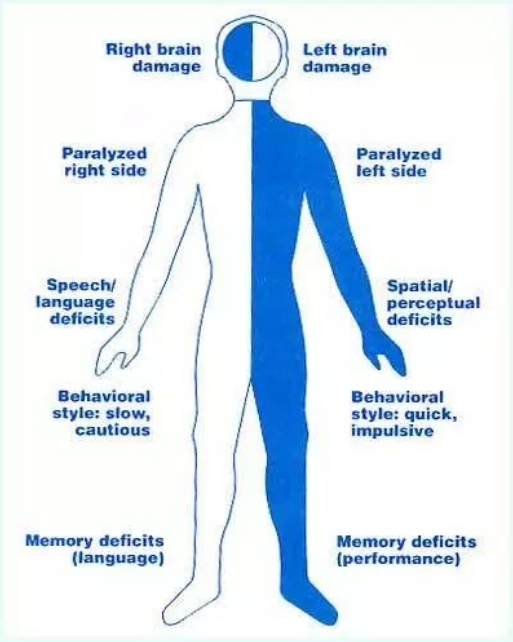
Smartphone-based game application for finger dexterity

An adjunctive therapy application for stroke patients

P2 Project by Angela R. S. (176330010)

Guide: Prof. Girish Dalvi

Stroke - Hemiparesis



Hemiparesis is an after-effect of stroke. It is experienced as weakness and loss of function in one side of the whole body.

Hemiparesis can leave a person disabled but **normal conditions can be regained** through dedicated physical rehabilitation.

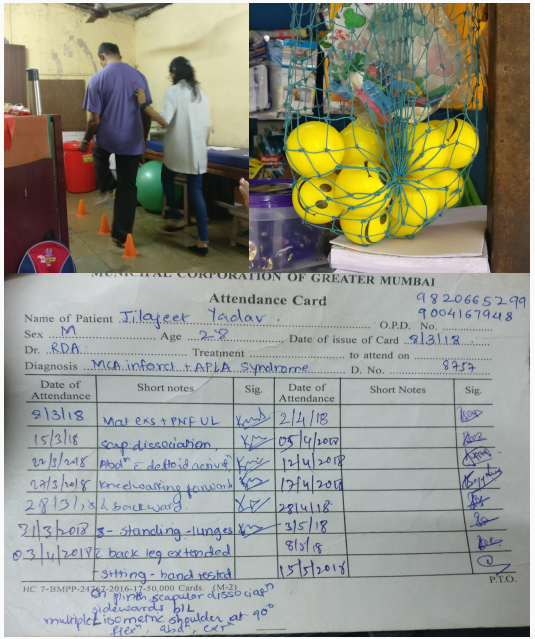
Post stroke rehabilitation

Primary Research

- Therapy here is free of charge
- Open from 9am-1pm (Adult Neuro: Tuesday, Thursday and Saturday)

Challenges:

- lack of enough space
- Resources
- Distance
- communicating the exercises to the caregivers
- therapist:patient ratio



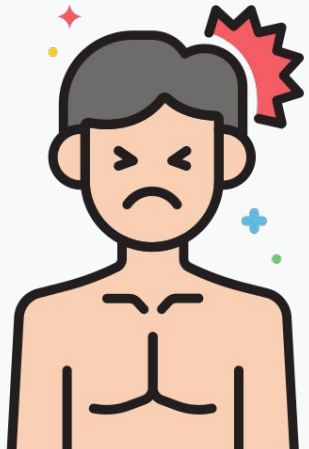
Who is Sameer?

Feb 2017 — **Feb 2018** — 2019

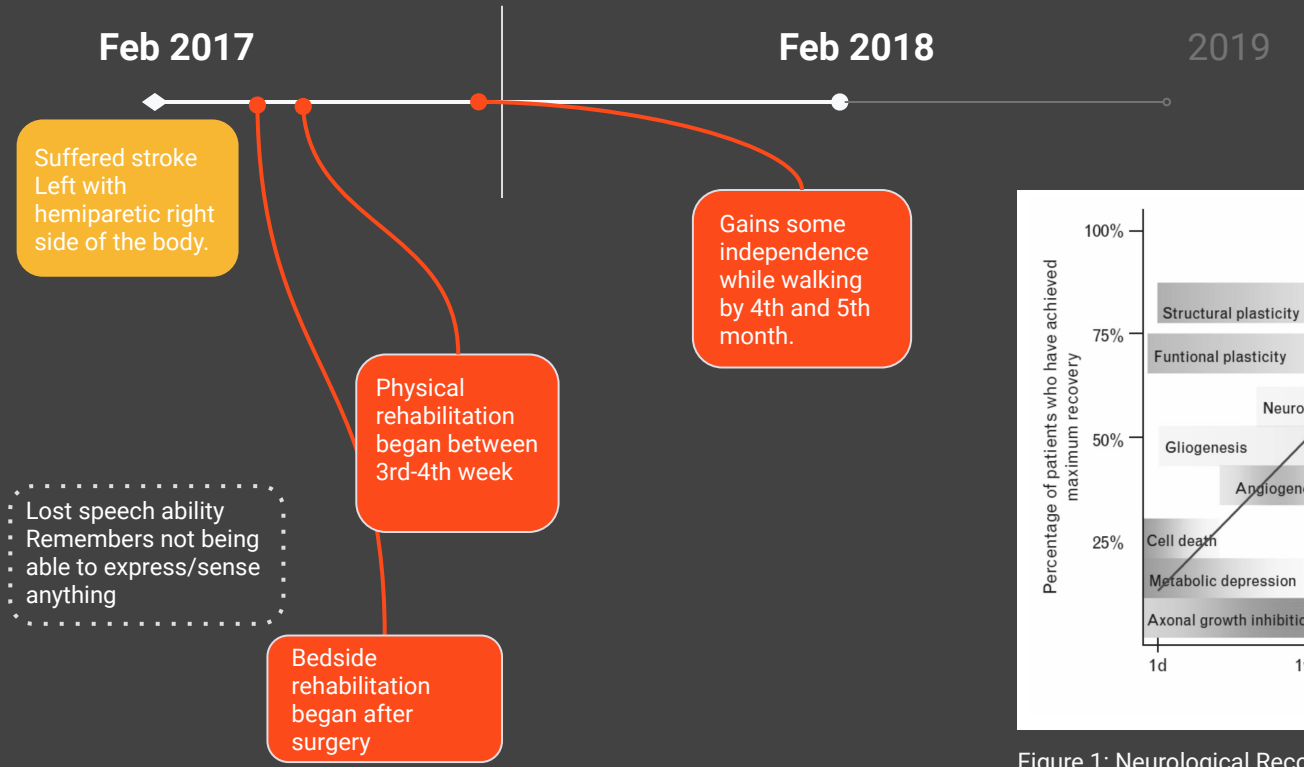
- Suffered stroke Left with hemiparetic right side of the body.
- Underwent surgery by 1st week after stroke.
- Lost speech ability Remembers not being able to express/sense anything
- Physical rehabilitation began between 3rd-4th week
- Bedside rehabilitation began after surgery
- Has to leave job.
- Travels 2.5 hrs to the therapy centre

  Spends about Rs 900 on cab journey per trip for a month
- Travels independently by bus and later by train
- Gains some independence while walking by 4th and 5th month.

35 yr old



Who is Sameer?



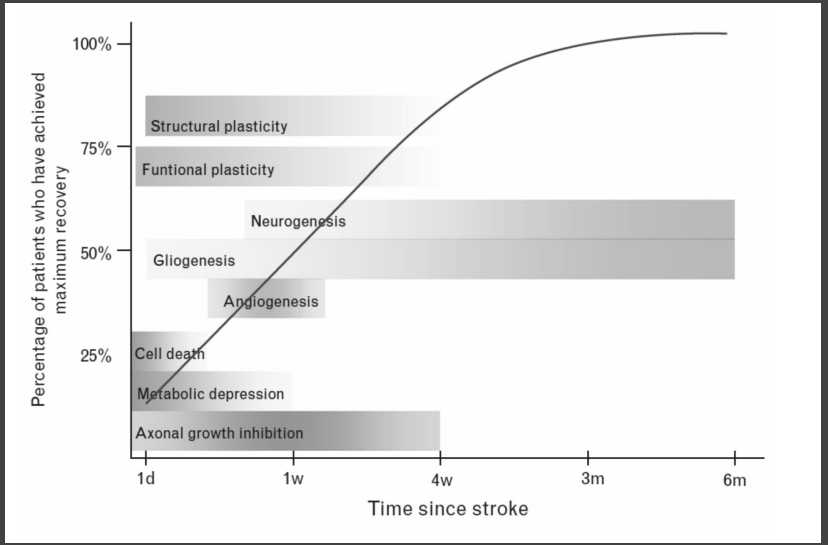
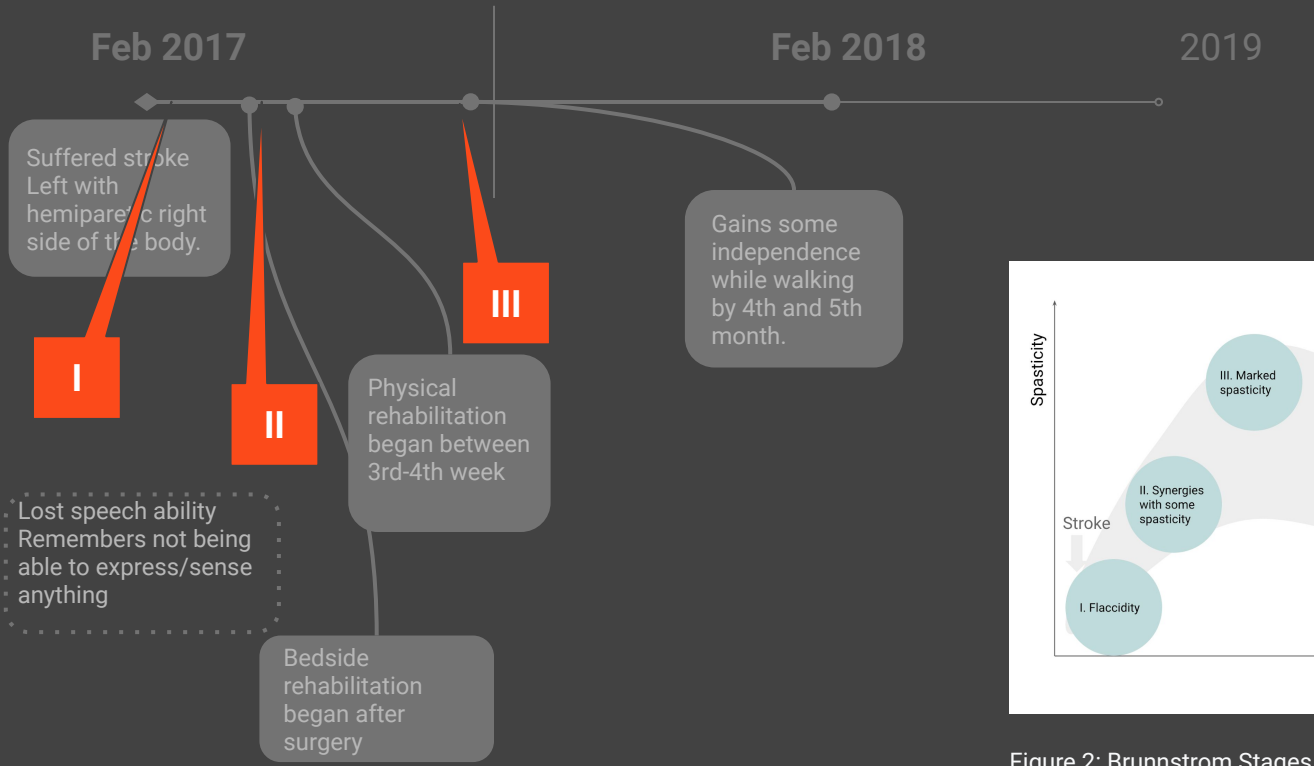


Figure 1: Neurological Recovery Process

Who is Sameer?



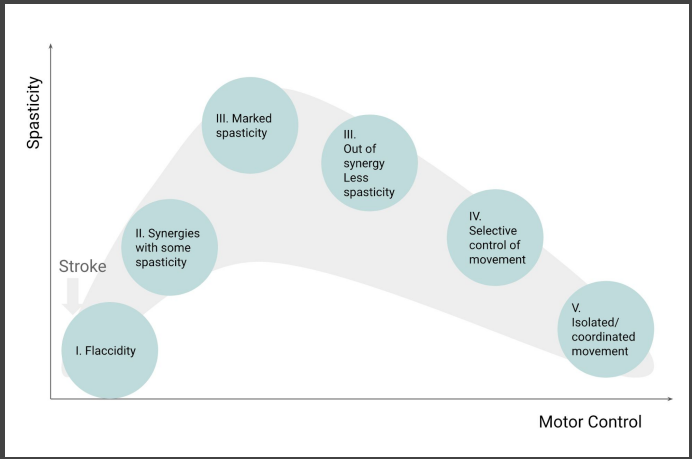


Figure 2: Brunnstrom Stages

Needs

1. Patients have to be highly motivated to be regular in their rehabilitation.
2. Patients take up sedentary lifestyles and jobs that are not physically demanding.
3. Patients and their family members have expressed frustration related to the speed of improvement.
4. The patients also tend to cheat with the assigned repetitions or does the exercises incorrectly in a hurry while the therapist is unattentive.

- **Engagement**
- **Motivation**
- **Improvement that can be measured**

Focus Area - Fine motor skills

With Disability comes the inability to take care of oneself.

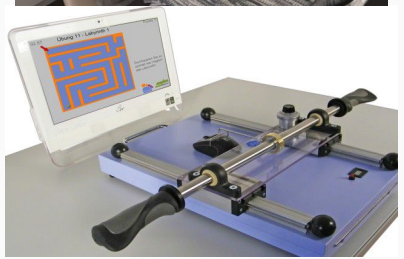
- Patients at nair hospital **receive well-instructed strength training to regain their gross motor skills.** It is with the fine motor skills they struggle.
- Frustrations of these patients mostly is about not being able to do ADL activities related to fine motor skills though they have been able to walk independently and do simple chores like lifting bags/buckets (things with handles).

Game-based interventions

Off-the shelf

Using commercially available hardware - kinect, wiimote, sony eyetoy, leapmotion, VR headsets etc.

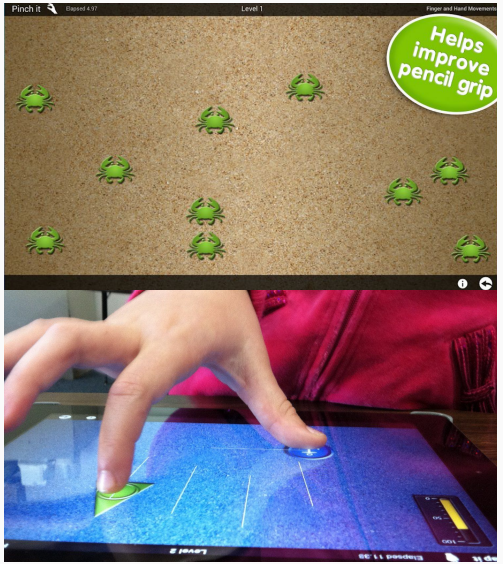
Custom made



Game-based interventions

Custom made

FlintRehab
Tools to spark recovery

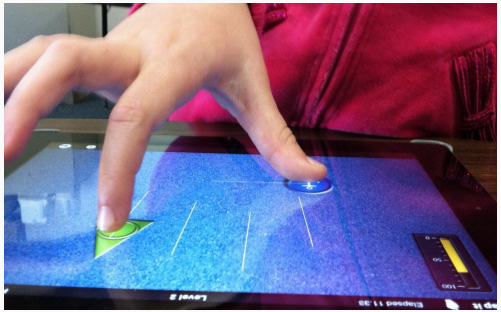


Types of Exercises

Custom made

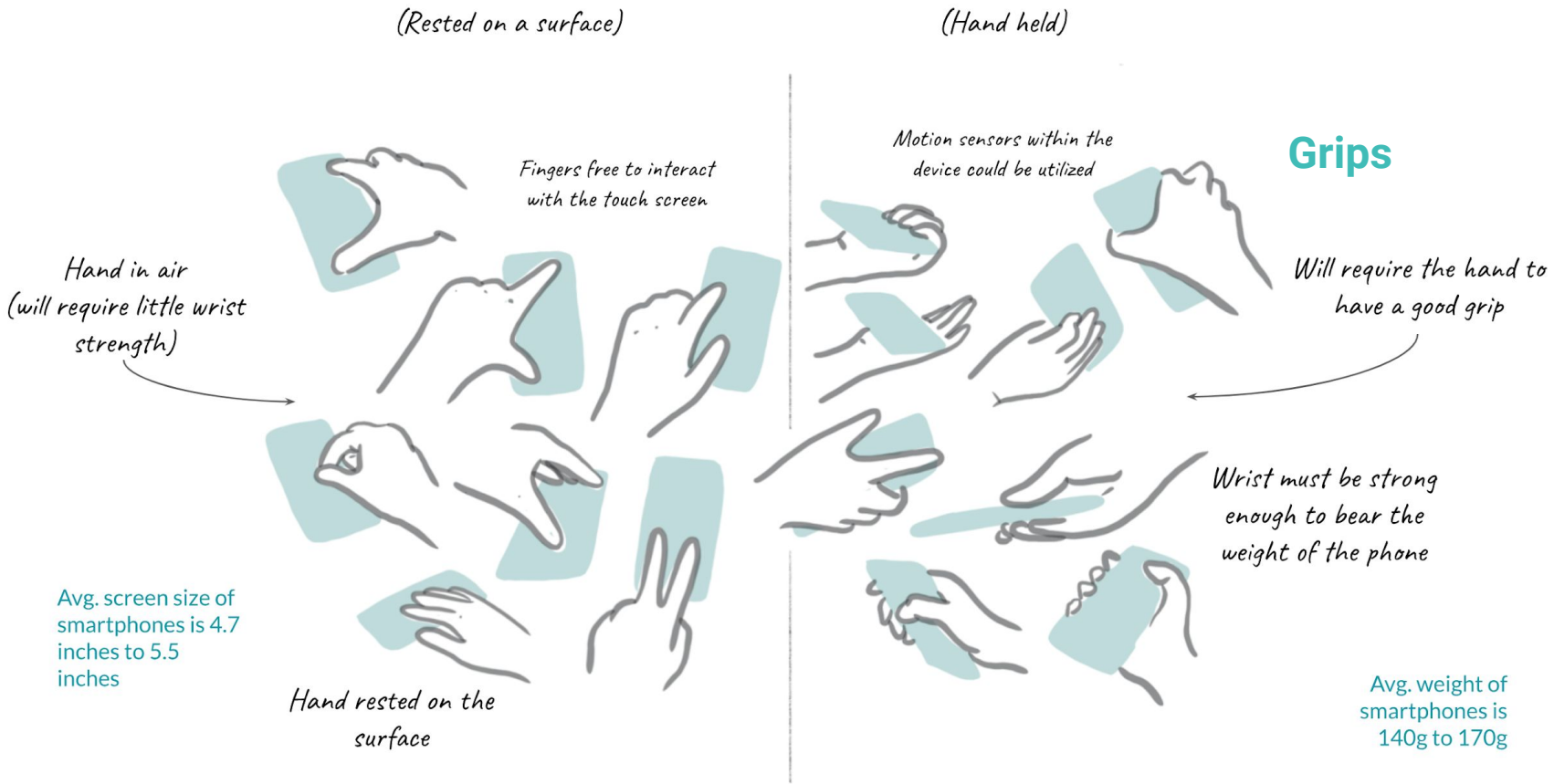
Grips

Thumb opposition



Coordination and pinches

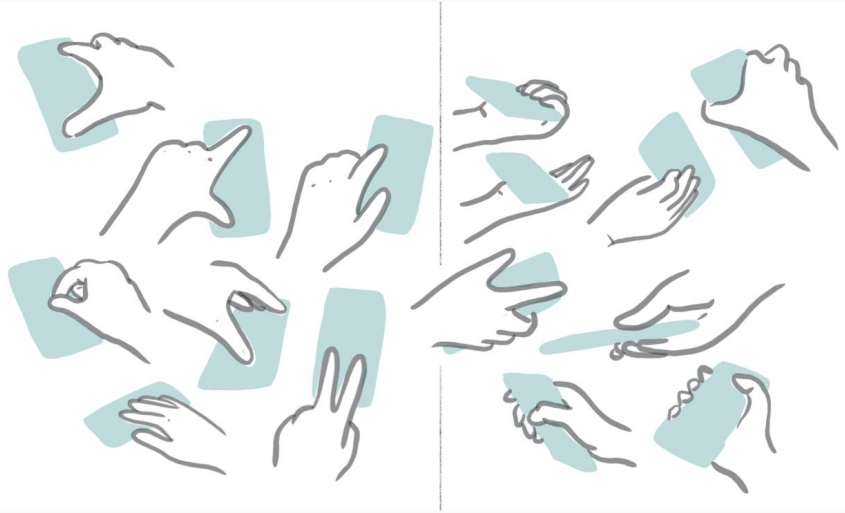
Smartphones as exercise tools - Explorations on ergonomics



Smartphones - Adding interactivity

Smartphones are –

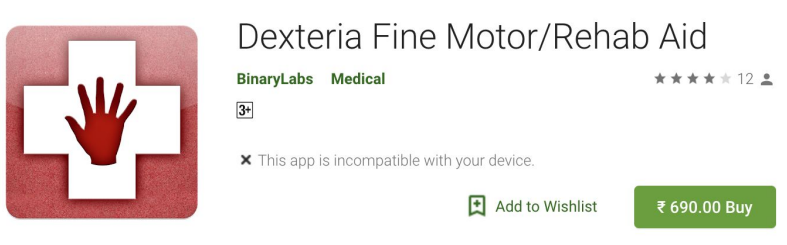
1. Readily available
2. Input sensors - Gyro, accelerometer, Capacitive touch screen (display), microphone
3. Output - Display screen, audio speakers, vibration motors

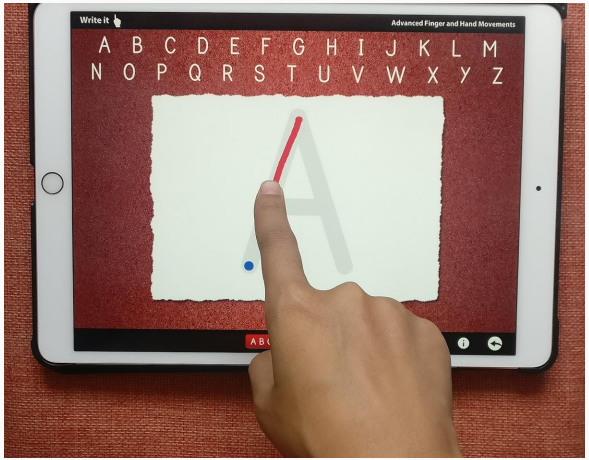


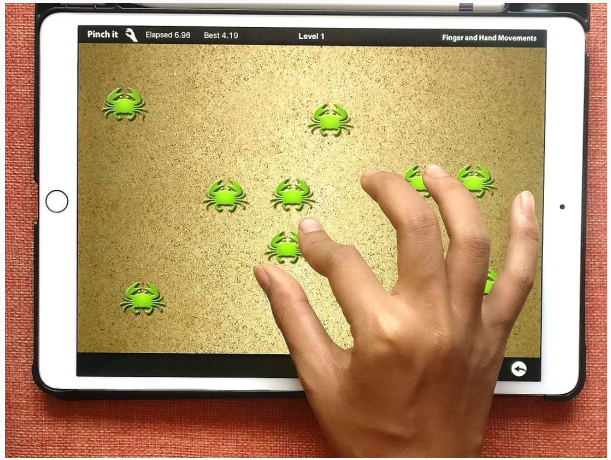
Pilot Study

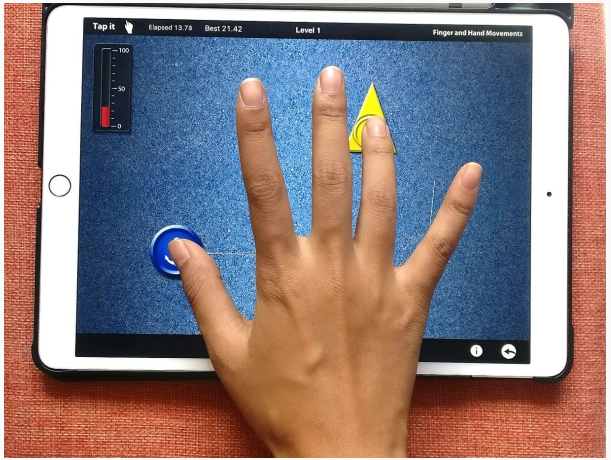
1. To observe interactions between the patient and the therapist upon introduction of a touchscreen tablet for hand exercises.
2. To derive insights on patient's acceptance to the use of technology for rehabilitation exercises.
3. To gain an understanding of the deeper intrinsic motivations of a patient and the way therapists harness these motivations (especially when an unfamiliar approach is introduced as part of the therapy).
4. Qualitative analysis of transcripts to derive themes

Application 1

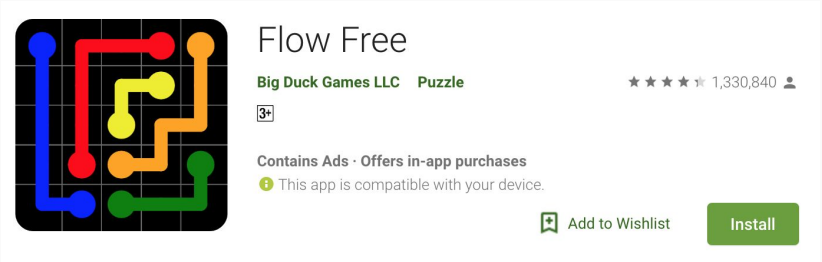


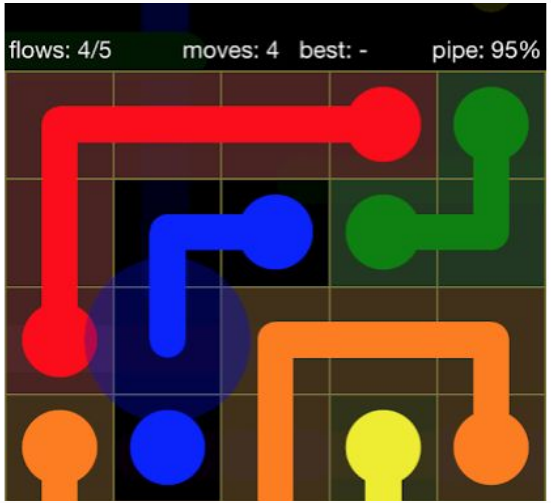






Application 2





Design Research

Themes: ADL, Patient independence

An understanding of the deeper intrinsic motivations of a patient and the way therapists harness these motivations must also reflect in the design of therapy apps in order to encourage their independent use for long term.

1. Therapists encourage the patient to **maintain a strict routine**.
2. They increase the intensity of an exercise at a **pace that is unique to the patient**'s recovery speed.
3. They give **constant reminders of how the exercise is relevant** to their recovery and what activities will be possible by practicing those exercises.
4. **Every exercise also has an alternative method** which requires only household items; not any specific exercise tool.
5. **"Yeh toh Ghar mein bhi phursat se kar sakte hein."** - Patient (28 yr old) on Flow app

Focus Area - Impaired hand functions

With disability comes the inability to take care of oneself.

Clutched Palm - Poor strength in the back of the palm



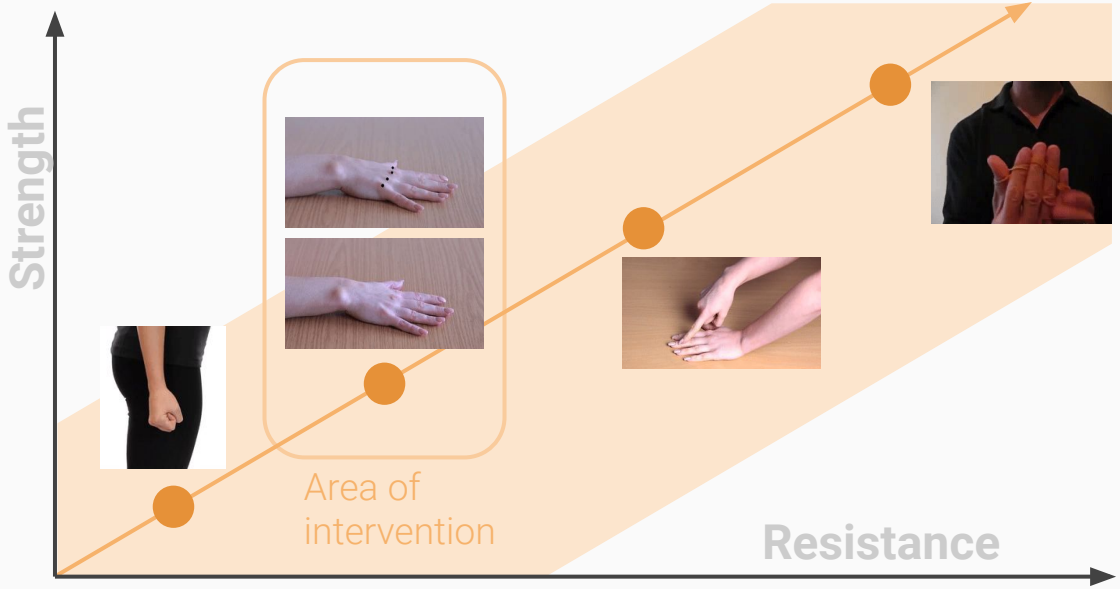
Electric stimulation for muscle initiation

Exercises - Finger Extension

The extensor tendons are located on the back of the hand and fingers. They let you open your hand and straighten your fingers.

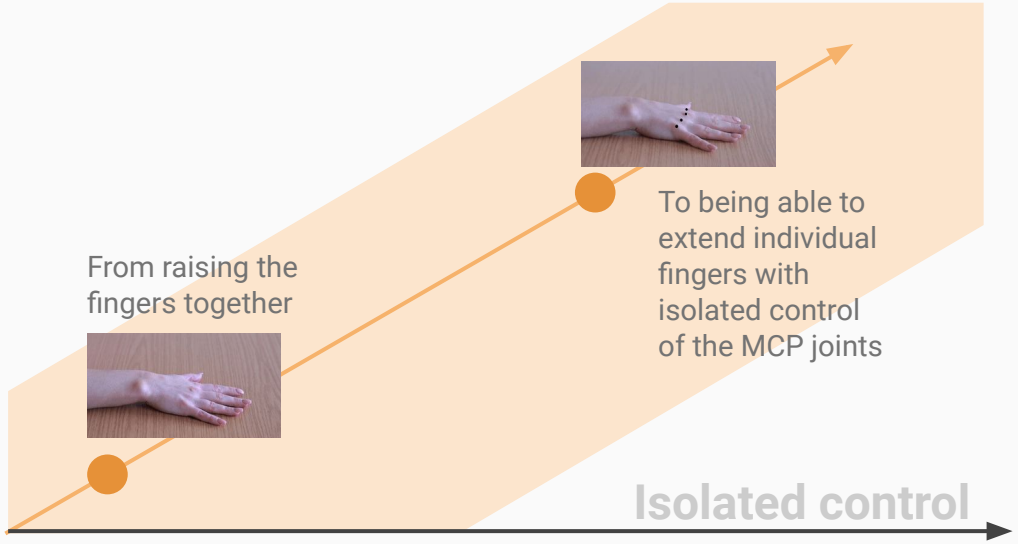
Step by step process of building strength in the back of the palm.

1. Gravity assisted extension
2. Active finger extension against gravity
3. Isometric finger extension (mild resistance)
4. Finger extension with resistance from a rubber-band

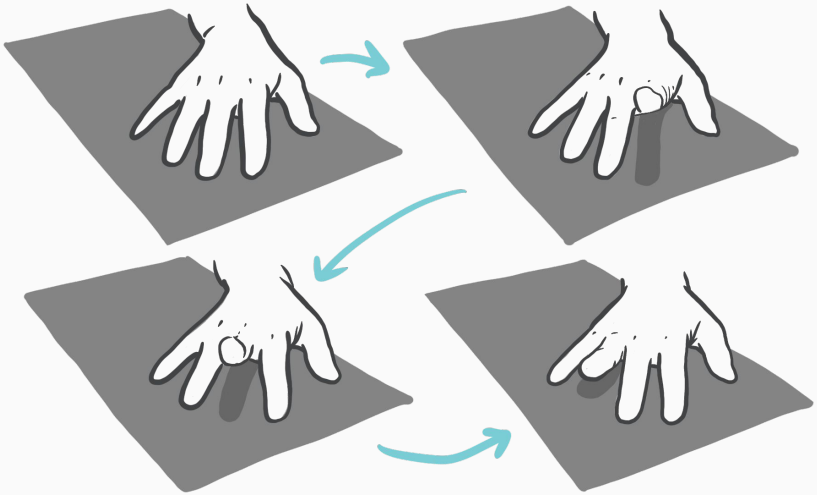


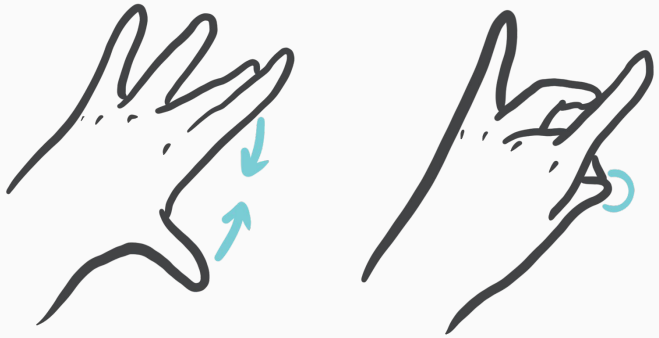
Active finger extension against gravity

The game will help the patient to perform the following.



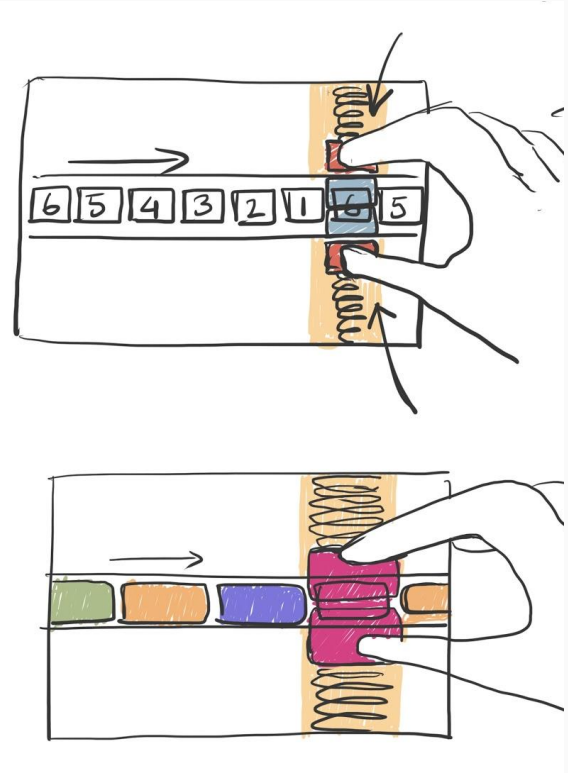
Touch-Interaction Design





Concept Idea 1

Pinch the dice number to move ahead in the game.

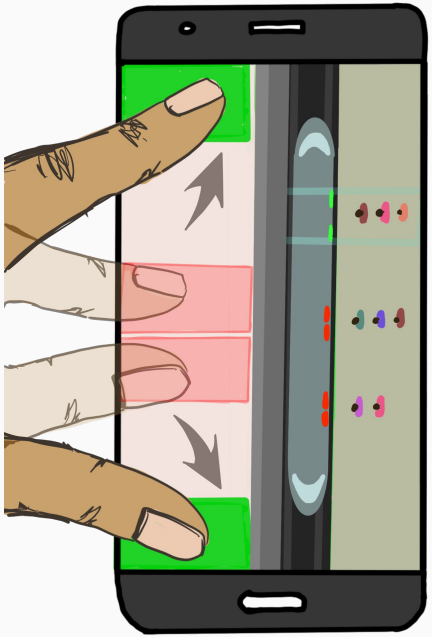


Game mechanics involves pinching in the correct time to obtain the desired number.

The game mechanics can be applied for turn based multiplayer game for eg. Ludo and Snake & Ladder. The player then exercises till the end of the game.

Concept Idea 2

Pinch to open and close the door.



In the current level shown in the image, exercise is administered by 3 repetitions per stop.

Difficulty is increased by increasing the no. of boogies, introducing time limit and increasing the speed of the game.

Gameplay: Mumbai Metro needs you! Help the train master close and open the train door for the passengers at the right time. Complete local journeys to earn coins and upgrade your train. Unlock new destinations.

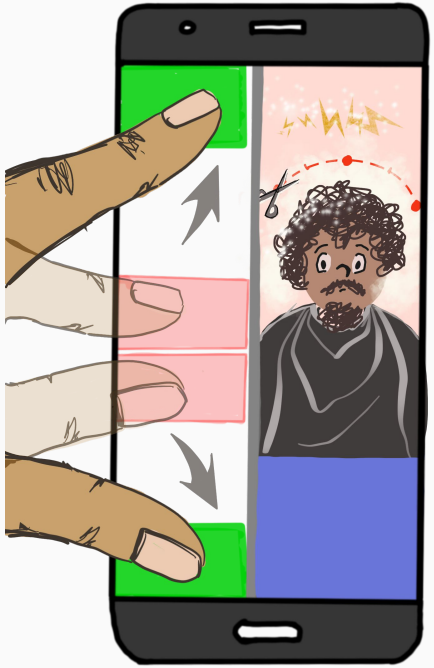
Make sure you keep up. Passengers will increase with time. With power comes great responsibility.

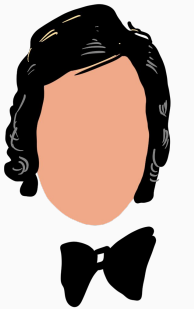
Game genre: Adventure, Arcade

Graphics: 2D

Concept 3

Pinch fast enough for the best hairstyle.



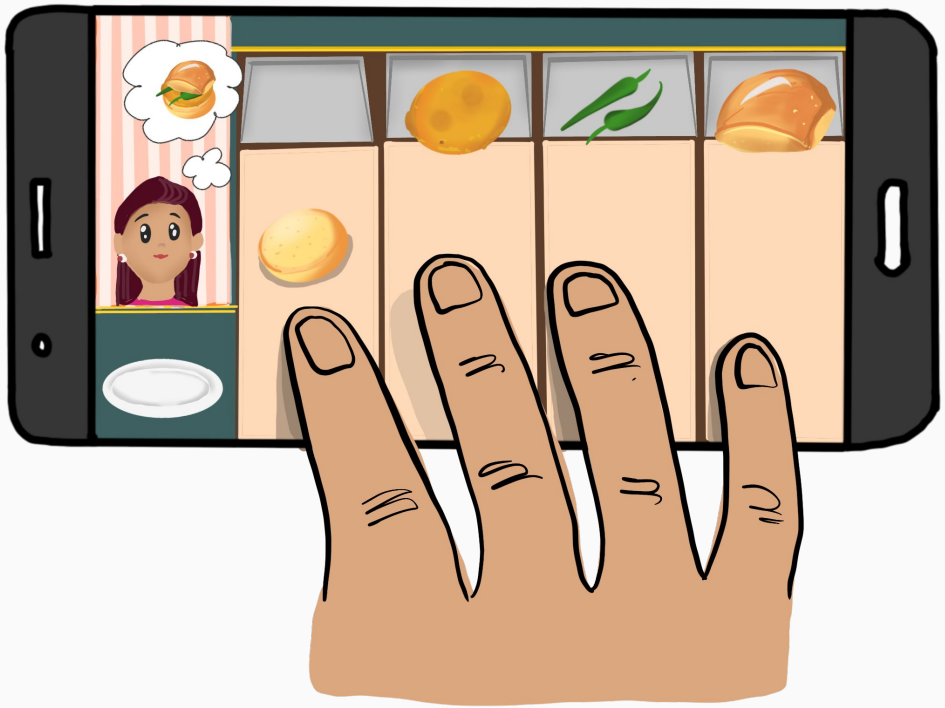


The player pinches to get the best bollywood hairstyle for the customer.

Difficulty is increased by increasing the no. of pinches for special hairstyles.

Game Design - Iteration 1

Lift your fingers to process the food order for your customer.



The patient rests the fingers on the screen and lifts them one by one to allow the gameplay.

Difficulty is increased by increasing the no. of orders and randomizing the order of the ingredients.

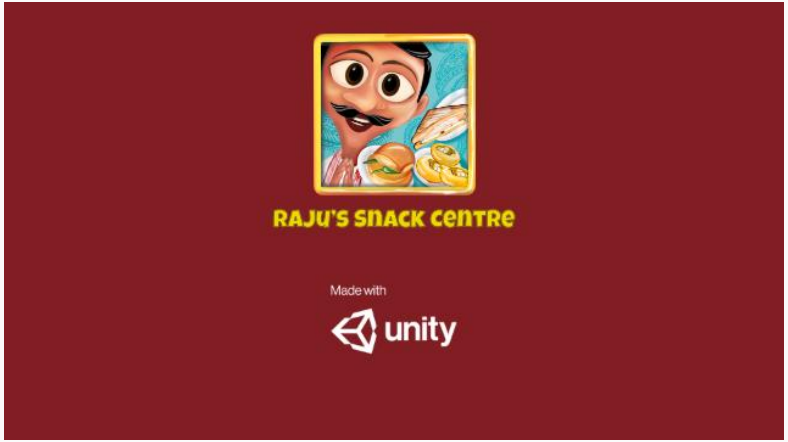
Gameplay: Your stall is attracting customers. Hurry up and process the orders fast. Stack the ingredients in the order that they appear for a perfect score.

Game genre: Arcade

Graphics: 2D

Final Concept

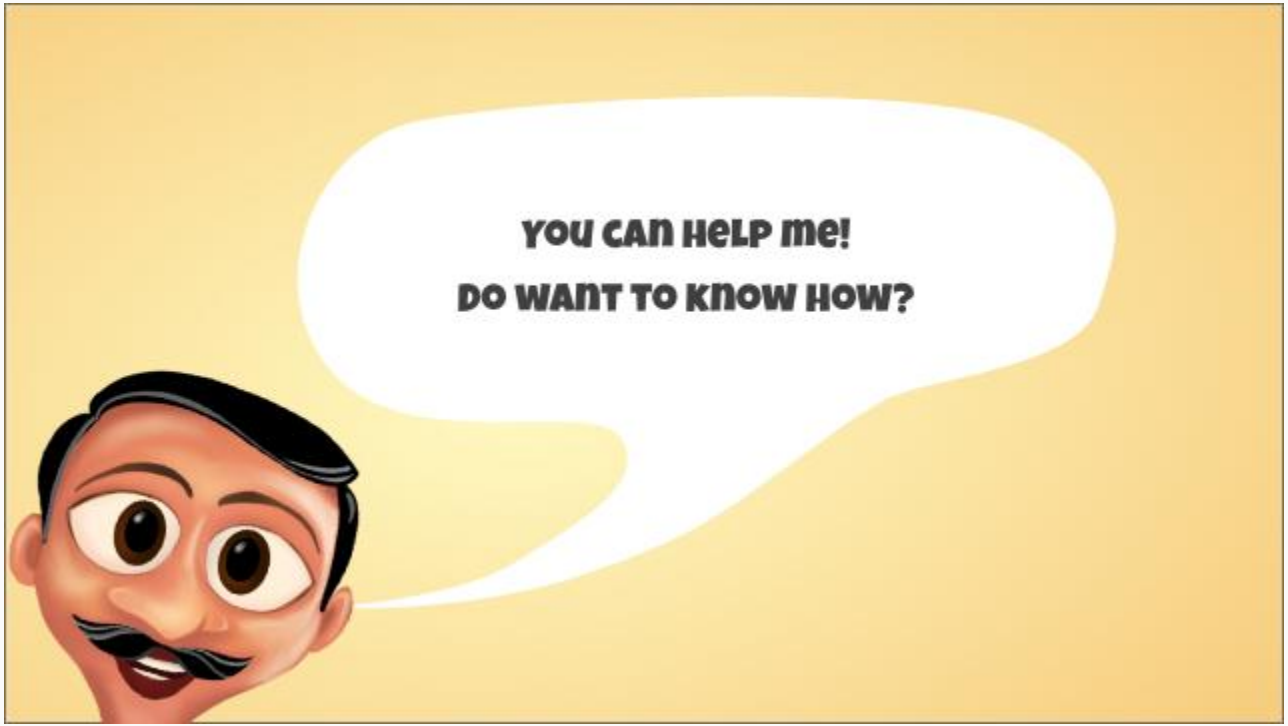
1. Game Trailer Video
2. Game Story and Ecosystem
3. Game Mechanics
4. Game Features




HI I'M RAJU!
I LOVE COOKING. I SELL ITEMS LIKE VADA PAV, GOLA AND PANI PURI AT MY STALL.


I LIKE TO LEARN NEW RECIPES FROM PEOPLE AND MAKE NEW DISHES.

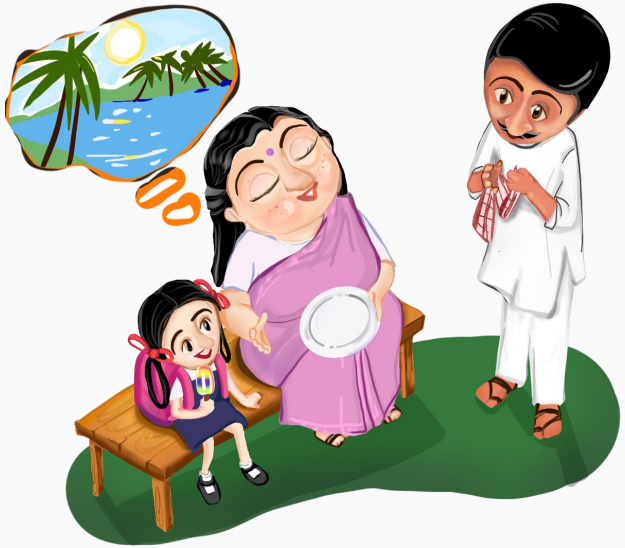

Someday I will travel across the country and collect all new recipes to be the best cook ever.
Raju's


YOU CAN HELP ME!
DO WANT TO KNOW HOW?

Story and Ecosystem

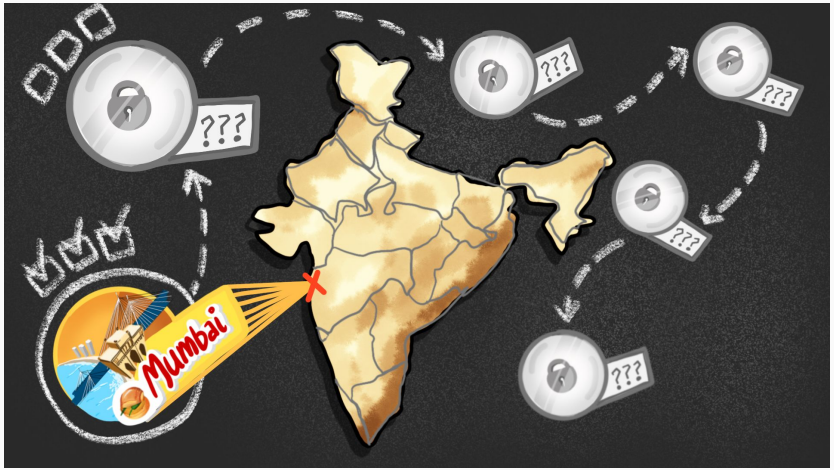
1. Food - Gender neutral theme, male character.
2. Travel - Light and adventurous, discovery.
3. Opportunities for new engaging content.
4. App will be introduced to the patient as a means to exercise independently and playfully even while at home.

Mechanics



1. Game play progresses by **tap action**.
2. One task of staking a food item is one complete exercise.
3. No. of customer orders corresponds to no. of exercise repetitions.
4. **Speed of the food order** is a variable to note progress of the patient.
5. Completing a level successfully unlocks a new recipe.

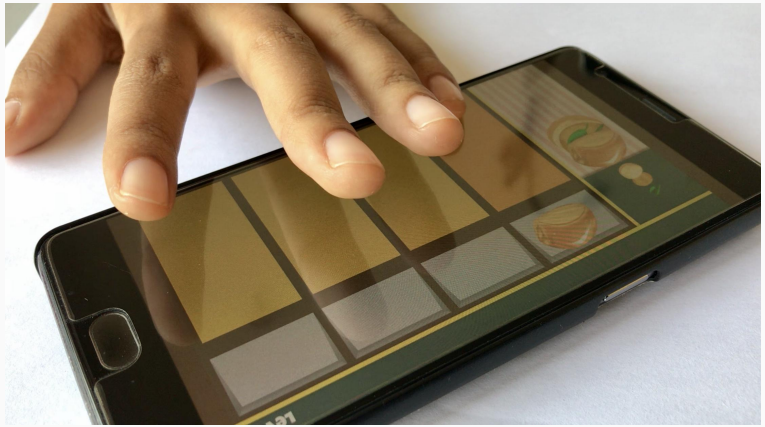
Features



1. New recipes and locations for engaging content to help scaling the game.


12 / 15
280/300
XP
15/30

Error-handling Features



1. Game pauses if the fingers are off the screen.
2. The correct food item blinks if the patient accidently picks the wrong item.
3. Vibration motors give haptic feedback.

Expert Evaluation Feedback

“This will help even the caregiver to take out some time for themselves, while the patient is engaged in a useful activity.”

- Ms. Namrata A. (Occupational Therapist, CMC Vellore)

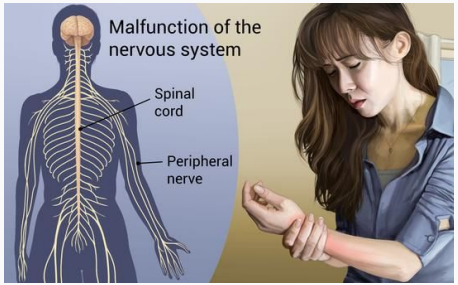
Expert Evaluation Feedback

Feasibility

Game theme

Motivations

Exercise

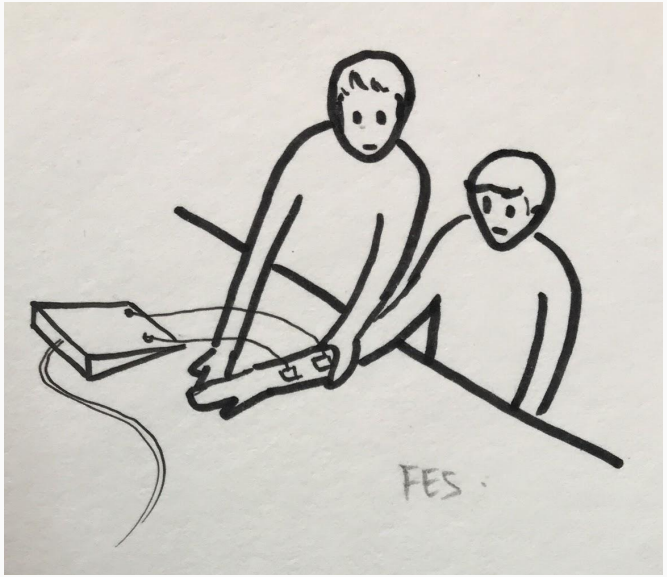


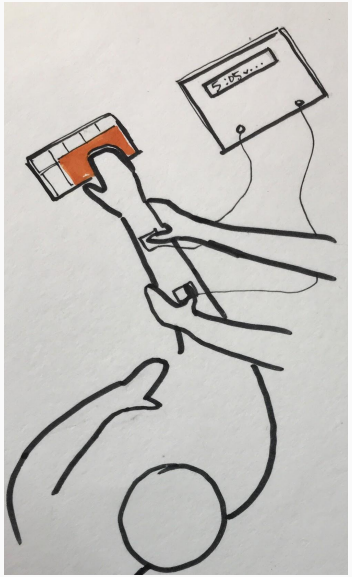
2 experts

1. **HOD, Physiotherapy** - Nair Hospital Mumbai
2. **Occupational Therapist** - CMC Vellore

- The patient won't be able to immediately lift one finger at a time.
- You can increase the difficulty by starting with extending all four fingers at a time and then reducing the no. of fingers.
- The most difficult part is extending 1 finger at a time.
- More relevant for patients who have muscle/tendon injury.
- Should be avoided by patients who also have Complex regional pain syndrome.

Use Scenario

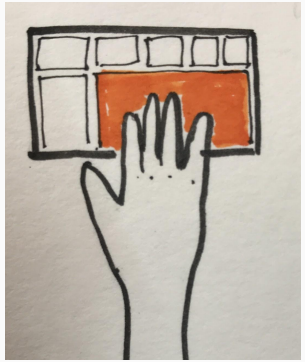


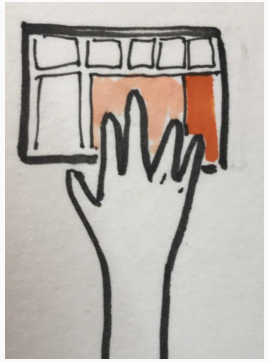


Patient can be introduced to the game at a very early of rehabilitating the hand. This is **during the initiation of muscle activity** by electrical stimulation.

The therapist shall use the game as a count keeper and a visual feedback during the process.

Modifications - Game Challenge





The no. of fingers to be raised will be reduced as the difficulty level increases.

The game's objective will be met when the player is able to complete the level requiring isolated finger extension.

4 fingers

Last 3 fingers

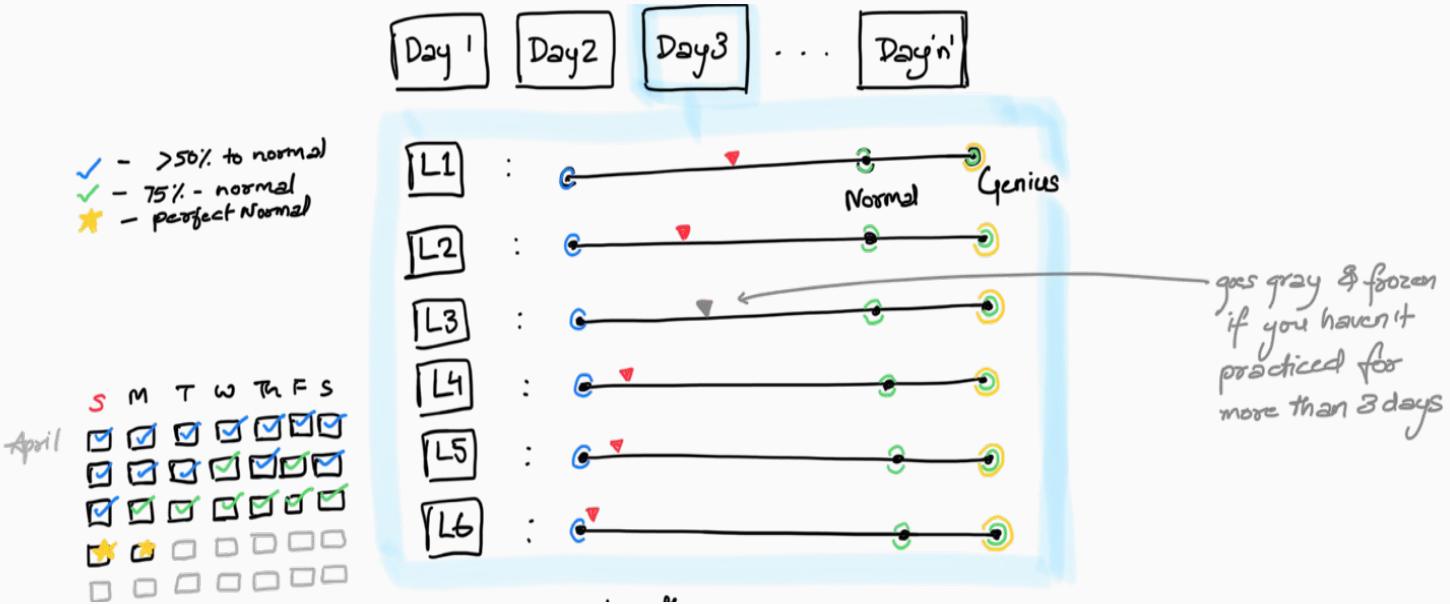
First 3 fingers

Last 2 fingers

First 2 fingers

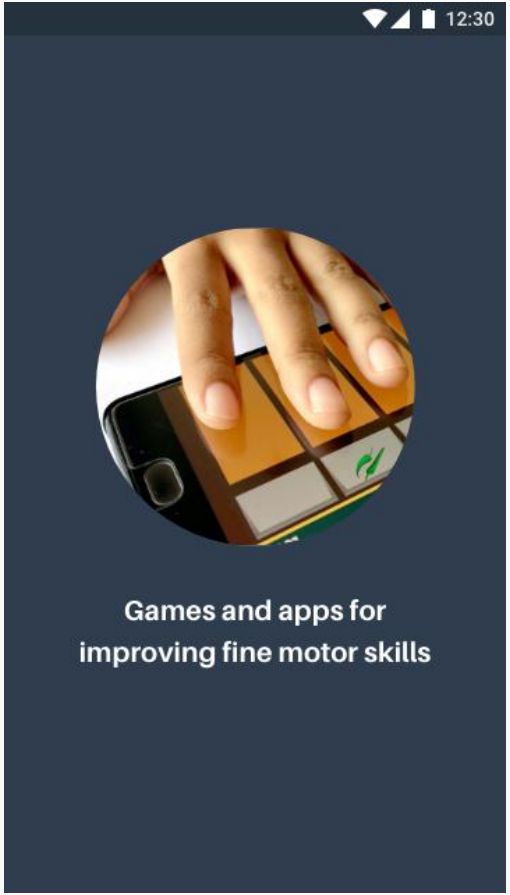
Modifications - Progress tracker

Level design has to be done to map the progress of a patient in a tabulated manner.

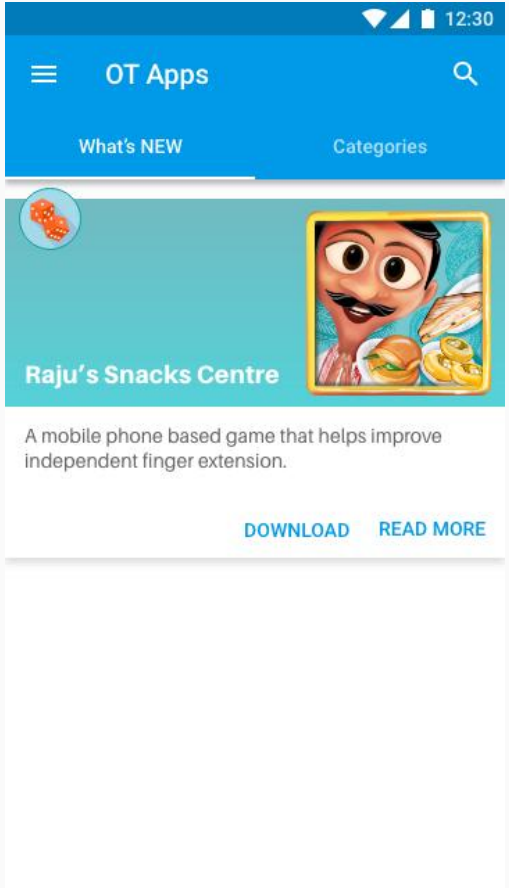


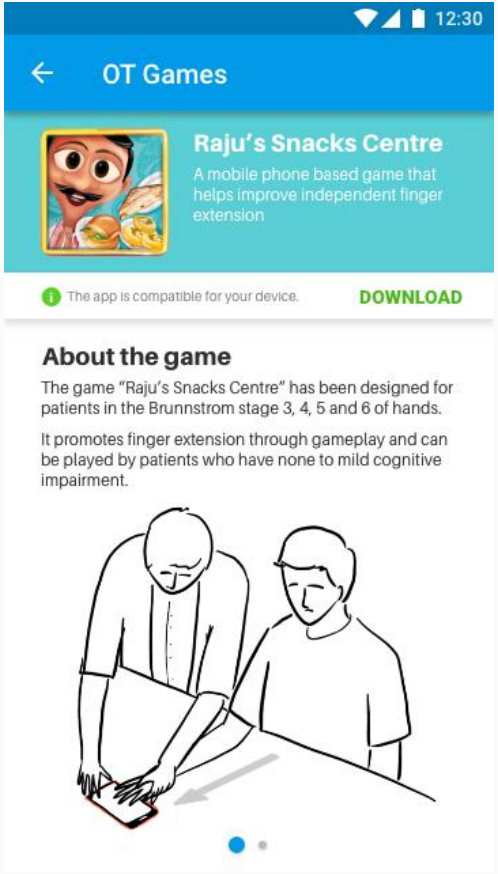
How the therapist would discover such games?

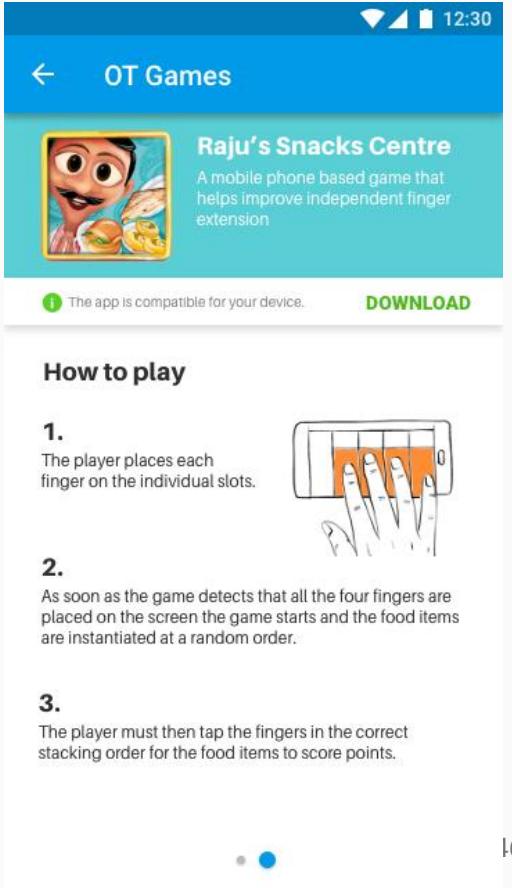
‘OT App’ - A mobile application for occupational therapists and physiotherapists to discover new games and apps for their patients in rehabilitation.



How the therapist would discover such games?







Comments and Questions

Thankyou