

MOBILI 



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# Intro

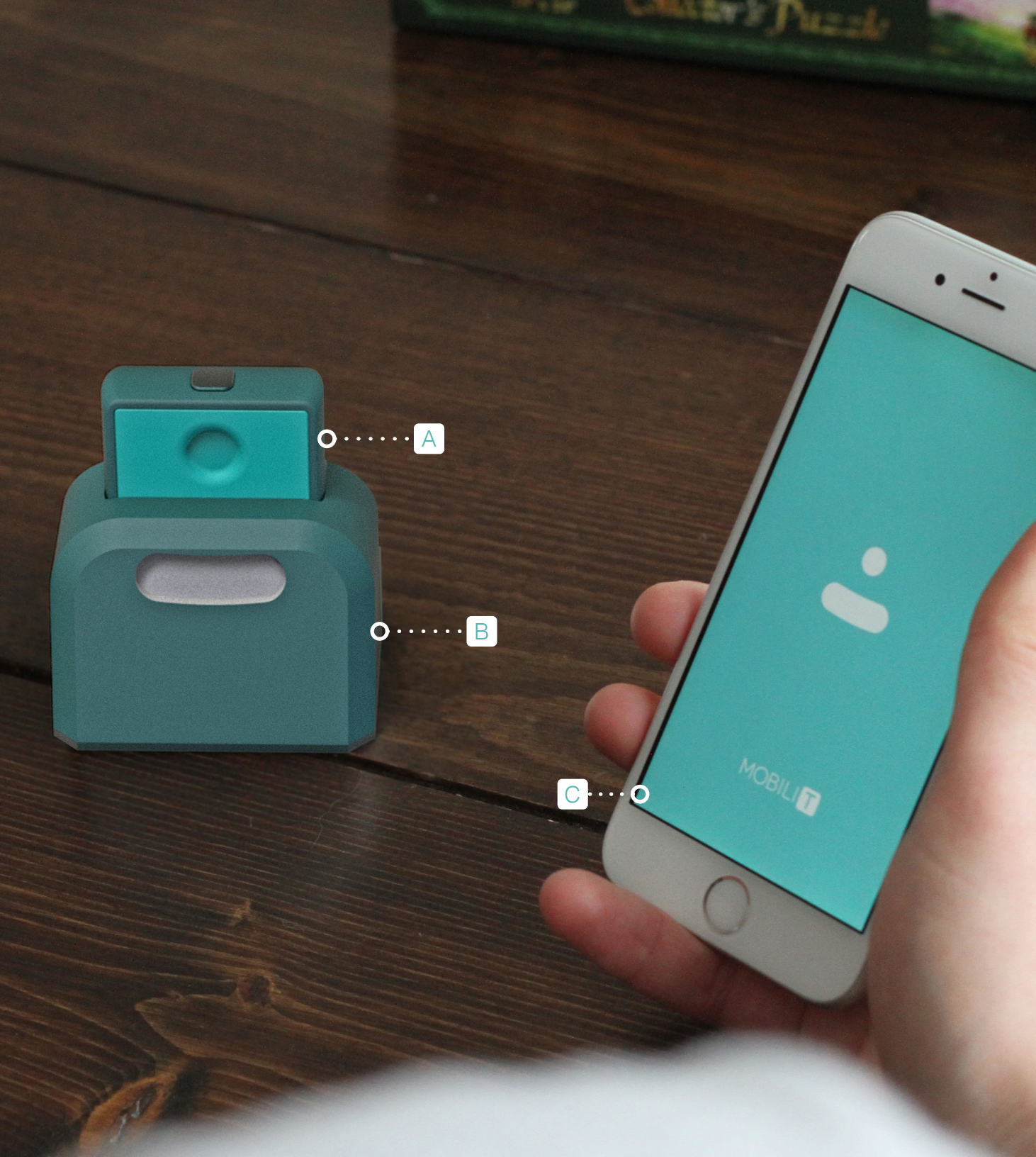
Individuals with a swallowing impairment are often unable to consume a normal diet, which can lead to dependence on tube feeding. This alteration in eating can impact social interactions, and dismantle overall quality of life.

Mobili-T aims to reduce the current barriers to therapy, such as access to rehabilitation centres, by providing a motivating, portable solution to individuals affected by a swallowing disorder.

Mobili-T is portable, but will likely spend much of the time living in an individual's home. We want owners to welcome this technological companion in their home and be proud to call it 'My Mobili-T'. It will act as both a virtual guide and physical reminder for their swallowing therapy which will be essential to improve their quality of life.







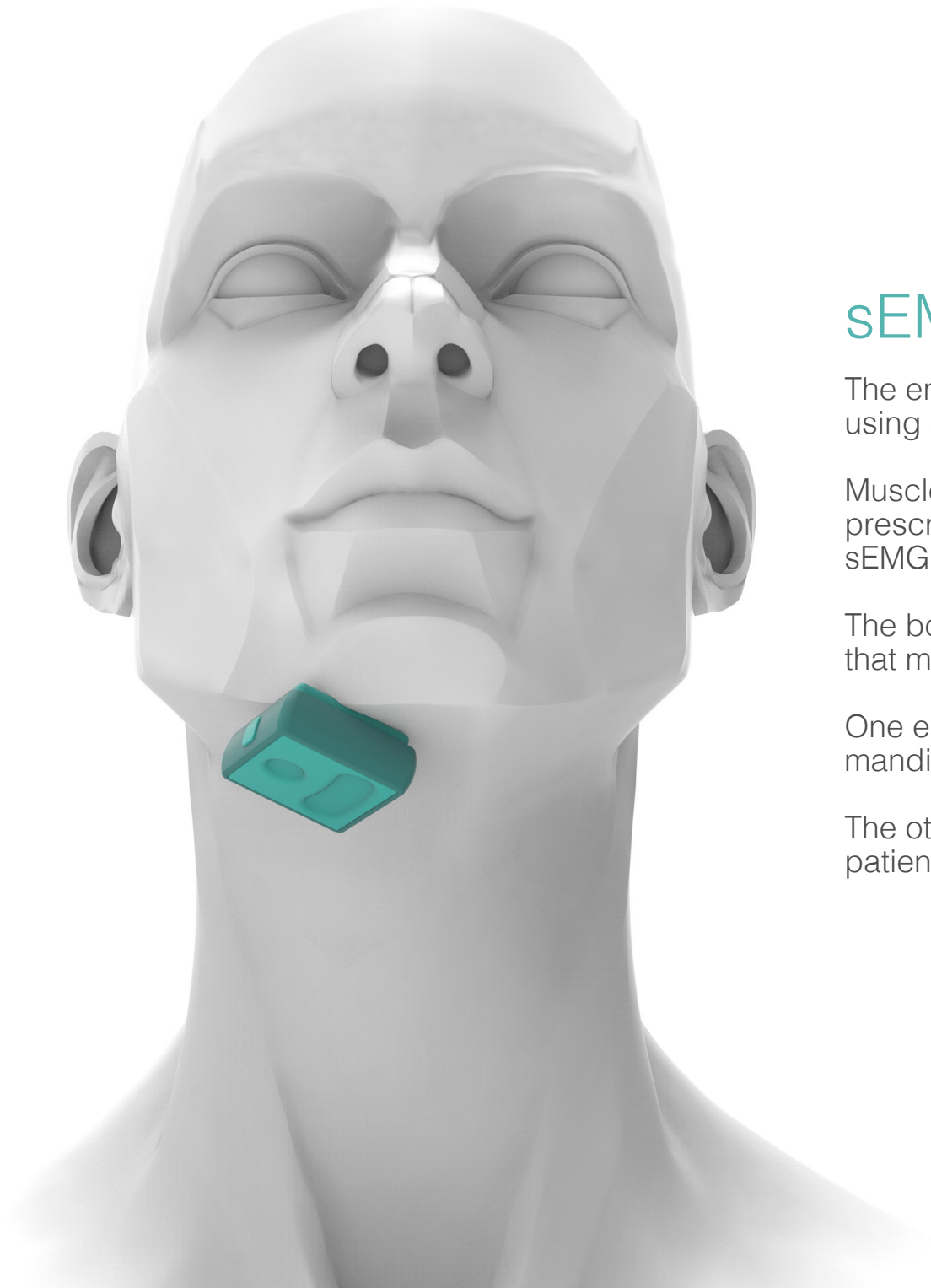
## Elements

A sEMG Enclosure

B Charging Dock

C iOS App





## sEMG Enclosure

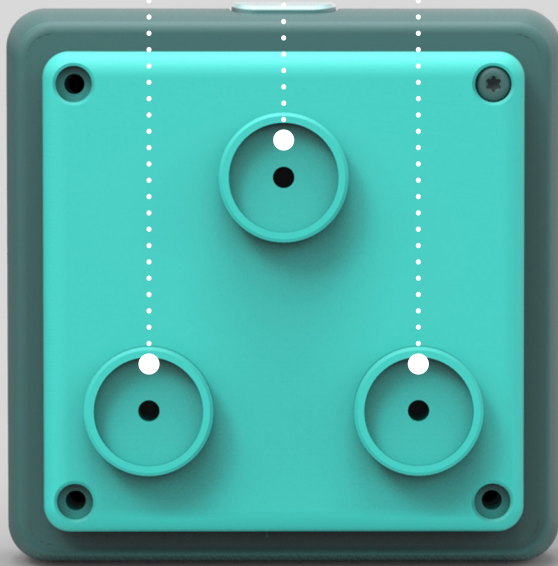
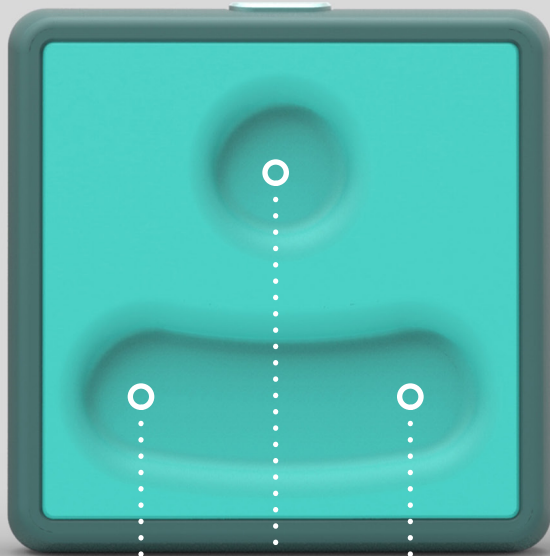
The enclosure is placed under the user's chin using a skin sensitive adhesive.

Muscle activity is measured during the prescribed swallowing exercise routine using sEMG (surface electromyography).

The bottom surface features three electrodes that make contact with the user's skin.

One electrode must be aligned with the mandible (the bone of the jaw).

The other two electrodes align with the patient's swallowing muscles along their neck.



## Enclosure Indents

The top surface of the sEMG enclosure features an eye and a smile.

These friendly recesses act as tactile/visual references to the position of the sEMG electrodes.

The eye lines up with the ground electrode, while the two lead electrodes align with the smile.





## Enclosure Indicators

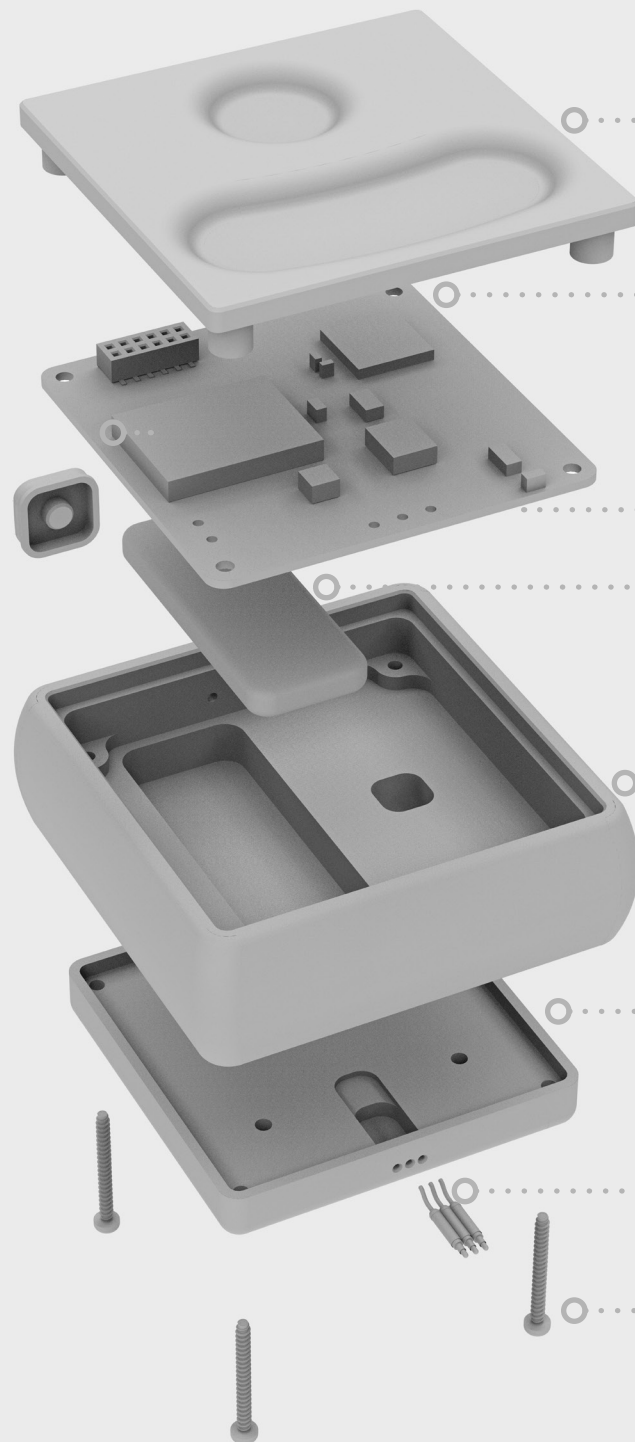
The enclosure features two colors of LEDs - Blue to indicate 'Power On' and Red to indicate 'Needs Recharging'.

Blue acts as a signifier for newness - a new session is a fresh start. The color blue is perceived (in a North American context) as producing a calming effect, evident with associations in nature (sky, water).



Red indicates a depleted state, and is recognized as a warning color that signifies immediate attention.

# Enclosure Components



Enclosure Face. Top surface has visual/tactile recesses that vertically align with the sEMG electrodes at the base of the housing.

PCB. Printed circuit board. Connects components via conductive tracks. Bluetooth module allows for wireless connectivity.

Power Button. Uses a momentary switch to avoid accidental power down of the device.

Battery. Provides power to the hardware for multiple therapy sessions.

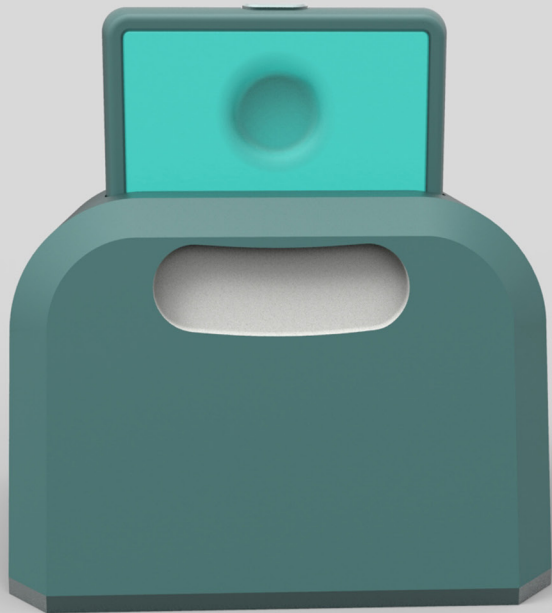
Housing Body. Securely houses all the hardware components. Is modular - allows for multiple base versions to be tested without a complete enclosure redesign.

Housing Base. Using a reusable adhesive, is the portion of the hardware that is placed in contact with the user's face. Contains the charging pins and 3 electrodes that detect muscle activity.

Charging Pins. Come in contact with the dock to charge the hardware.

Screws. Recessed plastic screws seal the enclosure.



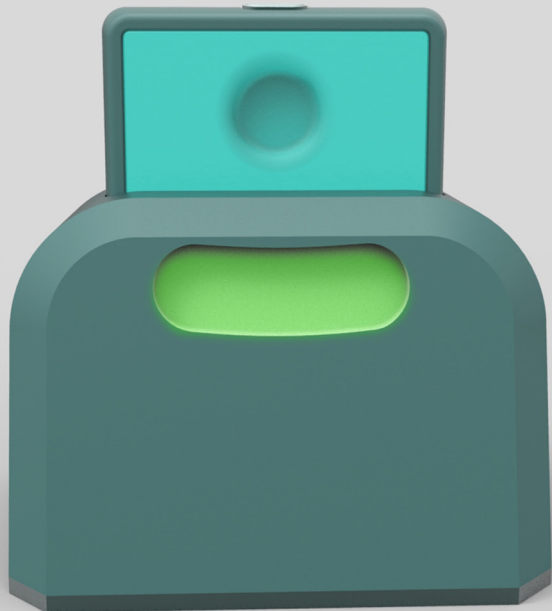
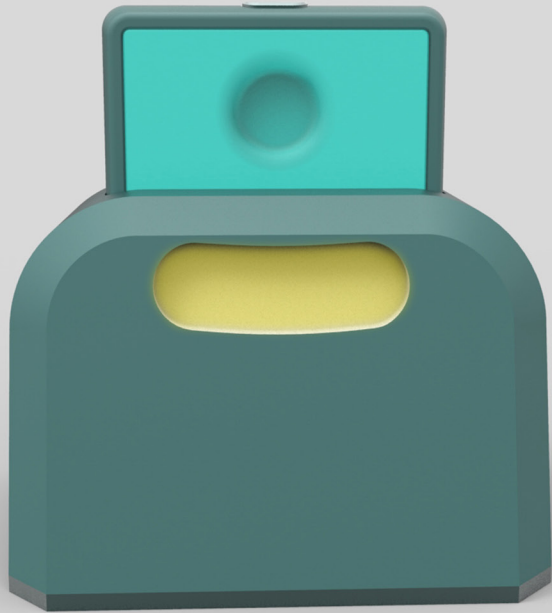


## Charging Dock

In order to form a routine, a cue is essential. If the system is set aside in a drawer, the likelihood of prompting a cue to form a routine lessens dramatically.

We hope Mobili-T owners are proud of their progress, and develop a sense of companionship with their Mobili-T that will lead to more effective routines and adherence to their prescribed therapy.

The dock continues the visual indents of the enclosure, featuring a 'smile' that acts as the charging indicator.



## Charging Indicators

The dock will feature 2 additional colors of LEDs - Yellow to indicate 'Charging in Progress' and Green to indicate 'Charging Complete'.

Working as a visual system with the enclosure colors, blue acts as a signifier for newness - a new session is a fresh start.

The remaining colors rely on a familiar 1 system - traffic lights. The red is a clear indication of 'Stop'. Yellow is a transitional color, while green means 'Go'.

Relying on a familiar system of color coding is appropriate for the Mobili-T age demographic, that otherwise may struggle to learn a new indication system.





## iOS App

The iOS app provides the Mobili-T owner with visual biofeedback related to a swallowing therapy prescription established by their clinician.

Each swallow within the prescription is represented by color coded cubes. The results of each swallow are tracked and can be reviewed by both the Mobili-T owner and their clinician to evaluate and encourage adherence to the prescription.

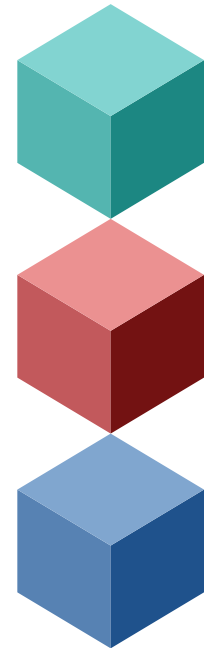
# Color

The color palette relates to the three types of swallowing exercises prescribed in the exercise progression. Within the app, a repetition of an exercise is represented by a cube (one rep=one swallow=one cube) - essentially a building block. Each block has a top highlight, a central color and a dark accent. This creates visual depth for the blocks, but it also provides a suite of complimentary colors that appear in the app.

Green for Regular. A regular swallow is exactly that - a swallow as you would normally do. Green means 'Go' and the regular swallow is the starting point and cornerstone of the therapy, as it is used in both calibration and as the warmup at the start of an exercise routine. The main color is used in the logo, secondary branding and acts as a highlight color throughout the app.

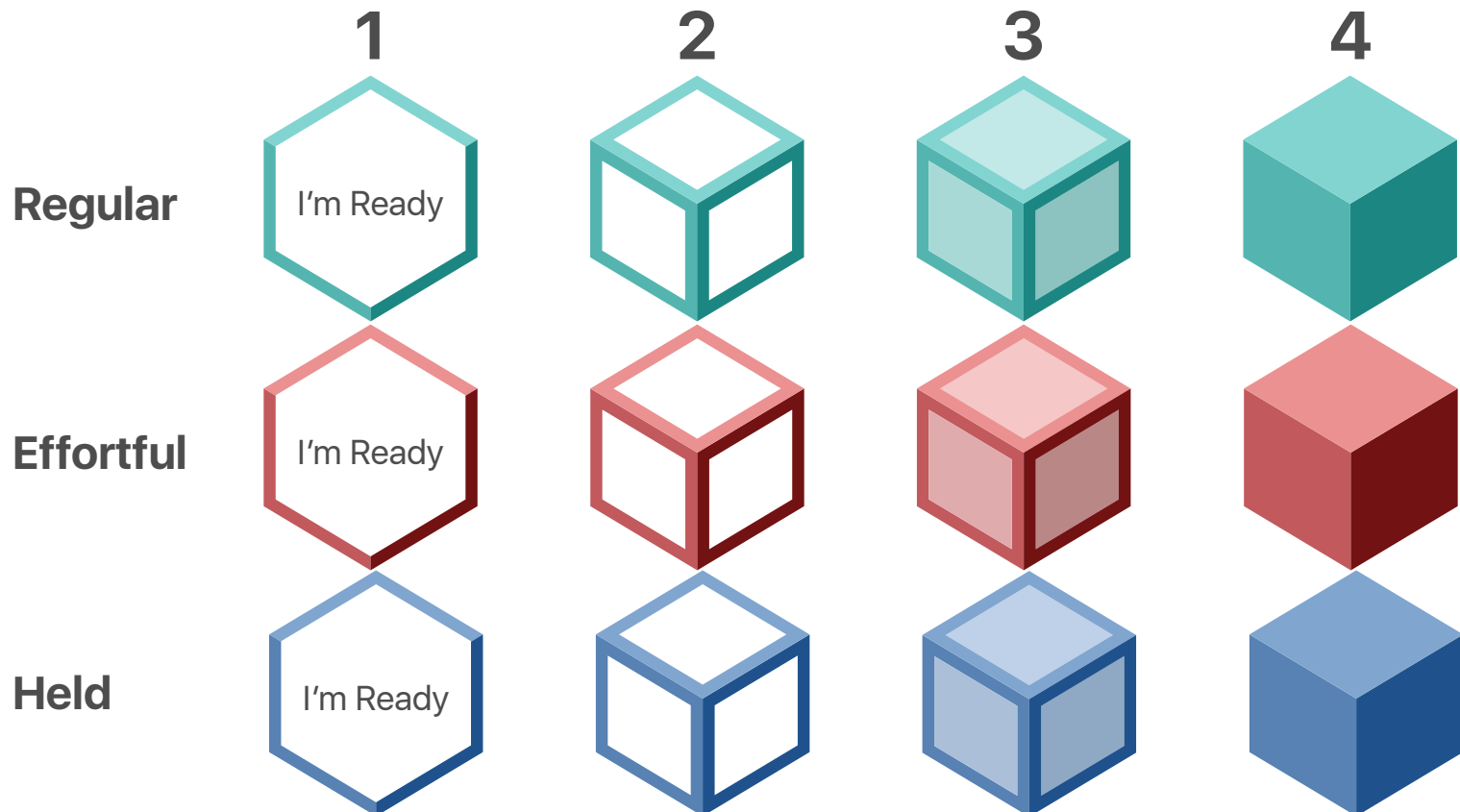
Red for Effortful. An effortful is a swallow with as much intensity as the patient is capable. Although red has many negative connotations (blood, danger), red is associated with energy, strength and power. It is an intense color, which matches the intent of the effortful swallow.

Blue for Held swallows. Also known as the Mendelsohn Maneuver, a held swallow requires the patient to swallow and then, using their swallowing muscles, hold at the peak of the swallow for 2-5 seconds. Blue represents tranquility and calmness, and was chosen as an appropriate color for what will likely be the most difficult exercise for most patients, requiring the most concentration.



# Swallow Feedback

1. Start a Swallow. Color coded interactive outline to start and stop a swallow (I'm Ready/I'm Done)
2. No Activity. Nothing registered - swallow was started, but no muscle activity registered.
3. Swallow attempt - swallow was attempted, but did not meet the goal.
4. Complete Swallow - Met the goal.



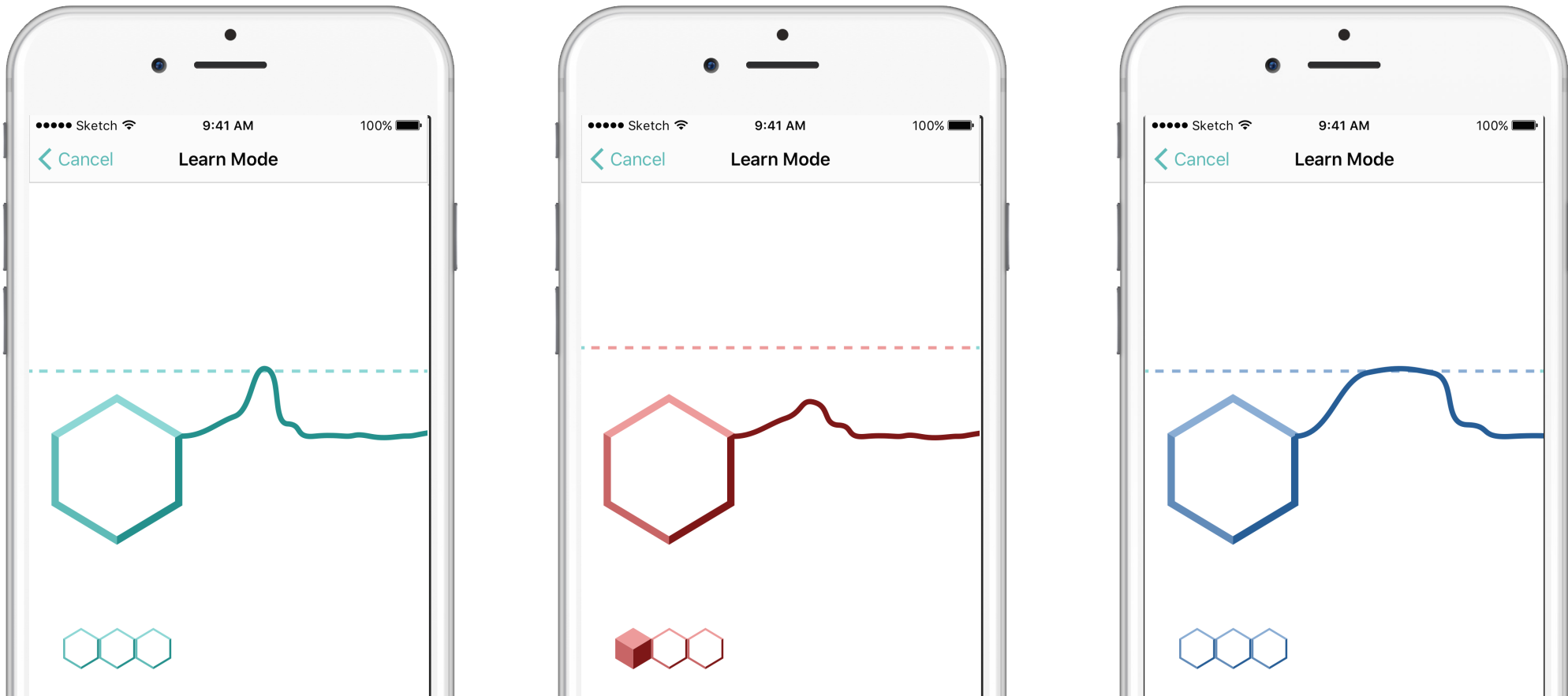


# Visual Biofeedback

A goal is established (the dotted line on screen) by performing calibration swallows, so that the muscle activity is accurate to that day.

A patient's swallow is represented by a visual biofeedback line that emerges from the 'start a swallow' point of interaction. Similar to the waveform that represents heart activity on a monitor, there are spikes in the line when activity is measured.

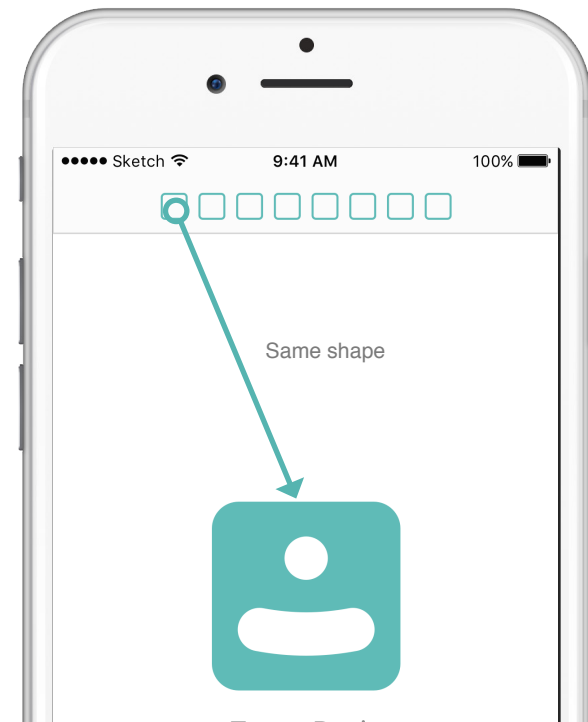
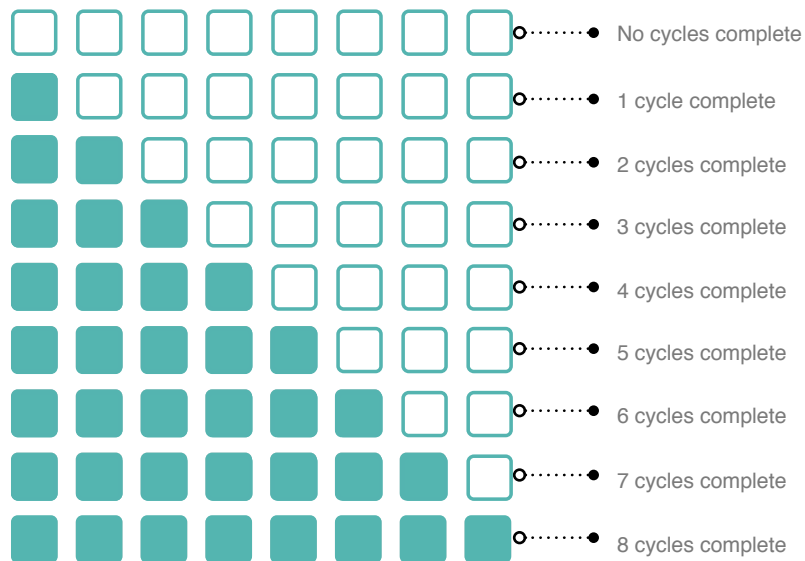
The goal for the patient is to make their swallow line meet the goal line. The point of interaction will then display whether they were successful by changing to a full cube (met the goal), a partial cube (swallow was attempted, but did not meet the goal), or a cube frame (no muscle activity registered).



# Daily Set Tracking

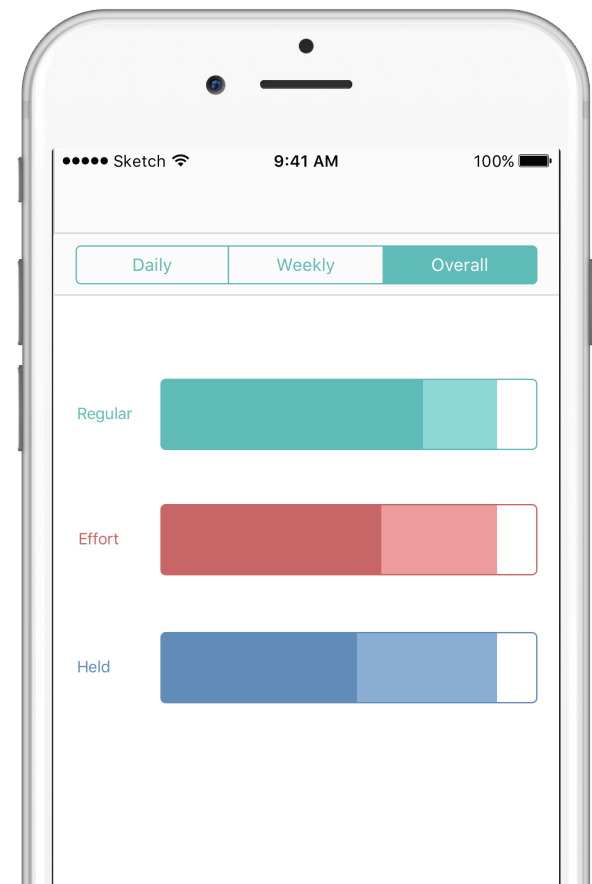
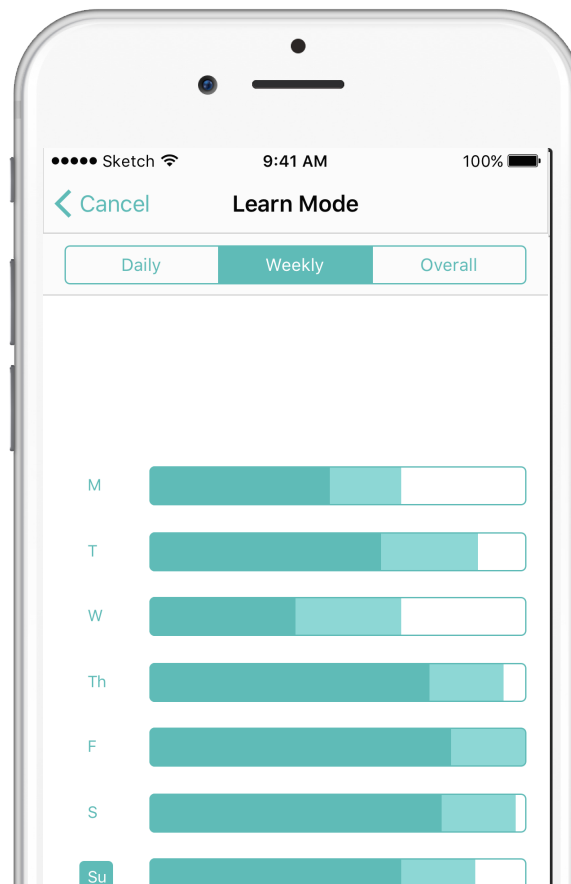
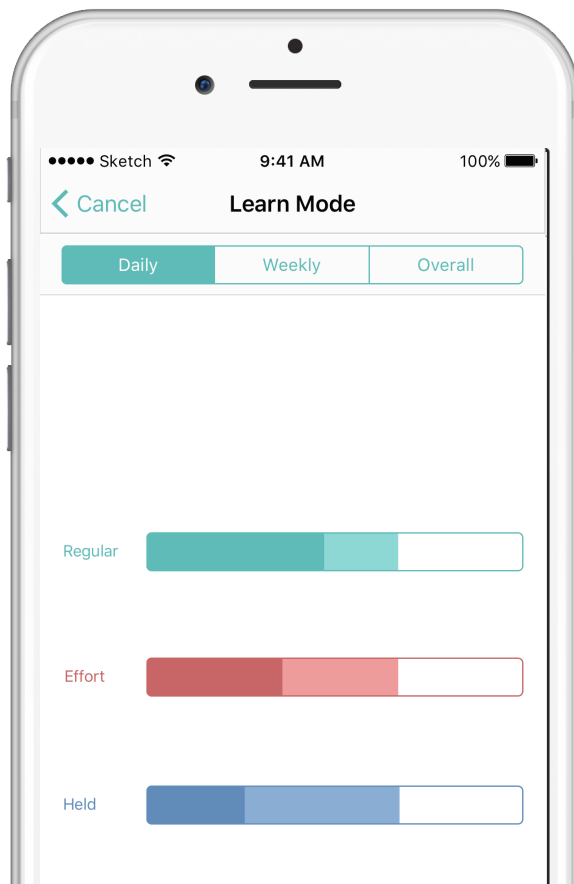
For the clinical trial, there is a defined prescription of 8 sets per day comprised of 3 reps of regular, 3 reps of effortful and 3 reps of held swallows for each of the 8 sets (72 reps total). To visually aid the tracking of sets, 8 squares will appear in the top navigation once their prescription begins. These will initially be an outline, but will change to the filled central color upon completion of a set.

The squares are the same shape as the interactive button to begin exercising. The shape establishes a relationship between starting an exercise and completing a set.



# Progress Tracking

Mobili-T owners will be able to track their progress through daily, weekly and overall tabs. The meters will fill with color as they progress. The darkest color in each bar shows how often a user reached their target. The lighter color in each bar shows how often they attempted, but didn't quite make the target. The white in each bar represents incomplete swallows - either how many times the system did not register a swallow or swallows from incomplete sets. The weekly summary shows day to day progress. The Overall section shows the total of completed, attempted and incomplete swallows.





# Instructional Imagery

In app - where anatomical imagery is used to instruct (such as when learning to place the device), human-like renders featuring a geometric aesthetic are used. The geometric mannequin is understandable as a representation of a human, without the limitations of illustrations or the potential misrepresentation of photographs. Anatomical illustrations are less likely to accurately communicate the complexity of instructions such as finding your mandible for the placement of the ground electrode. Photographs may not be relatable from individual to individual due to the variety of differences related to head and neck cancer. The 3d mannequin provides a visual middle ground while also relating to the cube geometry featured in the iOS app, providing a fictional, but understandable communication device for anatomical instructions.



## Logo

The 'T' in Mobili-T stands for therapy.

The emphasis on the 'T' creates a simple, memorable icon that relates to the intent of the system - mobile therapy for patients that have been bound to hospital therapy or home based therapy with minimal guidance.

This is visually communicated through the framing of the 'T' as an app icon.

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# Secondary Element

The smile is linked directly to the hardware, as the surface of the enclosure includes the smile as visual and tactile placement guides that relate to the electrodes used for measuring muscle activity.

Within the app, it is used as the central interactive element to begin an exercise session. The intent is for the users to connect a personality to the system, which veers from the typical cold medical devices that many of our patients are accustomed to using.

Patients are more likely to be engaged and consistent with their prescribed exercises if they are comfortable with Mobili-T. Creating a system with a friendly personality increases the likelihood of this happening.





# Research

Swallowing disorders, particularly focused on head and neck cancer, are issues that require knowledge from a variety of disciplines. A variety of research was completed to ensure these disciplines were best able to design for the needs and limitations of this patient group.

Design sprints were a technique used early in the discovery phase of the project to commence a dialogue between disciplines. We included patients in the activities to make sure their point of view was included in early stage ideation. Their presence kept the team focused on the human problems that needed to be addressed. Utilizing the style of design sprints from Google Ventures that involve building individual storyboards and a voting system that creates idea heat maps, the team was able to identify assumptions and plan research techniques to validate those assumptions.





# Cultural Probes

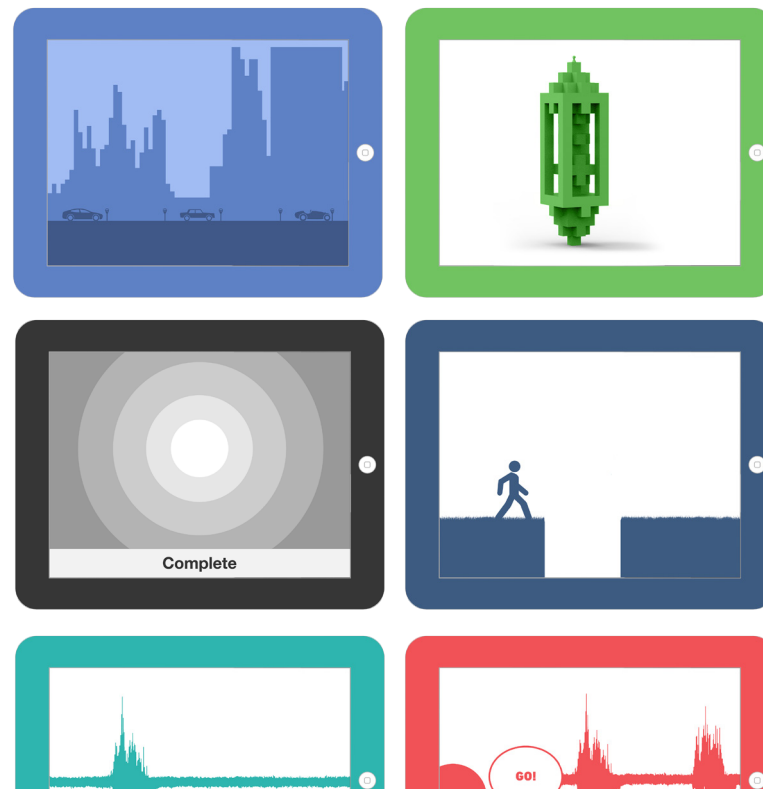
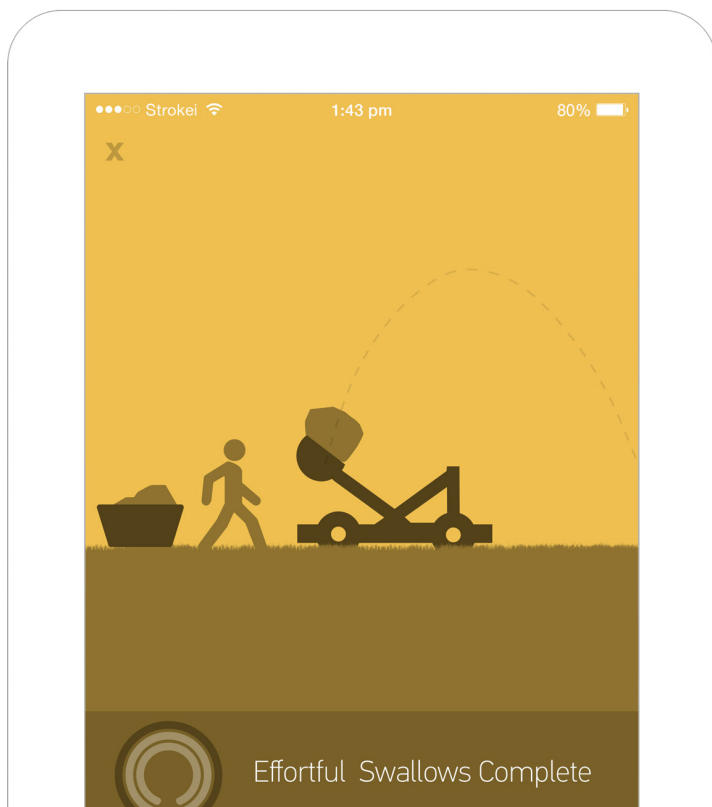
Head and Neck Cancer patients were given cultural probe kits containing a disposable camera, writing utensils and three different notebooks with various questions and activities. Cultural probes are used to inspire, inform and create a dialog between designers and intended users, particularly in the early stages of research and ideation. This study revealed various themes, such as the ongoing fatigue and difficulty of concentration associated with head and neck cancer, that drove the need for a simplification of the app experience. A paper discussing the findings was published in the University of Alberta Health Sciences Journal with the title “Designing for patients: Using a cultural probe in the development of a mobile health device and application for swallowing therapy in head and neck cancer patients.”



# Interviews

A series of interviews with head and neck cancer patients were conducted in order to learn about two topics - (1) Identify self-reported factors that influence adherence to conventional home therapy without a mobile device in HNC patients, and (2) identify appealing biofeedback designs that could be used in a health app. The designs were presented through video walkthroughs and storyboards. Thematic analysis of semi-structured interviews was used to answer the first objective. Convergent interviews were used to obtain reactions to biofeedback designs. Some of the findings included feedback on performance during swallowing exercises should retain the chief goals of biofeedback (e.g., immediate representation of effort relative to a goal). Simple, intuitive graphics were preferred over complex, abstract ones. Continued engagement with the app could be facilitated by tracking progress and by using visuals that build or create structures with each subsequent use.

An article was written on these interviews titled “Designing a mobile health application for patients with dysphagia following head and neck cancer” which has been approved for publication in the Journal of Medical Internet Research: Rehabilitation and Assistive Technologies.

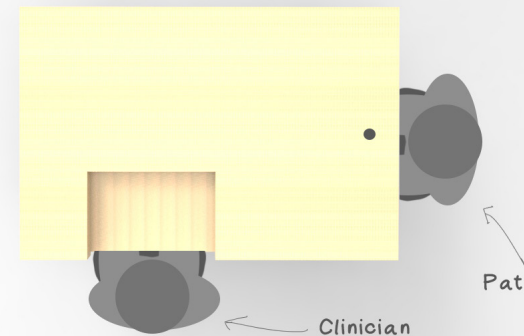
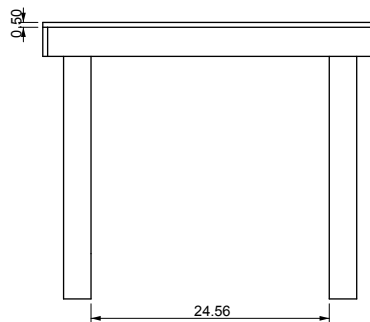
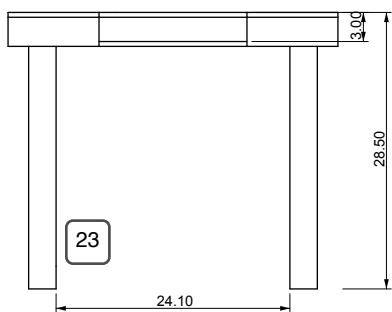
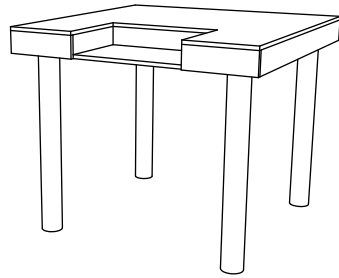
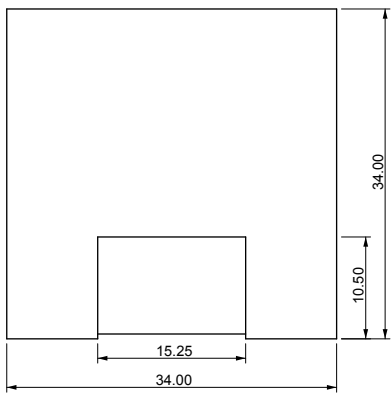




# Technology Evaluation

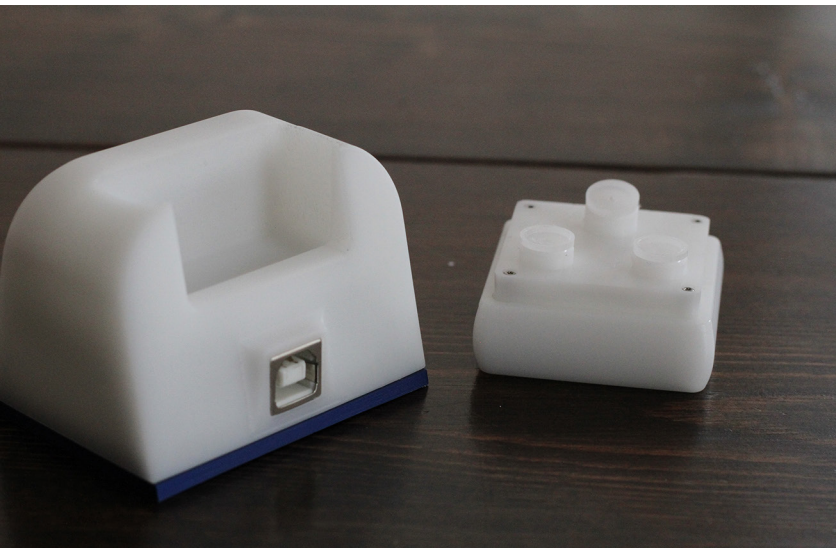
Surface electromyography (sEMG) is used in dysphagia therapy to demonstrate the activity of submental muscles during swallowing exercises. Mechanomyography (MMG) has been suggested as a potential superior alternative to sEMG; however, this advantage is not confirmed for signal acquired from submental muscles. A study was conducted to compare This study compared the signal-to-noise ratio (SNR) obtained from sEMG and MMG sensors during swallowing tasks, in healthy participants and those with a history of head and neck cancer (HNC), a population with altered anatomy and a high incidence of dysphagia. Physical testing involved fabricating a clinical testing table that housed sensors used during a patient trial.

The findings of this study were published in *Dysphagia* in August 2016, titled “Electromyography and Mechanomyography Signals During Swallowing in Healthy Adults and Head and Neck Cancer Survivors”.



# Patient Feedback

Hands-on feedback and user testing was used throughout the project. Ranging from storyboard walkthroughs to functional testing of the hardware and software. This was integral to the project, as it kept the team grounded in the reality that these patients face every day. The enthusiasm from these individuals also kept the team driven to provide a meaningful system to address their needs.





Our team cares immensely for the people for which this system was designed. We believe the work takes in to consideration the human and emotional components that are often overlooked in the development of functional medical products.

Thank you for your consideration!