to provide comfort and support

Uses gross motor skills to trigger control elements



Concept 3

Evaluation



Pros:

- Optimizes the usage of most easily achievable movements
- Comfortable arm resting position
- Lots of scope for customization
- Intuitive interface
- Ambidextrous

Cons:

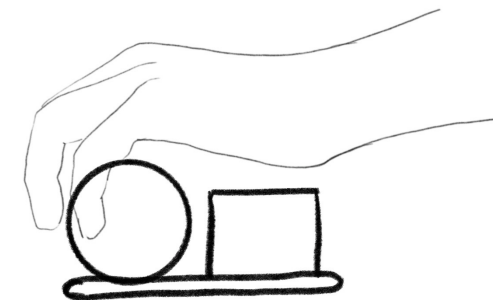
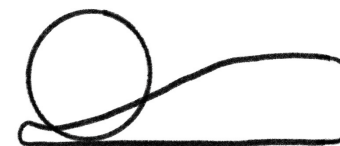
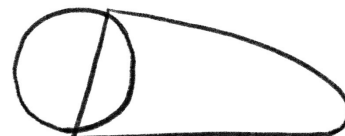
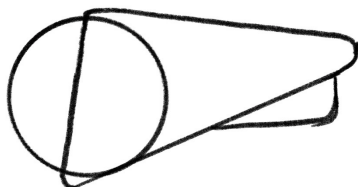
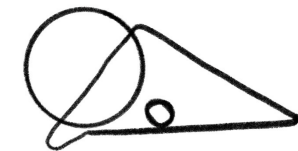
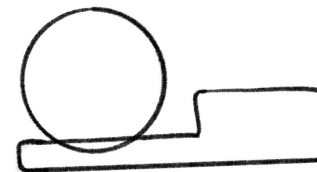
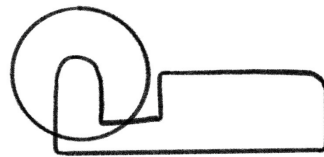
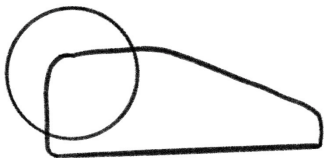
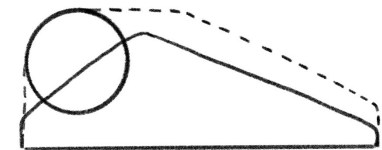
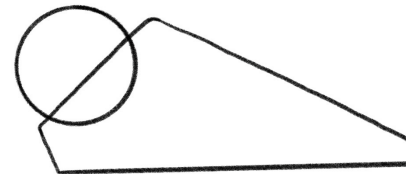
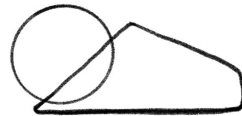
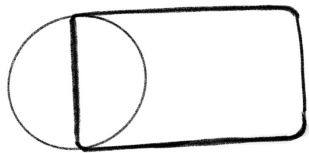
- Touchpad might not work for all patients
- Might cause fatigue in wrist because of the angle



Final concept

Formal exploration

The initial formal exploration looked at different arrangements of a trackball and wrist support, in order to achieve the most comfortable hand position.



Sacrificial mockups

The term 'Sacrificial Concepts' was created by IDEO, which is a practice in user research to build deep empathy about a specific group of people. Building deep empathy is a critical part of this practice in the case we need to gain insight about the people we are designing for. Sacrificial concepts are especially useful for people we don't know much about.

In this process of discovering and defining the people we don't know much about, I came up with concepts that weren't necessarily viable or feasible, and moved on to the next concept without spending a lot of time on the concept itself.

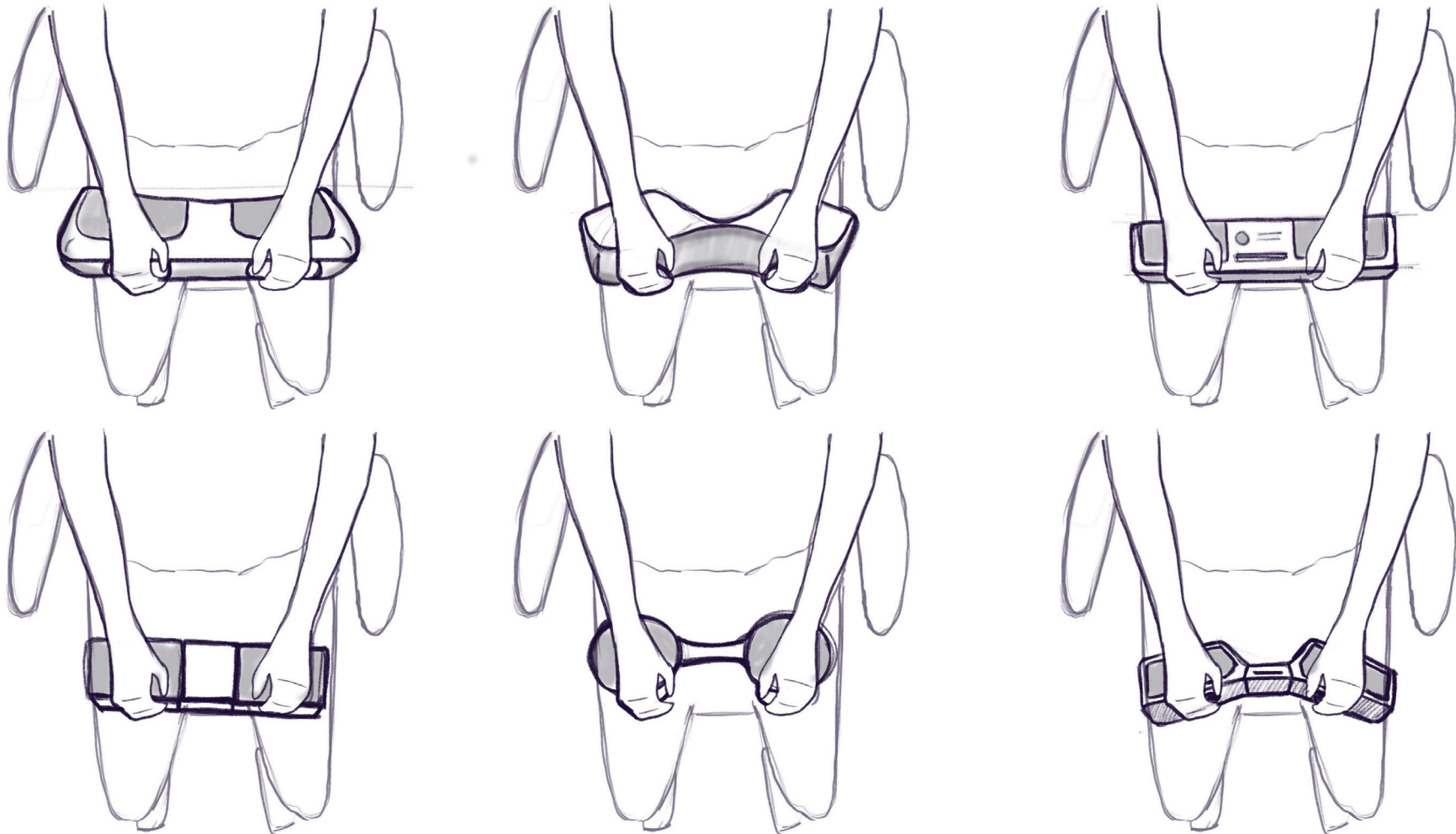
The concept is just available just to understand user's thoughts and behavior and is not to be taken literally or for the user to be consumed by it.

The purpose of this exercise was to understand a group of people and create conversation among users [3]

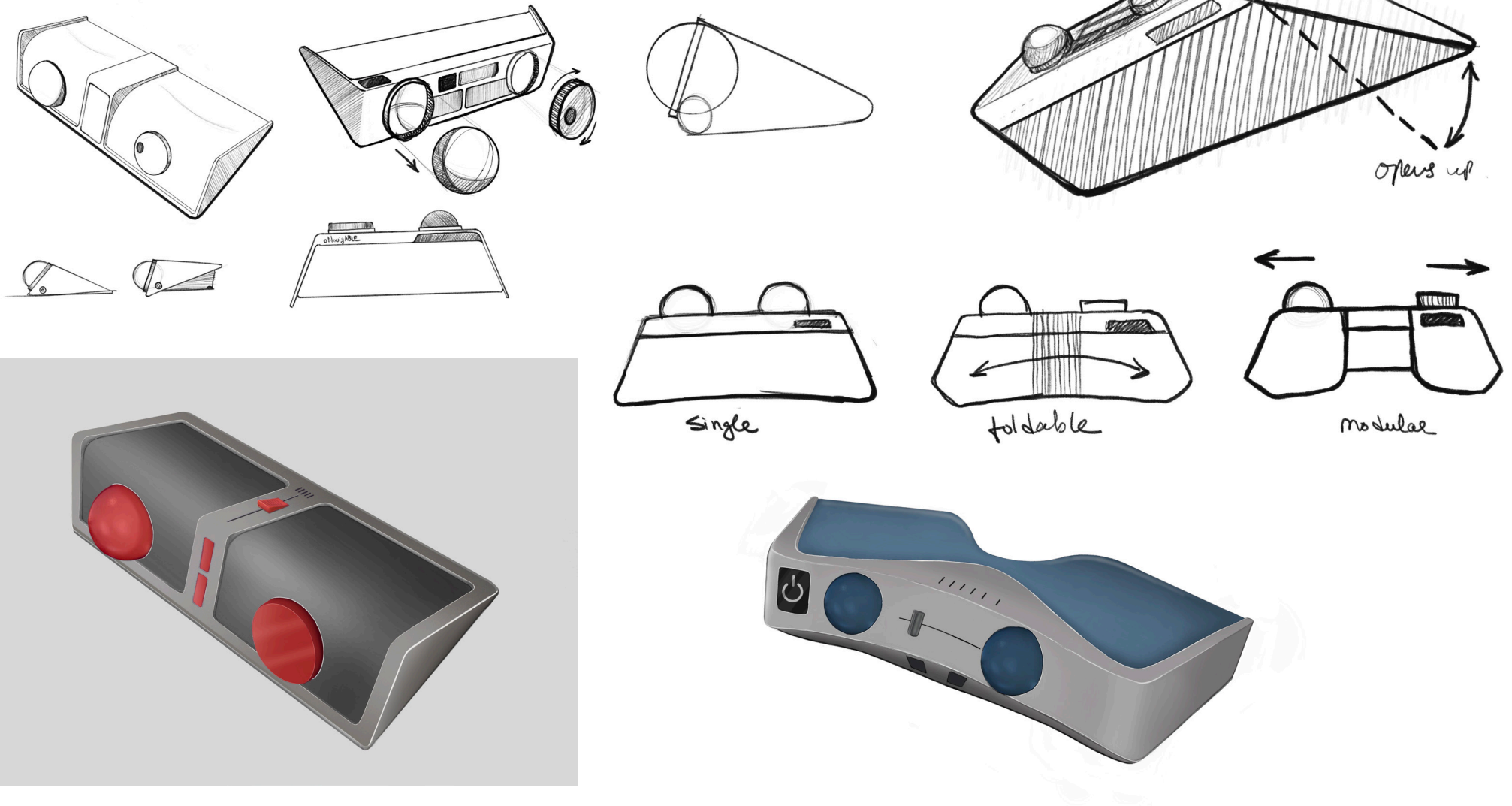


Form generation

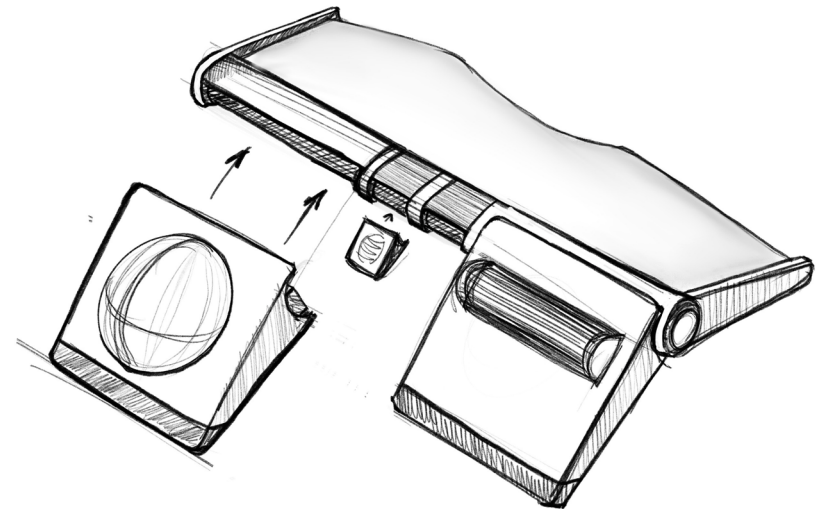
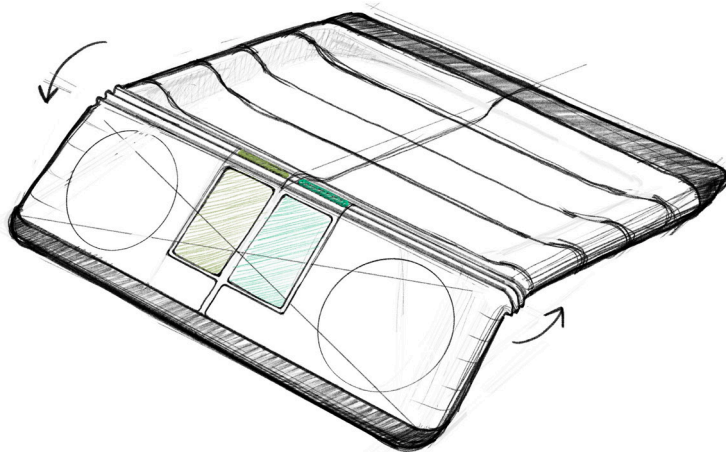
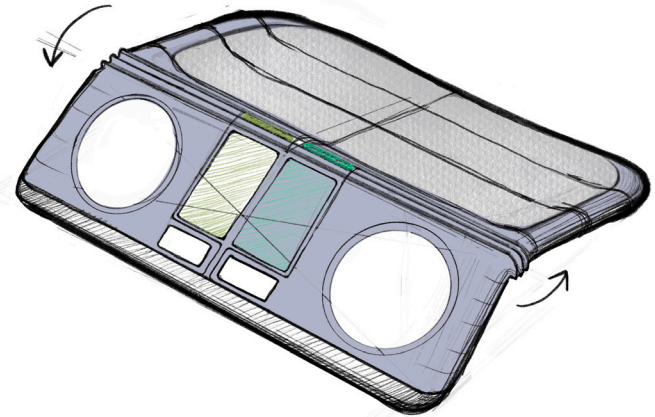
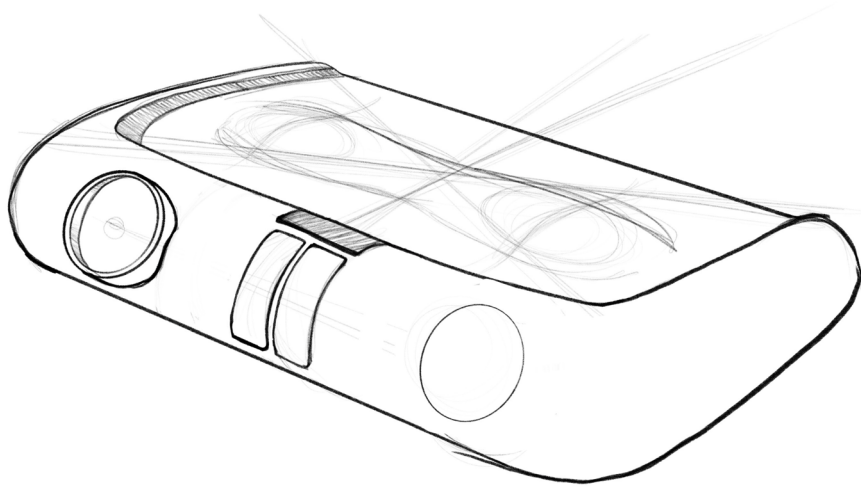
The above exploration was translated to derive the form of a controller that rests on the lap and can be operated by both the hands.



Form generation

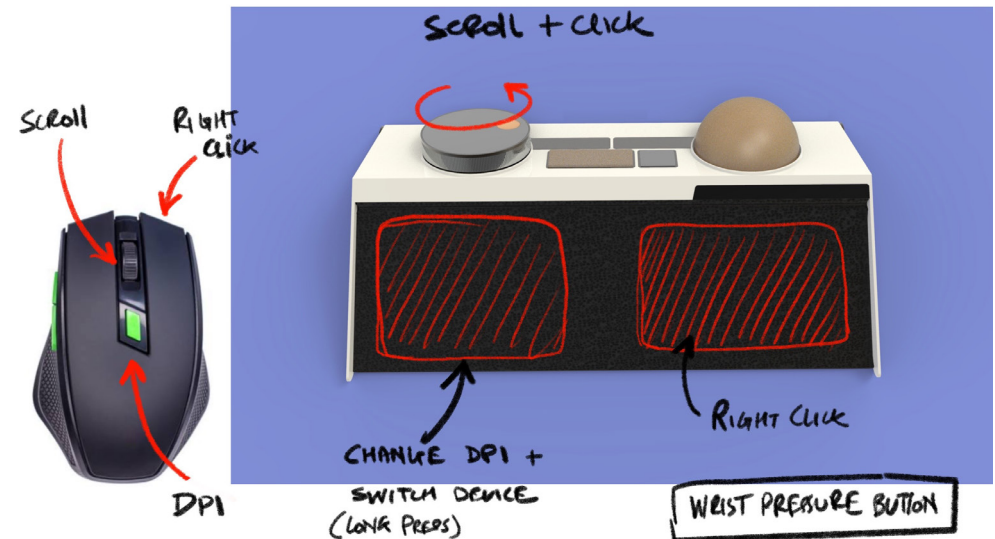
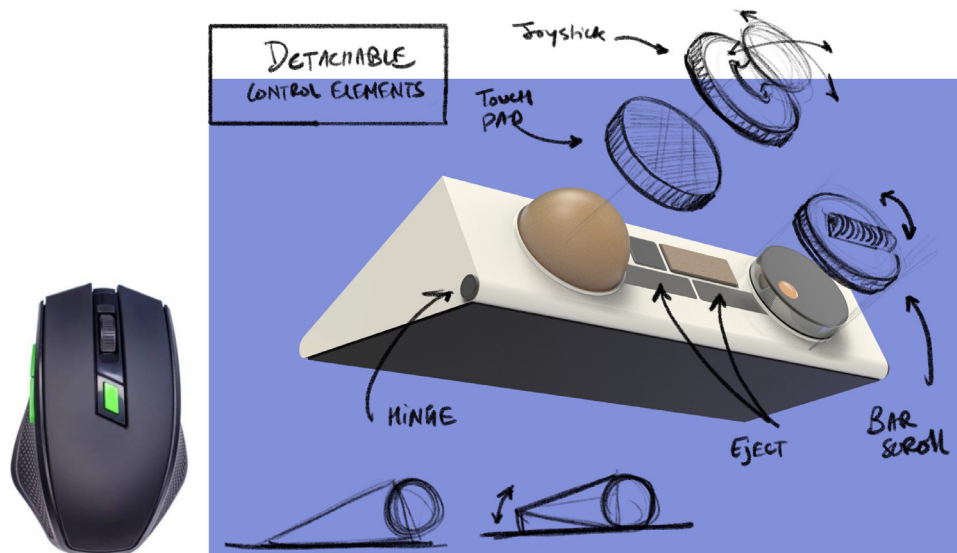
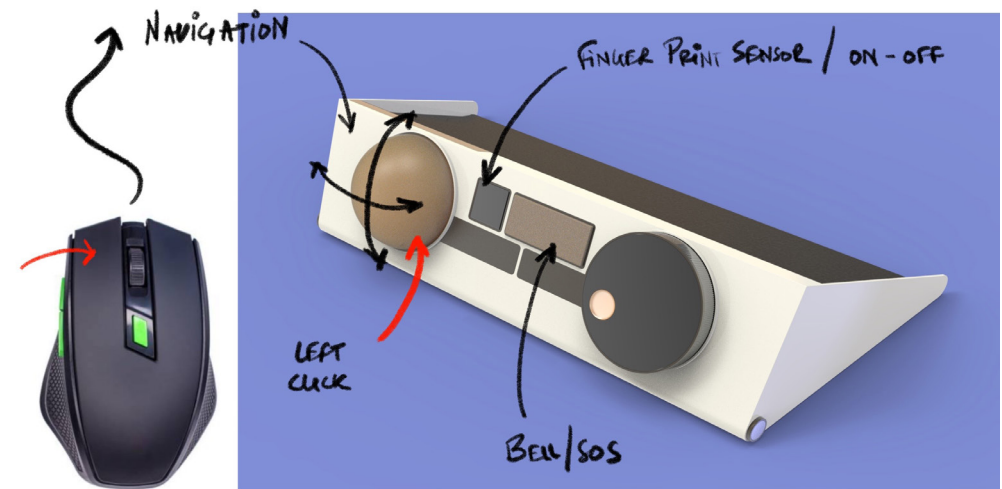


Form generation



Interface design

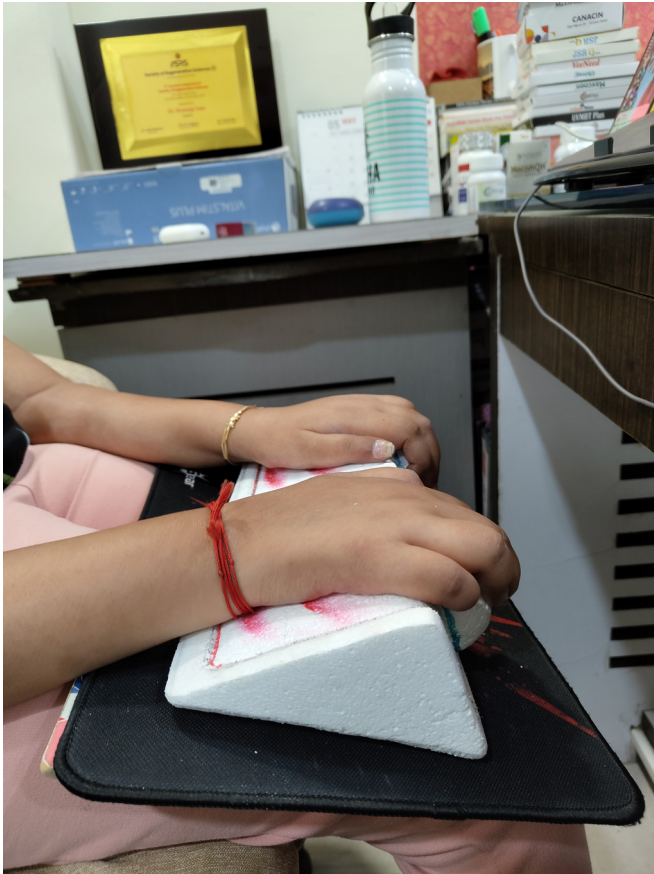
For the sake of testing, all functions of a standard mouse and additional features like Call button and DPI change button were located on the mockups. There were other considerations made like height adjustment, modular attachments and combination of keys provide a better user experience. It also allowed customization that fits needs of all users.



User Testing

There were several mockups made with varying control elements were tested and critiqued by doctors and patients a Neurogen.

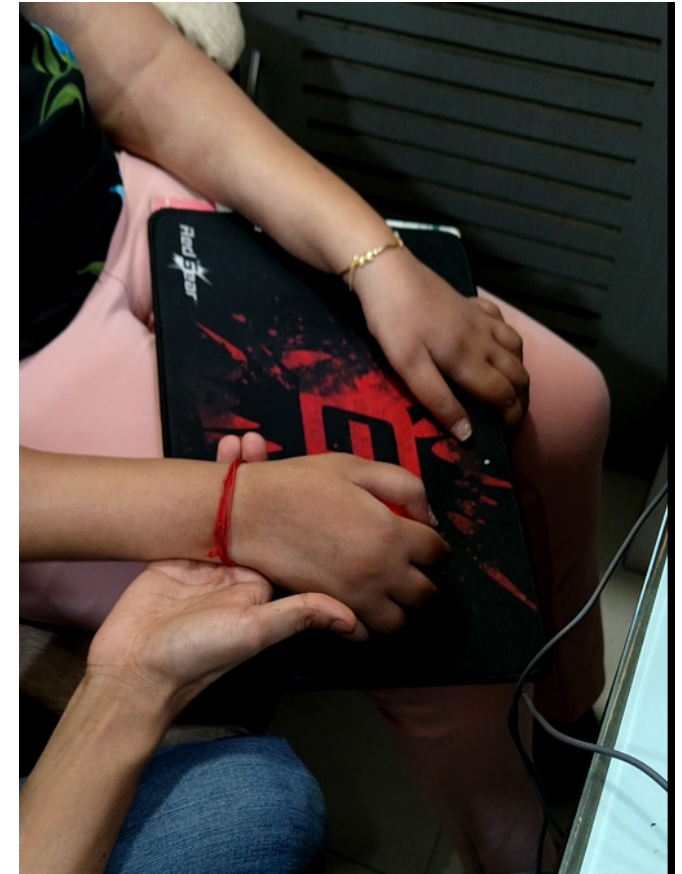
These tests allowed me to refine the product interface.



Testing of mockup with trackball at the clinic



Testing of mockup with Scroll bar at the clinic

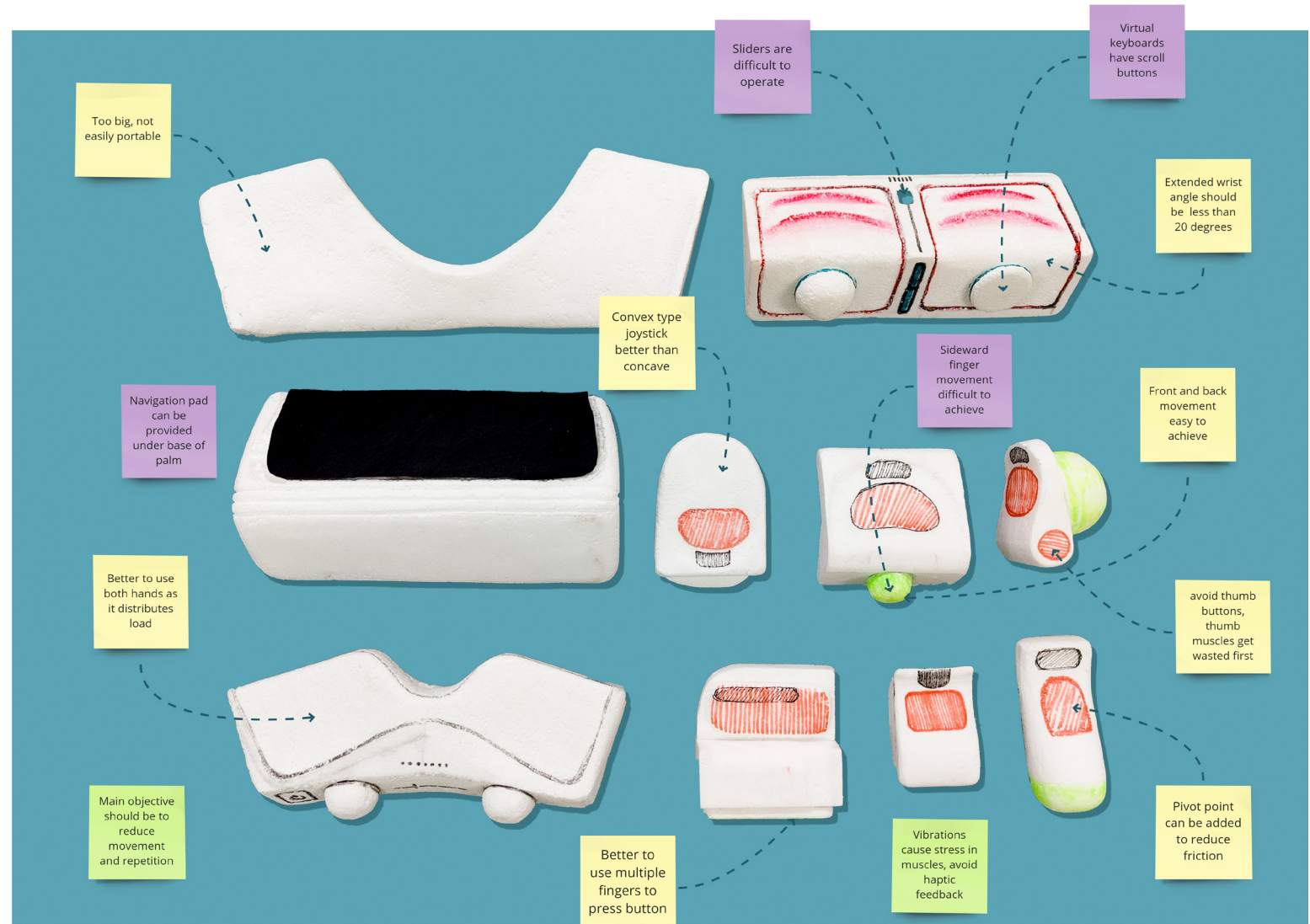


We also tried placing a ball under the patients hand to observe the movements

Concept evaluation

The mockups were again critiqued and tested by the doctors, therapists and patients at Neurogen. Their comments, advices and critiques are shown in the image on the right.

- Critique
- Suggestion
- Inferences



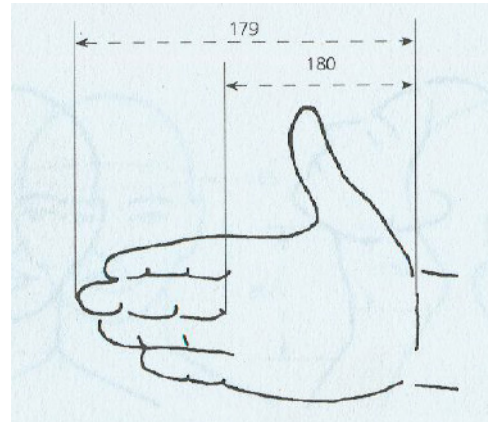
Comments and suggestions received from patients and doctors at Neurogen clinic

Ergonomics

Ergonomics plays a vital role in the design of assistive devices by focusing on user comfort, accessibility, and optimal functionality. By considering factors such as body posture, joint alignment, and customization options, ergonomics ensures that assistive devices are comfortable and suitable for individuals with diverse needs and abilities. Ergonomic design enhances usability, promotes user independence, and reduces the risk of musculoskeletal injuries. By prioritizing user safety, efficiency, and satisfaction, ergonomics facilitates the development of assistive devices that improve the overall well-being and quality of life for individuals with disabilities or limitations.

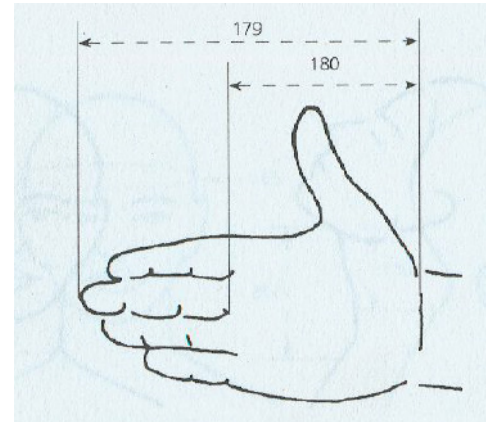
For this project, dimensional range of 5th to 95th percentile of Indian combined adult population was considered. This ensures that the product is an ergonomic fit for a wide range of patients.

179 Hand length in mm



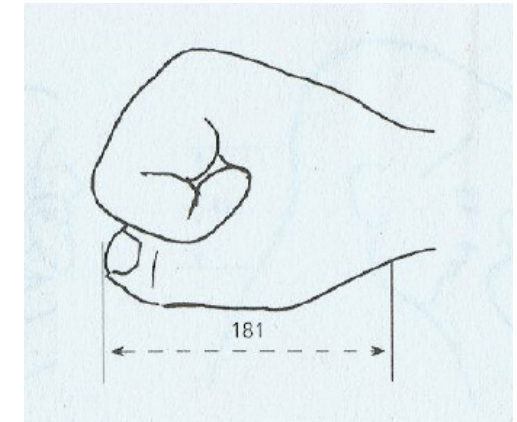
5th percentile - 158
95th percentile - 197

180 Palm length in mm



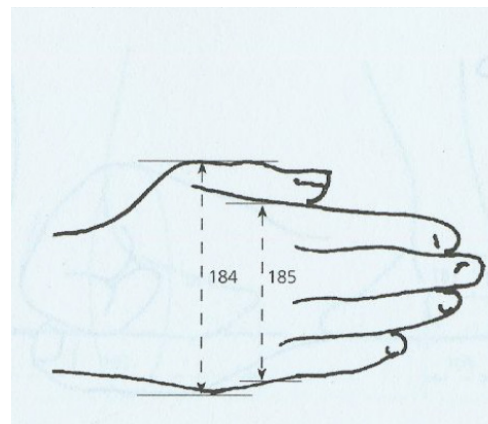
5th percentile - 89
95th percentile - 114

181 Fist length in mm



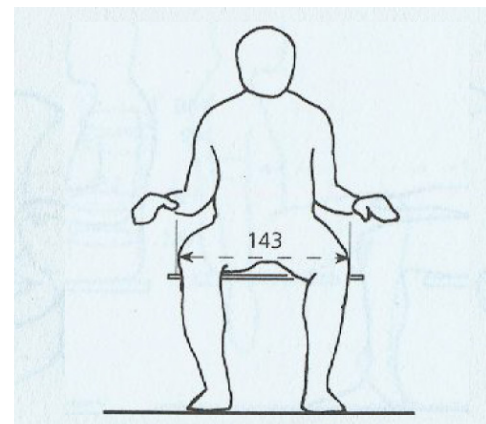
5th percentile - 81
95th percentile - 115

184 Hand breadth with thumb in mm



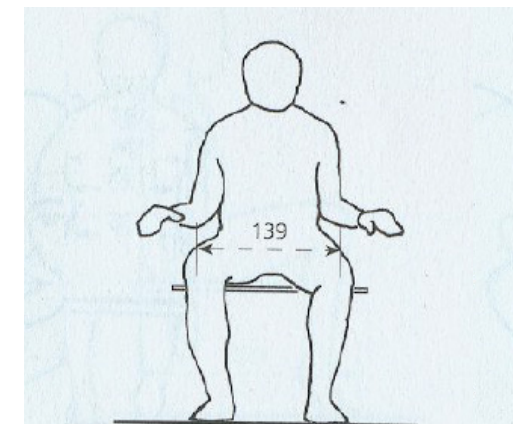
5th percentile - 81
95th percentile - 109

143 Knee to knee relaxed in mm



5th percentile - 252
95th percentile - 529

139 Mid thigh to thigh breadth in mm



5th percentile - 252
95th percentile - 479

Mockup for testing

Based on the tests conducted at the clinic, a new mockup was made with navigation joystick under the wrist. It was made as per the ergonomic data for 5th percentile and 5th percentile of Indian Population.

The device has 5 control elements, based on the most easily achievable movement by the patients. In order to establish the default settings and functions of the control elements, this mockup was given to multiple

people and they were asked to assign functions to the 5 control elements. The result was then used to assign default functions.

List of functions:

Left click, right click, bell/call, back, change DPI, on/off and bluetooth connectivity.



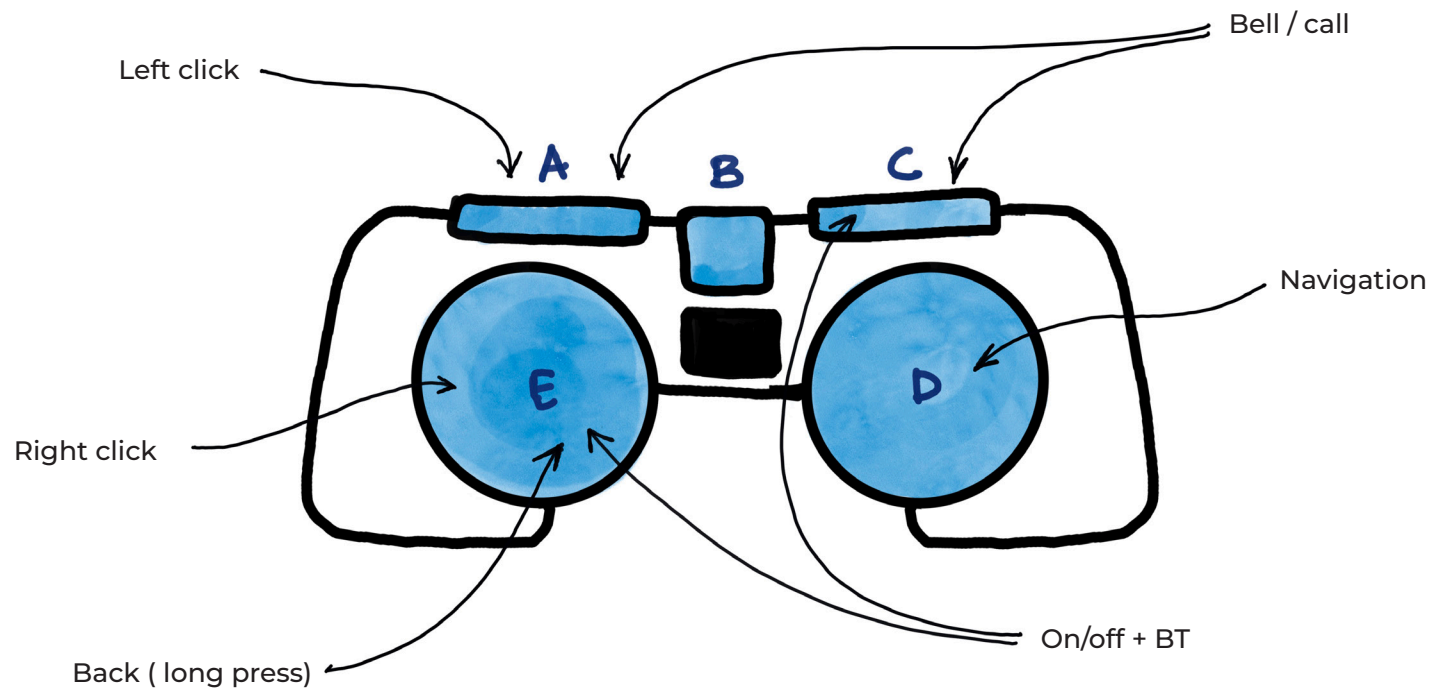
Mockup made for ergonomics and product interface testing



Roleplaying to test ergonomics and define product interface

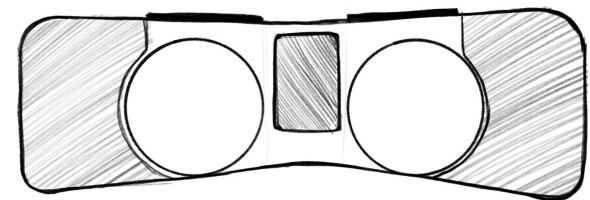
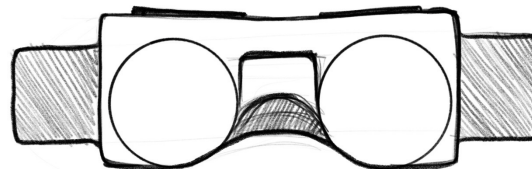
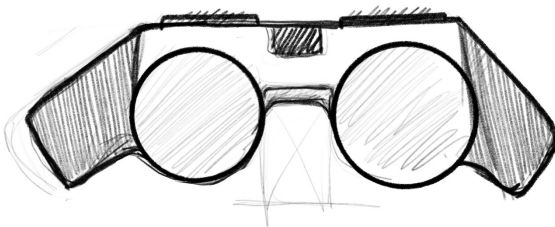
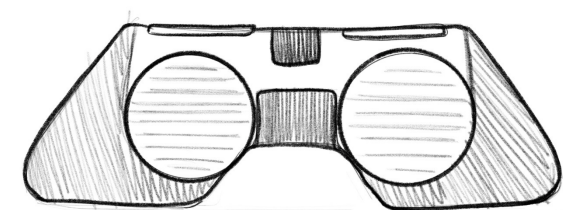
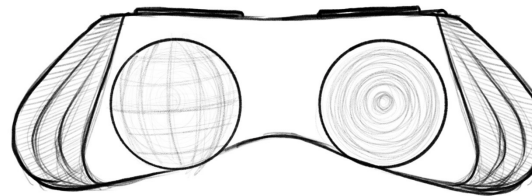
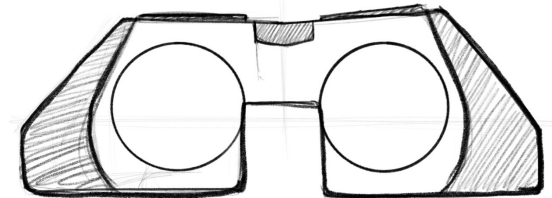
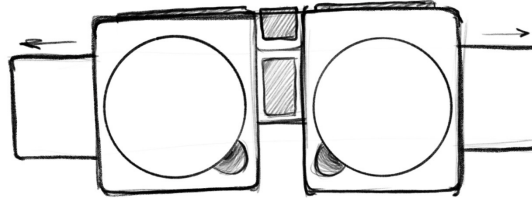
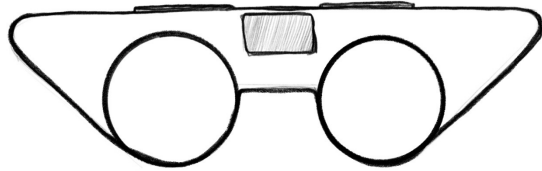
Product Interface

Functions	User1	User2	User3	User4	User5	User6	User7	User8	User9	User10	Final
Left click	A	A	E (2 buttons)	A	A	A	A	A	A	A	A
Right click	D	E	E (2 buttons)	C	C	E	E	C	C	E	E
Bell / call	A + C	C (L)	C (L)	E (L)	A + C (L)	C (L)	A + C (L)	C (L)	A + C (L)	A + C (L)	A + C (L)
Back	E	D	A	E	E (L)	D	D	E	E (L)	E (L)	E (L)
Dpi	D (L)	Screen	Screen	Screen	Screen	D (L)	Screen	Screen	Screen	D (L)	Screen
On/off + BT	B	C	B	B	E + C	E + C	E + C	B	E + C	E + C	E + C

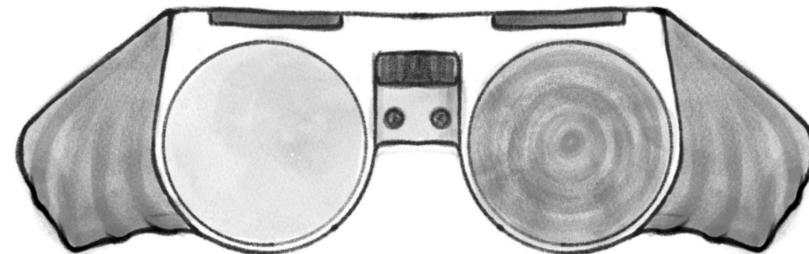
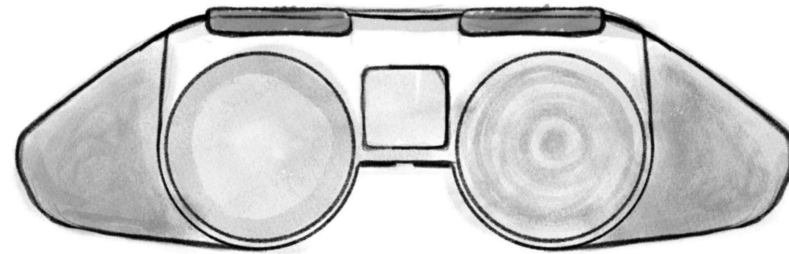
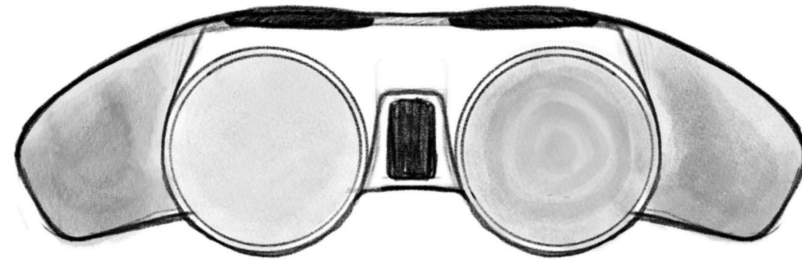
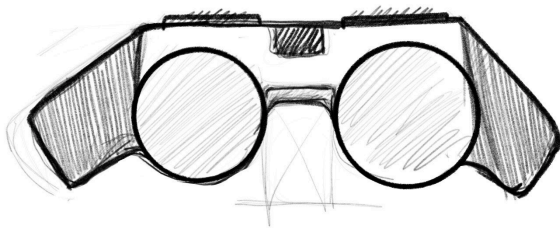
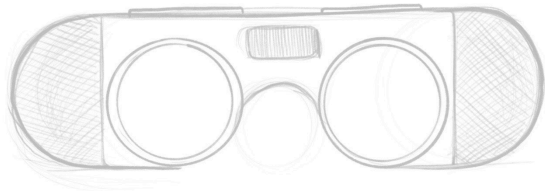


Default control element functions as per the reviews received

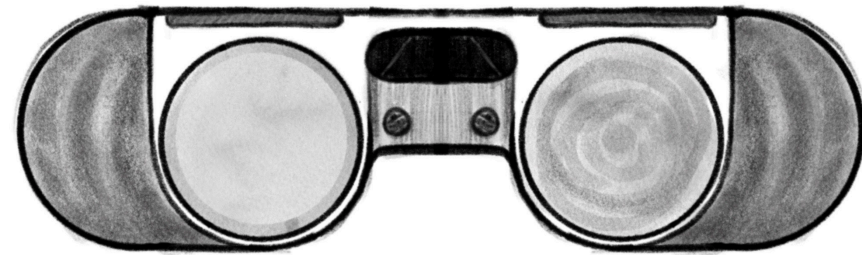
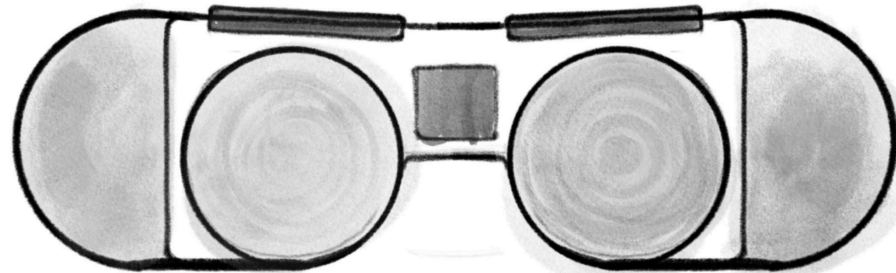
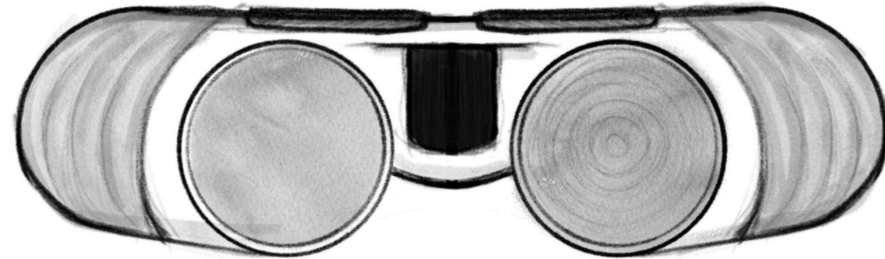
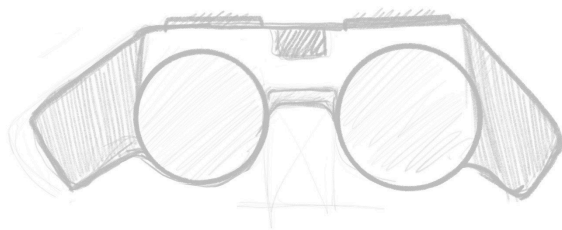
Form refinement



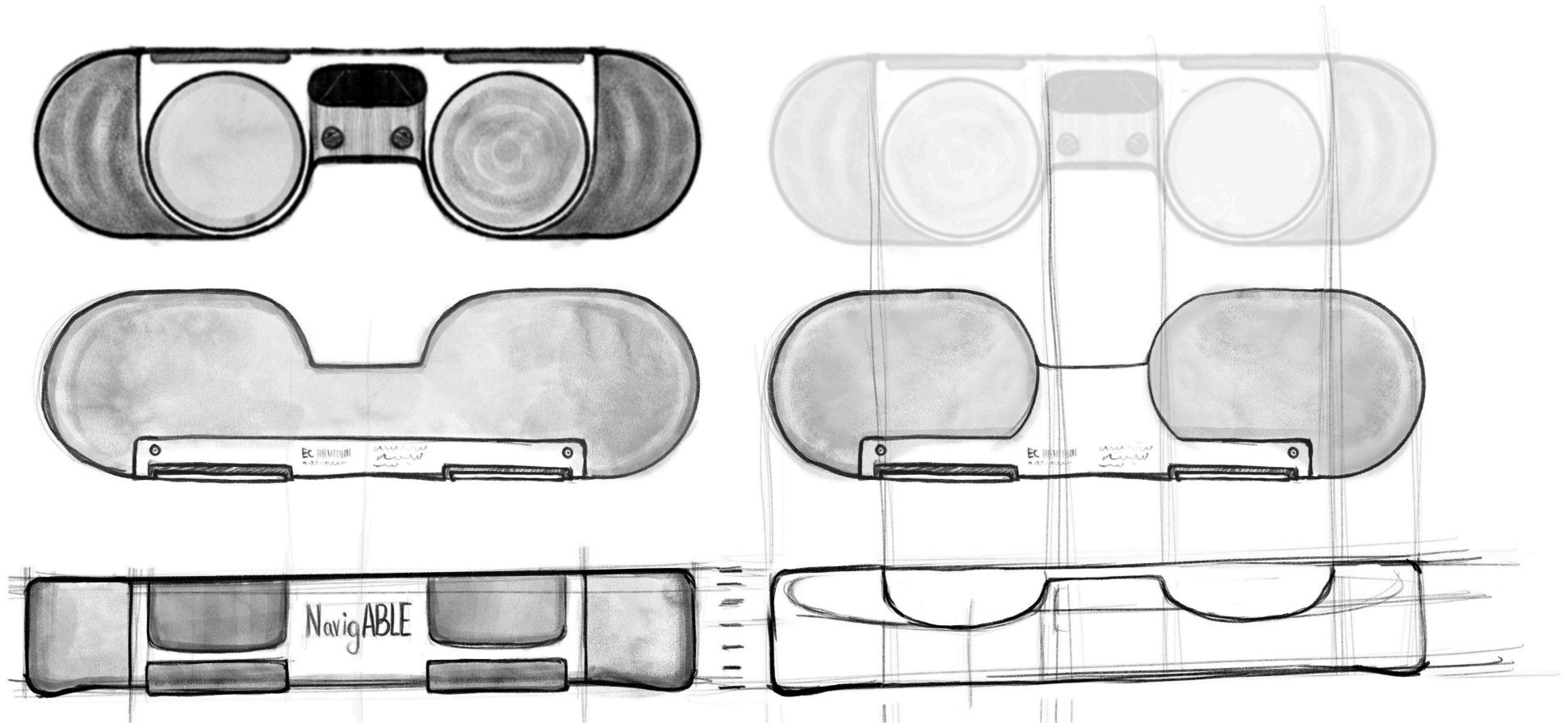
Form refinement



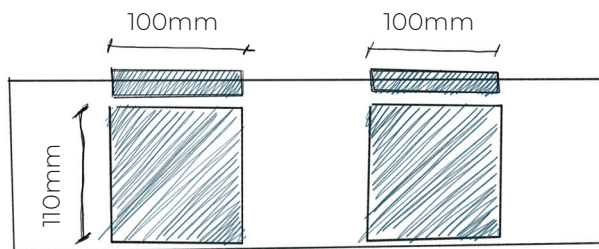
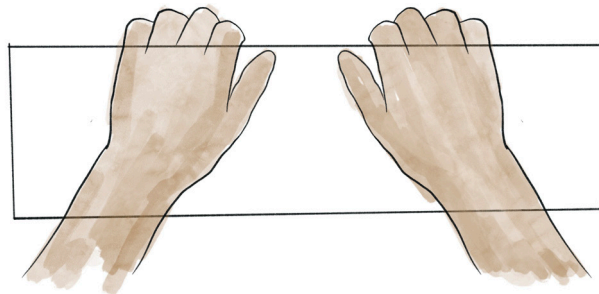
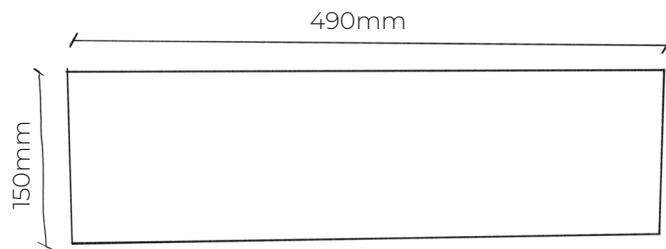
Form refinement



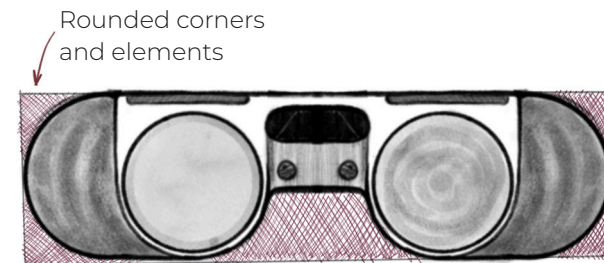
Final Form



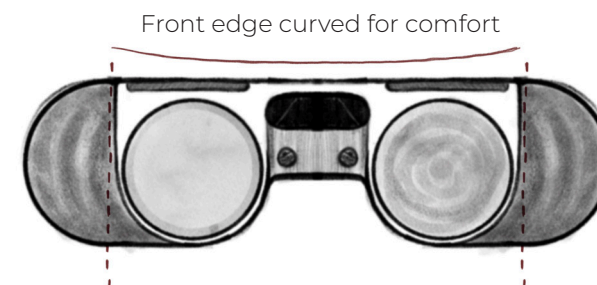
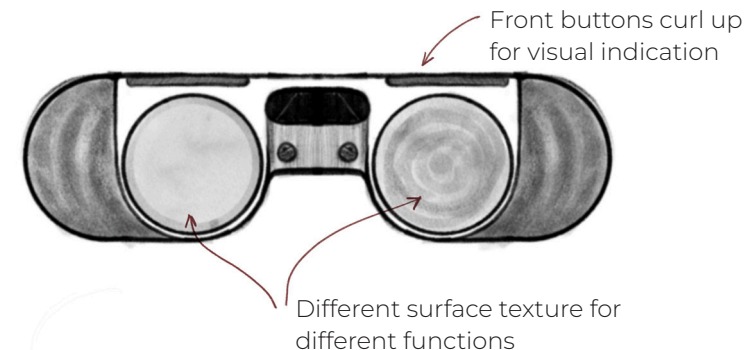
Form derivation and dimensions



Demarcating trigger zones as per position of hands



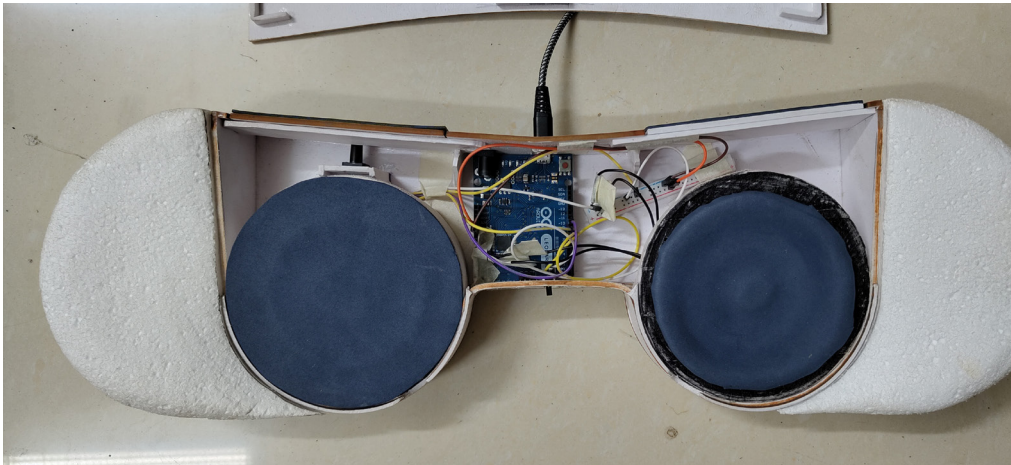
Creating voids
Major surface area resting on thighs
Easy to hold
Material reduction



Stark material and colour difference to differentiate work and rest

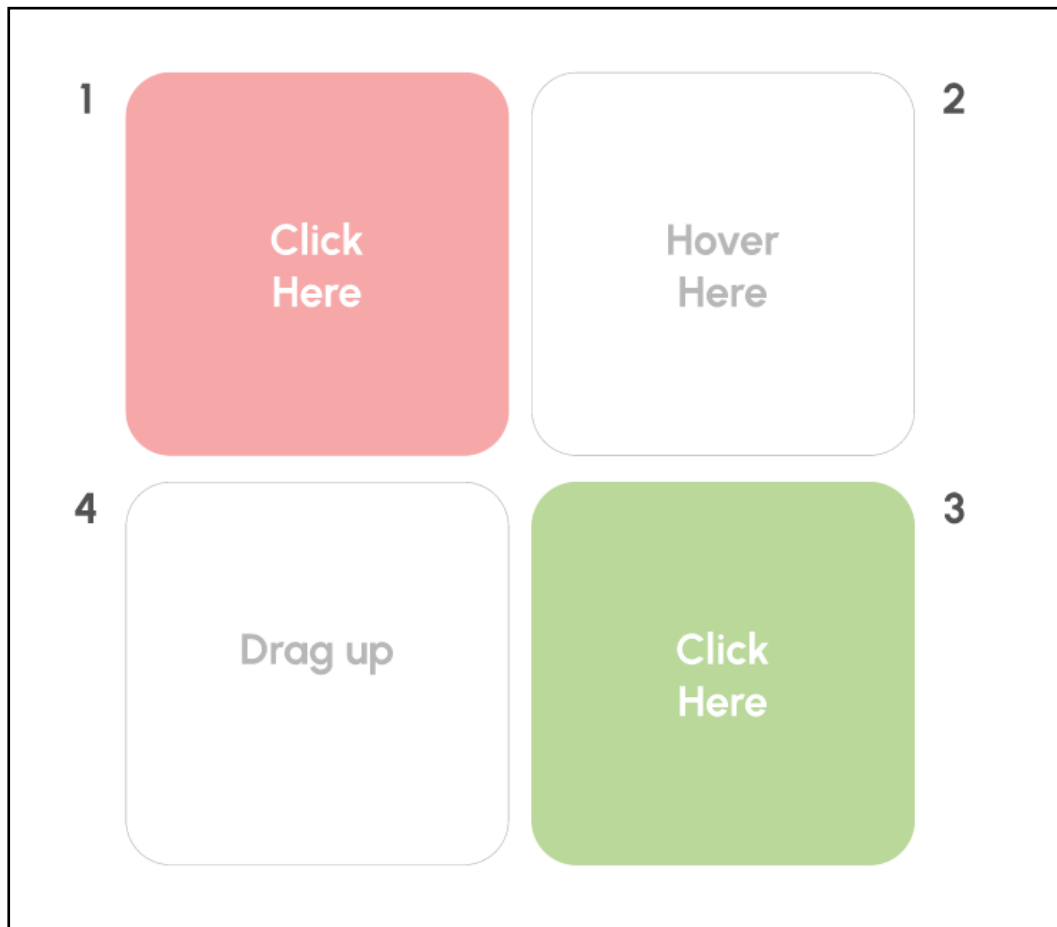
Working rig

Based on the tests conducted at the clinic, a new mockup was made with navigation joystick under the wrist. It was made as per the ergonomic data for 5th percentile and 5th percentile of Indian Population.



User testing

A test was created on Figma, that tracked the cursor movements and clicks. This helped to test if the patient could execute all functions of a regular mouse with the new device. It tested the patients ability to move the cursor freely in all directions and trigger clicks with less efforts and fatigue.



Layout of the test



Confirmation screens after executing the commands

User testing

The working rig was tested by Dr. Hemangi Sane at Neurogen clinic



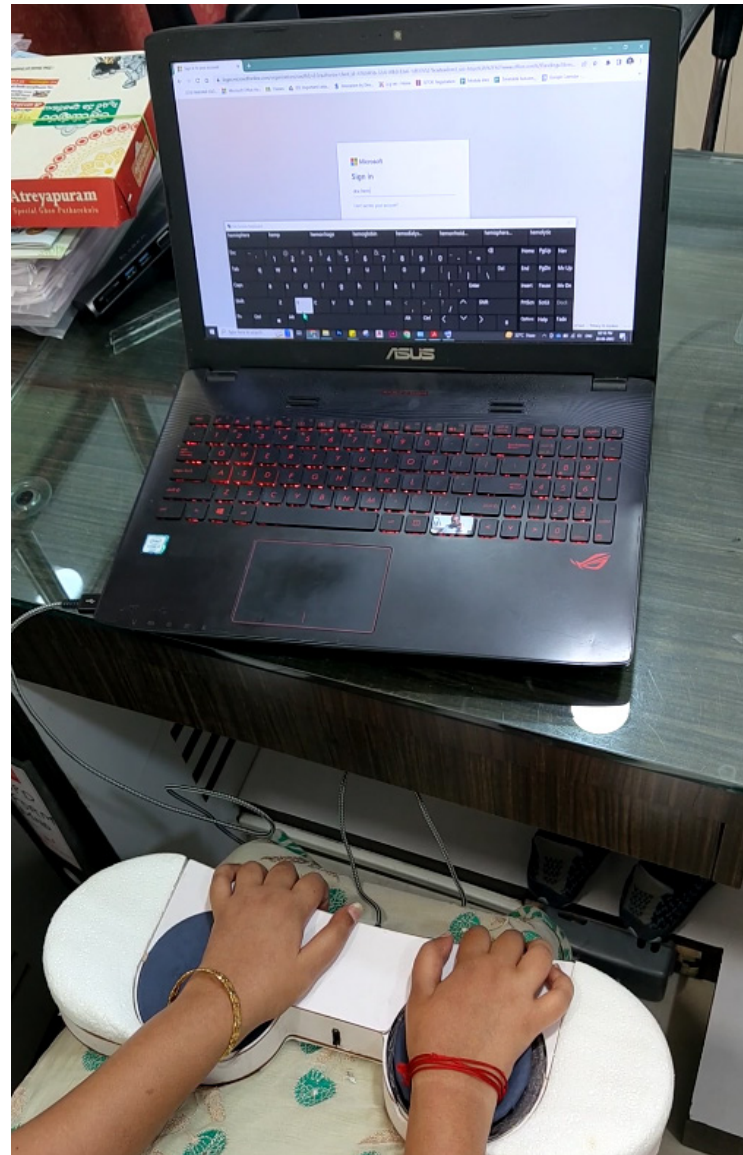
Dr. Hemangi Sane's assistant Latika ma'am helped set up the device for testing at Neurogen clinic



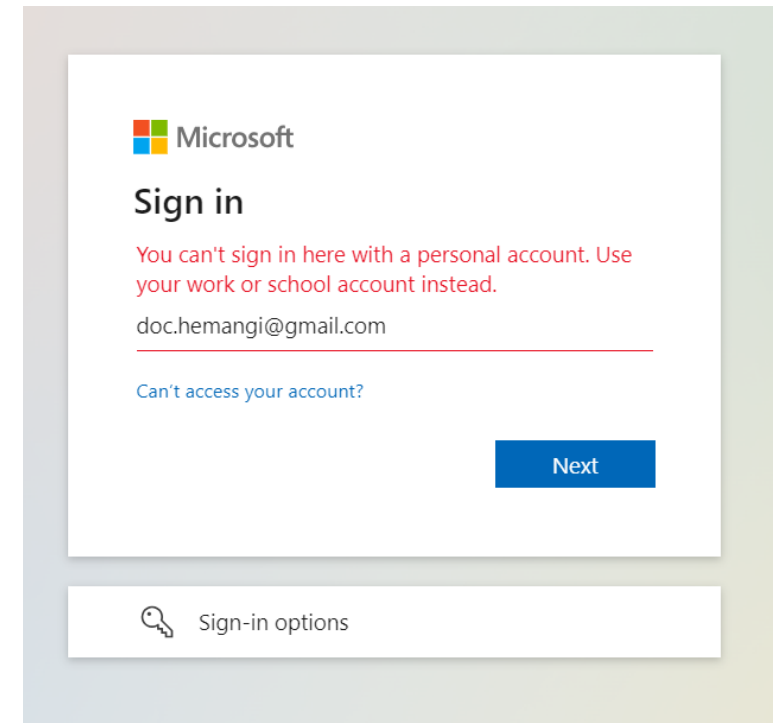
Dr. Hemangi Sane trying out the rig. [Click to see the video](#)

User testing

As an additional test, Dr. Sane also used the rig to type on a virtual keyboard to insert her email ID.



Click to see the video



Pros and cons

Following are the Pros and Cons as mentioned by Dr. Sane after testing the rig.

Pros

Sits properly on the lap with both hands comfortably placed in resting position

Buttons under the wrist can be comfortably used

Joystick enables navigation in all directions

Well spaced and sized buttons

Many combinations can be used for different functions

Undo button is very helpful

Can be used by many people with minimum fine motor skills

Prevents sweating

Uses weight of the hand for movement

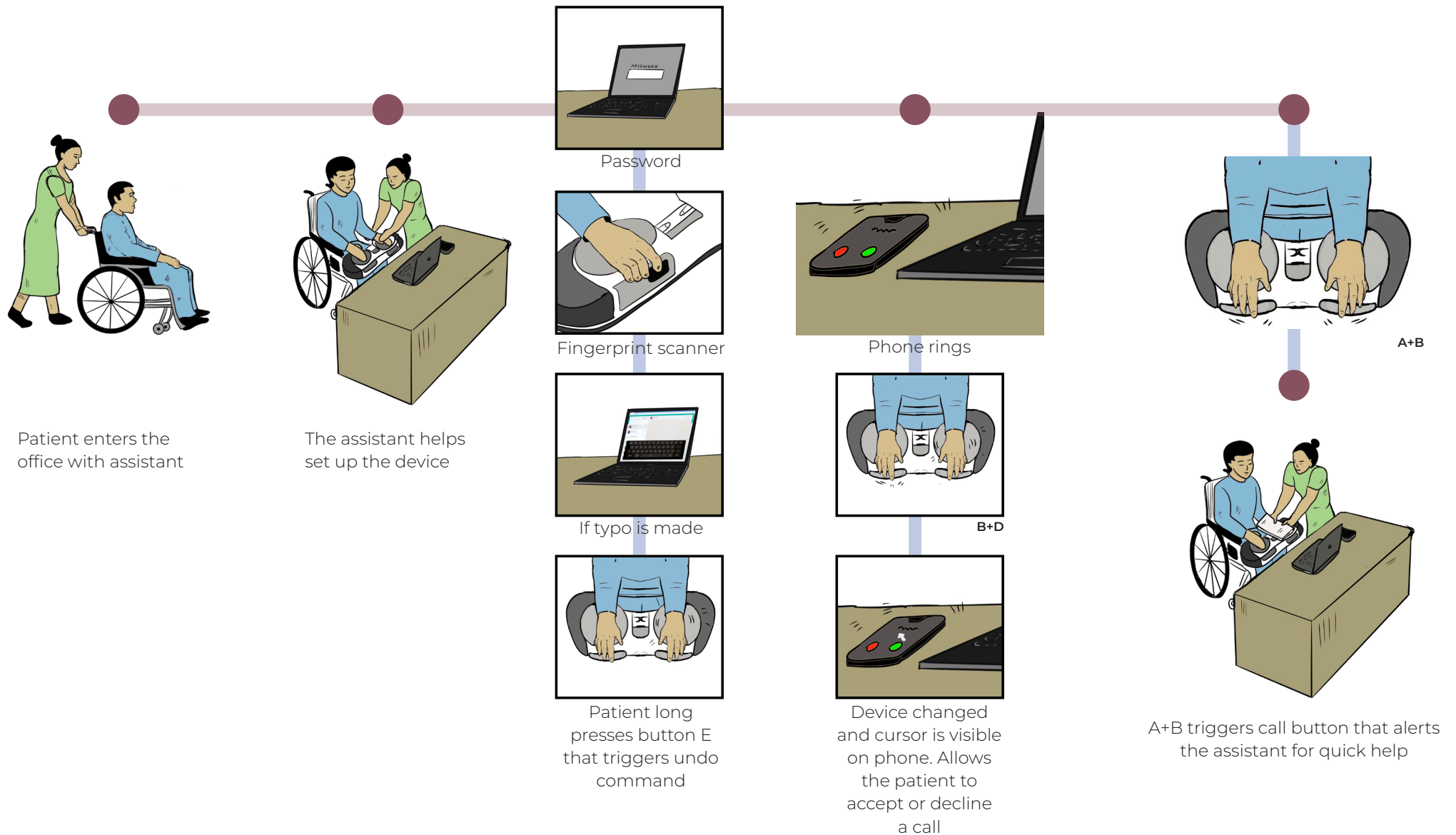
Cons

Alternative option can be added where cursor moves in real time

Buttons can be more easily pressable

Requires training

User scenario



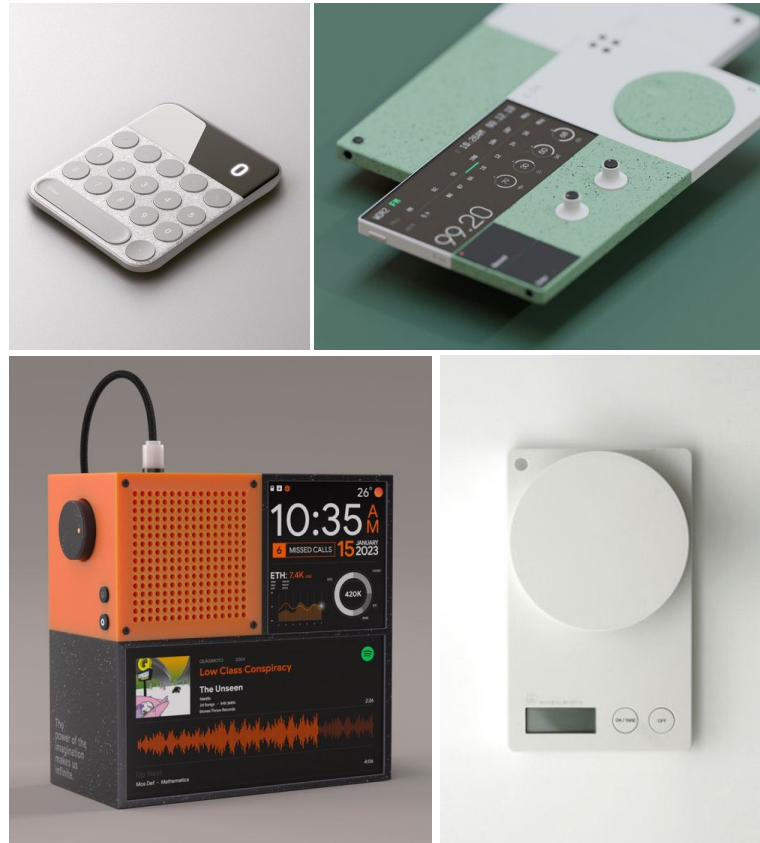
Moodboard

The moodboard reflects the visual appeal that is desired in the product. It also governs the look and feel, material palette and the emotive value it generates when used. I have tried to follow the current trends in product design to make the product more relatable and up to date.

Controller



Retro futuristic



Friendly



Final product



Final product



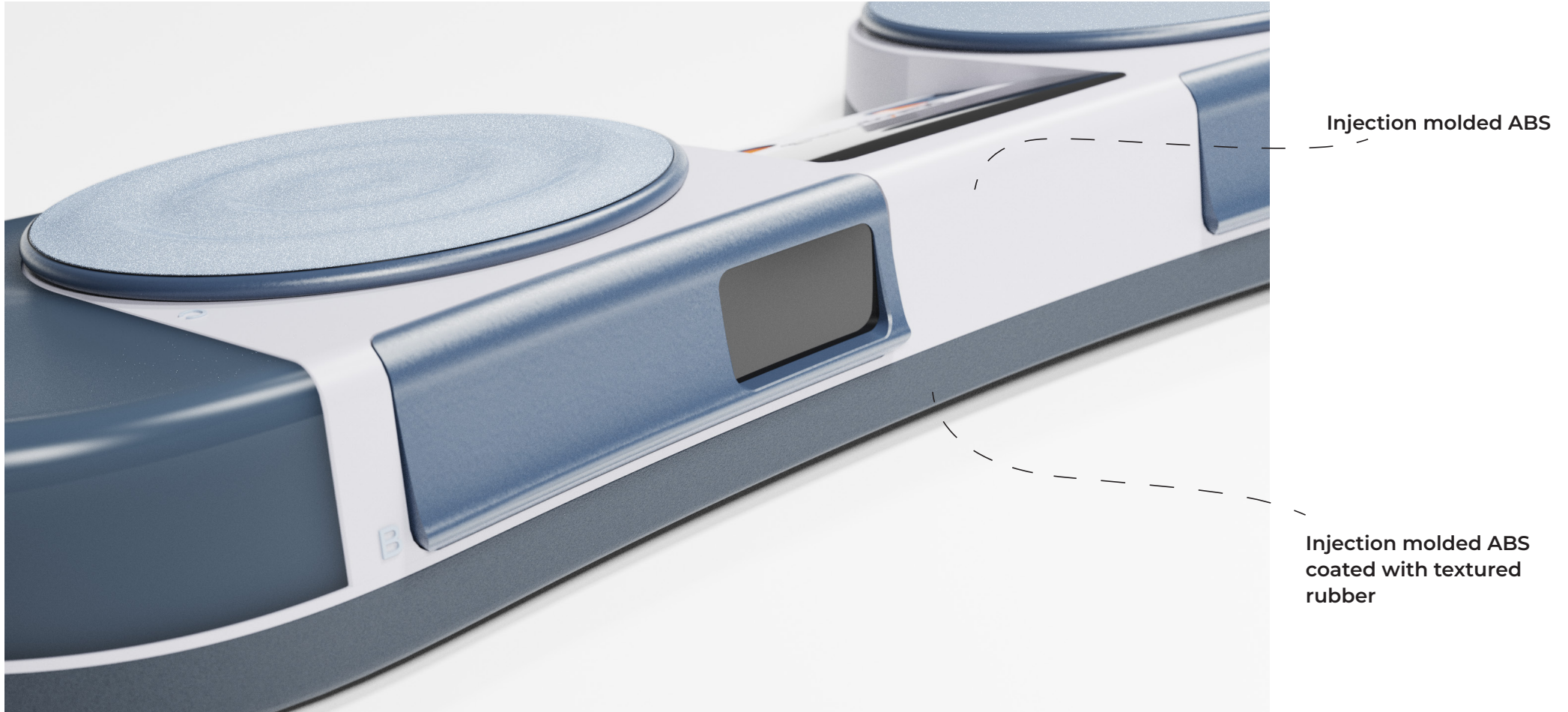
The bottom of the device is curved in order to fit on the lap comfortably

Final product



The navigation pad has ripples to provide more grip to the wrist

Final product



Fingerprint sensor makes inserting passwords and unlocking devices very easy

Final product



The device has three 3.5mm headphone jacks that allows other assistive devices to be connected and used along with this device.

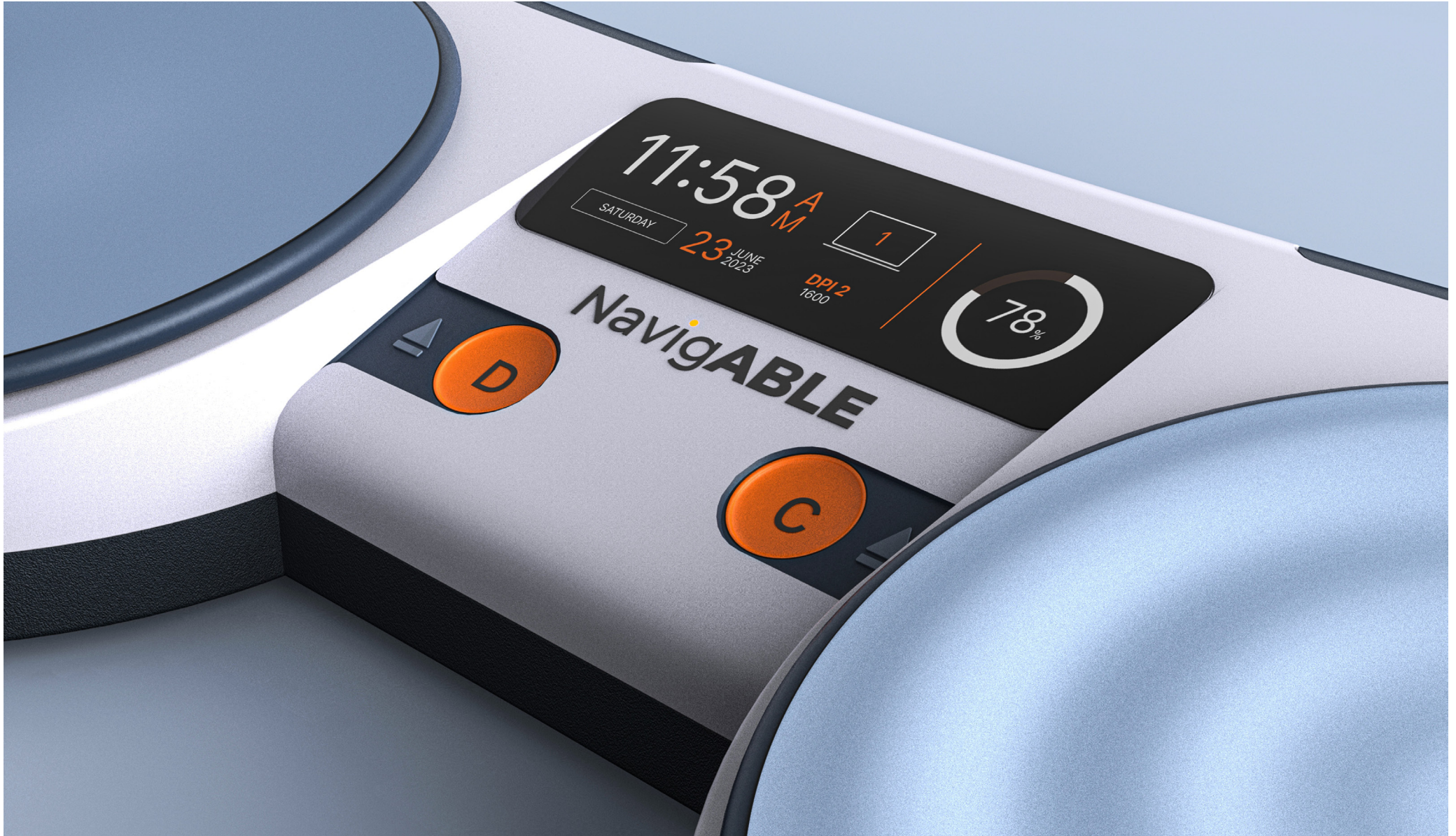
It also has a c-type charging port.

Final product



Buttons D and C eject the corresponding circular pads that are interchangeable so that the device is ambidextrous.

Final product



References

1. <https://www.ashaekhope.com/what-is-mnd/>
2. https://en.wikipedia.org/wiki/ALS#cite_note-Lancet2011-3
3. <https://medium.com/@christinamchung/sacrificial-concepts-200993246364#:~:text=%E2%80%9CSacrificial%20concepts%20are%20early%2C%20raw,a%20specific%20group%20of%20people>
- <https://www.nhsinform.scot/illnesses-and-conditions/brain-nerves-and-spinal-cord/motor-neurone-disease-mnd>
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- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4629510/>
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- <https://www.nhs.uk/conditions/Motor-neurone-disease/>
- <https://www.mndassociation.org/app/uploads/2015/02/an-introduction-to-mnd-booklet.pdf>