ebb& glow

Project Summary

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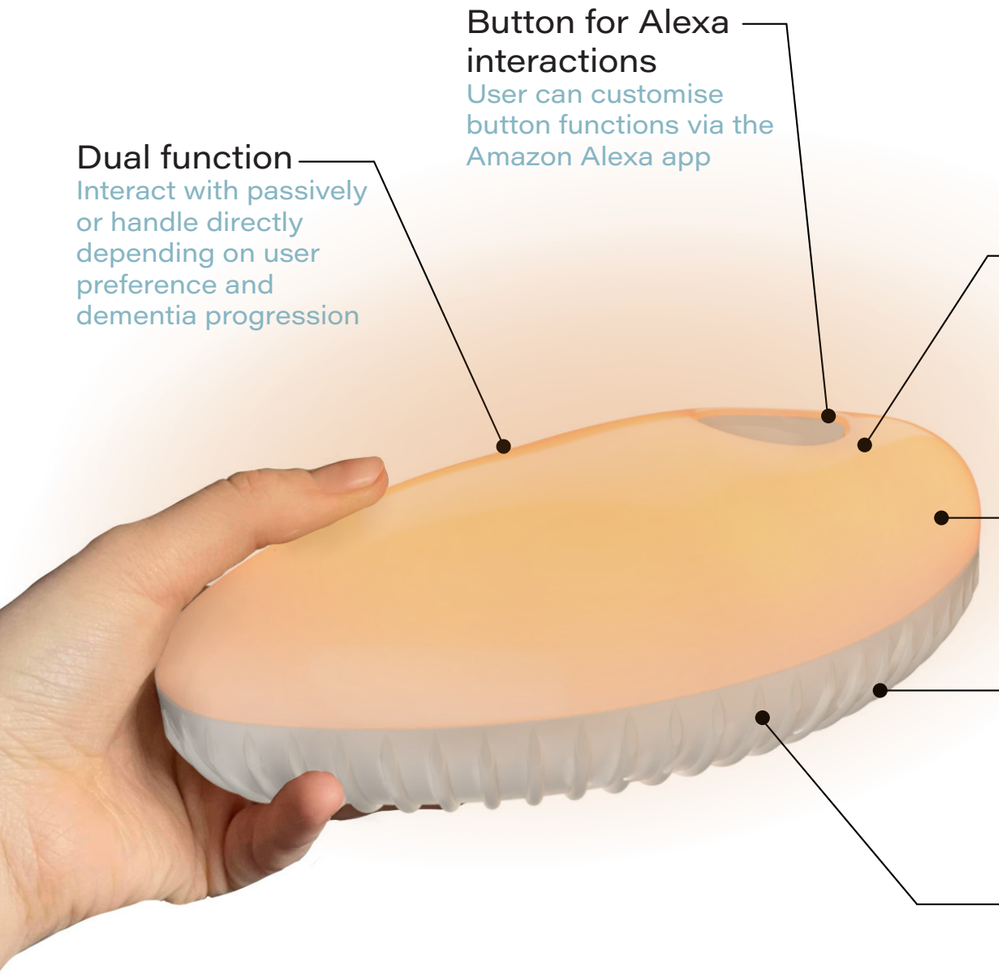
Product Overview



Button for Alexa interactions
User can customise button functions via the Amazon Alexa app

Dual function
Interact with passively or handle directly depending on user preference and dementia progression

Blue light therapy
Narrow bandwidth blue light to improve sundowning symptoms and suppress melatonin production in the mornings

Warm light
Warm coloured light in the evenings to induce production of melatonin

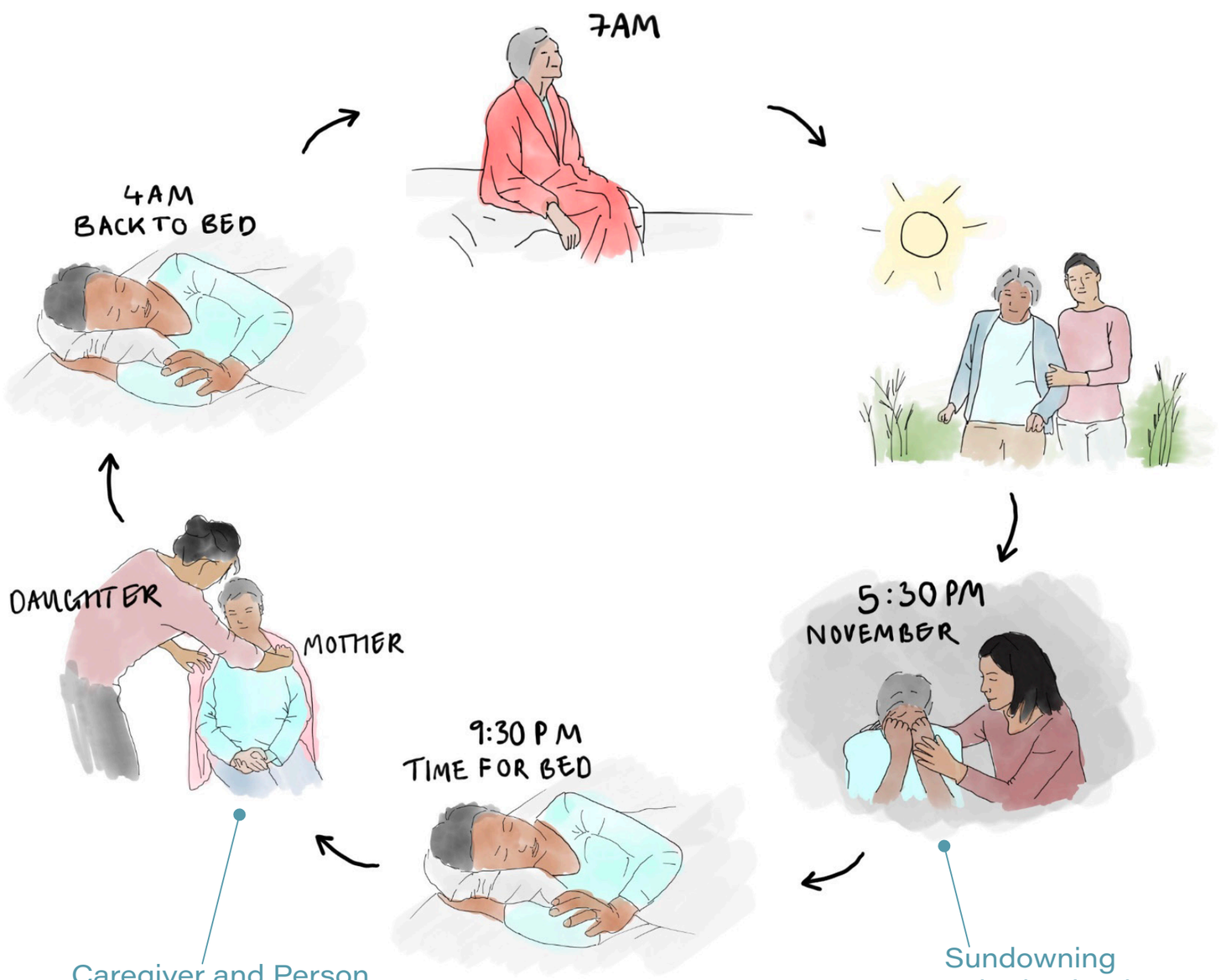
Light timer interface
Light progresses around the product signifying how many minutes of blue light therapy remain

Wireless charging
Easy, fast charging

App Connection
ebb&glow and Alexa app allow users to customise ebb&glow function as dementia progresses

ebb&glow is a device for people living with dementia (PLWD) experiencing sundowning. It can be introduced early into dementia diagnosis and stay with someone throughout their dementia journey to promote routine.

The Problem: What is Sundowning?



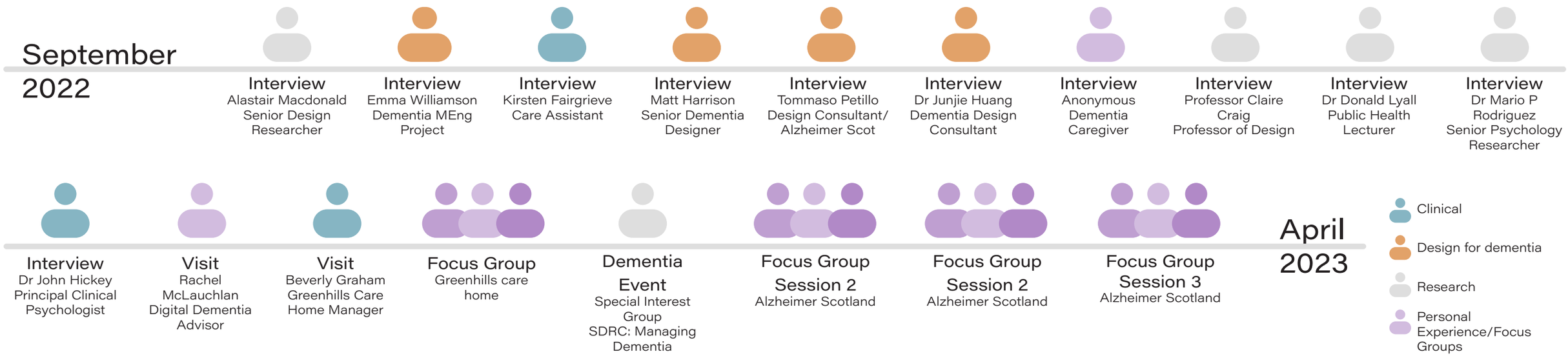
Sundowning is defined as agitation, anxiety or aggression which occurs in the afternoon, evening or when the sun goes down. It occurs as dementia causes pathological changes to the part of the brain which regulates the circadian rhythm.

944,000
PLWD in the UK, expected to increase to 1.6 million by 2050.

66%
of PLWD can experience sundowning.

Sundowning symptoms can cause caregivers to reach breaking point while trying to provide the best possible care for their loved ones.

User Engagement and Research Insights



The main causes of agitation in People Living With Dementia (PLWD) are:

- Inability to communicate pain/hunger/thirst
- Frustration/natural agitation at predicament
- Sundowning

Key Findings:

Sundowning needs more awareness for people to recognise and treat symptoms early into diagnosis

Focus on providing relief for caregivers.

Implementing routine can minimise sundowning/ agitation symptoms.

Most current products are designed only for advanced stages and often resemble kids toys.

Smart home products can help people living with dementia, however they have not been designed in a dementia-friendly way.

There will be no one size fits all solution.

Research Findings and Concept Generation

Early Concept Generation

Initial concepts incorporated a combination of different ways to help sundowning including:

- Multi-sensory stimulation
- Sensors to detect agitation
- Simulated presence therapy
- Bright light therapy (to regulate circadian rhythm)

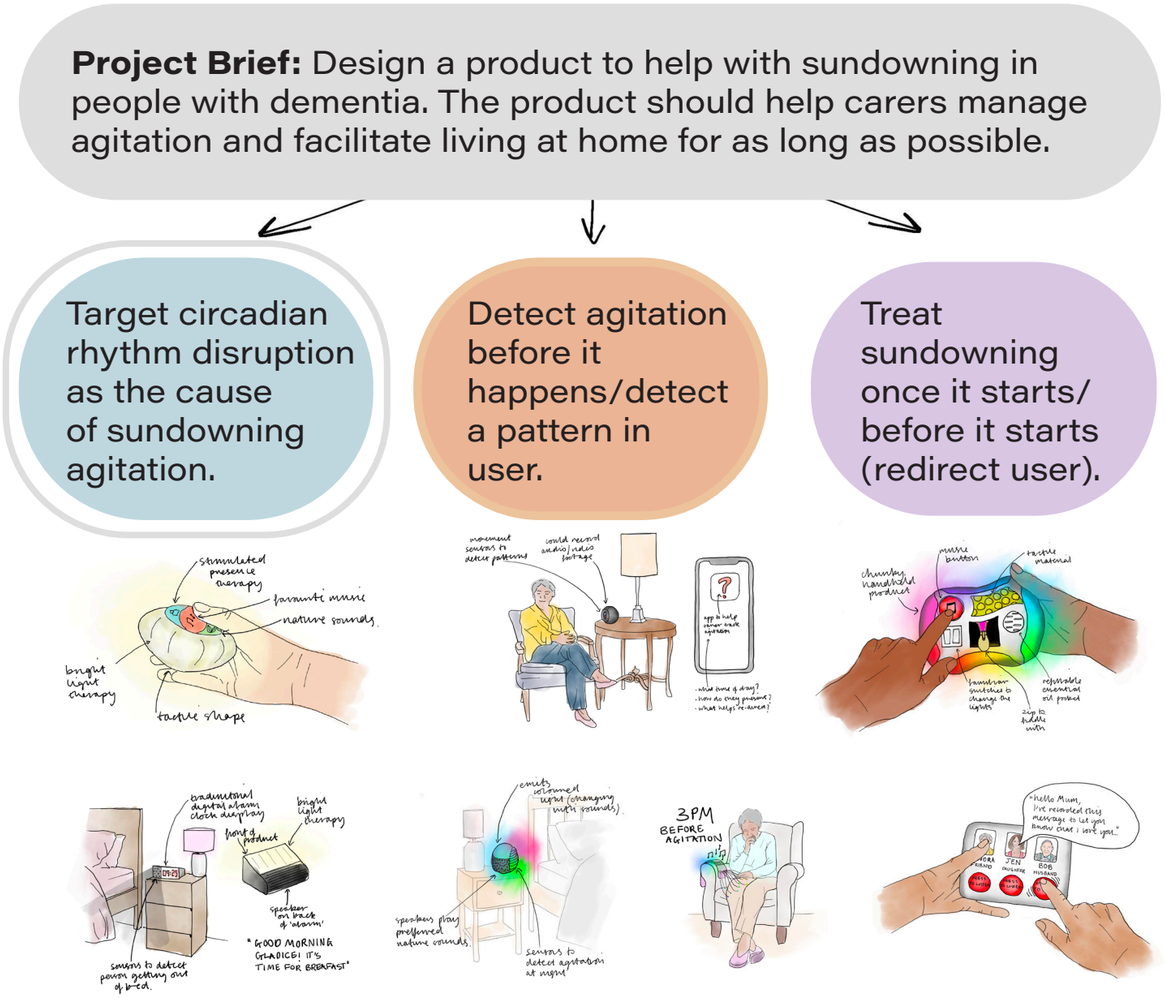
The brief was then split into three categories as shown to give the project a clear direction. Targeting circadian rhythm disruption problems as the cause of sundowning chosen as the project focus, although it was important to establish what key features from other treatments could be incorporated into the product for maximum effect.

User-Centred Development

Stakeholder insights helped develop a list of key requirements during the concept generation phase:

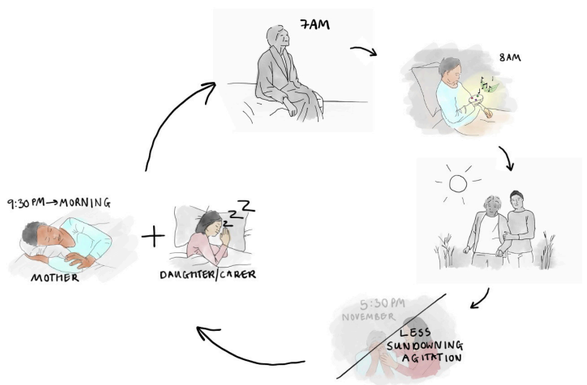
- Music/sound
- Tactility
- Customisability/unpredictability
- Encouragement of routine

Using narrow bandwidth blue light meant that the brightness could be significantly reduced when compared to bright light therapy, meaning that the product could be held by users in more advanced stages of dementia.



User Journey Analysis

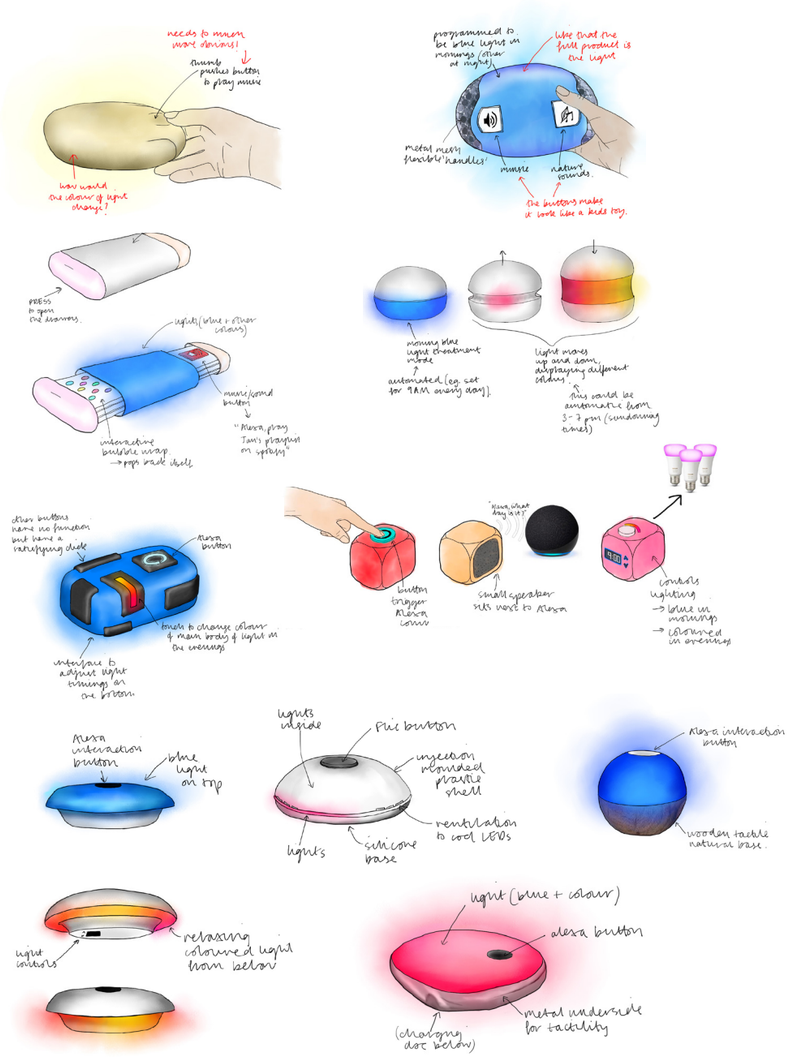
Concepts were mapped into user journeys to understand how PLWD would interact with the product throughout the day. This helped determine what kind of intervention would be most beneficial to caregivers.



Concept Development and Co-Design

2D Development

Design sketches were evaluated by focus groups at Alzheimer Scotland and local care homes. While the option include fiddle-toy aspects was explored, stakeholders decided **simplicity was key** to encourage people to interact with the product. Concept evaluation matrices were used to prioritise key functions to be included and determine whether a single product or 'suite of products' was most suited to the user requirements.



3D Development

Foam models and 3D printed prototypes allowed me to get feedback from caregivers, PLWD and staff at Alzheimer Scotland. People could interact with tactile, pebble-like shapes, allowing for detailed insights on size, irregularity, and the use of texture and surface finish.

Anthropometric data was considered to ensure the product is comfortable to hold for a large range of hand sizes.

Development and Co-Design

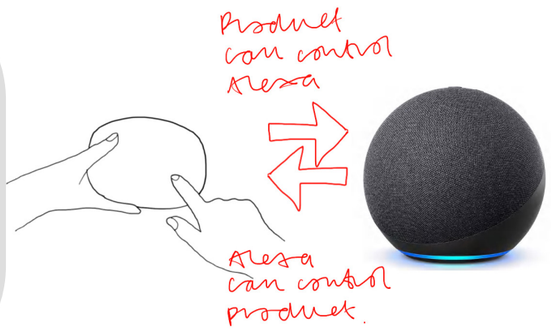
Incorporating Music and Smart Speaker Technology

After stakeholders identified that music was a key function to be included in the product, it was important to select the correct way to incorporate music and sound, specific to the user requirements.

Collaborating with Alzheimer Scotland and working closely with users allowed me to determine how comfortable the user group generally is with technology. They expressed that Amazon Alexa devices can be incredibly beneficial, however they have not been specifically designed for PLWD. This means there are use limitations including forgetting to interact with Alexa, or forgetting how to interact with the technology.

Advantages of Alexa technology for PLWD include:

- Music/sound
- Conversations
- Reminders
- Customisable interactions
- Smart home controls
- External monitoring by loved ones/carers



Overcoming Current Limitations

With current products (such as prompt cards) existing to encourage and remind PLWD to speak to Alexa, this was established as the focus. The product must be able to facilitate interaction with Alexa, without requiring speech or memory.

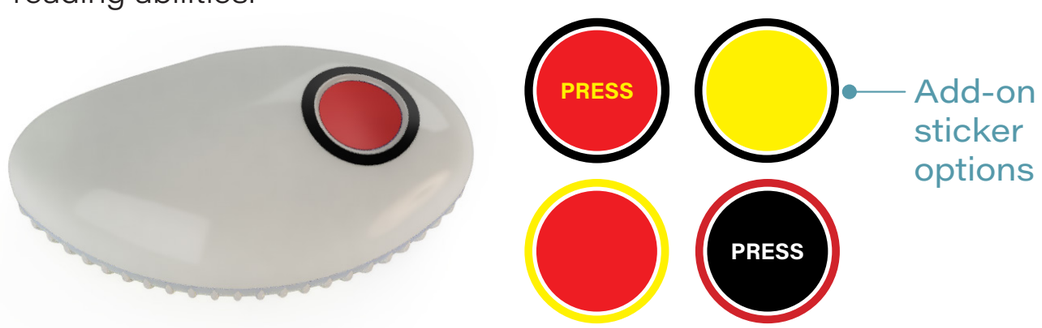
User feedback established a single intuitive button was the way to do this. The button should have several functions (or Alexa 'routines'), depending on how it is pressed. The functions can be triggered by deliberate actions by users in early stages of dementia and can be a 'happy accident' when pressed by users whose dementia has progressed.

Function Growing with Changing Needs

The user interface and user experience was prototyped with existing smart LEDs and an Alexa interaction button (by Flic). This meant user testing of the finished product was possible. Users responded well to how customisable the process was with Alexa offering a wide range of button routines from changing the colour of the ebb&glow light, telling a funny story, playing music from the 50s and so on.

Dementia Accessibility

Insights from digital dementia experts reiterated the complex sensory changes associated with dementia including difficulty perceiving certain colours and low contrasts. Many products on the market do not cater to this, including large-button modified mobile phones. While the product was designed to fit into a home environment, a set of add-on vinyl sticker should be provided to enable the caregiver to select which colour contrast works best for the PLWD. The stickers come in the recommended red, yellow and black and have optional text stickers depending of the PLWD's reading abilities.



User Interaction: Early Diagnosis

Ellen, 67
Ellen has recently been diagnosed with dementia and has implemented ebb&glow into her routine. She uses it in the mornings for blue light therapy and in the evenings to give off a sunset glow. It sits on the charging dock during the day.

Ellen felt empowered that she could use a product that might help her as dementia progresses.

She likes that the ebb&glow light therapy punctuates her day and she is finding it helpful that she can set reminders on Alexa too now that she has it working together with ebb&glow.

Morning use to suppress melatonin production

Product placed on dock, Ellen goes out for the day

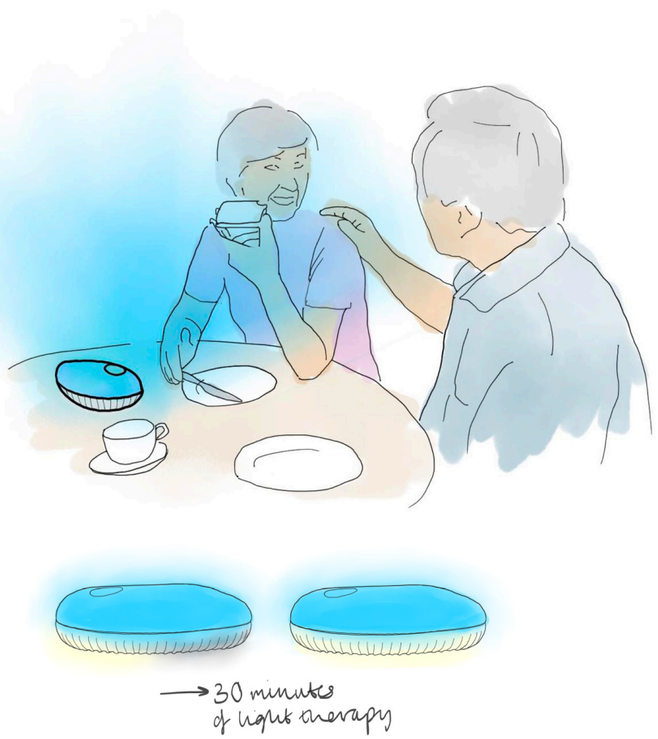
Evening use to stimulate melatonin production

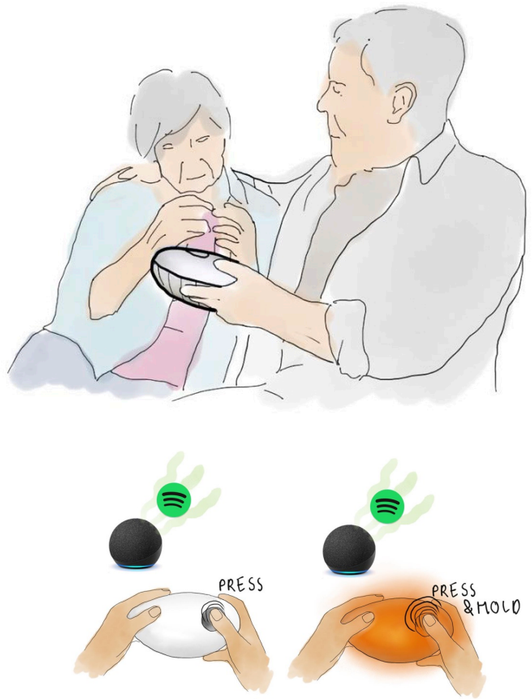
User Interaction: Middle-Late Stage Dementia

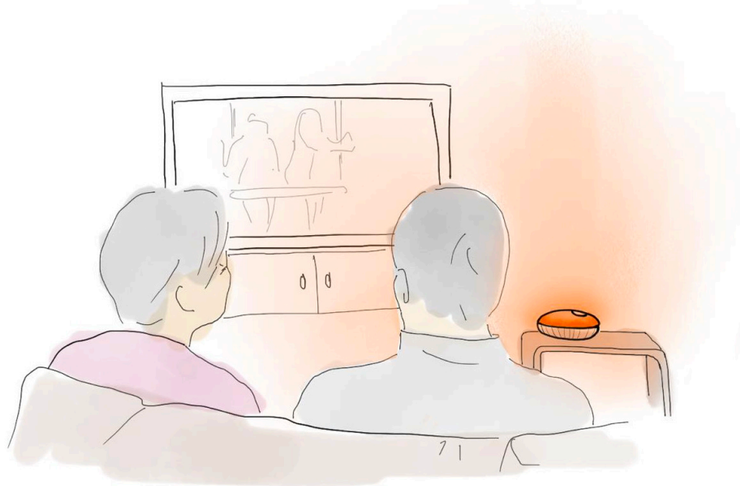
Ellen, 73
Six years on, Ellen's husband now cares for her at home as her dementia has progressed. He facilitates morning light therapy and passes her the device to interact with in the afternoon. In the evening they both enjoy the coloured the coloured light to help them feel sleepy.

They are both used to using ebb & glow and helps them keep to a routine.

Ellen's interaction with the product has increased. She likes to hold it and press the button to get Alexa to play her favourite music and turn the light orange, her favourite colour.







Morning use to suppress melatonin production

Afternoon use before sundowning

Evening use to stimulate melatonin production

Technical Development

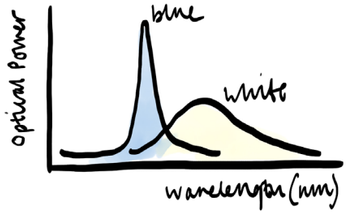
Narrow Bandwidth Blue Light Treatment

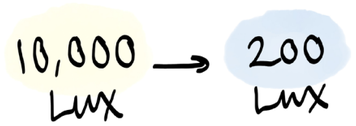
This project aims to achieve the fine balance between technical and user requirements. Narrow bandwidth blue light was chosen as an alternative to bright light therapy as the product must be able to be held close to the user to meet tactility requirements. Experiments and research into previous trials were completed to identify the correct wavelength, illuminance and beam angle required to output the correct 'dose' of light therapy.

Why is Blue Light Therapy More Appropriate?

User requirements reinforced that bright light therapy is too bright for users and can cause side effect such as dizziness, headaches and agitation.

Shorter wavelengths in the blue region penetrate deeper into the eye than other wavelengths.





Therefore, blue light has reduced illuminance requirements for equally effective circadian rhythm shifting when compared to bright light therapy.

$\Omega = 2\pi(1-\cos(63°)) = 3.43$ steradians

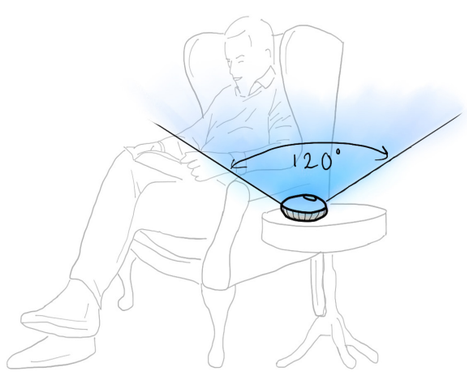
luminous intensity = $\frac{17 \text{ lumens}}{3.43 \text{ steradians}}$

$= 4.96$ candela

luminous flux (0.6m) = $\frac{4.96 \text{ candela}}{0.6 m^2}$

$= 13.78$ lux

$\frac{200 \text{ lux}}{13.78 \text{ lux}} = 14.51 \Rightarrow 15$ blue LEDs



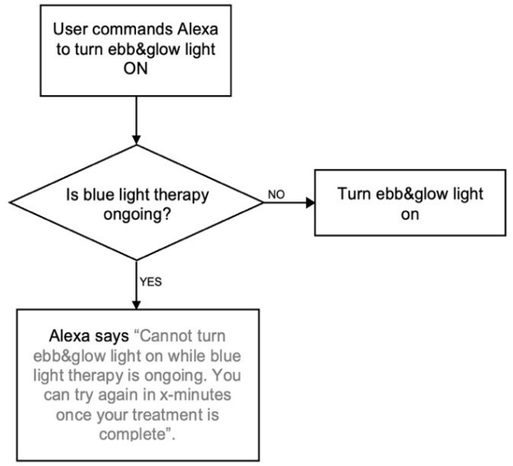
Product Orientation

The product had to be multi-directional to prevent incorrect use. Selecting a light source with a wide beam angle enabled light to reach users when the device is positioned on any surface at roughly 60cm from their eyes.

Fail-Safe Design

Blue light is often perceived to be 'bad for sleep' as it can send the brain 'wake up signals' if used at the incorrect time.

The Alexa skill must be programmed such that the user is unable to turn the blue light on in the afternoons. The program must also prevent blue light therapy time being interrupted by users turning on the ebb&glow light a different colour.



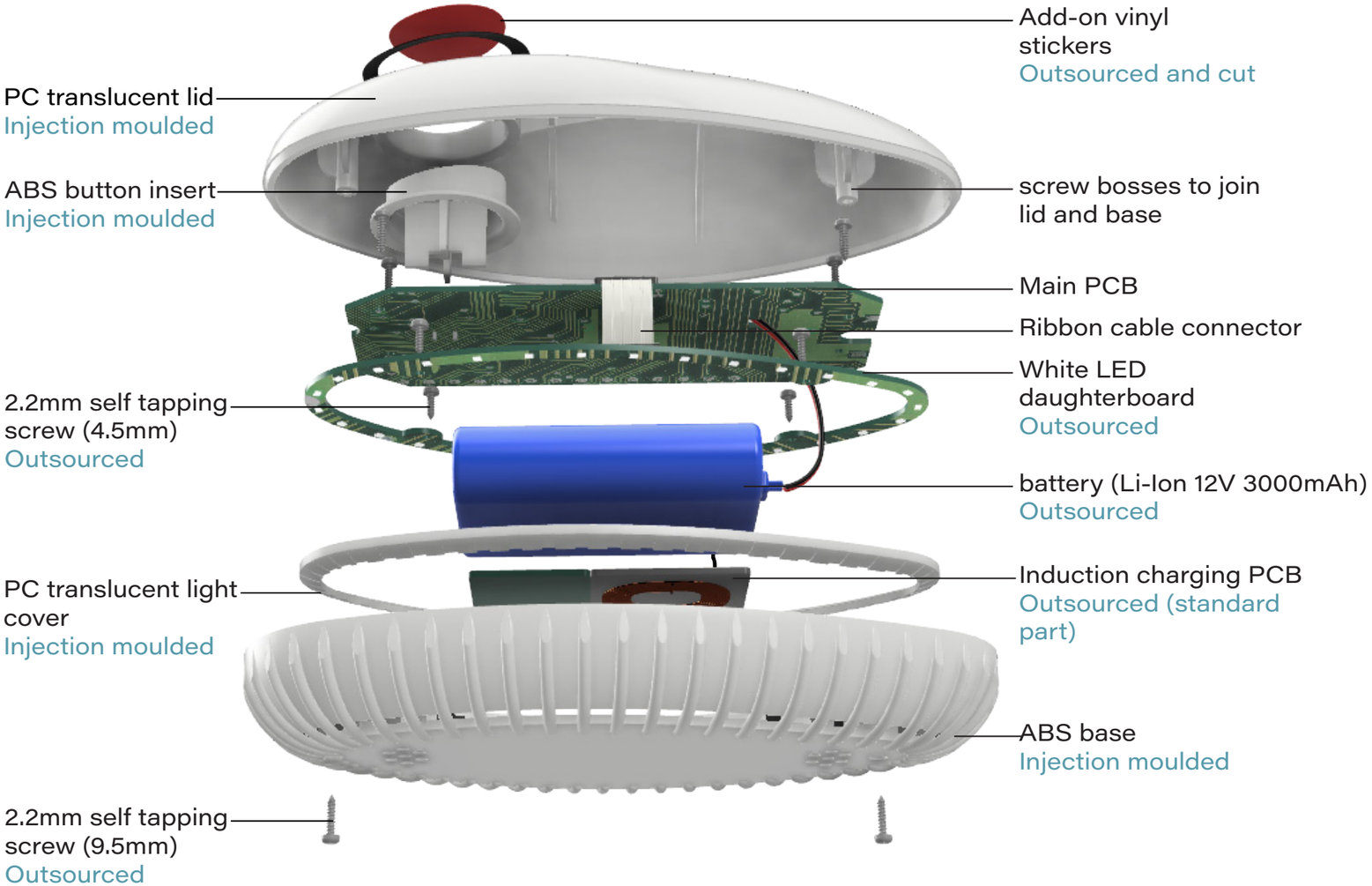
User Safety

Research ensured that the spectral characteristics of the chosen blue light source were within the safe allowable range, preventing risk to retinal damage from the blue light hazard. LED heat experiments were run to ensure the product could not heat up excessively. Despite temperature increase being insignificant, ventilation was added to the base of the product with ridges to maximise airflow. This ensured that, if the product was covered and insulated for some reason, it would not overheat.

Future Research

While blue light has been successfully trialled for seasonal affective disorder (SAD), blue light should be trialled in PLWD experiencing sundowning to increase product development opportunities. As SAD and sundowning are both related to melatonin production and both respond to bright light therapy, it was assumed that the blue right efficacy will translate to sundowning.

Materials, Manufacture and Assembly



Design for Manufacture and Assembly Principle

Standard parts have been used where possible to minimise development costs. The design tried to minimise PCB complexity, however, detailed design evaluations determined a main PCB and daughterboard were required to create the compromise between sleek, user-centred design and reducing manufacturing costs.

Design for Injection Moulding

The external casing, button insert and base light cover are manufactured from injection moulded plastics. User requirements guided material selection criteria. For example, the product must be impact resistant and resistant to common cleaning products.

The design adheres to injection moulding guidelines including constant wall thickness where possible, screw boss design and ribs to add additional strength.

Electronics Design

PCB component requirements have been determined from technical light treatment specifications and user requirements.

The main PCB will require:

- 15 x Blue LEDS
- 9 x RGB LEDS
- 1 x microcontroller (MCU) unit
- 1 x Alexa Connect Kit (ACK) module with Wi-Fi function

and other components including LED drivers and resistors.

A future development plan has been outlined to prototype the Alexa interactions and design, build and test Alexa skills before release.