The Suitable Machine:

Exploring style through storytelling to inform design

by Ashleigh Kennedy

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Much love
Ash xx

Abstract

The Suitable machine demonstrates how aesthetic change can be made to a Continuous Positive Air Pressure (CPAP) device, allowing it to suit the visual style of a specified bedroom environment that has been described. Digital data (3D scans) of the CPAP device provided specific measurements allowing a wide variety of aesthetically styled outputs that were tailored to fit. Each suitable to the people, home and machine they are designed for. CPAP devices that are used to treat patients with Obstructive Sleep Apnea (OSA) are considered strongly driven by a medical aesthetic. The Suitable Machine explores how CPAP devices, hoses and masks can be housed within these bedroom settings, producing designs to personalise the domestic environment and reduce stigma through the improvement of aesthetic qualities. The research uses Research Through Design (RtD) as a methodology. Background Research, Design Audits and Narratives are used to define the scope and criteria, providing parameters for the research and design outputs. Background research shows both knowledge gaps and bias to a growing dilemma; suitability. Development of the designed outputs makes use of Sketching, 3D Scanning, CAD Modelling, digital Rendering and 3D Printing as methods; producing an experimental indication of what could be possible for the personalisation of medical devices through aesthetic change in domestic environments.

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Introduction

Currently, engineers dictate the appearance of the CPAP device; translating complex engineering methodologies into a product that is user administered. Engineers have an objective to ensure that the device functions sufficiently, and do not prioritise the considerations of consumers differing aesthetic preferences. Hence this thesis proposes the question:

Can 3D printing enable the personalisation of CPAP devices so that they can aesthetically fit in specified home/bedroom environments?

The research investigates the aesthetic of CPAP devices, through manufacturer and user narratives, as a form of storytelling. Aiming to explore the democratised personalisation of these devices through digitally defined 'Sleeving', to house the clinical device, by 3D scanning, 3D modelling, digital rendering and 3D printing as a method to visually describe the potential aesthetics that the process allows. The CPAP devices function exceedingly well, are user administered and are situated in the domestic environment. However, they do not fit harmoniously into a majority of home environments, embodying an engineering centric 'medical aesthetic'. Industrial designers have commonly housed products. This is their job to provide what they think suits; wrapping the idea, innovation and technology. The difference that this thesis suggests is that the designer who makes visual decisions for all, to cater to all, should focus on the use of specific visual styles based on an environment, for a person and how they use the technology. 3D printing can allow suitable personalised products to be produced rapidly, allowing both the designer and consumer to co-create the style of a product. This research intends to inform the future development of CPAP machines in manufacturing companies and may encourage CPAP manufacturers to produce similar products or systems that could be better suited to home environments and peoples personal preferences. Research Through Design (RtD) is used throughout the research as it provides a basis on which to produce and reflect on designs through a naturally developing process. Narratives are used as a form of storytelling to inform potential designs. The Narratives expand on Persona generation through storytelling, describing a scenario, to produce information and criteria that allow designed concepts to embody the aesthetics of what is described. Leading to the aesthetic reconsideration of a CPAP device. These Narratives are an essential part of this research, allowing for immersion of perspective in context while enabling the understanding of a person's experience of life when using their CPAP device.

Style
noun

1. a distinctive appearance, typically determined by the principles according to which something is designed.
2. fashionable elegance and sophistication.

Narrative
noun

1. a spoken or written account of connected events; a story.
2. the practice or art of telling stories.
3. a representation of a particular situation or process in such a way as to reflect or conform to an overarching set of aims or values.

Sleeve
noun

1. the part of a housing that wholly or partly covers an object. "the Sleeve covers the device"
2. protective shell or cover for an object.

Suitable
adjective

1. right or appropriate for a particular person, purpose, or situation.

Background Research 001

Literature Review

The purpose of this literature review is to build a foundation of leading work that helps to identify the scope of the research, leading to a critical understanding of the subject. The critical points identified from the research question were broken down into four parts: the object & problem (OSA & CPAP), the environment in which this is situated (Healthcare in the Home), ways the subject could be improved upon (implementation of Democratisation) and lastly a process & manufacturing technique that could be used to achieve a resolution (Mass Customisation and 3D Printing). OSA & CPAP examines the illness, device, patients and compliance. Healthcare & Home investigates the design of medical devices, the division of medical devices & homewares, user-centred wellness, style and personal taste in the home environment. The democratisation section explores the historical definition of democratisation in the context of mass manufacturing, its uptake in design and the relationship to user innovation in design. Lastly, the Mass Customisation and 3D Printing section investigate past & present Mass Customisation, and 3D printing's relevance to this; identifying essential elements that influence automation of customisation.

OSA & CPAP

Obstructive Sleep Aponea (OSA) is a chronic disorder that is defined as the collapse of the upper airway due to muscles relaxing and narrowing, causing interruption of breathing during sleep (Strollo & Rogers, 1996) (Fig 1.1). It is estimated that OSA affects "16,000 adults and 2% of children in New Zealand" (Health Navigator, 2008) and approximately "2% of women and 4% of men" in the USA (Young et al., 1993, pg 1234). OSA symptoms can include but are not limited to: a constant feeling of fatigue and daytime sleepiness, headaches, depression, irritability, lack of concentration, being overweight, high blood pressure. People with

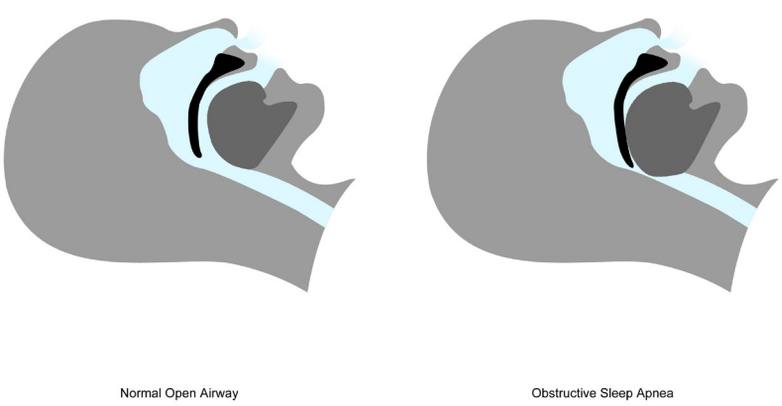


Figure 1.1. Diagram of a normal open airway (left) & closed airway of someone with OSA (right).

symptoms may also have intervals where breathing has stopped for 10 seconds or longer and may frequently waking up for no reason, getting up two or three times a night to urinate (Health Navigator, 2008). OSA can also affect stages of rem sleep from proceeding, which is needed to allow for the human body to heal and rest. Many undiagnosed patients believe they sleep throughout the night, but don't get any rest. One patient discussed that, prior to being diagnosed, they spent eight hours in bed and would continue being exhausted during the day; occasionally having "irresistible urges to sleep at inconvenient times—when driving or during a dinner with guests" (Gøtzsche & Berg, 2010).

Primarily Continuous Positive Air Pressure (CPAP) therapy is prescribed to prevent and reduce snoring and stop apnea episodes from happening during sleep (Health Navigator, 2008); however, apparatus such as Mandibular Advancement Devices (MAD) or Tongue Retaining Devices (TRD) can be used. Strollo & Rogers, authors of Obstructive Sleep Apnea, describe MAD and TRD as second-line therapies, as the response to these may not be beneficial for all patients. Tracgeistimym,

palatal or maxillofacial surgeries can also be undertaken but are usually only carried out in highly severe cases (Strollo & Rogers, 1996, pg 102-103). CPAP machines function by pumping pressurised air through a tube and mask to keep the airway open. The pressure of the air is adjusted depending on the severity of the patient's OSA; while humidification systems (inbuilt and attachments) can also be used to reduce dryness and irritation on the lips, nose and throat. The device consists of the CPAP machine itself, a hose and mask. CPAP masks are generally prescribed based on patient's breathing habits; mouth breathers require full face masks, whereas nose breathers can use nasal masks. There are also different brands of CPAP devices (Fig 1.2), and these are given to patients based on the clinician's choice or what they have on hand.

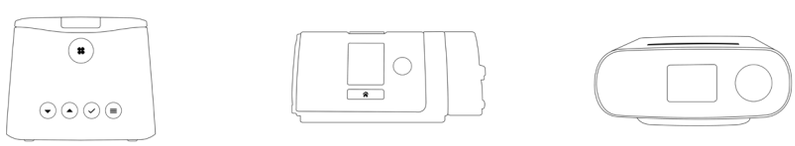


Figure 1.2. Illustrations of CPAPs (left to right), Sleepstyle (Fisher & Paykel Healthcare), AirSense 10 (Resmed) & Dreamstation (Philips Respironics)

In the article, Compliance with CPAP therapy in patients with the sleep apnoea/hypopnoea syndrome, CPAP usage is discussed as variable between patients; with "the average duration of CPAP use (4.7 hours/night)" (Engleman, Martin, & Douglas, 1994, pg 265), pointing out that this compliance can be hindered by many things such as, incorrect air pressure level and mask discomfort and irritation. Hence the authors emphasise that there is a need for "adequate follow-up care and problem management for patients prescribed CPAP" (Engleman, Martin, & Douglas, 1994, pg 266), this would ensure these issues are resolved. In the journal article Sleep apnoea: from person to patient, and back again, Gøtzsche & Berg describe other reasons for non-compliance. Pointing out that this may happen as some patients do not want to rely on their therapy or look to be ill when seen with or using their CPAP device (Gøtzsche & Berg, 2010). The Shapiros back this up by explaining it as the stigma around a "clumsy machine"; a "constant reminder of the patient's chronic condition" and as an embarrassment to egos (Shapiro & Shapiro, 2010). Hence we currently see CPAP stigmatisation by visual appearance and the sense of visual illness. In the article Factors that influence CPAP adherence: an overview, the Shapiros also discuss that this stigma and perceived value are huge

factors that should be considered during the development of CPAP devices (Shapiro & Shapiro, 2010). Support is also essential to therapy compliance; family, friends and bedpartners can affect this. If a 'bed partner' were to complain about the device in any way patients may be more inclined to defer from their therapy. The Shapiros back this up by stating "Support from the patient's bed partner is crucial in the decision to purchase a CPAP machine" (Shapiro & Shapiro, 2010). Bed partners and family acceptance also bring into question the CPAP device's 'medical aesthetic'. The journal article, Adherence and tolerance of an auto-CPAP, backs up the positive effect of the aesthetic by stating: "A pretty bedroom designed CPAP device is associated with a therapeutic duration up than 5hr30. An affective-based customer societal approach of such treatment seems relevant to enhance patient adherence" (Hazouard, Maffre, & Kubiszewski, 2012). The article clearly describes the need for aesthetically pleasing devices, as they could increase CPAP usage time and compliance to the therapy.

Healthcare at home

Technology-assisted healthcare in the home is becoming more common, factors that increase the use of medical devices in a home environment include, an ageing population, increase of chronic conditions, early discharge from medical facilities and emergency situations (Gupta, 2007). Noemi Bitterman, author of Design of medical devices—A home perspective, agrees that this attributed to through "demographic changes, development of health systems, a greying society, decreased birth rate and the rise in chronic diseases" (Bitterman, 2011). There is also increased awareness and knowledge of self-care, people can access information regarding medical concerns through the internet; this self-monitoring and use of home therapy transform the hospital and patient relationships.

The aesthetic style of home-use medical devices shows function; however, when placed in the home environment the devices lack visual cohesion with their surroundings. Bitterman, 2011), outlines this, describing the need to produce adaptable, defined equipment that allows tasks and environments to collaborate. Product developers of medical devices often produce function rather than visual style and creating inclusive medical devices is important in domestic environments. Stephen Wilcox, the author of Using Ethnographic Research to Develop Inclusive Products, notes "developers are not always sympathetic to the issue of inclusivity" (Wilcox, 2006). Wilcox's statement reflects the contrast that we see between ordinary consumer products (such as homewares) and home use medical devices (such as CPAP's, blood pressure monitors, glucose monitor and oxygen monitors). Hence many factors need to be considered when designing and manufacturing medical devices; these include "business, technology, the design and development process, regulation, manufacture, point of provision, use, support, liability and disposal of home-use medical devices" (Gupta, 2007). Developers also need to consider regulation approval of the medical device they are producing; this is especially important when it comes to home healthcare, as these are generally user administered. It is a requirement by most laws around that world that manufacturers/sellers must gain regulatory approval, the requirements for this can be vastly different from continents to countries (Kaplan et al., 2004). Home-use medical devices have additional considerations that need to be made as the home environment may be seen as unpredictable and uncontrollable; each patient has differently styled homes, needs and requirements, both medically and aesthetically. Again Bitterman points out, the "home is challenged with concerns of aesthetics, design trends, style, fashion and compatibility with the home's interior design" (Bitterman, 2011). Bitterman discusses this further stating, "home health care devices need to avoid the image of sickness or disability" (Bitterman, 2011). Comparatively, the hospital and home are two very different places;

We see hospitals as places of individualised sickness, bleach, metal, plastic, beeping, hard surfaces and bright lights. Whereas the home as a place of relationships, relaxation, warmth, living and belonging. The journal article, Effects of interior design on wellness, author R. S. Ulrich discusses differing aesthetics and the positive and negative distractions in medical environments where patients, visitors and staff spend time (Ulrich, 1991). Ulrich describes "hard settings" as environments that contain uncontrollable factors such as light, temperature and noise; these can affect patient's stress levels, wellness, compliance to therapy and can increase the burden of illness (Ulrich, 1991). However in these hospital environments "positive distractions" can be used to hold attention, interest and evoke beneficial emotions. Ellen Key, the author of Beauty for All, also describes this similarly through her essays on beauty; discussing that to transform and better their lives people need to create beautiful surroundings for themselves, creating festiveness and happiness through visual decoration (Lane, 2008); this suggests the connection between what we feel and what we see. Ulrich points out that allowing patients to be in control of these situations may also alleviate some of these negative implications that can arise from hospital and clinic situations. (Ulrich, 1991). This sense of control is reflected by Karen Fernandez's discussions of the role of personalisation in the home and its appearance to "help elicit the feeling of safety" creating a sense of control as this plays a "critical to the enjoyment of one's home." (Fernandez, 2007). Hence it is vital that healthcare devices that are both aesthetically pleasing and function to the highest standards within the environment in which they are placed (Bitterman, 2011).

Again it is essential to consider the other people who may be living in the home. While the device may be useful to one person, it may be cumbersome to the other. In the article Beauty For All, Ellen Key describes the human need for beauty in the home. She discusses the inhabitants of homes all having different needs, and these needs should be met and arranged to suit the people living in them (Key & Facos, 2017). Key makes a sentimental statement this, saying:

"A room only receives a soul when a human being reveals her soul there, when she displays her/his memories and things she loves, when the home reflects how she works and spends her days." (Key & Facos, 2017).

Democratisation

Democratisation is defined as the expanding of democracy. The notion of democratisation "has become a key reference point in understanding political change throughout the world" (Harrison, 2018) where accessibility is the connection and action towards equality. We see democracy defined as "government by the people; especially: rule of the majority", where the population chooses representation; usually through held elections ('Democracy', 2018). The impact of such democracies can have a positive impact not only on the population of a particular state or country but also the further world. However, there is no set in stone end game to a democracy, but rather a process that should aim to continuously action toward a higher level of such democracy. This idea of continual action reflects the ability of democracies to have reflective relations that are broad and open to understanding that focusing on equality is a priority. (Gurses, 2011). Elections play a major part and can be the starting point of democratisation; allowing a population to have a choice that reflects their own feelings, needs, wants and values. We also see that culture and tradition has become a prominent talking point in politics and can often affect how technological advancements are used to aid, rate and count the political players and potential election results (Mancini, 2014). Mancini's observation of this notes the disparity in political writing language readability to the general population and the effect that it can have on people's understanding of choice in their governmental systems. There is no way to fully gauge how much control or authentic choice the population has. As we have seen over many decades, the population may feel that their voices make a difference. However, the governmental system abiding by values of democracy may be being run or colluded with ineffective, dysfunctional, fraudulent or corrupt representatives (Gurses, 2011). While this is the most prominent form of democratisation and democracy, we are moving into an age where specific ideas of democratisation are occurring.

One of these being the democratisation of design and innovation; which we see becoming increasingly prominent as technology and internet access increases the accessibility of information. In the book, Democratizing Innovation, Eric von Hippel eminently discusses this type of democratisation and its reflection on design and innovation as User Innovation. It explores the democratisation trends, adaption, manufactures roles and how this user innovation can be converted into information of value (Hippel, 2005). User-centred Innovation is discussed in the book as the user/owner of a device or object who makes modifications to develop or adjust what was initially purchased. This is purely done for themselves but is often freely distributed or found by listening ears. These audiences often adopt these modifications to

suit their own needs by improving overall function. Advancements in technology have allowed design tools to become increasingly common, with Hippel stating "Hobbyists have access to sophisticated design tools for fields ranging from software to electronics to musical composition" (Hippel, 2005, pg 122). 3D printing makes it possible to produce and easily test ideas physically. The internet allows these extensive and ranging resources to be distributed and accessed by anyone. It can create new economies (that are separate from manufacturers economies) within these user communities where a diverse range of content is accessible (Tanenbaum, Williams, Desjardins, & Tanenbaum, 2013).

Figure 1.3. Screenshot of Thingiverse explore page.

Currently, websites such as Thingiverse (Pettis, 2008) (Fig 1.3.), allows anyone to share user-created digital design files that can be produced physically and 3D printed. Thingiverse's' online platform considers itself a community, allowing users to upload, share and discuss digital designs and projects openly. The creator of Thingiverse, Bra Pettis, was also the former CEO of MakerBot Industries; a 3D printer manufacturing company (Pettis, Mayer, & Smith, 2009). The two have become services that can go hand in hand; Makerbot is the democratised innovation, and Thingiverse is the User Innovation and Democratised Design. It has lead to co-creation of value; the user has created content that is used by companies to create their products (Clive Grinyer, 2009). The content created and shared on Thingiverse is quintessential to understanding what the user wants. In an interview for 99U Mark Rolston, founder and

chief creative at Argodesign, discusses that designers may have to look at how human and machine will interact, he describes these as "things that we can touch, see and act upon" (McCue & S, 2016). Suggesting the designer's role in the future may be focused on creating the service itself rather than the objects it produces; there is a continual necessity to have designers being apart of the creative process. Designers have the ability to curate, collate and interpret information that users may not be able to see or understand. In the same interview dor 99U Georgianna Stout, Founding Partner and Creative Director of 2×4, talks about design experience and a designers ability to visualise and create by, understanding how different aspects will be incorporated to build and portray an experience in a curated manner (McCue & S, 2016). Designers, however, can transfer and materialise intentional ideas into the intended product; they make things tangible. This leads into what is currently known as cooperative design. "The cooperative prototyping approach aims to establish a design process where both users and designers are participating actively and creatively based on their differing qualifications."(Bødker & Grønbæk, 1991, pg 454). Clive Grinyer points out that that non-designers and un-tested products would be more unhelpful; and the overall experience of products (purchasing, unboxing and using), would be hindered by the User innovation. We all live in interiors, and interior design is important to our any enclosed space, work, shopping, travelling, vehicles. Users do not have the complete ability to refine the roughness of user innovation. These User innovators usually make simple adjustments to what they already have and know (Clive Grinyer, 2009). They may also have the inability to look past the current product and create new intentions, whereas may designers have been educated to do so. The Democratisation of Design and Innovation is quickly turning into what could be considered the Customisation Industry.

Mass Customisation & 3D Printing

Mass customisation builds on ideas regarding personalisation and control described in the democratisation section of the background research. Mass customisation adds value to product markets where there is limited choice for consumers and gives designers an opportunity to create singular, one-off products for clients and consumers (Tseng & Hu, 2014). Paul Zipkin, the author of The Limits of Mass Customization, similarly describes Mass Customisation as "the capability to offer individually tailored products or services on a large scale" (Zipkin, 2001, pg 81). In his article, Zipkin clearly outlines three key elements of Mass Customisation, Elicitation, Process Flexibility. Making clear that they need to be "linked tightly to form a coherent, integrated whole" (Zipkin, 2001, pg 84). The process of flexible manufacturing, such as 3D printing for mass customisation, "enables designers to change the CAD model easily" (Tseng & Hu, 2014, pg 839), this utilisation of computer technology, can allow for faster development time. Mass customisation is considered made-to-order rather than made-to-stock and can improve inventory, supply chain management efficiency, production, supply scheduling, product development. However mass customisation requires considered and concise planning to achieve a usable outcome. Understanding the customer's needs can help the direct interaction between the consumer, their needs and the direct designing of the product. This interaction is discussed by Zipkin though some of the key limitations of Mass Customisation. Zipkin points out that a capable system would be required to elicit the true wants and needs of the consumer, and gaining the necessary information could include methods such as physical measurements or automated scanning that can create digital data. Mass Customisation demands adaptable manufacturing methods and innovations that use digital information technology. Zipkin does not specifically state 3D printing; however, we may now have the capability to achieve mass customisation through this method; this is backed up by Tseng & Hu. They state "3D printing technology may significantly stimulate the development of new MC" (Tseng & Hu, 2014, pg 842).

In the article, 3-D Printing: The New Industrial Revolution, Barry Berman examines 3D printing, mass manufacturing comparing the manufacturing

technologies. Berman describes Mass Customisation being "based on pre-assembled modular parts in different combinations" and 3D printing as "automated manufacturing based on CAD software and additive manufacturing" (Berman, 2012, pg 157). 3D printing is often defined as a "form of 'additive' manufacturing, where a three-dimensional object is 'printed' or built by adding layer after layer of a particular material" and is a form of rapid prototyping (Rayna & Striukova, 2016). Berman defines this discussing that CAD (computer-aided design) software enables defined digital files to be 3D printed precisely through generated cross-sections that create a printable structure. The computer then deposits the material where dictated. Waste can be kept to a minimum through the restriction of material deposition and material recycling/reuse (Berman, 2012). Designers, engineers use the 3D printing process the process for efficient ideation, prototyping, tooling and manufacturing. As discussed in Advances of Three Dimensional Printing, even from 3D printing's commercial beginnings in 1997 'prototyping and concept tooling' were considered a very valuable use of the process. It has only been in the past few years that technology and different methods of 3D printing have allowed the process to reach a higher making potential, with improved print qualities, faster production time and further development of materials (Dimitrov, Schreve, & Beer, 2006). Stratasys is one of the world leaders in 3D printing solutions, producing and machines that enable multi-material printing and full colour (voxel) printing (Stratasys, n.d.). Valuable assets & services such as Shapeways are currently allowing designers and consumers alike to create and print their own products through 3D printing; consider this mass customisation (Shapeways, n.d.). They also offer various methods of printing, primarily Selective Laser Sintering (SLS) and Binder Jetting (BJ). These can produce different materials such as nylon, stainless steel, sterling silver, brass, gold, platinum, sandstone, resin-based acrylic plastic and ceramic (Shapeways, n.d.). A company who utilises this service is Nervous System; who use the Shapeways platform to print customised products for consumers. Nervous Systems form of customisation uses a website and software program that allows consumers to create/ generate their own customised, necklaces, earrings, bracelets, rings and art, that can then be 3D printed and sent to them. This service also enables consumers to produce a family of products from the same generative model; if a necklace is created, a set of earrings can be produced based on the previous item's digital data (Nervous System, n.d.) (Fig 1.4).

Figure 1.4. Screenshot of Radiolaria, Nervous System product generator.

One area in the 3D printing field that has not been viscously explored is large-scale 3D printing. There is a small handful of objects online that have been built using large-scale FDM printing as the process; scholarly articles or research around this scale of 3D printing are even harder to come by. Large-scale printers, printers capable of producing volumes $1m^3$ or larger, come with a hefty price tag and are generally only purchased by companies. Finished examples consist minutely of stools, small chairs, large vases, small tables and wall panelling; which have been produced by the printer manufacturer or their commissioned designers to suggest the possibility of creating with FDM printers. There is a plentiful amount of commercial FDM printers at this scale; however, there is little to nil viable examples of objects and projects. This could be due to many reasons such as the cost of the printers and usability of the printers. However, projects such as Studio Ilio's Hot Wire Extensions (Fig 1.5); use methods of 3D printing or 3D printing materials to produce large-scale objects. Ilio has exploited nylon powder used for SLS printing to create large furniture sized '3D prints', by electrically charging a wire that has been bent and moulded to create designed forms before being packed in a bed of SLS (nylon) printing powder to achieve the desired effect and design. This method has created a bubble/tube aesthetic and has produced a new and exciting method of medium to large scale printing, showing technologies are continually being changed, their limits pushed and materialities explored.

Figure 1.5. Hot Wire Extension Stools by Ilio.

Reflection

To summarise, the research undertaken for this literature review has highlighted critical points of interest and the relevant criteria to be noted. OSA is a chronic disease when undiagnosed can be detrimental to personal health. CPAP therapy allows people with OSA to have an uninterrupted night's sleep. However compliance to the devices varies drastically between people, this can be affected by a multitude of aspects, such as therapy experience, use, support, functionality and visual appearance. As the bedroom is a very personalised space, essential factors must be considered as functionality, and aesthetic styles differ for everyone in the home environment. There is a strong visual division between Medical devices and homewares; If these devices were to be incorporated into the home sufficiently or were considered by companies as 'homecare/homewares', this could not only make therapy easier but may reduce some of the stigma surrounding CPAP devices. It is crucial to consider customisation holistically; design is necessary throughout the customisation process to create value and intention in the product as well as the service. 3D printing is integral to the future of mass customisation; its varied material can be printed in both single and separate build processes, accurately and with the ability to quickly change designs through CAD modelling. Co-operative design may be a useful tool in enabling patients and consumer control of choice. As there was a lack of literacy articles on the future of mass customisation though 3D printing this review only notes the current situation, there were no significant points noted; this suggests there is an opportunity to investigate the application of Mass Customisation through 3D printing as future possibilities of the process combined could be endless.

The background research outlined the stigma that medical devices may create through visual appearance and the sense of visual illness. Aesthetics are an important part of a home and bedroom space; changing the style of the CPAP device it may reduce stigma, CPAP devices currently do not visually fit into their situated environment. Hence the aim of this thesis will be to proceed by exploring methods of covering the CPAP device (in a sleeve) in a manner that will not change the technology and will not hinder the CPAP function. Finally, the aim will be to personalise and customise the CPAP device.

Criteria identified in this section:

The design needs to demonstrate the ability to be customised, to create tangible value.

The design should intend to aesthetically fit into the environment in which it is situated.

The design must retain its functional integrity, as this could affect regulation acceptance.

Methodology

Research Through Design

TThe research in this thesis is directed by Research Through Design (RtD) and will follow an explorative design process that allows the creation of designed elements and reflective practice through discussion and evaluation throughout. In the conference paper, Research Through Design as a Method for Interaction Design Research in HCI, authors Zimmerman, Forlizzi, & Evenson describe RtD as "an active process of ideating, iterating, and critiquing potential solutions" (Zimmerman, Forlizzi, & Evenson, 2007. pg 497). The research uses this structure in each chapter as it will provide insights into potential designs, informing the production of the design process. The research will follow the natural design process of design idea experiments, iterations and refinements to create outcomes that are informed by the research and process undertaken. Finally, RtD also offers the opportunity to "reflect on the potential impacts research might have" (Zimmerman, Forlizzi, & Evenson, 2007. pg 501). Criteria will be developed throughout the thesis and will allow any designs produced to be reflected on. To aid this process, written & designed digital and physical artefacts such as narratives, sketches, renders and prototypes will be produced. These will be critical to the overall documentation, context and communication of the potential design outputs (Hannington & Martin, 2012, pg 146). These are necessary to develop the thesis as this critical reflection allows the preparation of criteria for each design phase (Zimmerman, Forlizzi, & Evenson, 2007).

Methods

Design Audit

The Design Audit chapter explores the object and context of the CPAP and potential design solutions to its aesthetic design inability. Semi-Structured Observations will be used in the design audit to allow the collection of qualitative data (Hannington and Martin, 2012, pg 120). For this photographs, sketches and diagrams of the object and space are taken and created to review aspects, ideas and reflective thoughts from the authors perspective. This will enable discussion into the identification of aesthetics, materials and physicality, of the CPAP device and the bedroom environment so that that areas of commonality and disparity can be identified to improve the product and create applicable customised sleeves.

Data collected and discussed were as follows:

Touchpoints

- Interface
- Movement/disassembly (cleaning/replacement/movements of parts)
- Accessibility/Storage

&

- Overall visual quality
- Shape/form
- Materialities
- Size/weight
- Sound
- Colour and light

For these Semi-Structured Observations, the object and environment have been audited using the design audit table (Fig 1.6.).

	Comments/notes
Shape/form	
Materialities	
Size/weight	
Sounds	
Touchpoints	
Interface	
Colour and light	
Overall visual quality	
Movement/disassembly (cleaning/replacement/movements of parts)	
Accessibility	
Storage	

Figure 1.6. Design audit table template. See Appendix A for completed examples.

Cognitive Mapping

Cognitive Mapping is used to reflect on, visualise, and make sense of research, information found and particular situations and experiences (Hannington and Martin, 2012, pg 30). This will allow the visualisation and breakdown of information in the design audit, so that it can be reflected upon to identify relationships and connections found.

Narratives

As this thesis explores style through storytelling to inform design, written and visual information will be created for the environments of the characters discussed. Persona generation will be used as a method to expand on through narration; providing "focus through the creation of fictional Personas whose goals form the basis for scenario creation" (Pruitt & Grudin, 2003. pg 2). The research aims to achieve this by describing more than just personalities; it will use thoughts, emotions, situations, environments and artefacts to build upon personalities to create a description of lives, scenarios and the aesthetics of living environments. Tim Brown, the CEO of the IDEO design, would describe this as a form of Storytelling, as these narratives look to "inhabit the user's perspective and feel what that person feels" (Brown, 2009). However, as this thesis looks at the conceptualisation of an idea and its future potential, the Scenario-Based Design framework (Fig 1.7.)

will be used alongside the expanded Persona Generation to structure these created narratives (fig 1.7 and 1.89). Traditionally Scenario-Based Design (SBD) is used to develop and create computer systems and applications and is defined as "a narrative description of what people do and experience" (Carroll, 1995, pg 3) in the ICT field. Scenarios are created so that is accessible and understandable to all people who, in this case, may read & view the scenarios.

Figure 1.7. A diagrammatic overview of the SBD framework.

As shown in the Figure 1.8., the first stage will use 'Problem Scenarios'; to create a Manufacturing Narrative, employing a fictional interview style to explain the situation in its current state. The second stage will use 'Activity Scenarios'; to create User Narratives, these aim to explain the usability of the CPAP and the situation in which they reside. The three fictional User Narratives provide information, actors/personas, metaphors, adjectives, images and sketches that will give guidelines, parameters and aesthetics to create the Design Criteria for the 'Usability Specification' stage (Design Phase 2). Through using SBD's methodical action based style of fictional writing, the thesis is able to explain and portray the use and emotion that people may have towards the CPAP.

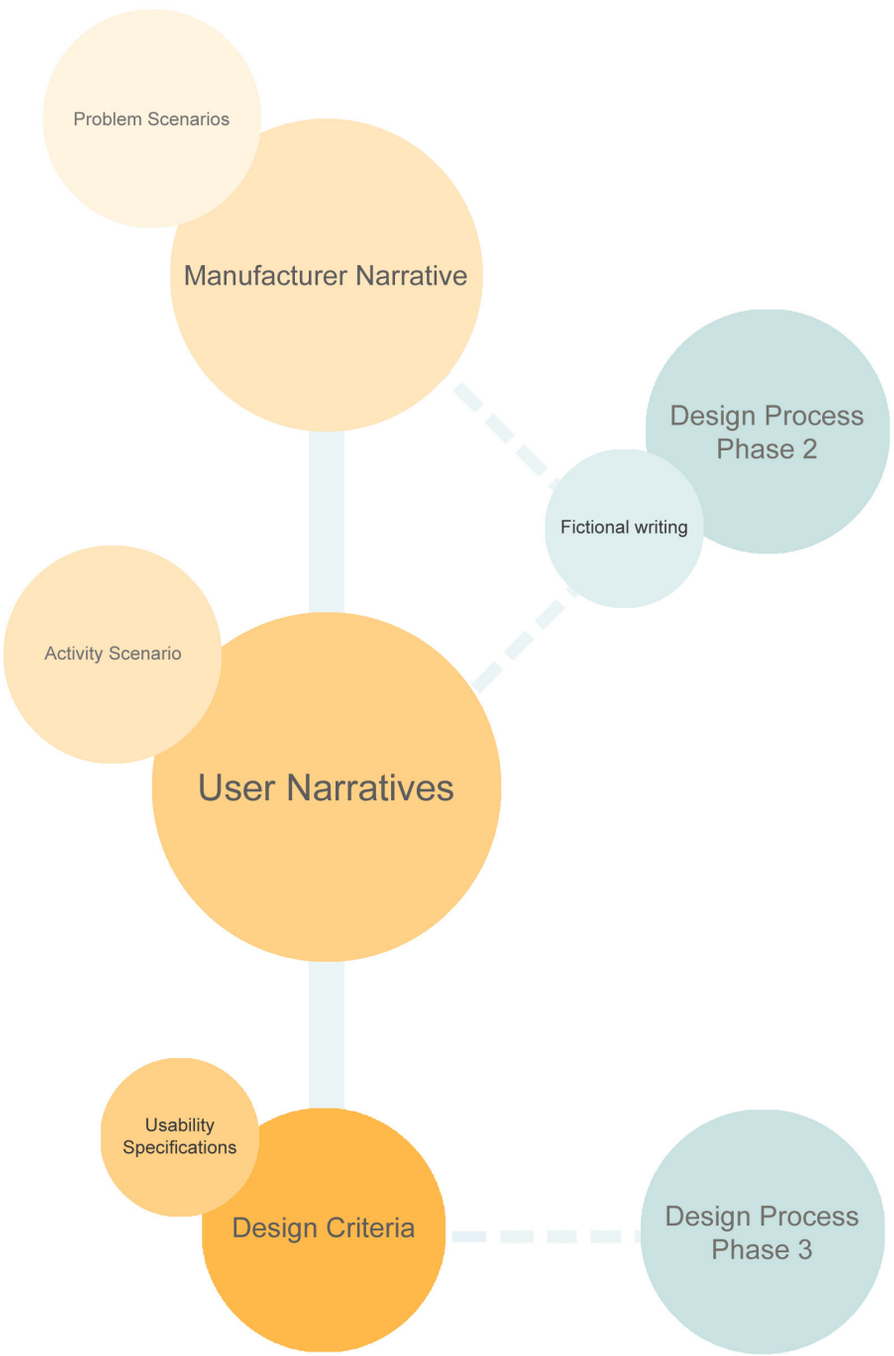


Figure 1.8. Proposed Narrative framework for this thesis.

Design Phases

Digital design methods are used in the design phase 1 & 2 to enable, digital difference and accuracy of designs.

3D scanning

In this thesis 3D scanning is used to generate CAD models for Design Phase 1 & 2; a generic object (glasses case) & a CPAP device. This is an essential part of the design process as it allows a digitally precise CAD model to be created and allows the perfect physical fit. To carry this out structured light scanning with an Artec Eva 3D scanner is used (Artec 3D, n.d.). Artec Studio 12 software with Autopilot is used alongside this to produce a live digital file on the computer while the object is being scanned. As the scanner uses SLS to video map objects; shiny parts of the CPAP device will be covered to avoid light reflection from the scanner distorting the digital file being produced.

CAD modelling

Computer-Aided Design (CAD) modelling in is undertaken Solidworks & Meshmixer. These programs are used throughout the thesis to visualise and ideate objects and designs (without colour & material). Alongside the 3D scanning, this is a precise way to produce designs and allows the designs to be visually reflected upon.

Rendering

Keyshot is used to digitally demonstrate the potential aesthetics of the designed CAD models in a rapid manner. This will enable designs to be rendered in a varied range of materials and colours, and integral to producing a broad range of aesthetics. Rendering will also allow the designs to be implemented in contextual images, where they can then be reflected upon based on the aesthetics suitableness to the environments where designs are being placed.

3D Printing

3D printing will be used in this research as it enables the ability to fully customise designs through material, form, shape, size and surface finishing, allowing designs to be materialised through single or multiple processes. Fused Deposition Modelling (FDM) printing is used as a processing method as it provides an accessible and quick method of producing prototypes from CAD models. Polylactic Acid (PLA) filament will be used as its portability and hard wearing materiality is suitable for

prototyping. FDM printing provides fast print rates and resolution quality up to 0.1mm. It is important to note that PLA is a more sustainable material, compared to the more widely used Acrylonitrile Butadiene Styrene (ABS) filament, as it is defined as a thermal bio-plastic derived from renewable sources. Wood, brass, bronze, copper, iron steel and carbon fibre are can also be mixed with PLA to produce composite filaments. Hence, PLA filament will be used with FDM printing to create physical prototypes; as it will enable the reflection of the designs physical forms, their size and the aesthetics they embody.

Design Audit 002

Design Audit

This chapter investigates a CPAP device in its current state and the bedroom environment in which it is placed. The chapter aims to create an understanding of the product and environment, to outline any particular criteria that may need to be met when designing sleeves for a CPAP device. Semi-structured Observations allow for themes, qualities, parts and areas of the CPAP and bedroom to be identified, discussed and reflected on. These observations were conducted in the author home; hence there are no photographs or images of the environment.

Semi-Structured Observation

Bedroom

Overall Visual Qualities

Most objects in the bedroom are softly edged, contrasted with sharp corners of the bedrooms walls and the slightly softened edge of wooden furniture. It is simple, pleasant to look at, not excessive and there is not too much happening creating an overall relaxing and placid space. Figure 2.1 below describes the environment as a Modern/contemporary space with a subtle amount of antique furnishings. Figure 2.2 below describes the emotion of the space as leaning into a conservative feeling, rather than more extravagant, loud or flamboyant.

Figure 2.1. Diagram describes the aesthetic and style of the bedroom(Antique vs Contemporary).

Figure 2.2 Diagram describes the feeling/emotion of the bedroom (Extravagant vs Conservative).

Materiality

The bedroom is abundant with soft furnishings, knitted textiles, linen, wool, cotton, faux fur. Hard furnishings are elemental basics, wood, ceramic, glass and chrome.

Colour & light

The predominant base colour is a cool white paired with subdued blues and greys; added splashes of baby pink and pastel yellow are used sparsely as accent colours. Although this space has soft artificial lighting these are not usually used as the natural light from the window gives the room an indirect warmth rather than a brighter harsher ceiling inset light or side table lamp.

Placement/Storage

The device has been placed on the bedside table as this seemed to be the most logical place for it to be situated. The CPAP takes up about a quarter to the top surface, leaving only three quarters remaining for a lamp; this changes the aesthetic appearance dramatically. Figure 2.3 shows the device placed on the right side table, highlighted in turquoise green. The overall look of the bedroom is changed as the CPAP device is quite dark in colour whereas the bedroom in swashed in light colours/ pastels.

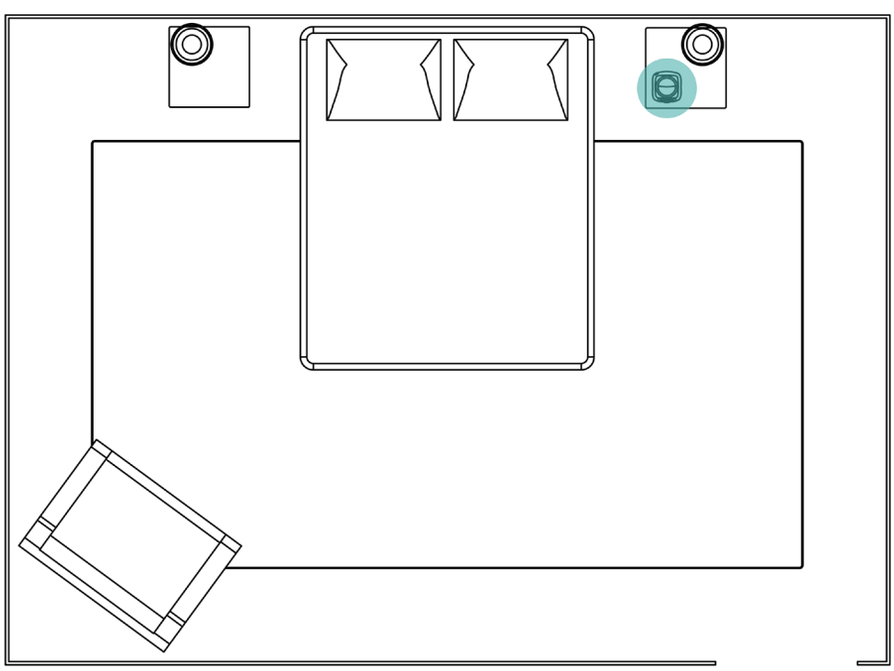


Figure 2.3. Illustration of the bedroom with CPAP, CPAP device on right side table.

Interaction points

Main points of interaction in the bedroom are the bedside table, door and wardrobe; all have different levels of usage. Some of the interaction points can be manually adjusted, for example, the furniture and living accessories. Re-positioning of objects may dramatically change the overall atmosphere and physical, visual experience. Fig 2.4 shows the relative movements during sleep; the colour is prominent where the most movements were made during the night.

Noise/Sound

It is easy to hear the humming of the CPAP machine when first getting into bed, however, the device is quiet enough that it is still possible to fall asleep. Valves on the mask primarily make the most noise, and sleeping closer to the device made it more difficult to fall asleep. Figure 2.4 visually describes the sound values and areas that may be affected by them.

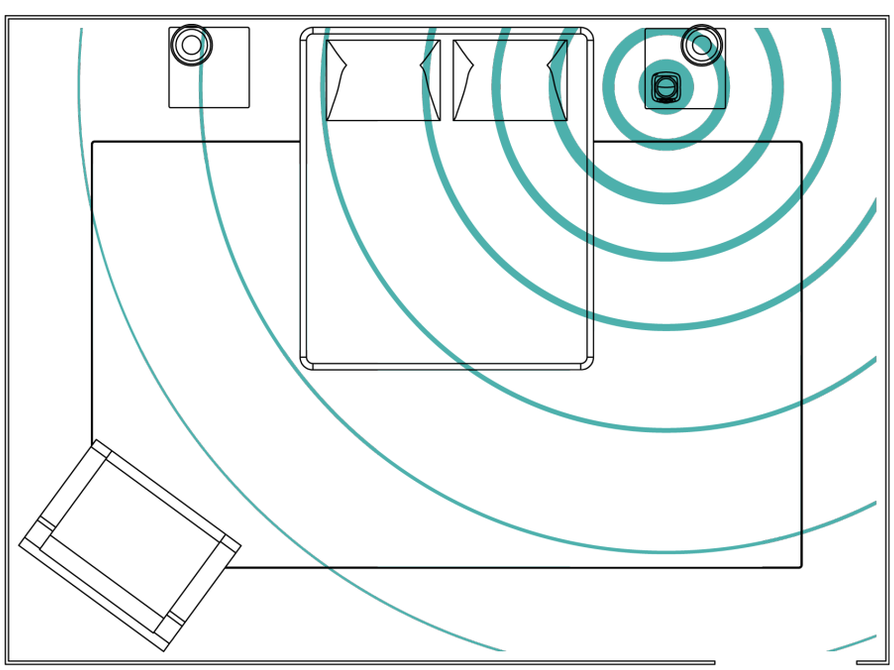


Figure 2.4 CPAP sound illustraion, bedroom with CPAP device on the side table.

CPAP

These notes were written during and after use of the CPAP in a bedroom environment.

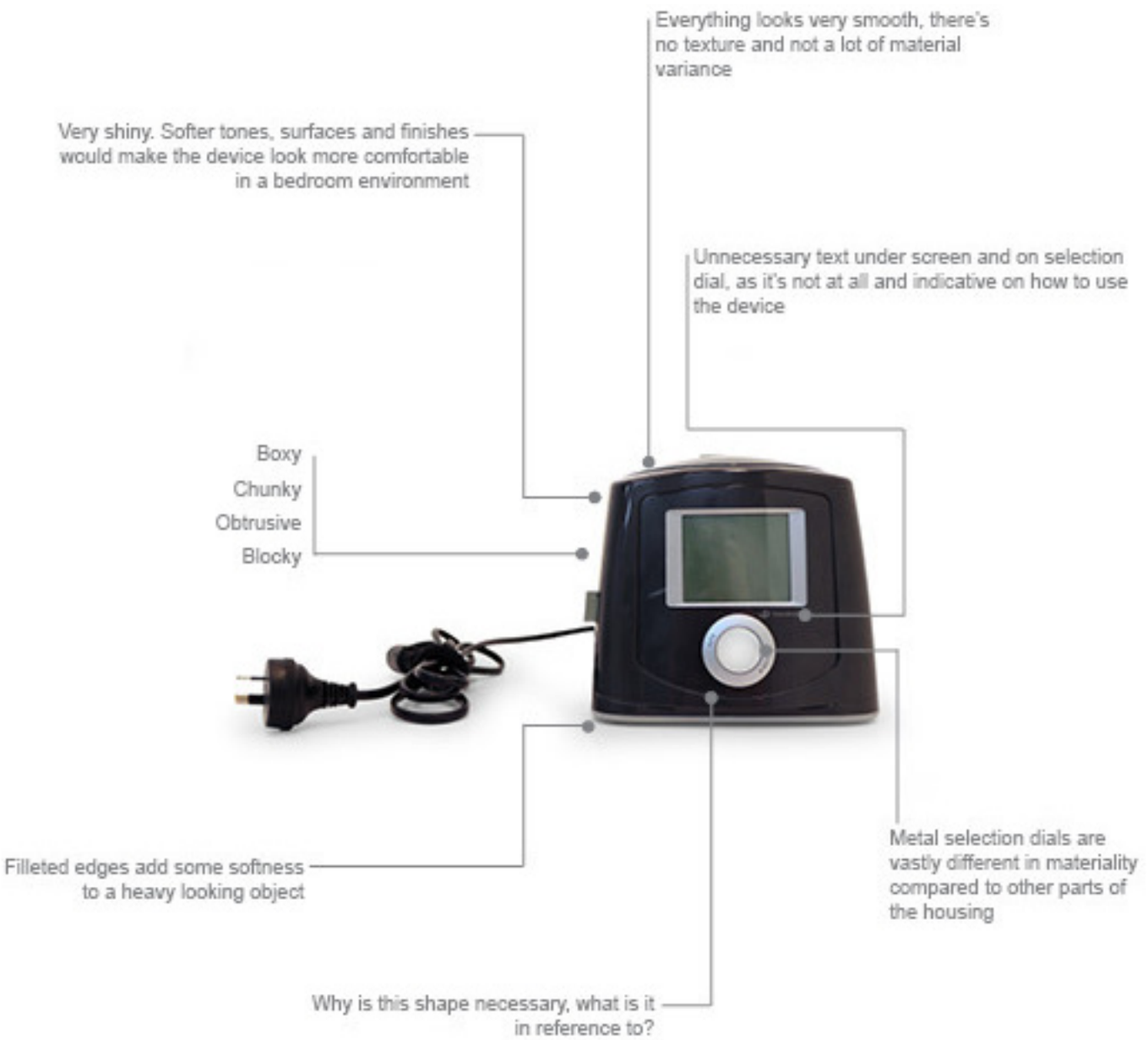


Figure 2.6. Image of annotated CPAP. Front view.

Figure 2.7. Images of annotated CPAP. Back & top view.

Overall Visual Qualities

The device and its exterior housing look visually clean, not particularly slick or ultra modern and is comparable to a box-shaped vacuum cleaner. It visually fits into a medical aesthetic without the glaring bleached metal, but is softer somehow, looks hygienic and is packed with technology. It does not sit into a particular aesthetic style or group and is devoid of character, causing it to further lean into this medical aesthetic. Figure 2.5 shows the disassembled CPAP device, including the mask, showing the sheer number of parts involved with the machine.

Form/Shape

The CPAP is a simple box shape; however, there are no completely flat surfaces apart from the base of the device. These curves make the CPAP appear softer and less aggressive. The object sits clunky and large taking up space and makes the room look disjointed.

Materiality

The exterior housing consists of slate-grey plastic; smaller or accented parts are a light grey colour. Selection buttons have a softened and a polished chrome coating, while the internal/removable water chamber and screen are comprised of clear and frosted plastic.

Interface, Colour & light

Interaction of turning the dial creates a soft bleat sound. However, the volume of this would be too loud if used in the middle of the night. When adjusting the settings, it was difficult to identify where everything was, as each selectable option was only shown by a single dot before it had to be selected, to see what it actually was.

Touchpoints

Touchpoints and points of interaction for the user begin on the left of the CPAP machine with the info USB, Water chamber, menu screen, selection dial and selection confirmation button (Fig 2.8.). Indicative dots on the top of the device of the CPAP are helpful, yet in the dark, they would not be seen; aesthetically they are intrusive to the smooth, unbroken plastic, it seems they were put there last minute. The turning of the lid may be difficult for some people and was awkward to turn as the hand needs to be slipped nearly entirely under the lid to have a good enough grip. The water container is quickly pulled out and vice versa. Filling the water container may be difficult depending on the size of the faucet as the structural support at the top of the container covers parts of the openings. Selection buttons are quite smooth making it potentially difficult for some users to turn the dial incrementally; due to the slip of resistance of the turning motion. The confirmation button, however, does have spring resistance feedback. It does not click

Figure 2.5. CPAP Inventory. Disassembled CPAP device, including the hose & mask.


Brevida

manually, instead makes a bleep/beep sound confirming the click. The information USB that stores the data for device usage merely is tucked away on the side. The info USB uses a simple push in pop out mechanism, though it is slightly tricky to remove as the end of the USB is flush with the housing. Figure 2.8 shows the focused interaction points the user operates.

Figure 2.8. Interaction Points of CPAP.

Movement & Disassembly

The CPAP tube was problematic to manoeuvre in the dark and gets caught in bedding and objects on the side table. The housing itself has

a bit of resistance when trying to turn/angle the device and requires being picked up due to its rubber feet. As there are a large number of parts (Fig. 2.5), figuring out which ones need to be cleaned requires referral to the instruction book; these instructions are at first difficult to understand due to the use of the coinciding letter to device part indicators. Disassembling parts that need to be cleaned is relatively easy, most simple pull/click apart. However, the structure of the support on the water container would make it difficult to clean; hence a modified brush would have to be used to reach all parts of its interior.

Noise/Sound

As noted in the bedroom observations the CPAP device does produce some sound; however, this is minimal approximately 29 dBA. The valves on the mask produce a majority of this sound, which causes a slight whistle; the sound of blowing air is also dominant when the mask is taken off.

Size/Weight

The CPAP weighs a hefty 2.2kg (this does not include the mask and tubing) and is 160mm x 170mm x 220mm. The CPAP would not be the easiest to carry around when travelling. However, this is not a problem while it is in the bedroom environment unless it needs to be moved for cleaning.

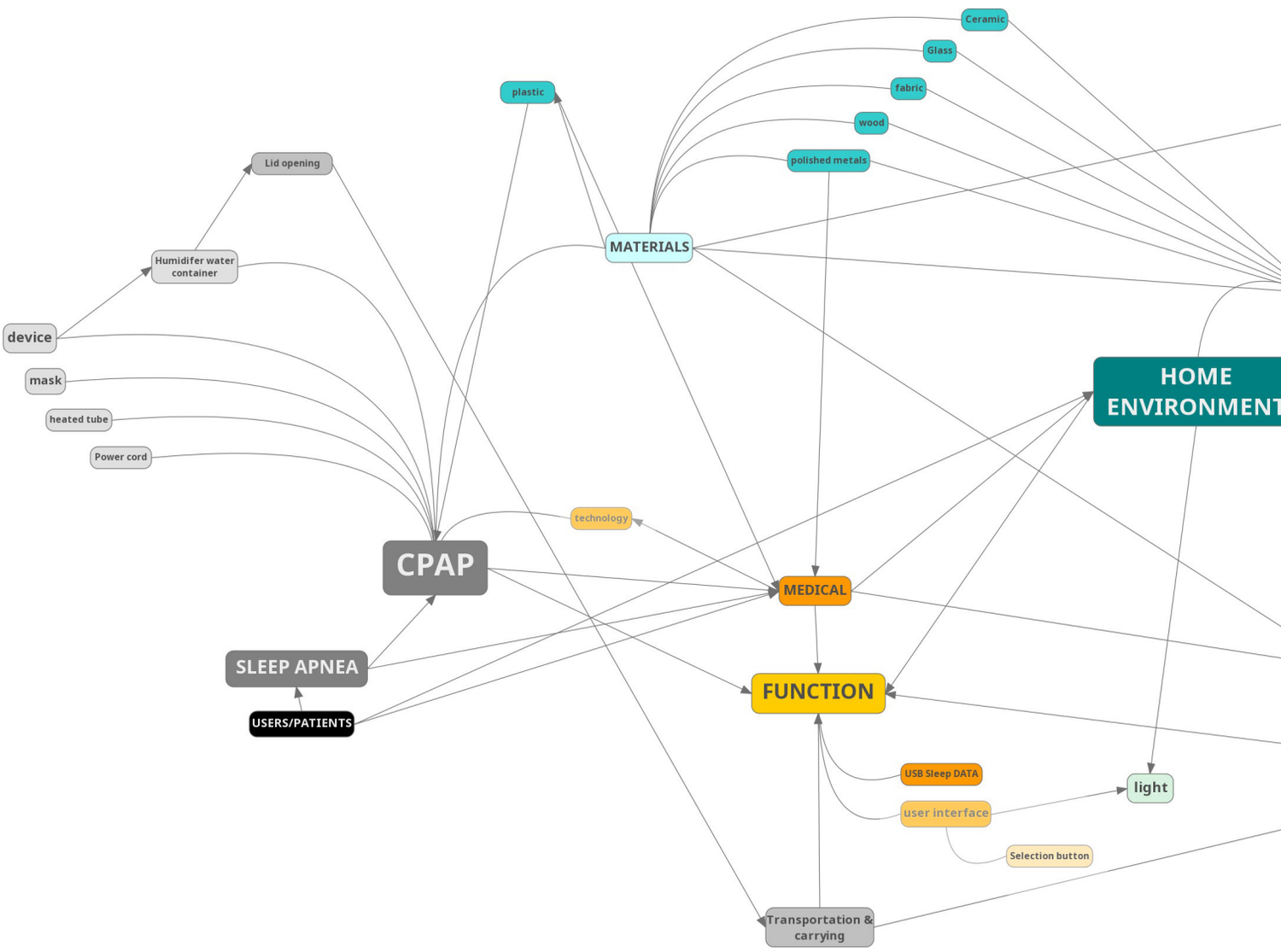
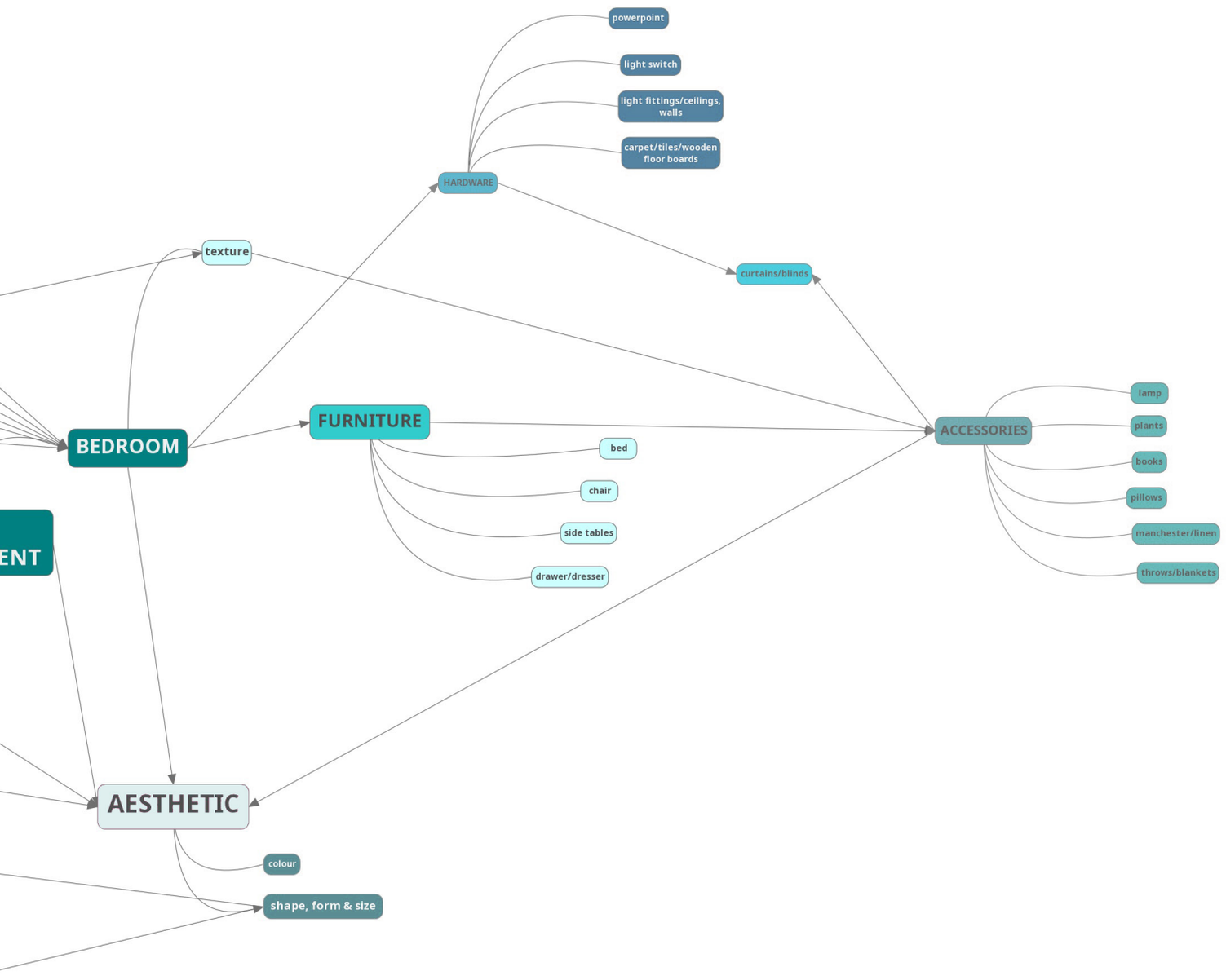


Figure 2.9. Cognitive Map


powerpoint
light switch
light fittings/ceilings, walls
carpet/tiles/wooden floor boards
HARDWARE
texture
curtains/blinds
BEDROOM
FURNITURE
ACCESSORIES
lamp
plants
books
pillows
manchester/linen
throws/blankets
bed
chair
side tables
drawer/dresser
ENT
AESTHETIC
colour
shape, form & size

Reflection

The bedroom is a place of sleep, partnership, relationships, intimacy, relaxation and comfort, and should be treated as such; anything added that is foreign to this space may affect this. The CPAP device currently takes away from the suggested comfort. The identified disparity shows the contrast between the CPAP device and bedroom. This is seen through materiality, hard grey plastics of the CPAP housing and the softer and raw forms of materials used in the bedroom. Changing anything both visually and physically needs to be seriously considered, throughout and curated; as this may change the overall aesthetics, as well as the emotion of a space.

The cognitive map Fig 2.10 explores the ideas and relationships between the CPAP device and the bedroom. Key points on the Cognitive Map show that furniture and accessories are an essential part of the bedroom. It also suggests that there is correlating importance between materials of the CPAP and bedroom environment; again while the CPAP housing is plastic, the bedroom is dominated by soft and elemental materials.

Reduction of sound made by the CPAP device would be helpful. However, this may not be reduced as much as possible, as a majority of this sound comes from the mask. It is important to note that the interface and touch points should be accessible to the user if they are covered this may affect the function of the device.

These touchpoints are:

- Menu screen
- Selection button and dial
- USB information stick & port
- Back air vent
- Power cord
- Hose connection point
- Water chamber

Design Phase 1

003

Sleeving

This chapter aims to explore the enhancement of CPAP device through aesthetic; in environments where the current CPAP housing may contradict visual style, material and emotion. However, this would not be applicable or appropriate, as in doing so could change the technology's functional integrity. Hense, a Sleeve (consider this a housing) that is volumetrically modified, to add additional form and shape, is proposed. Designing a sleeve to fit over or around a CPAP device may not change functionality and would allow selection buttons, screens, vents and lids to still be used to the same degree. A precedent case study for this is the iPhone, where the consumer can select from a multitude of covers to personalise a generic product (the findings from this can be found at Appendix B). Creating a sleeve will allow the CPAP to be aesthetically and physically modified, styled to personal taste or styled to the environment when it is being used. Digital data that will be created through 3D scanning will allow Sleeves to be created to fit both machine and environment precisely. In turn, this could create and add value to an environment through the modification of an object's aesthetic; by removing conflicting aesthetics within a space. Further to this, value could also be developed by way of emotional connection through aesthetic and the possibility of improved functionality or added use (duality) and may increase the potential of compliance to therapy.

In this Design Phase 1, exploration is conducted into the viability of the potential solution. Aim being, to evaluate that the sleeving process will work on a generic object before it is applied to a CPAP device; allowing and digitally accurate design, while enabling change of aesthetic. This is carried out through the design exploration of creating sleeves for a generic glasses case; allowing the visualisation of customisation through dimensional and functional characteristics. Therefore removal of the CPAP machine and domestic environment from the question will allow the exploration to be focused on developing a sleeving process that shows the potential for varied and specific aesthetics and fitting of the sleeve to the object. This aims to develop the re-sleeving process for the main Design Phase 2 where it will be applied to a CPAP device and designed for respective aesthetics in home and bedroom environments.

Criteria to follow and discuss in this design process phase:

The designs should show the potential aesthetics and physical modifications that could be produced with the Sleaving process.

The designs must retain the object's function.

The designs should fit Into the object on which it is based.

The designs may enable better function, or dual use of the object.

Sleeving Process

This process exploration should confirm that is possible to easily create a sleeve that is perfectly fitted to an object using 3D printing. Digital data created through 3D scanning should enable modification to the Sleeve, changing the visual appearance of the object. A Glasses case will be 3D scanned (Fig 3.2.) to create a precise, accurate digital dimension, on which the designs will be based and fitted too. This 'digital skin' (Fig 3.3.) will then be modified and styled; allowing specific customisation; to preference, style, environment, or function. These variations in visual aesthetic will be shown through renders.

The sleeving process proceeds as follows:
SCAN - The object is 3D scanned.
DIGITIZE - Digital dimensions of the object generated a CAD model.
DESIGN - The CAD model is added to, modified and designed (sleeved) around the objects digital dimensions.
PRINT - The designed modifications are 3D printed.
FIT - 3D print fits perfectly onto the object.

To create a range of sleeves that explore multiple styles, forms and functions, the designs have been split into three groups (Fig 3.1.).

1. **Simple skins** through renders that vary in materiality
2. **Modified Sleeves** through augmentation of form and material.
3. **Functional sleeves** through modification that adds to the current function, creates a second use or increases functionality.

The first are simple skins that that keep the same form of the glasses case, only add a small amount of additional volume, which acts as an extra layer on top of the object; exploring customisation through material change. The 2nd are modified sleeves that in addition to fitting to the object, add further volume and alter the overall form and shape of the object; exploring customisation through form and materiality. Lastly, the 3rd are functional sleeves that modify the overall form and create a second use or increase the function of the object through added volume. Random locations, styles and functions will be used to inform the aesthetics of the designs.

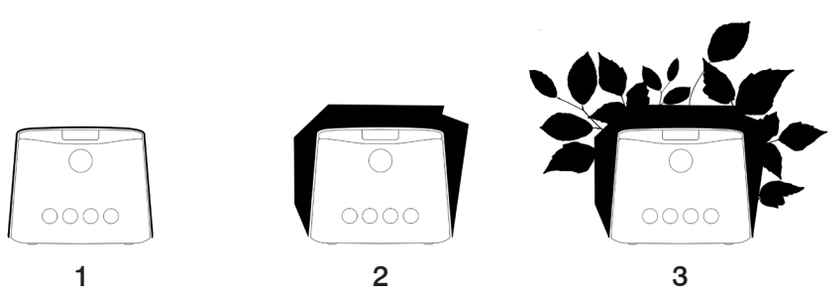


Figure 3.1. Illustration of the 3 sleeve modifications, using the CPAP as the object.

SCAN

Figure 3.2. 3D scan of Glasses case

DIGITISE

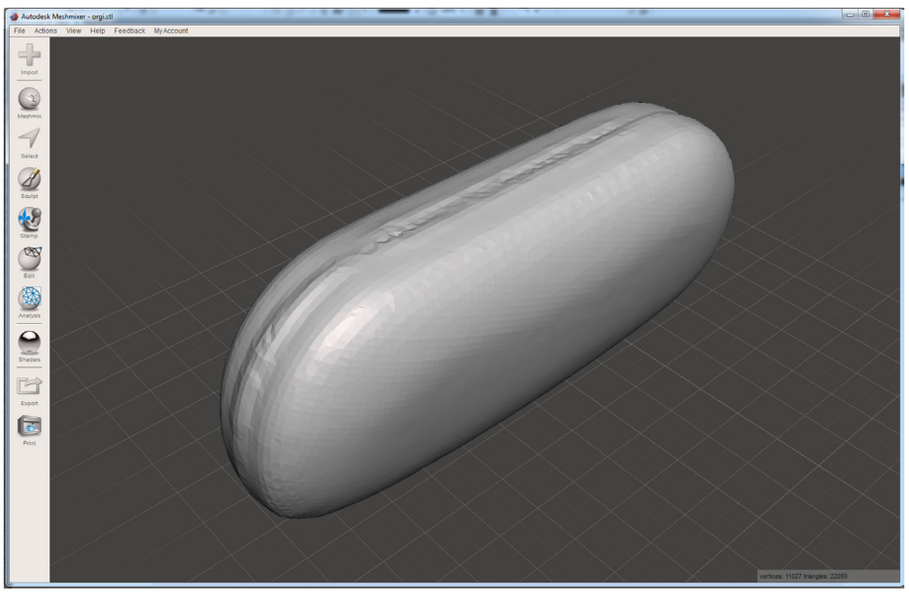


Figure 3.3. Screenshot of CAD file of Glasses case opened in Meshmixer

DESIGN

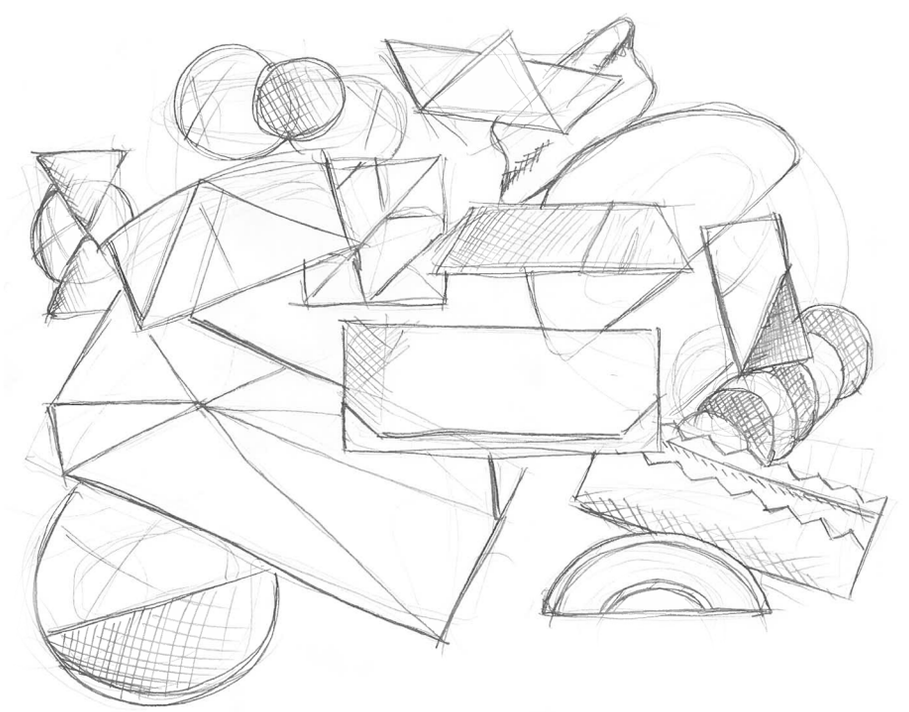


Figure 3.4. Concept sketches produced for initial sleeve designing.

Simple Skins

All simple skin sleeves are explorations of material and colour based aesthtics. Allthough the form of the glasses case is kept for these sleeves, the renders show the variation possible through simple material change (Fig 3.5. - 3.15.).

Figure 3.5. Hammered Copper (left), Chrome Polished (right).

Figure 3.6. Brushed Brass (left), 14K Gold Polished (right).

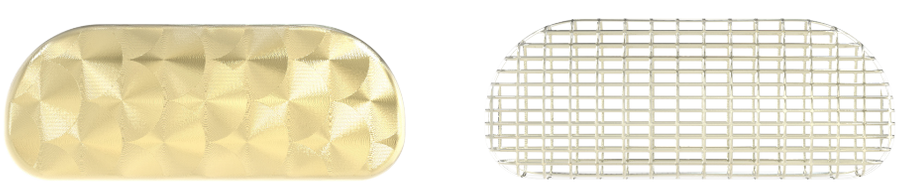


Figure 3.7. Swirled Gold (left), Rectangle Mesh Nickel (right).

Figure 3.8. Scratched Nickel (left), Scratched Steel Ultra (right).

Figure 3.9. Ashphalt (left), White Marble (right).

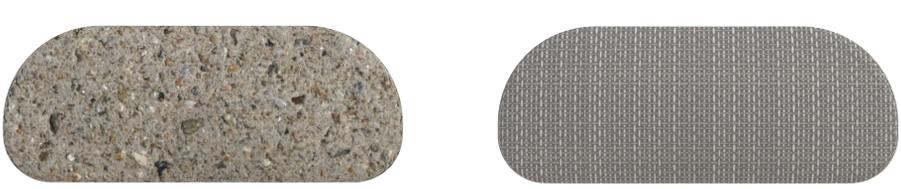


Figure 3.10. Cement (left), Woven Fabric (right).

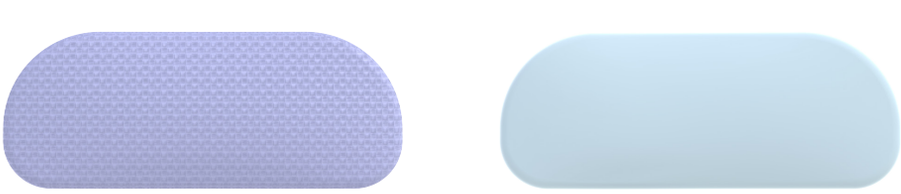


Figure 3.11. Nylon Fabric (left), Velvet Fabric (right).

Figure 3.12. Light Oak Wood (left), Walnut Wood (right).

Figure 3.13 Mahogany Wood (left), Soft Shiny Plastic (right).

Figure 3.14. Hard Shiny Plastic (left), Clear Shiny Plastic (right).

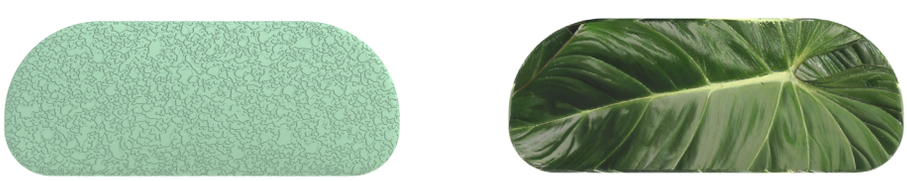


Figure 3.15. Soft Textured Rubber (left), Leaf Print (right).

Modified sleeves

All modified sleeves are explorations of the potential forms, materials and colours that could be produced. Designed sleeve renders are based on/were ideated through 3 subjects; the beach, the home and style eras to show these potential visual and physical aesthetic possibilities.

The Beach

All beach based sleeves generally keep the overall form of the original glasses case; only enlarging the total volume of the glasses case and sleeve by a small amount so not to hinder the size and function of the object.

Ripple (Fig 3.16.), this concept looks at refelcting the wavelike surface of water, and uses this to position the users fingers, each slotting into a trench, for easier holding; exploring surface quality without varying the overall form. Umbrella (Fig 3.17.), the forms and shapes reflect the of spokes of an umbrella, while layering of colour and cylindrical shapes continue this exploration of surface change, only slightly varying the overall form of the sleeve.

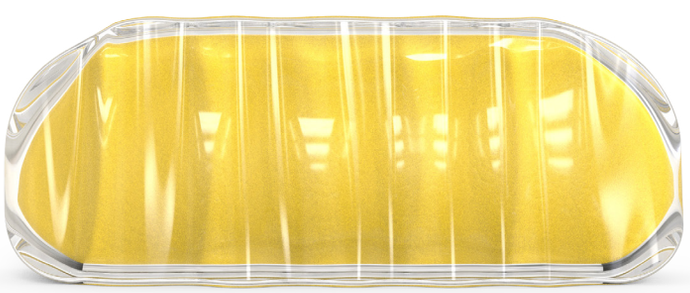


Figure 3.16. Ripple. Hard Clear Shiny Plastic.

Figure 3.17. Umbrella. Hard Shiny Plastic.

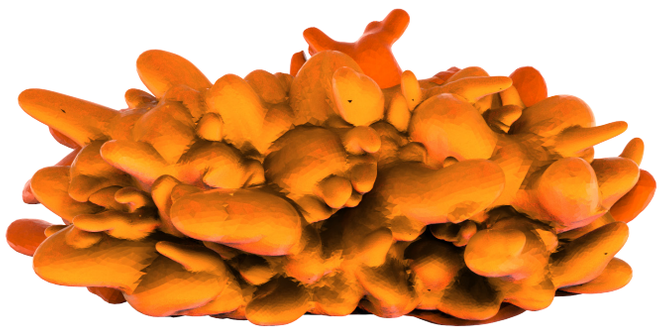


Figure 3.18. Coral. Rough Orange Plastic.

Figure 3.19. Bubbles. Clear Blue Plastic.

Figure 3.20. Shell. Soft Turquoise Rubber.

Coral (Fig 3.18.), exploration of irregular control of form though blobular modification. Although there is gross irregularity and varying physical attributes, the rough overall form of the glasses case is keep; changing its visual appearance dramatically. Bubbles (Fig 3.19.), exploring simple shapes/form by adding variable sized spheres to reflect the refractive quality of bubbles. Shell (Fig 3.20.), uses curved tapered tubes to reflect the shape of a shell that may be found on the beach. Brighter lighter rough turquoise material to reflect this summer style.

The Home

All home based sleeves had the aim of exploring and reflecting visual qualities that may be found in the home. While some sleeves focused on form augmentation, other show aesthetic change through surface form variation and embossing.

Car (Fig 3.21.), the form uses form movement lines similar to that of a car. The overall form has a masculine tone due to hard edges and darker colouring. Patterned Surface (Fig 3.22.), the fabric and etched pattern reflects other materials and textures found in the home, resembling an audio speaker surface through the material.

Figure 3.21. Car. Hard Shiny Plastic.

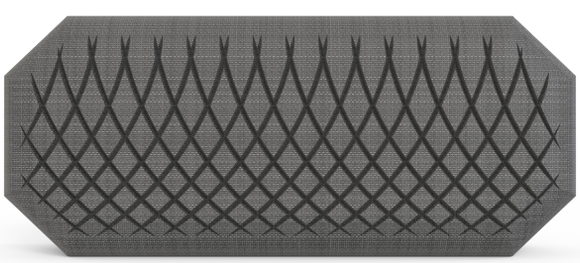


Figure 3.22. Patterned surface. Grey Woven Fabric.

Figure 3.23. Leaf Embossing. Philodendron leaf stem embossed into a soft form and material surface.

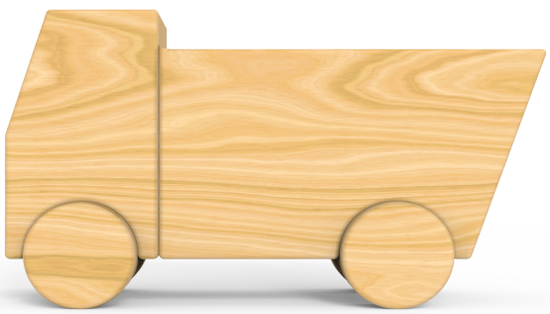


Figure 3.24. Wooden Truck. Ash, Wood.

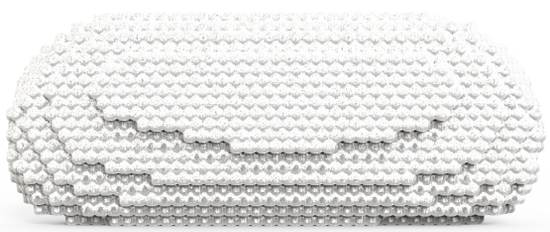


Figure 3.25. Beads. Hard Shiny Plastic.

Leaf Embossing (Fig 3.23.), mimics the indoor plants that are kept in homes. Wooden Truck (Fig 3.24.), the wooden truck may be seen as a toy or novelty item. It can be roll along a desk or floor; and reflects a child related approach to aesthetic. Beads (Fig 3.25.), this explores the visual qulaities of beads, childrens toys or building blocks that may be found in the home. The form is not varyied, however, the surface quality is.

Style Eras

All style era based sleeves explored aesthetics from a fashion standpoint. These are based on visual aesthtics from current and 50-80's style fashions. Again augementation of form, surface, material and colour is used tho show the potenial variation possible.

High Fashion (Fig 3.26.), the exploration of current high fashion, through the ironic use of vacuum forming the object that is stored inside; casuing the sleeve to look as though the glasses inside may have streched/ pushed through the case. Current Luxury (Fig 3.27.), this sleeve reflects a feminine style, though use soft colours, fabrics and precious metals. The sleeve changes the overall form by increasing the cases' size, similar to that of a purse or small bag.

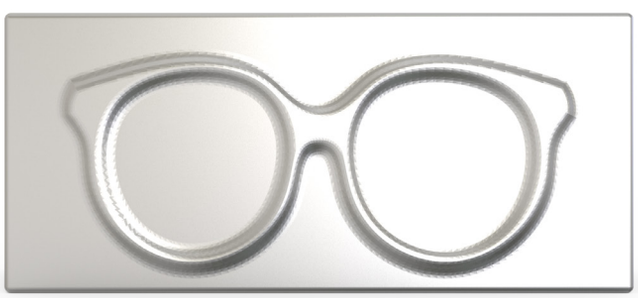


Figure 3.26. High Fashion. Matte Silver.

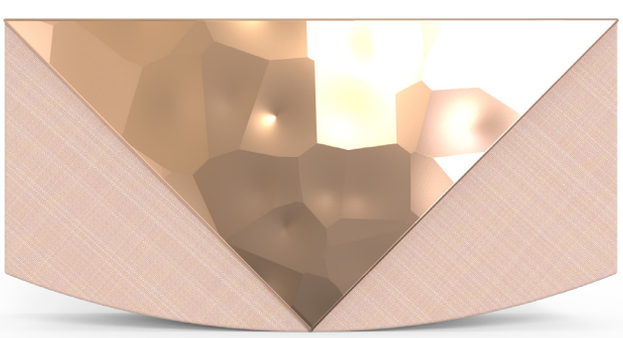


Figure 3.27. Current Luxury. Woven Fabric & Hammered Copper.

Figure 3.28. 70's-80's. Soft Shiny Plastic.

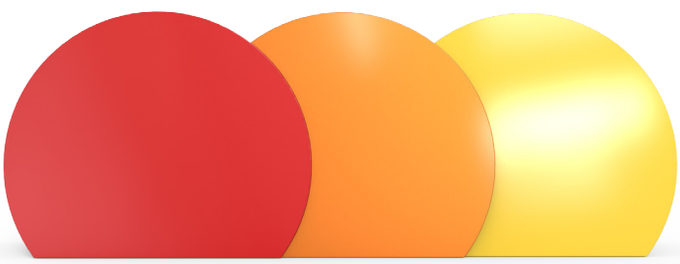


Figure 3.29. 60's. Hard Shiny Plastic.

Figure 3.30 50's-60's. Clear Shiny Plastic.

70's - 80's (Fig 3.28.), the bulbous, rounded, gummy form of this sleeve reflects the a retro soft/curved forms from this era. A strap on top of this sleeve makes it easier to hold alongside the slight curve/indentaion of the form. 60's (Fig 3.29.), bold colours used alongside simple forms and shapes, reflect a 60's mod aesthetic.The use of overlapped circles chnages the form of the sleeve more dramatically than a surface augmentation. 50's -60's (Fig 3.30.), the half circle shape reflects a 50's-60's style makeup compact, it bulbous and clam-like, reflecting a retro style.

Functional Sleeves

All functional sleeves look to explore the potential duality that could be produced through sleeveing. These designed sleeve renders are based on home use functions, to show these potential visual and physical aesthetic possibilities that could be applied and used in a home environement.

Jewellery Organiser (Fig 3.31.), This sleeve is a tray primarily for jewellery and glasses; the compartment at the back centre being for the glasses case. Earrings and rings can be placed in the left ribbed section, and the inset bowl shape on the right is a place for necklaces and bracelets. This could be placed anywhere in the home, however, it is intended for a dresser in the bedroom or a bench in a bathroom.

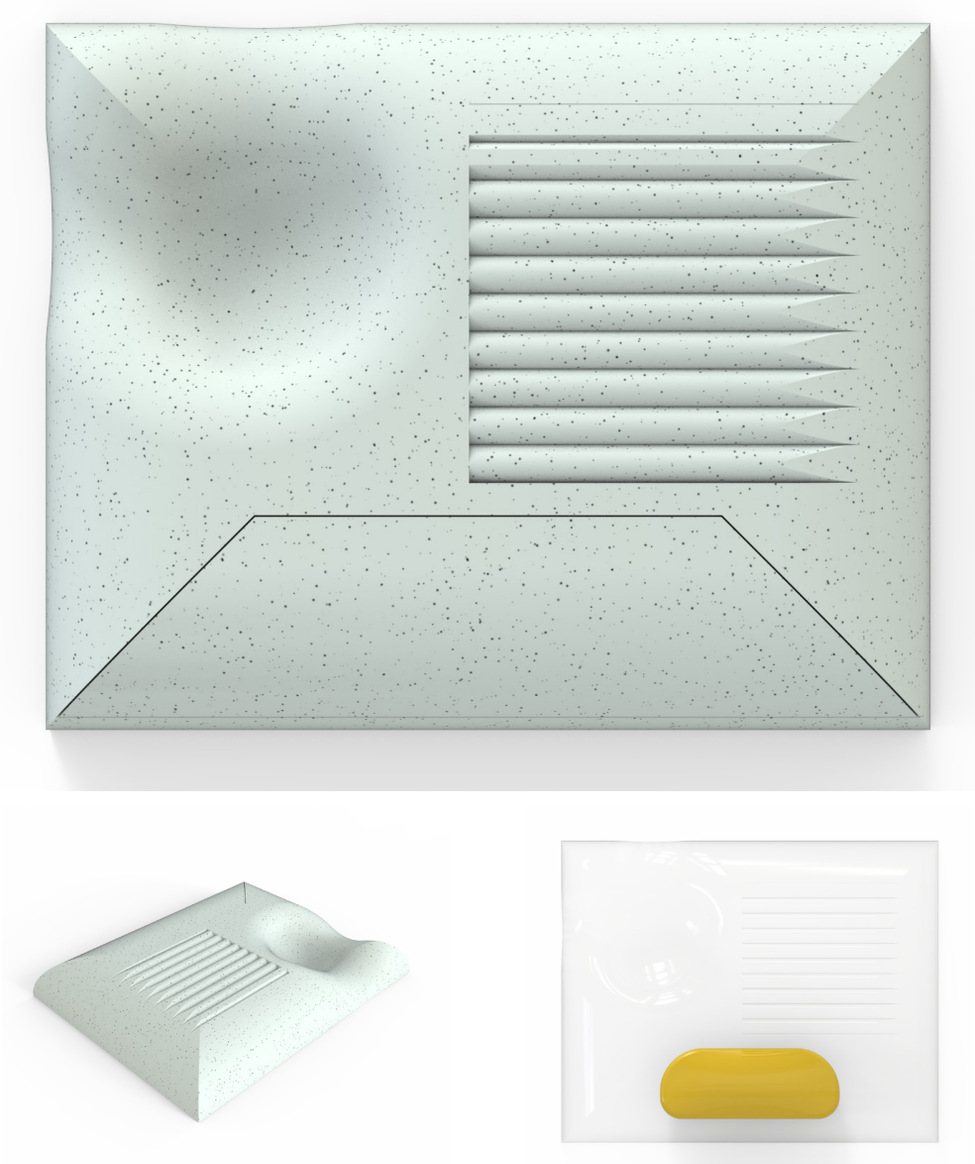
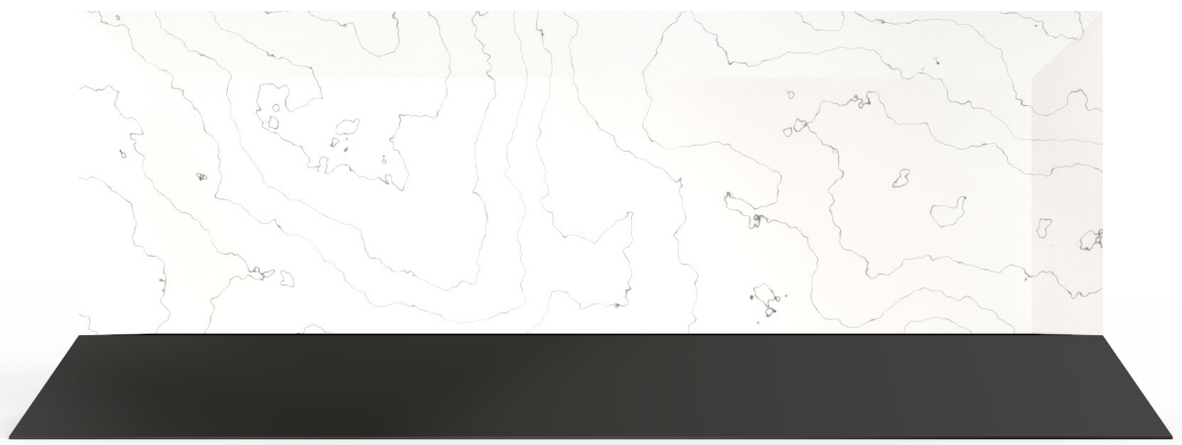


*Figure 3.31. J*ewellery Organiser. Sandy Ceramic.

Figure 3.32. Hook. Worn Brass.

Hook (Fig 3.32.), this sleeve explores function through an built-in hook, that could be latched onto a desk/wall partition, handle or book. This sleeve does not change the form of the glasses case dramatically, however the size is increased due to the hook extension.



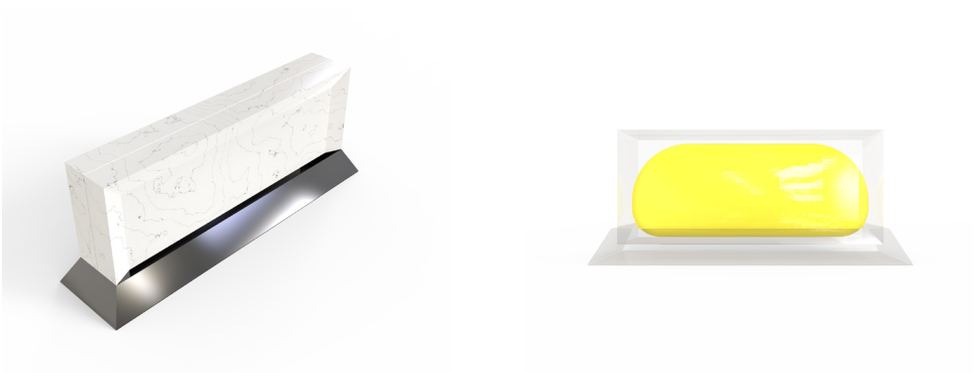
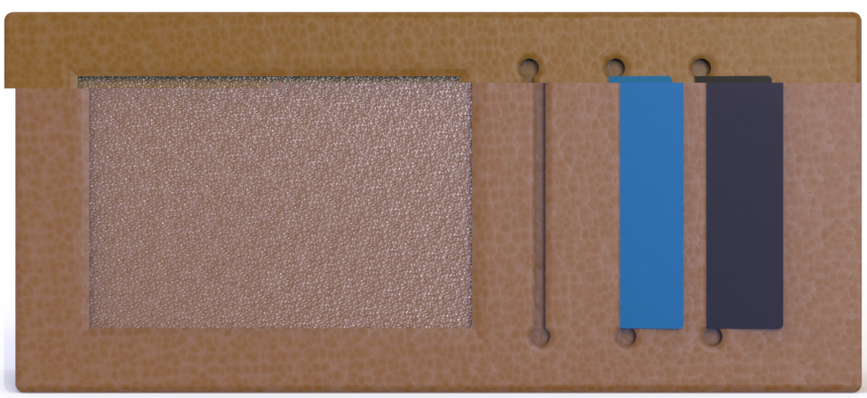


Figure 3.33. Rectangular Stand. White Marble & Black Chorme.

Rectangular Stand. Fig 3.33.), This sleeve is a simple rectangle; with the base/stand and inset edge mimicing similar details to that of skirtings and architrave forms in homes; materials reflect the smooth surfaces that are found in kitchens, marble & chrome. The glasses can then be removed from the case and placed on top to imitate an elevated stand for areas such as a kitchen where bench surfaces are not always clean.



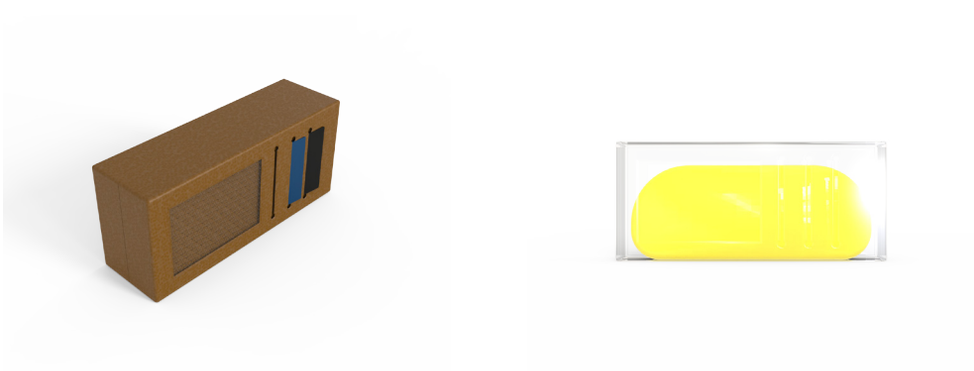


Figure 3.34. Wallet. Brown Leather. This explores the dual use of a sleeve,

Wallet (Fig 3.34.), where the glasses case is inside of a wallet. It covers the glasses case and can also be used to store eftpos, business and ethos cards. The form of the sleeve is only varied slightly from the case to allow for the leather to be streched and attached in an easy manner.

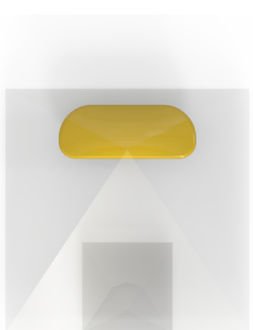


Figure 3.35. Geometric Pyramid. Black & White Marbel.

Geometric Pyramid (Fig 3.35.), a sculptural geometric sleeve, where the glasses can be stored inside the sleeve, or, between the two peaks on the bridge of the glasses; this would act as a stand. This double use simply acts as storage and display of glasses.

PRINT

3D printing some of the sleeves allows the testing of print quality through resolution and tolerances; to find if any adjustments need to be made so that the glasses case can fit in the sleeve. The following photographs show these test prints to describe what adjustments need to be made so that it can fit onto the glasses case. All test prints use Wood PLA filament.

Initial TestPrints (Fig 3.36.), models were printed at a smaller scale to see which form would print best. Print quality is poor, and needs to be adjusted for more refined prints. Wooden Truck Test Print (Fig 3.37), print quality is poor, this is due to printing filament and fast print speed (material is unable to stick to each layer correctly), the filament is unable to stick in position well. Tolerances are off, and the glasses case unable to fit in the sleeve.

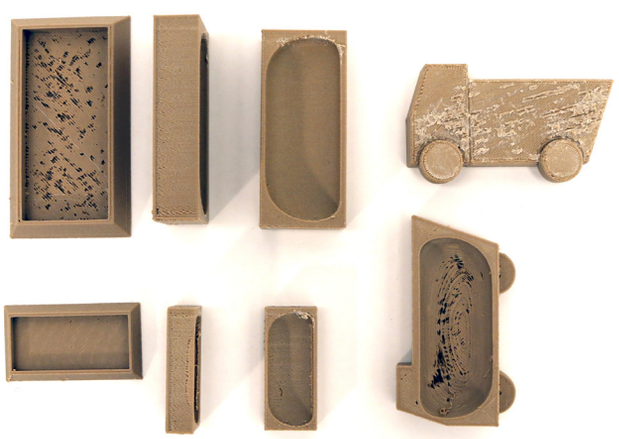


Figure 3.36. Initial Test Prints.

Figure 3.37. Wooden Truck Test Print.

FIT

Figure 3.38. Ripple Test Print 1. Correct tolerance for fit however, wall thickness hinders opening function.

Figure 3.39. Ripple Test Print 2.

Ripple Test Print 1 (Fig 3.38.), Correct tolerance for fit however, wall thickness hinders opening function. Ripple Test Print 2 (Fig 3.39.), shows thin/shell wall thickness, with correct tolerance for fitting.

Figure 3.40. Ripple Test Print.

Flinal Ripple Test Print (Fig 3.40.) Showing thin/shell wall thickness. Fits tight with no glue or sanding required.

Reflection

The aim of this Design Phase 1 was to test that the sleeving process would be achievable and has been met through rendering to show aesthetic change, while 3D prints of one of the Sleeves show the fit to the glasses case. The Sleeves produced show the exponential ways that an object could be augmented through this sleeving process; allowing the visual and physical aesthetics of the object to be changed and adjusted to suit any material, location, style or function.

The renders produced, show the small part of aesthetics that could potentially be produced, changed and styled. Renders also show the additional volume added to the glasses case. The printed sleeves show that it is necessary to make considerations towards the needs and functions of the hinge on the glasses case. It is important to note, tolerances of the CAD/print also need to be adjusted depending on printing material and the object it is being fitted too. Further consideration needs to be made regarding the wall thickness of the sleeve as this may change the hinge's rotation movement ability. The test prints also show that the thin wall prints look better, and keep the volume of the sleeves to a minimum.

As this process has provided a decent means of granting and producing editable aesthetics, without hindering function of the glasses case, it will be applied to the CPAP device in Design Phase 2.

Criteria

Design Process Phase 1

The designs should show the potential aesthetics and physical modifications that could be produced with the sleeving process.	This is shown through renders and 3D prints produced.
The designs must retain the object's function.	This is shown 3D prints produced.
The designs should fit onto the object on which it is based.	This is shown through 3D prints produced.
The designs may enable better function, or dual use of the object.	This is shown through renders produced.

Design Process
Phase 2

004

Preface

I have always preferred a creative fictional approach to writing. I feel that it allows for a more imaginative and emotive understanding, rather than a clinical or analytical idea of a subject. I find more than often that emotions can be overlooked or are unclearly interpreted in non-fictional writing. As the first three activity scenarios are set before or during sleep I encourage you, the reader, to sit/read these in a quiet, comfortable place to fully immerse yourself and understand the people, their thoughts and why they may have certain inclinations/biases. Don't just put yourself in their shoes. Imagine that you **are** *them for five minutes. And fall into the depths of how life may be for other people.*

Narratives

As reflected in the introduction of this thesis, Narratives are used as a form of storytelling to interpret scenarios and describe important insights and observations that will inform the designs in Design Phase 2. These Manufacturer (Fig 4.1. & 4.2.) and User Narratives (Fig 4.3. - 4.13.) offer the opportunity to immerse the reader in fictional narratives that explain and describe characters, environments, motivations and reasonings surrounding CPAP. While these narratives could be treated as assumptions, the basis for them has been taken from personal experience working with a CPAP manufacturing company and using the product. The Manufacturer Narrative describes a sneak peek into a CPAP manufacturers office in an interview style situation. The User Narratives will then allow readers to understand and empathise with some of the trials and tribulations that come with using CPAP devices. Delving into why design may not be as heavily considered as it should be during the manufacturing stage. These scenarios focus on describing some of the complex interconnected relationships and structures that dictate the current design outputs of manufacture companies, as well as the emotions and problems that people face when using the devices.

These Narratives aim to create manufacturer and user information to inform and provide design criteria for Design Phase 2.

Manufacturer Narrative

MediBreathe interview

"Ruby. Great to finally meet you. Welcome to MediBreathe"

"You must be Paul. Thanks for having me." I smile and shift my hand to give him an appreciative handshake. I need this interview to go well.

"We just have to sign you in as a visitor. Mary could you please chuck me the visitors pass for Ruby Dalton, she's come to see us from Sleepeasy Publishing." I look around the clean and bright room, Mary sitting concealed behind a tall reception desk.

"Here you go Paul" Her hand pops out above the bench, lanyard in hand.
Great, I get to wear that, how stylish.

"Thanks Mary. Your visitor's card needs to be worn at all times, If you get caught without it I'll be in trouble". He laughs lightly taking the lanyard and card from Mary and hands it to me. I'm lead down a short corridor to a set of shut doors. As Paul waves his swipe card to the left side of them. They peel open, and I swear I can see fog seeping in from the hallway. This place is like some sort of sci-fi movie.

"We'll head to my desk first, I have to get you to sign some forms and then you can meet the team."

"Ok sure," I say as we walk through the doorway and into another corridor, except this one is enormous, both in width and in length. "Wow. This hallway has got to be the length of two rugby fields."

"Yeah, it'll take us 20 minutes to get to my desk".

So as we walk I fill the conversation with questions; that I assume I can ask, without revealing any company secrets. My guess is he can't say anything of substance until I've signed some IP forms. "What's your main goal when your engineers are producing these devices?"

"Well, we think it is important to focus on making sure that the CPAP functions properly so that it keeps going uninterrupted. It's a medical device, it has to work properly. I mean, these machines keep people breathing during sleep, so they have to work. There are all sorts of medical regulations, and they are different depending on what country these devices are going to."

"Wow, that sounds intense. Do you ever get patients asking for customised machines?"

"It wouldn't really be possible to do that. We aren't really capable of producing such a high number of customised devices. The focus is on making one device work. We have to consider the cost of making, the amount of staff and the amount of time spent working on a device. Meaning we have to go for a one-size fits all concept, otherwise we would never have a decent product."

"What about masks?"

MediBreathe

Figure 4.1. MediBreathe Interview Document, pg 1.

"Well the masks, some people find them uncomfortable. And again it's the capabilities to get it to a high-level customisation, imagine trying to get thousands of people in here or to their clinicians for fittings, it's not really viable at the moment. The face is tricky, and of course, it is. It's foreign object being put on the body. Silicone is the best way for us to give everyone some level of comfort, but some people think its cheap."

"Clinicians?"

"Aww yeah, most people get their devices from a clinician or doctor. It's hard for us to make sure they are telling patients how to use the devices properly. We sometimes get people telling us their mask isn't working, but really their clinician or doctor just hasn't fitted them correctly."

After a few left turns and more long corridors, we finally make it to a room filled with hundreds of desks and people sitting at them tapping away at their keyboards.

"Here's my cohort," Paul says as we walk into the room. He parks himself at the desk closest to the door and pulls a pile of approximately 20 pages from his desk, slamming them on the table. "Take a seat. Here's a pen, you'll need to read through every page carefully. Make sure you sign at the bottom of every page and then put all of your details, here, here and here. Paul points then pen on different sections of the page as he flicks through the document.

"Aaahhh. Ok."

"Let me know if you have any questions." He turns to his computer and begins clicking away.

So I look down at the pile of papers and start reading. I initial each page as I go. Reading words on words, section on section.

MediBreathe

Figure 4.2. MediBreathe Interview Document, pg 2.

Reflection

The MediBreathe interview offers a few insights into manufacturings companies that may not be obvious. There is no denying that the primary goal of these companies is to produce the best functioning device possible; as people's health, and potentially lives, are on the line. Throughout the interview, insight is gained into the interconnected situations that run throughout this system. These are described through the clinicians/doctors, with patients; as mentioned briefly in the MediBreathe interview and Sandra's narrative, Paul states "It's hard for us to make sure they are telling patients how to use the devices properly". Ruby also notes, "I didn't even realise there was other brands and masks until I googled it." This suggests there are potential disparities and lack of communication between all three, manufacturer, clinician/doctor to the patients, and may also show that patients could often be misinformed or not given the information that is required or needed at all. The MediBreathe interview offers a few potential reasons for why manufacturers have developed their devices in such a way, such as regulations, dictation of tasks & projects or manufacturing capabilities. Generally, these all come down to financial, regulatory and competitive constraints, the potential loss of income (or risk of income) could be high; meeting a one size fits all, allows them to meet the needs (some of them) of more patients. This inability or incapability is why this research has been positioned towards customisation.

User Narratives

Sandra

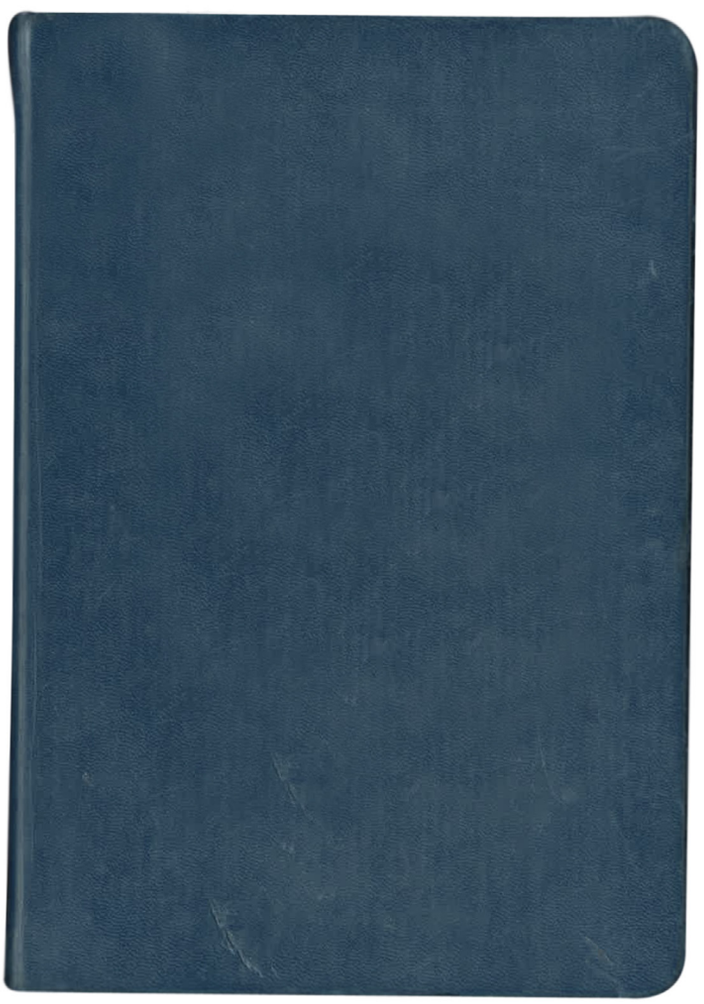


Figure 4.3. Sandra's Diary, cover.

God, it's so disjointed from the rest of the room.

My calming bedroom of whites and pastels has been invaded by what is, in a way, keeping me alive. My CPAP is like a dark noisy little gremlin that's been placed in a starkly different beach retreat space. I found it difficult to use when I was first given it; I'd only had one session with the clinician and no follow-ups. I didn't even realise there was other brands and masks until I googled it.

I step backwards away from the side table, turning to my wardrobe to find my Pj's. Pulling out the smooth milky blue fabric from the shelf, it slips through my fingers and pools onto the softly mottled hardwood floor.

My fingers caress the fabric, curling into the silk as I lift the cami from the ground. My heavy arms slip the fabric on as I patter towards the bed. I pull back the duvet cover and shuffle in next to Todd. God knows what he thinks of the thing. I just hope that he can live with it. I'm sure he'd tell me if he some sort of aversion to the little black box.

I gather the knitted blanket at my feet. If anything the mask is the only thing that gets between us. Although he has said that the light on the CPAP screen is a little bright sometimes.

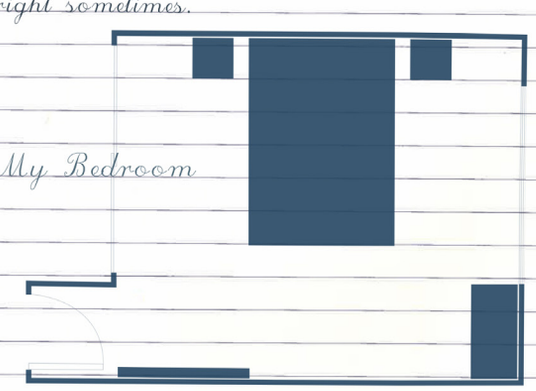
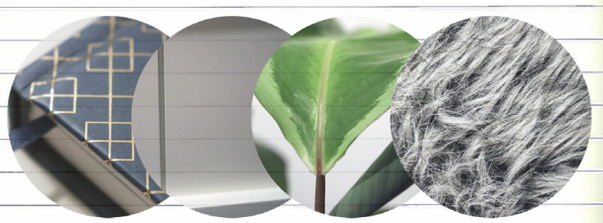


Figure 4.4. Sandra's Diary, pg 1 & 2.

Sitting up in the bed I unclasping my earrings; reaching across my side table I place them into the low cut sandy ceramic bowl.

As I lean back, settling into the bed, I remove my glasses; pick up the CPAP mask and stretch it over my head, riggling it under my nose and haphazardly adjust my ponytail as I strap myself in. The linen duvet shifts as I unfold my arm



stretching to press the chrome button that will blast air into me.
The button springs beneath my finger pushing and fanning tepid air into my lungs.

I turn over, thinking about what is on the agenda for my staff tomorrow.
I sink into the bed. Fabric engulfs me, cocooning my sleepy body.

Todd pecks me on the cheek,

my tired eyes squint back,

he smiles tenderly,

Figure 4.5. Sandra's Diary, pg 3 & 4.

Figure 4.6. Sandra's Diary, pg 5 & 6.

Barry

"Dave ya bastard. Get ~~of~~ the bloody bench." I swipe at him, batting him off.

"Meow."

"Bloody cat." I grin at him, giving him a ~~st~~ scratch on the head. He's demanding some attention from me but I won't be giving ~~it~~ him anymore

I head ~~off~~ down the hallway. The walls are still ~~stu~~ skeletons, I really need to get onto putting the gib up in this hallway, it's chilly down here. I try to dodge a couple of nails laying out on top of the chipboard, but have no luck.

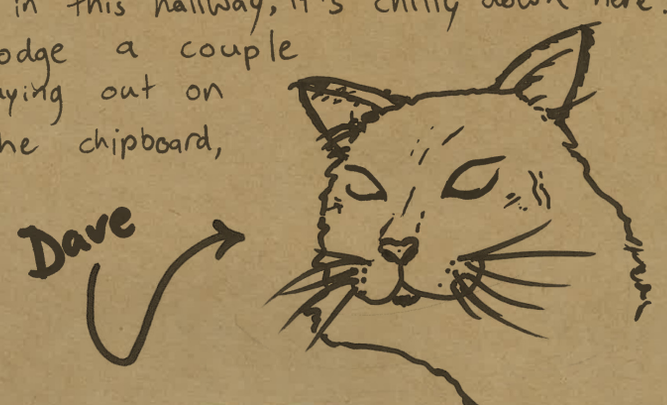


Figure 4.7. Barry's Diary, pg 1.

"Shit." And I've stood on one. Great. Bloody great. Good one Bazza. Thank god I've got my woolly socks on, otherwise the thing would have ripped my foot open.

I walk into my room, quickly rip my shirt off and chuck it onto the floor with the rest of my clothes. I ~~sit~~ sit down on my bed and pull my mask out from ~~under~~ under my pillow. Twisting I pick up the nose from the floor and peel off the bit of duct tape I've put over the open end;

I'm a little bit freaked out about bugs getting into the tube.

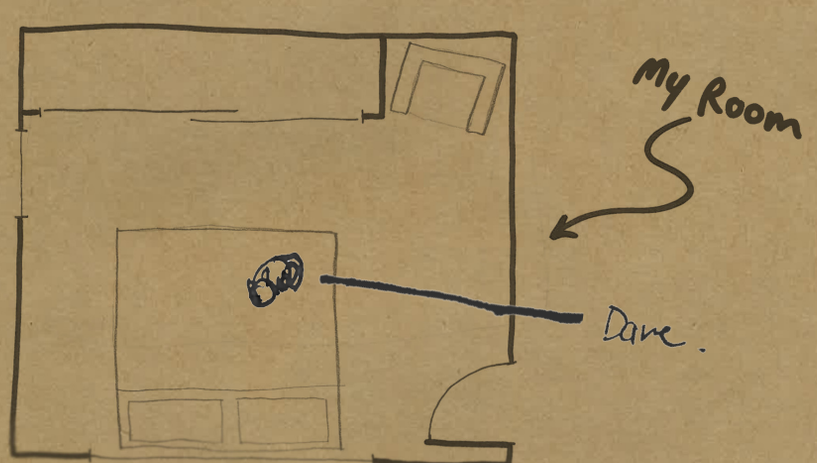


Figure 4.8. Barry's Diary, pg 2.

I've never really liked the thing. My CPAP that is, but it keeps me alive, and I've actually managed to have a decent sleep every night for the last five years. This is a ~~long~~ long-term thing for me and I will need it indefinitely, it's not something I can ~~just~~ just use when I feel like it.

So I line up the straps in one hand, holding the nose part in the other and lift it up to my face, stretching the straps over the little bit of hair I have left. I give it a wee riggle until it's settled in, but not fully ~~com fo~~ comfortable, that's when you know it is on your noggin right.

I bend down to the grey box and press the button. I'm hoping I can get a new one that looks a bit ~~cooler~~ ~~cot~~ cooler, I want it to look good in the house once I've finally finished building it.

Air blasts through the ~~hose~~ hose and I'm ready for a good old Bazza beautyrest. I've got to make sure I'm around ~~for~~ for my grandkids, because I don't want ~~to~~ to miss that for the world.

This is what I want my room to look like.

Figure 4.9. Barry's Diary, pg 3.

Tom

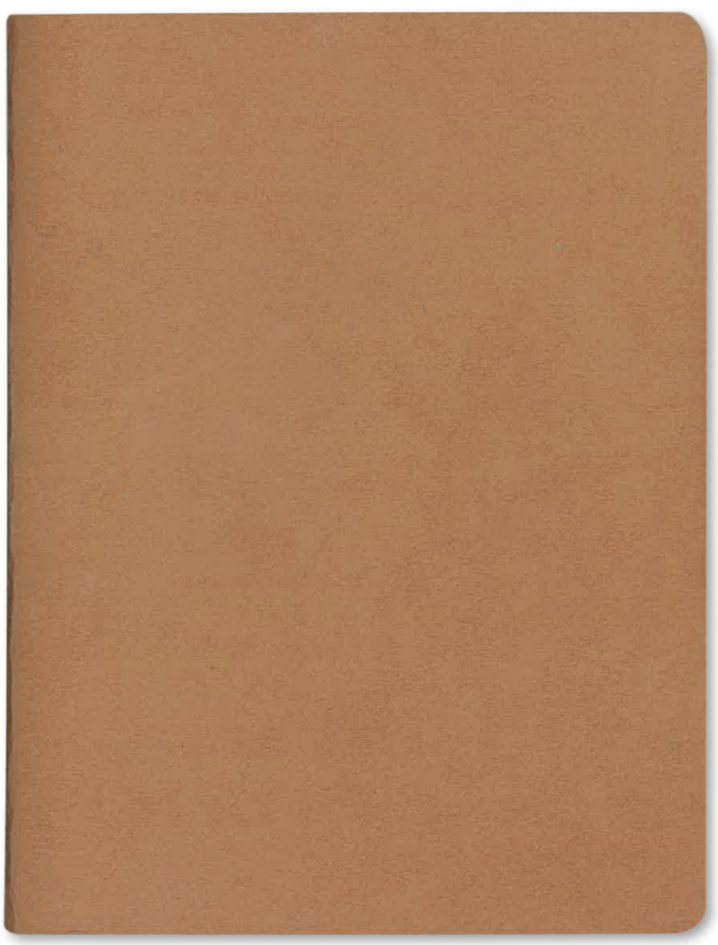


Figure 4.10. Tom's Diary, cover.

"addd"
I feel a tug on the sheets, a wee voice fills my thoughts.
"daaddd" quiet little voice whispers.
"Haayyyy ddaaadd" I feel Hunter's cold hand on my face. He's trying to pull my mask off. Allright,

Alright, I'm awake.
"Waa's p budd?" my voice is muffled until I gingerly pull off my mask. "What's up bud, what are you doing out of bed?"

"I had a scawy dream" Hunter confides, his blue eyes looking sleepy and a little watery.

Chucking my mask on the floor I get up carefully so as not to wake Emily. I lift Hunter, carrying him out of the room and down the hallway. The door creaks. And the resounding jingle on the dog's collar follows as he hears us moving through the house.

Hunter nestles his head against my neck. "I don wan to sleep in my bed"

"You've got to. You'll be fine" I move to the left pushing his ajar door open a little further.
As I walk through the doorway Jeb has caught up with us and I let him trail in. He gangly jumps onto the end of the bed, blue car sheets puffing under him.

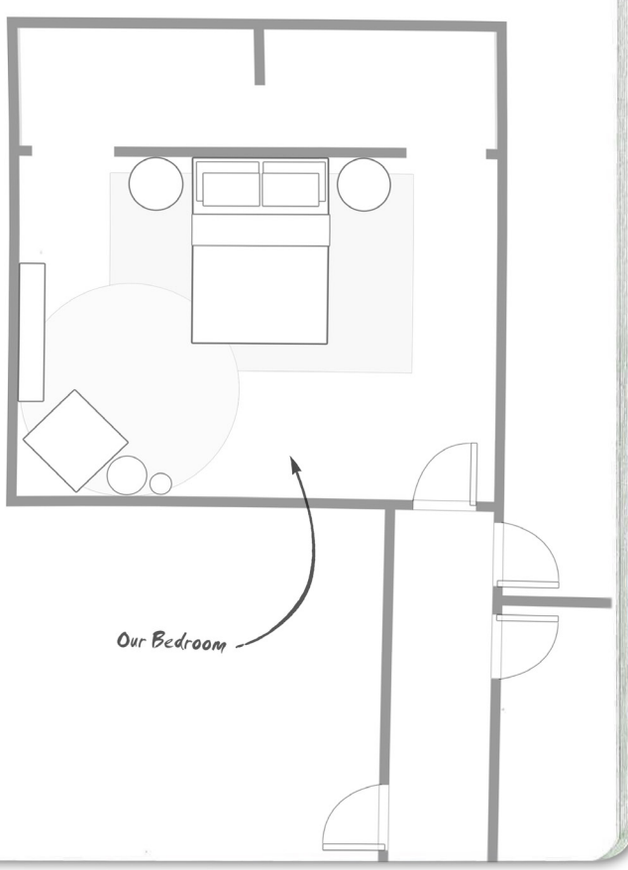


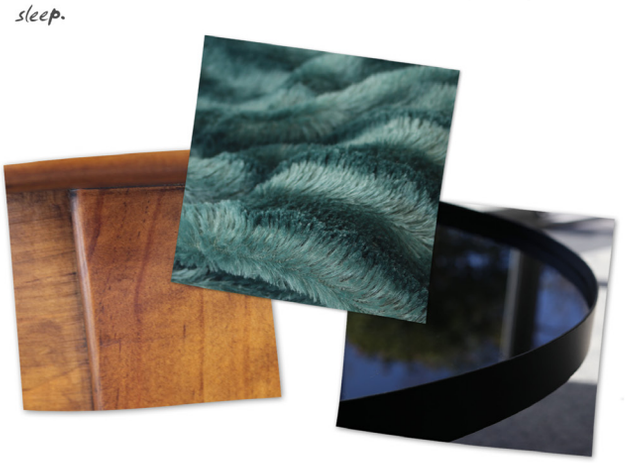
Figure 4.11. Tom's Diary, pg 1 & 2.

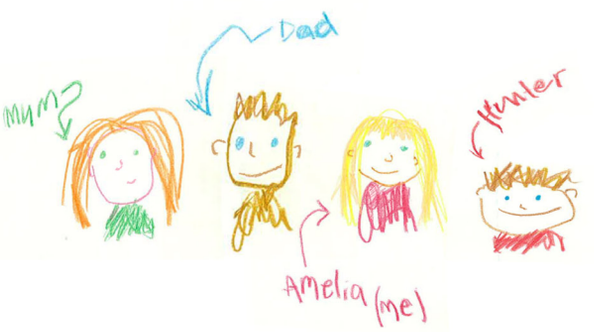
"But daadd I don want to have another scawy dream"

"Jebb will look after you." I pull the duvet over him and tuck his wee hands in.

"jebb geds to sleep in my bed for ta night?" Hunter looks up at me, waiting.

"Yea bud, if you get scared just give him a cuddle." His wary little face smiles. My 'strictly no dog in the kid's bedrooms' rule is out the window. But it'll be worth it if it means I get a good night's sleep.





"Ow kay dad. I lub you."

"I love you too bud" I say as I lean down to give him a kiss on the head. I throw in a "stay Jebb" for good measure as get up and head back to our room.

"Is he ok Tom?" Emily murmurs as I jump back in.

"Yea yea, I let him have Jebb in there"
I lean over the edge of the bed, pulling my CPAP from under the frame, pressing the button to get it started again. Which is when I realize that I left it going. Shit.

Figure 4.12. Tom's Diary, pg 3 & 4.

Figure 4.13. Tom's Diary, pg 4 & 5.

Reflection

All three narratives provide a small snapshot of a moment when the CPAP is being used or is about to be used. We get a feeling for some of the emotions that each narrative may feel during this snapshot of their daily life. Sandra clearly states her disdain towards the visual qualities of the CPAP, "my calming bedroom of whites and pastels has been invaded" it does not fit well with her furnishings and colours in her room. We see this reflected similarly with Tom; he points out the that his children are scared of the mask. Tom also notes that his wife gets annoyed by the sound that CPAP makes saying, "I know she must get annoyed with the noise". Barry, however, does not show any annoyance towards the visual qualities of the device; however he does note the discomfort of the mask, "it's settled in, but not fully comfortable", and the difficulty putting it on. Figure 4.14. notes the important aesthetic components that will be considered in the Design Process Phase 3 stage. Figure 4.15 shows a range of colours, based on the narratives, that could be used in Design Process Phase.

To summarise, each person's bedroom environment is described below.

Sandra's bedroom style is quite feminine. Overall her space is relatively conservative, through the lightness of colour palette and a mixture of soft and transparent materials such as knits, furs, linen, ceramic, and glass. The minimal amount of classic style of furniture, in white hues, opens the space up giving her bedroom environment an all round clean Hampton style vibe.

Barry's bedroom style is masculine regarding colour, monochromes, slight blues, with a touch of orange is thrown in; however, the round side tables and fabrics currently in the space, add a feminine touch. The metal floor lamp and shiny surface of side tables paired with grey fabrics give the space a mid-century contemporary feel.

Tom's bedroom is filled will a mass of textures, textiles and styles; suggesting a mixture of femininity, through the lightness of colour, and masculinity through added dark tones. Materials such as wood, stone and steel alongside soft furnishings, knits and glass have created a contemporary warm, inviting environment. The rustic undertones from the wood and steel furnishings create a softened industrial-style space.

The following criteria had been created based on the user narratives to lead Design Process Phase 3.

- The designs must retain the CPAP's function.
- Designs should change the current visual appearance of the CPAP.
- Designs should fit into the environment's aesthetic in which it is being placed.
- Design should be specific to each narrative.

Sandra

- Design should utilise the side table space, while still allowing room for other objects to make use of the surface.

Barry

- Designs should utilise the unfinished environment and house.

Tom

- Design should utilise the space underneath the bed.

	CPAP location	Issue to be remedied	Furniture	Homewares	Materials	Colours
Sandra	*Side table.*	*Cpap doesn't look good in her room. Visually and physically.*	*Side tables, bed, dresser, mirror.*	*Lamp, bowl, vase, plants, throws.*	*Wood, silks, linens, glass, ceramic, husk, flax, rope/husk, stone.*	*White, light blue, Navy, grey, light pink, smokey purple, soft green, soft yellow chrome,*
Barry	*On Floor (but this can be changed as the house is currently being built.*	*Worried about bugs getting into the hose.*	*Chair, bed, small sidetables.*	*N/A*	*Frabrics, black chorme, metal, carpet.*	*Whites, black, greys, dark grey blue, orange.*
Tom	*Under bed.*	*Kids find the CPAP scary looking.* *CPAP is noisy.*	*Side tables, bed, dresser, bookshelf, chair, small table, floor lamp, rugs.*	*Lamp, fern plant, oil burner, throw.*	*Grey carpet, fur, knit.*	*Dark green, black, grey, copper.*

Figure 4.14. Table: Main themes and important components noted from narratives.

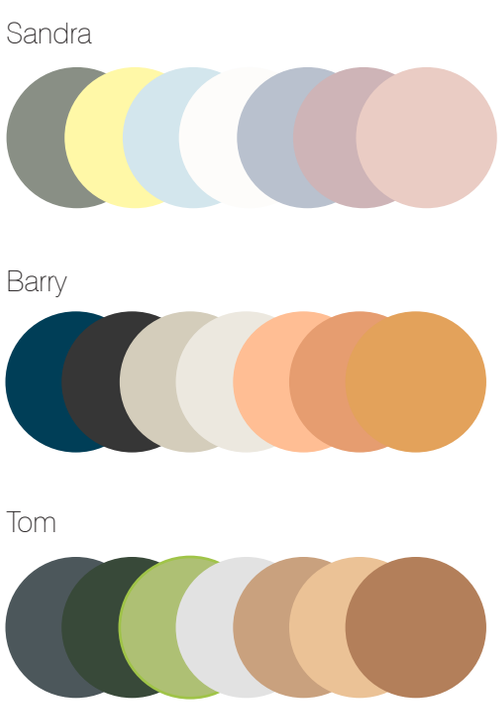


Figure 4.15 Colour swatches based on narratives.

Design Process
Phase 3

005

CPAP Sleeves

This Design Phase 3 chapter aims to explore the enhancement of a CPAP device through aesthetic. The intention of this is to create more cohesion within a bedroom environment, creating a better visual style through form, material and emotion of a potential sleeve. To do this, the sleeving process outlined and discussed in Design Phase 1, is applied to a CPAP device. Sleeves and their aesthetics are designed based on the narratives in Design Process Phase 2 and their coinciding criteria. The sleeves created should fit over or around the CPAP device without hindering functionality; enabling the continued use of the device's touchpoints. These sleeves should add value to the CPAP through physical and visual augmentation to potentially improve the device through added functionality or duality, the enhancement of emotional connection and improvement to therapy compliance.

Each section of this chapter is dedicated to the sleeves for each narrative. Each contains a series of ideation sketches and concepts, which are then developed through CAD modelling and renders to gain a visual understanding of how these object could fit into his or her required environments. The designs are then refined further where the proposed output is manifested into a bedroom context photograph from its corresponding narrative. After these sections exploration into the physical form and size of the proposed sleeves is carried out. This will be achieved through the creation of physical prototypes made with cardboard and 3D prints, to gauge an understanding of size and form of the sleeves.

All sleeves will aim to stick to the relative styles of the environments discussed in the narrative discussion of chapter 004. The sleeve designed for Sandra will follow a very conservative feminine style. As barry's bedroom style is somewhat monochromatic his sleeve design will stick to this; however, hints of colour may be added to create more visual interest and quirky tone. Tom's sleeve design will focus on a more masculine style through the use of materials, hard edges and forms.

Criteria

Design Process Phase 3

The designs must retain the CPAP's function.

Designs should change the current visual appearance of the CPAP.

Designs should fit into the environment's aesthetic in which it is being placed.

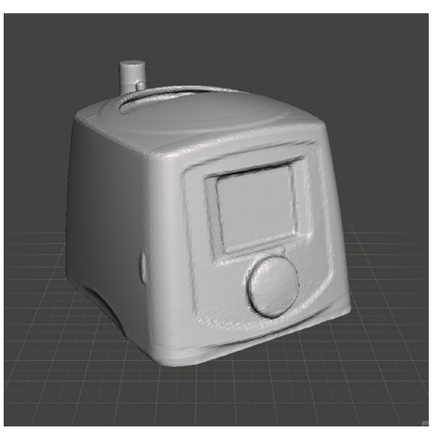
Design should be specific to each narrative.

SCAN

Figure 5.1. Rendered 3D scan of CPAP, in Hard Rough Plastic white.

DIGITISE

DESIGN



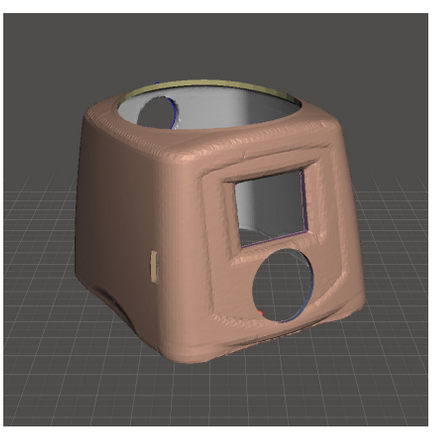


Figure 5.2. Digitized 3D scan of CPAP in Meshmixer (left).
Figure 5.3. Simple Skin created in Meshmixer (right).

Figure 5.4. Simple Skin on CPAP, in Hard Shiny Plastic, orange.

Figure 5.3. shows the Simple Skin created in Meshmixer, where thickness was added to the digitised scan (fig 5.2) and opening channels/cutouts were created to allow the use of the interaction points. Figure 5.4 shows the fit of the Simple skin to the digitised CPAP. The Simple Skin was then rendered in a multitude of generic materials (Fig 5.5. & 5.6.) in Keyshot. Figures 5.7. - 5.10. show the ideation sketches that explored form and augmented Sleeves in different bedroom styles.

Figure 5.5. Rendered Simple Skins on CPAP's, generic materials.

Figure 5.6. Rendered Simple Skins on CPAP's, generic materials.

Ideation Sketches

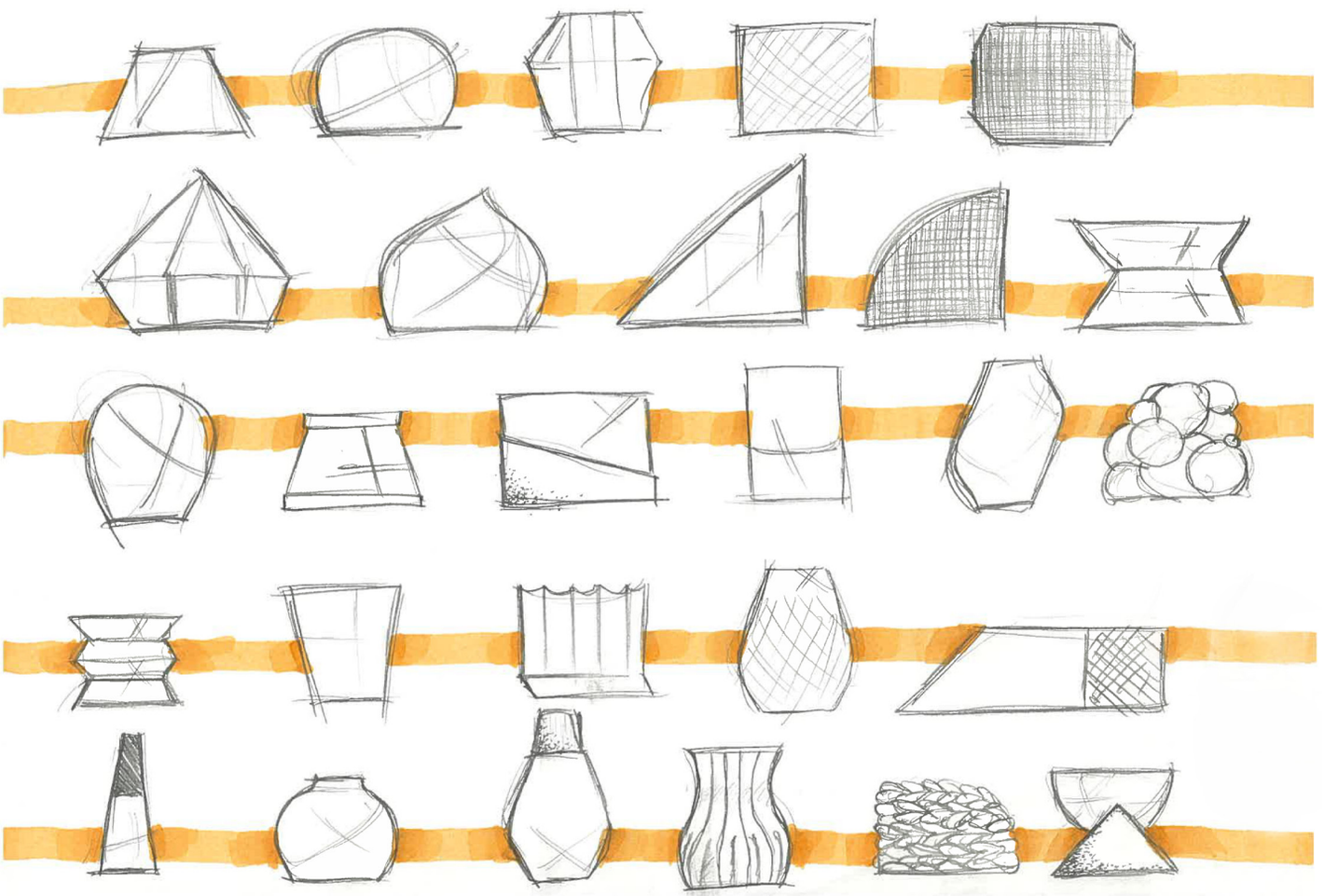


Figure 5.7. Form Ideation Sketches.

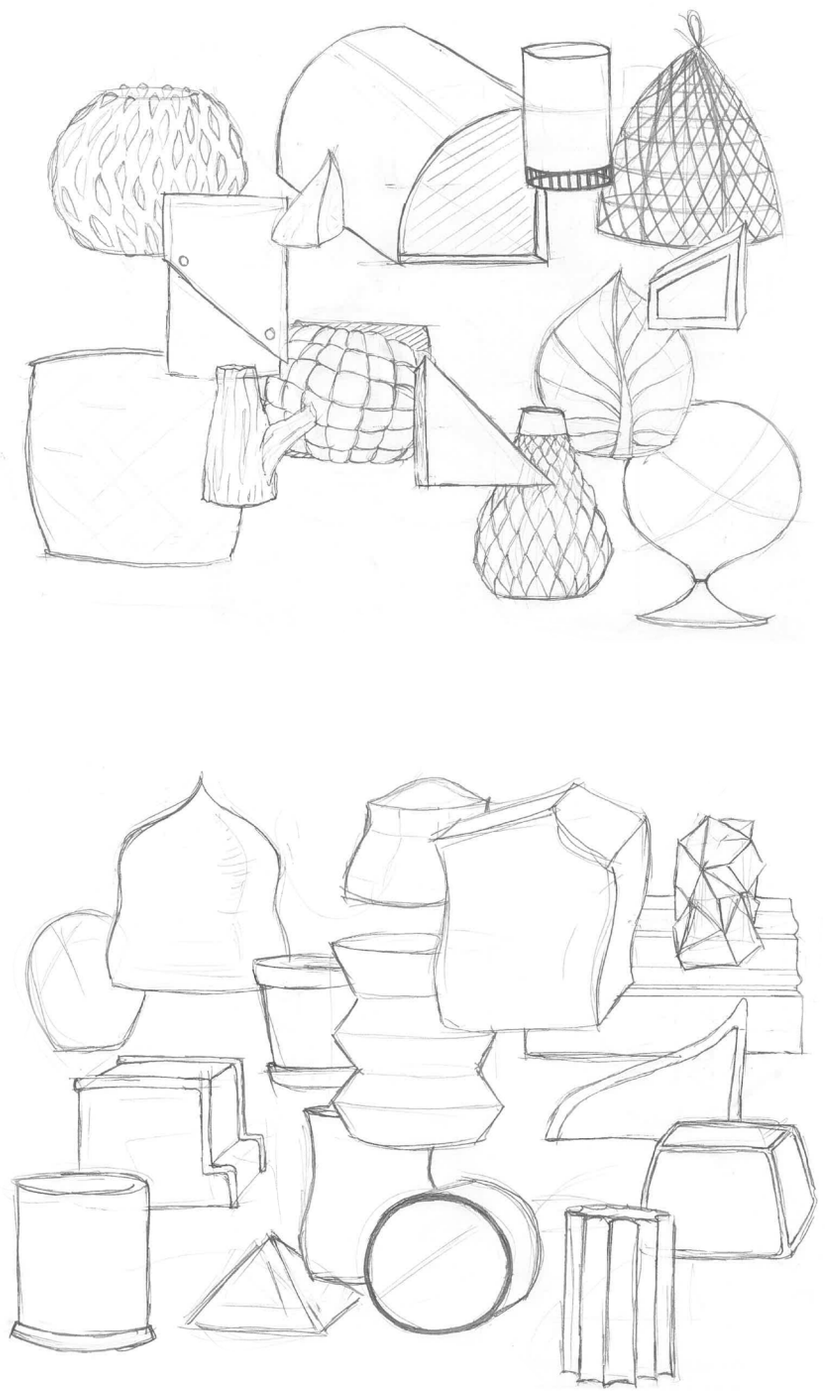


Figure 5.8. Form Ideation Sketches.

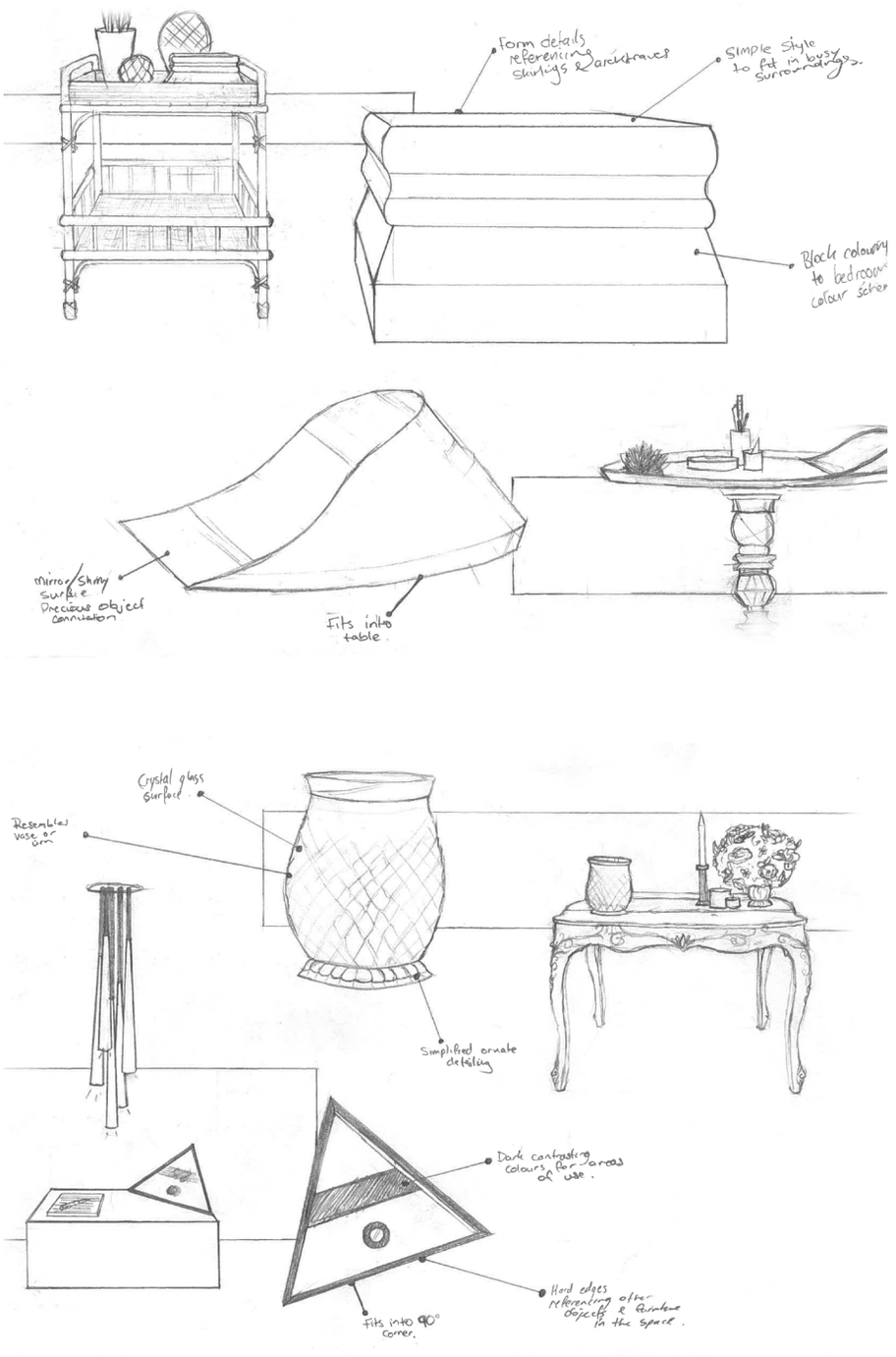


Figure 5.9. Sketches of ideation Sleeves for CPAP device.

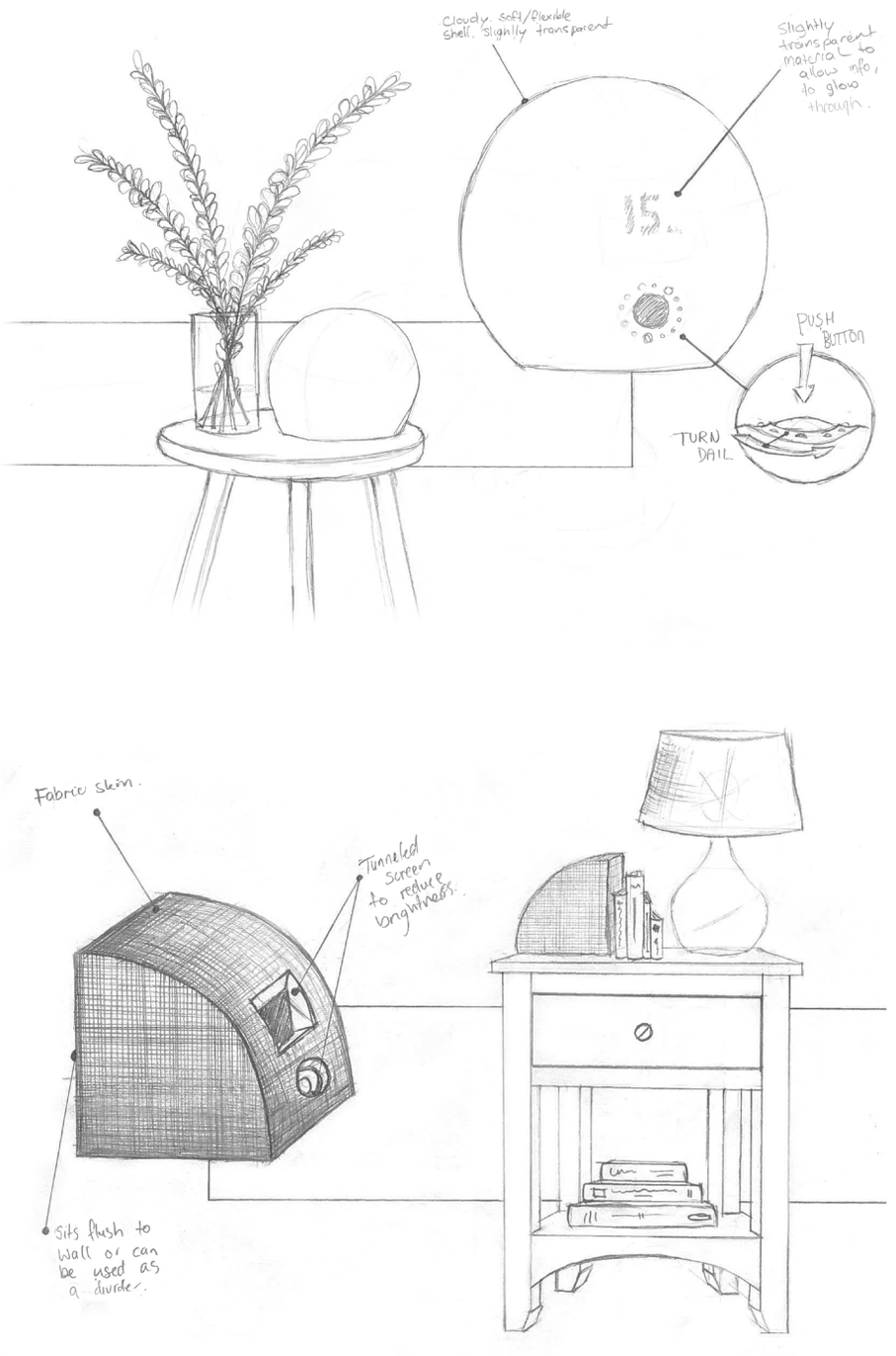


Figure 5.10. Sketches of ideation Sleeves for CPAP device.

Sandra

Figure 5.11. Photo of Sandra's Bedroom.

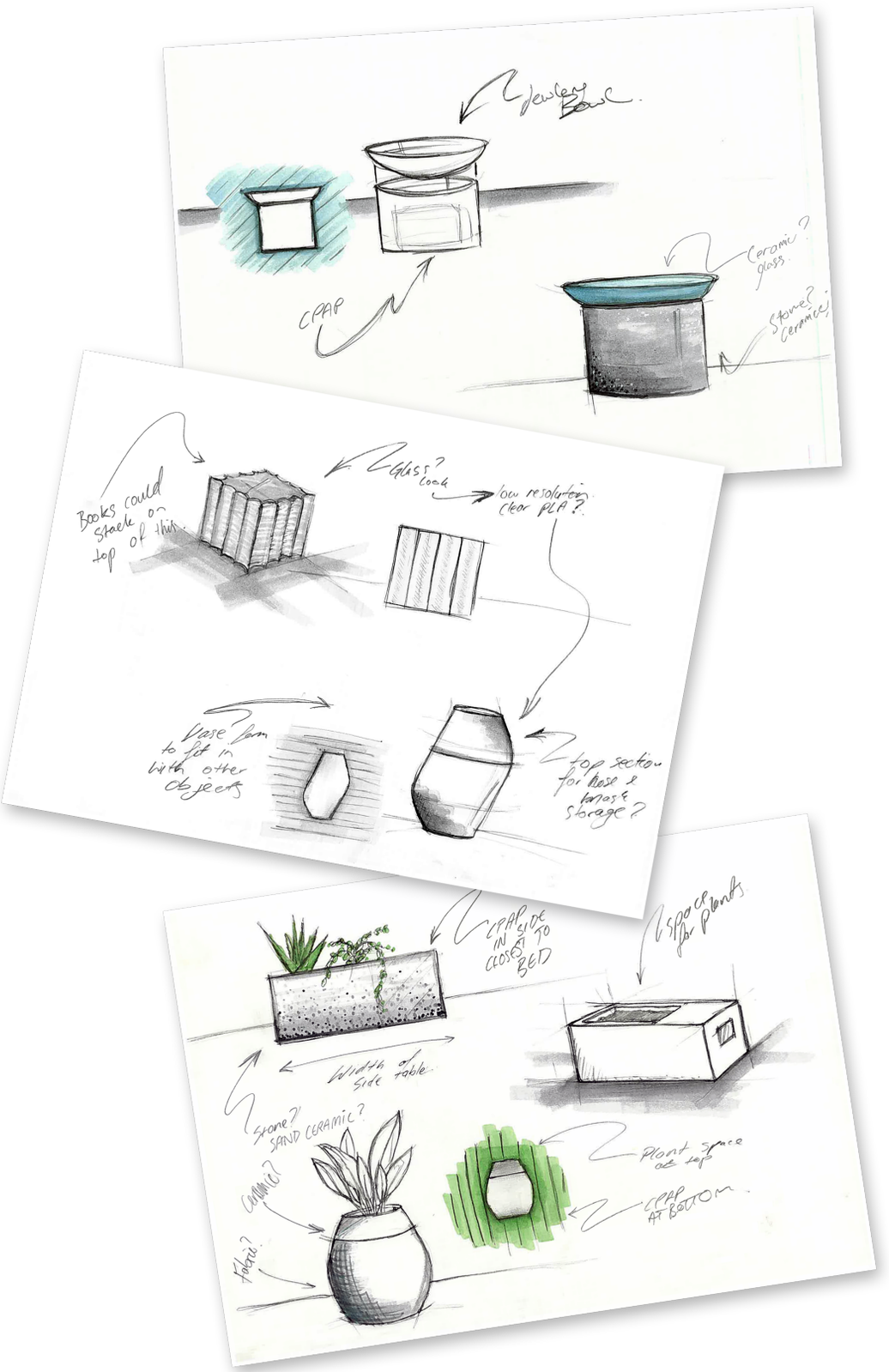


Figure 5.12. Sleeve Ideation Sketches for Sandra.

Concepts

Concepts were naturally produced and designed based on Sandra's ideation sketches (Fig 5.12.). The square & ridged cylinder sleeves (Fig 5.13. & 5.14.) have the intention of holding a CPAP mask, jewellery or book on the top piece/lid; while the main body of the sleeve would be used to house the CPAP device. The sphere, oval pot, arch end and bubbled cylinder (Fig 5.15. - 5.18.) sleeves have the single intention of housing the CPAP device. The oval pot sleeve offers further storage in the space above the CPAP for a hose and mask, with the intention to open the pot from the top. The Arch end also has the potential to sit flat against a wall or be used as a bookend.

Figure 5.13. Square Sleeve. Clear glass with CPAP inside (left), white marble base & porcelain lid (centre), hard shiny plastic in light blue base & hard rough plastic in grey blue lid (right).

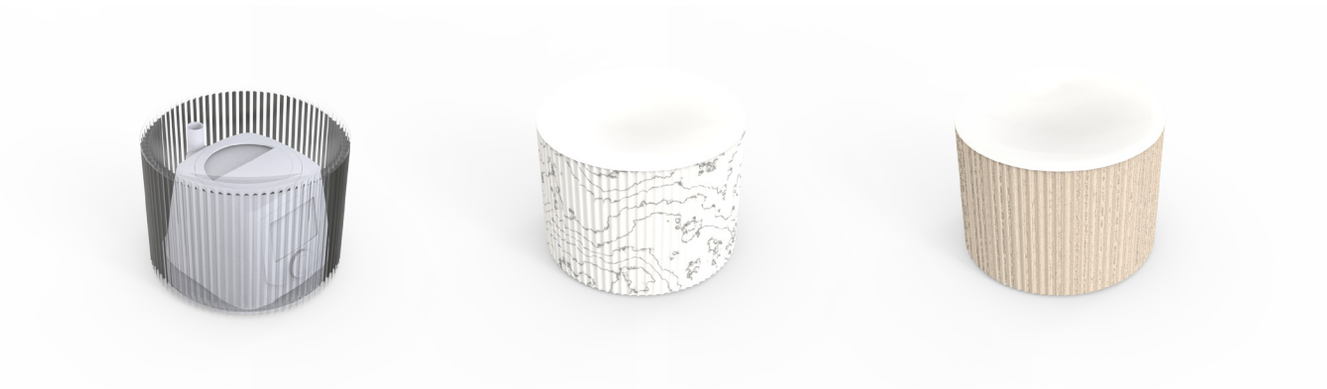


Figure 5.14. Ridged Cylinder. Clear glass with CPAP inside (left), white marble base & porcelain lid (centre), light washed wood base & porcelain lid (right).

Figure 5.15. Sphere Sleeve. Clear glass with CPAP inside (left), steel ultra scratched (centre), pink leather (right).

Figure 5.16. Oval Pot Sleeve. Clear glass with CPAP inside (left), white wool knit (centre), ridged glass in yellow (right).

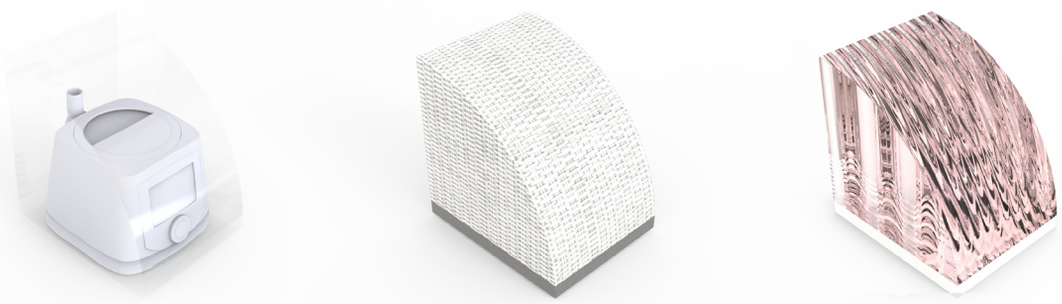


Figure 5.17. Arch End. Clear glass with CPAP inside (left), white wicker & hard rough plastic in grey base (centre), ridged glass in pink & porcelain base (right).

Figure 5.18. Bubbled Cylinder. Clear glass with CPAP inside (left), hard shiny plastic in metallic white (centre), hard shiny plastic in light blue (right).

Development

Figure 5.19. Development Sleeve Renders. Sleeve bodies in hard shiny plastic metallic white. Sandy ceramic lid (top), fingered brass top lid (centre), grey ridged glass (centre & bottom).

Figure 5.20. Development Sleeve Renders. Sleeve lids in sandy ceramic. Concrete body (top), pink porcelain (centre), blue porcelain (centre & bottom).

The developed sleeve is a twisted amalgamation of the oval pot and ridged cylinder. This development was CAD modelled through a series of guided lofts, revolved cuts and extrusions to allow for an irregularly curved cylinder, with a curved lid. This allows the curved vase form of the sleeve's body to move seamlessly into the lid. Figure 5.19. & 5.20. show exploration of materiality and colour through the developed sleeved.

The surface developments (Fig 5.21.) are an exploration of the cuts/grooves that wrap around the body of the sleeve. These give a sense of openness to an otherwise static object. The single direction cuts are subtle and simple, whereas the two differently directed cuts look highly decorative and are overbearing.

The diagram (Fig 5.22.) shows access points and essential design features of the sleeve. An access door allows the CPAP to be entirely shut away when not in use and directly clips into the front facade of the sleeve (Fig 5.24.). To avoid a harsh cut into the body of the sleeve, the surface detailing was used to guide the cut of the access door. A small opening channel in the bottom right corner of the access door allows the power cord to be fed through. The CPAP hose has a separate opening channel at the top edge of the sleeve's body under the lid; this allows the lid to be taken off so that the hose and mask can quickly be put on top the CPAP within the sleeve. This access lid allows the water chamber to be filled from the top, rather than having to reach into the sleeve from the side to gain access to this.

Surface Development

Figure 5.21. Surface Details. Exploration of potentail surface detailing. porcelin body & fingered brass top lid.

Refinement

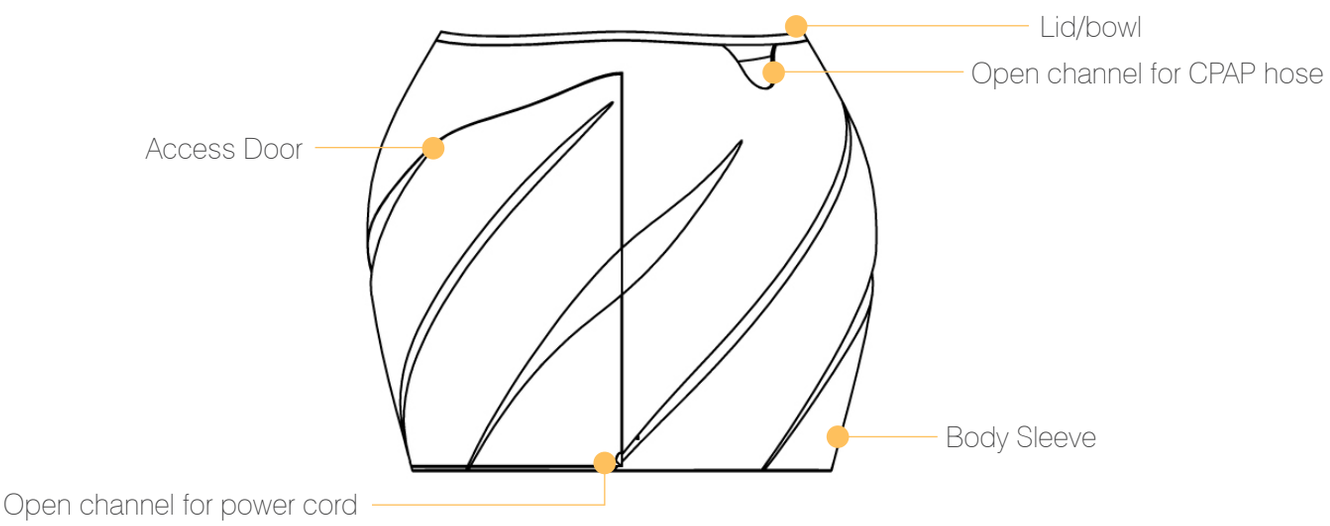


Figure 5.22. Sandra's Sleeve Touch-Points. Shows the where important parts and design details are on the sleeve.

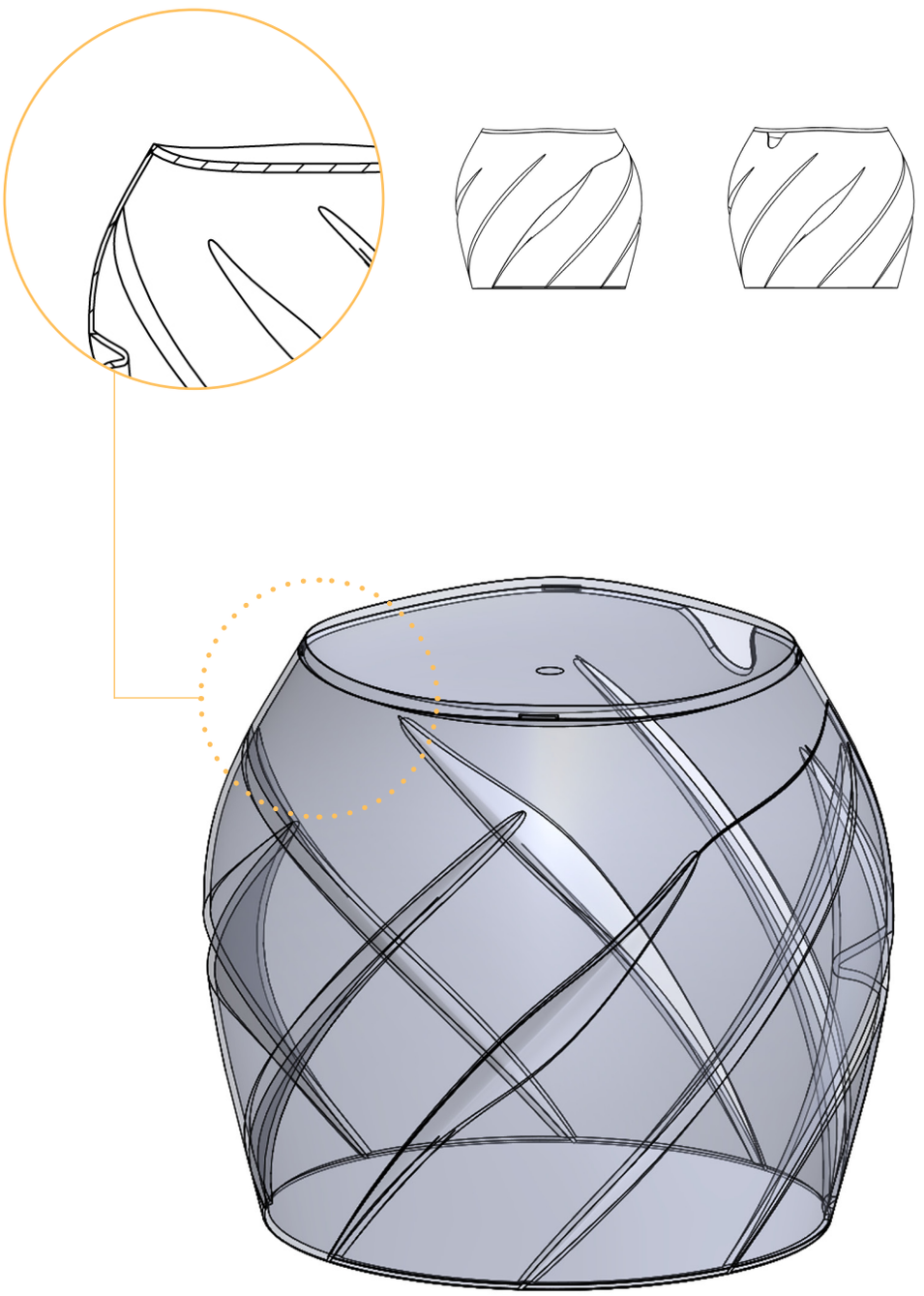


Figure 5.23. Sleeve Details. Transparent isometric, close-up section and front & back view show the overall structure, form and makeup of the sleeve.

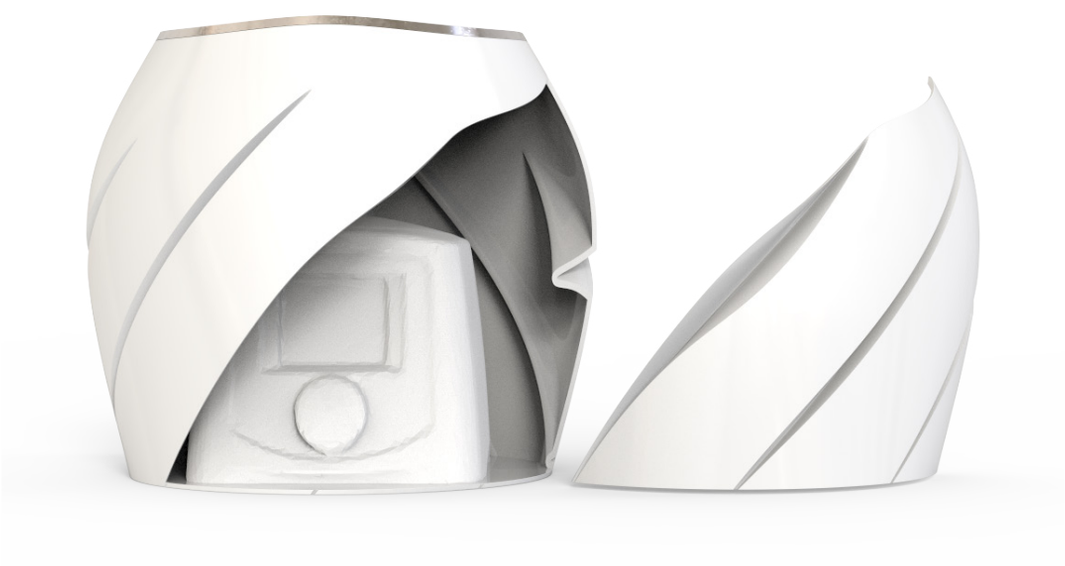


Figure 5.24. Sleeve Access Door. Front facing render shows the access door separated from the sleeve's body, revealing the CPAP inside.

Sandra's bedroom environment consists of what is considered feminine qualities, through the lightness of colour and materiality of objects within the space. This has lead to the final choice of material reflecting this femininity through use of white porcelain for the body and soft worn rose-silver lid. The refinement of the sleeve consists of width and height adjustments; to reduce the sleeves size as much as possible relative to the CPAP and bedroom environment. The number of surface cut channels was lowered to avoid over decoration, as the sleeve is going in an understated environment. Keeping the object simplistic and refined allows the sleeve to fit into the environment without being aesthetically distracting or disjointed from the space. 3D prints worked successfully. This Sleeve was printed in 6 parts on an UpBox FDM printer. It was then glued together before the prints were filled, sanded and then with paint. Figure 5.26 & 5.27. show the CPAP fitting into the Sleeve perfectly. There is also enough room to store the hose and mask in the top of the Sleeve when the CPAP is not being used. Figure 5.28. shows the Sleeve in Sandra's bedroom on the left side table.

Figure 5.25. Isometric Render. Shows the overall materiality of the designed sleeve. White porcelian body and soft worn rose-silver lid.

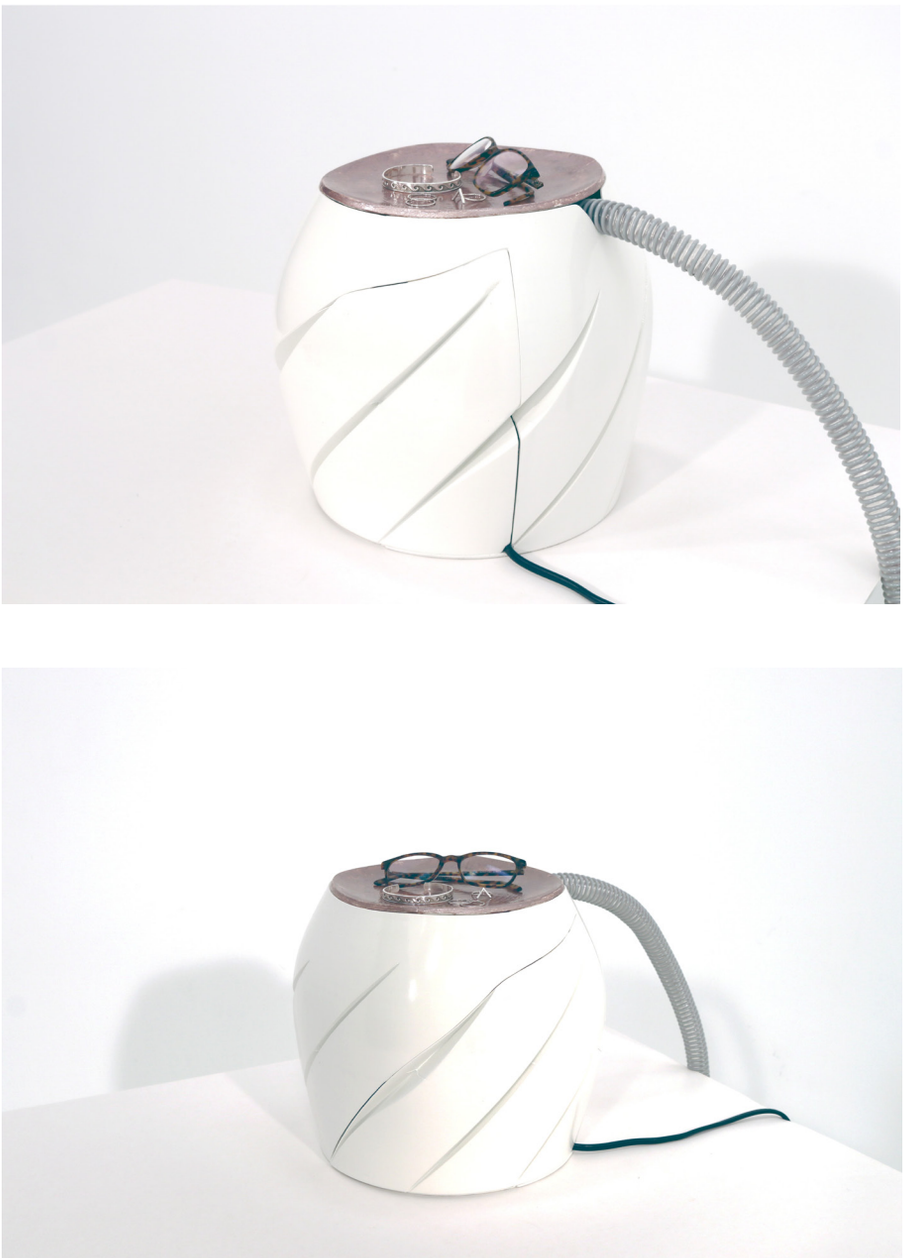


Figure 5.26. Sandra's 3D printed refinement Sleeve.

Figure 5.27. Sandra's 3D printed refinement Sleeve, with door taken off.

Figure 5.28. Refined Sleeve in context. Sandra's Bedroom

Barry

Figure 5.29. Photo of Barry's Bedroom.

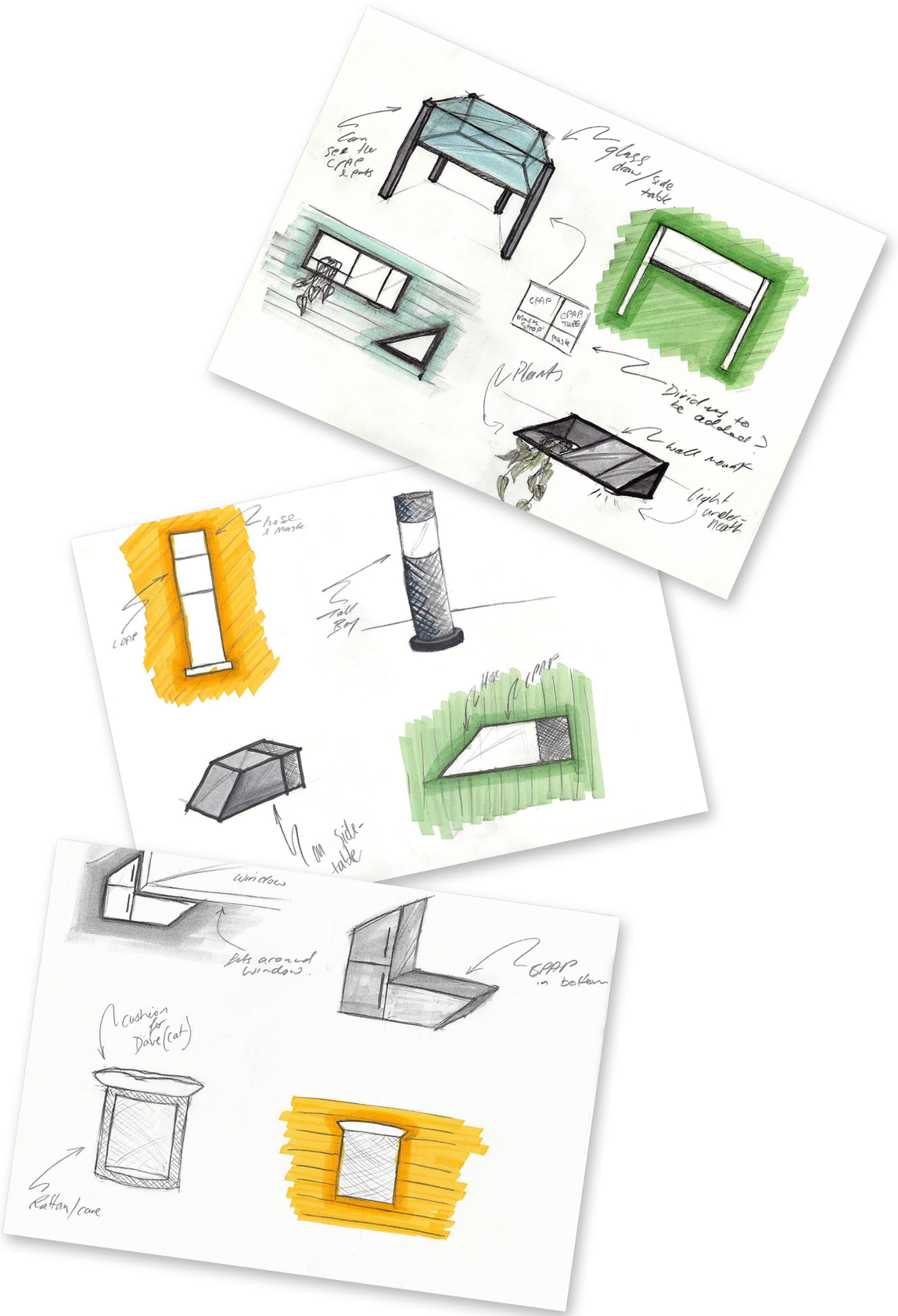


Figure 5.30. Sleeve Ideation Sketches. Barry.

Concepts

Figure 5.31. Wall Hanger. Clear glass with CPAP inside (left), ashphalt body & black hard rough plastic edge (centre), hammered chrome & black hard rough plastic edge (right).

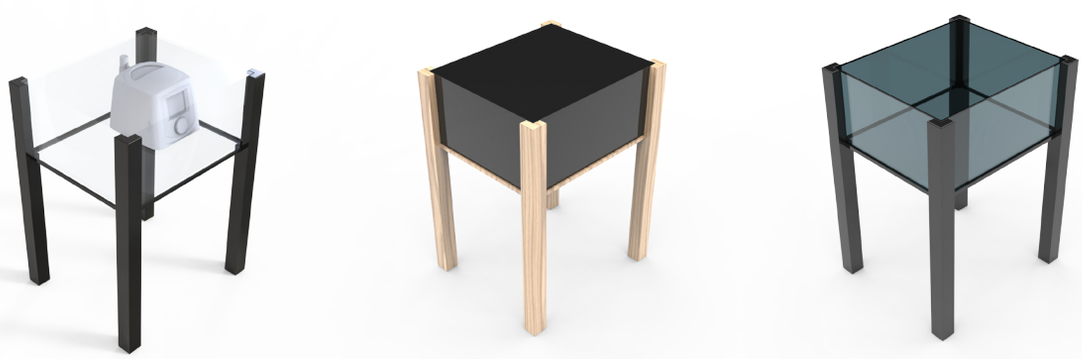


Figure 5.32. Square Sidetable. Clear glass with CPAP inside (left), balck hard shiny plastic body & oak frame (centre), dark turqouise dense glass & black hard shiny plastic edge (right).

Figure 5.33. Tall Boy. Clear glass with CPAP inside (left), black hard shiny plastic body & grey wicker section (centre), light oak body & grey hard shiny plastic section (right).

Figure 5.34. Round Sidetable. Clear glass with CPAP inside (left), mahogany legs, rubber surface body & black hard shiny plastic top (centre), chrome legs, frosted glass body, chrome top (right).

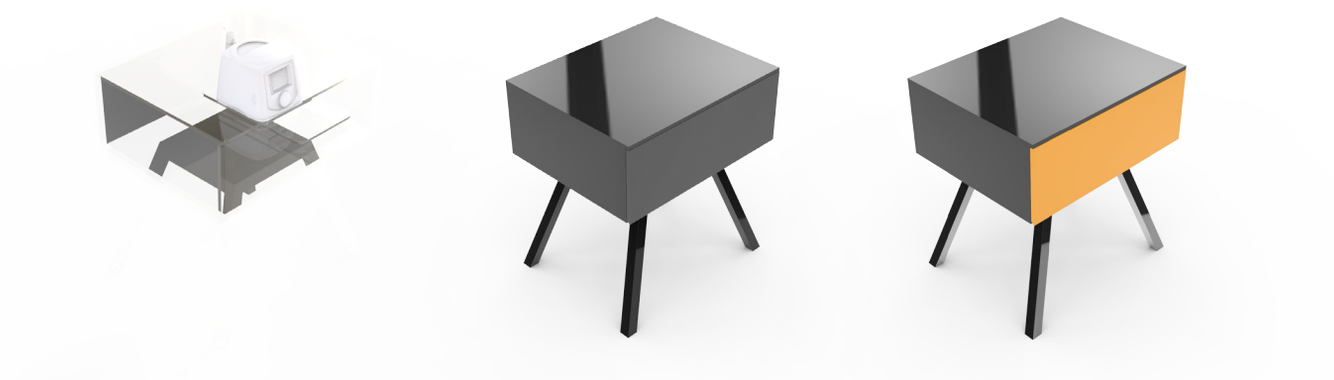


Figure 5.35. Mod Sidetable. Clear glass with CPAP inside (left), black hard shiny plastic legs, grey hard rough plastic drawer & black hard shiny plastic top (centre), black chrome legs, orange hard rough plastic drawer & black hard shiny plastic top (right).

Figure 5.36. Cylinder Sidetable. Clear glass with CPAP inside (left), dark grey fabric top, black hard shiny plastic body (centre), light grey fabric top, oak body (right).

Concepts were constructed around the intention to create a new item of furniture as Barry's house was unfinished and had space to do so (Fig 5.29.). The wall hanger sleeve (Fig 5.31.) has the intention of being attached to a wall and would hold a CPAP and accessories on the right; as well as housing a small indoor plant in the open left side cavity. Three differently shaped side tables, square, round and mod (Fig 5.32., 5.34. & 5.35.). These would act as the sleeve for the CPAP, mask and hose, as well as extra storage. The cylinder side table (Fig 5.36.) is augmented in a slightly quirkier way, with its top surface being a cushion for Barry's cat, Dave, to sleep on. The tall boy sleeve (Fig 5.33.) sleeve has the single intention of housing the CPAP device; however, this tall boy could also have an inbuilt audio speaker or extra storage.

Barry's developed sleeve builds on the side table concepts. The development was CAD modelled through a series of regular and angled extrusions and cuts. Figure 5.37. & 5.38. show the exploration of materials through a monochromatic colour palette, and hardwearing materials such as oak wood, steel and hard plastics.

Developement

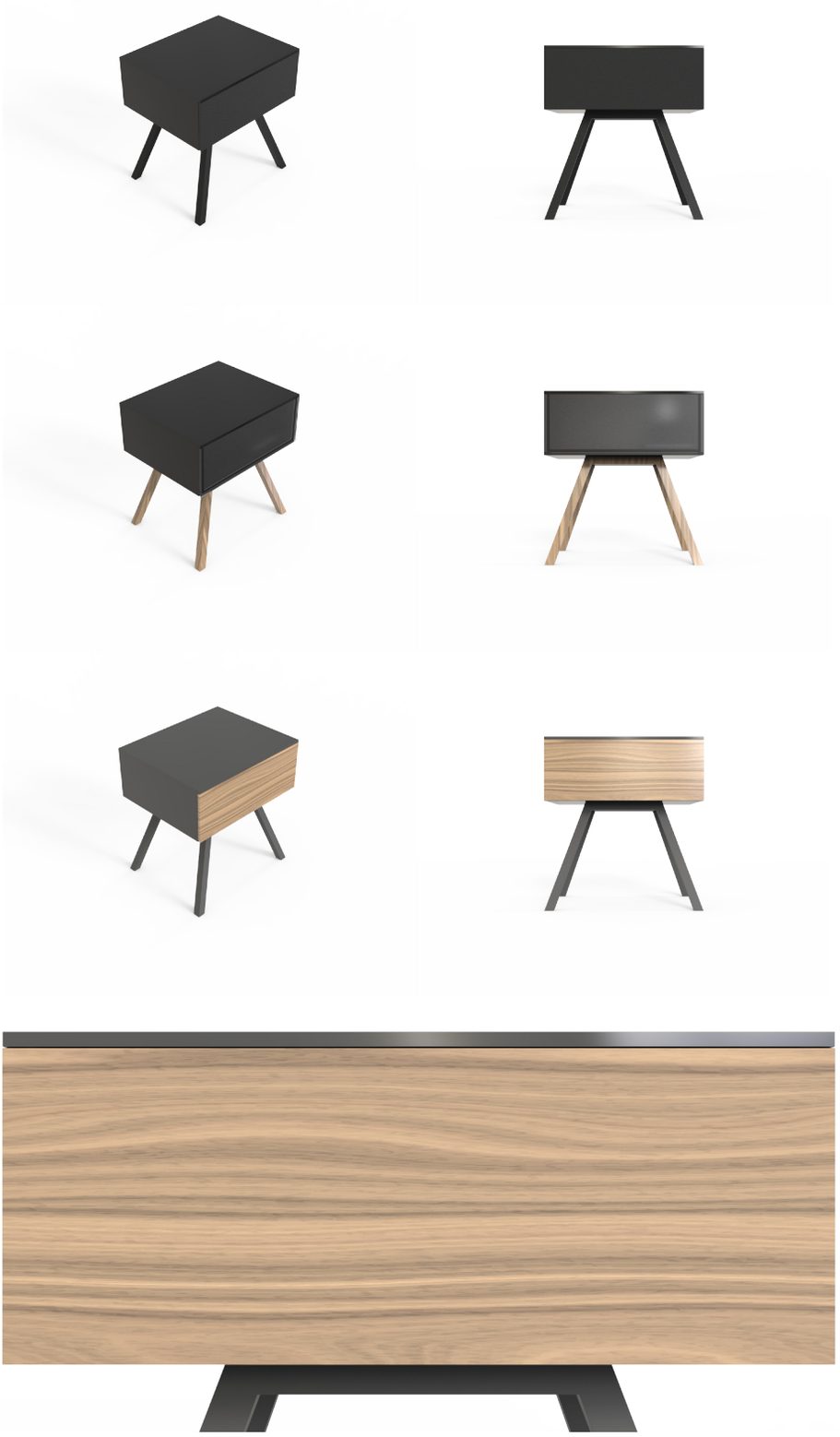


Figure 5.37. Development Sleeve Renders. Black hard shiny plastic body & legs, black hard rough plastic drawer (top), black hard shiny plastic body, oak legs, frosted glass drawer (centre), grey hard shiny plastic body & legs, oak drawer (centre & bottom).

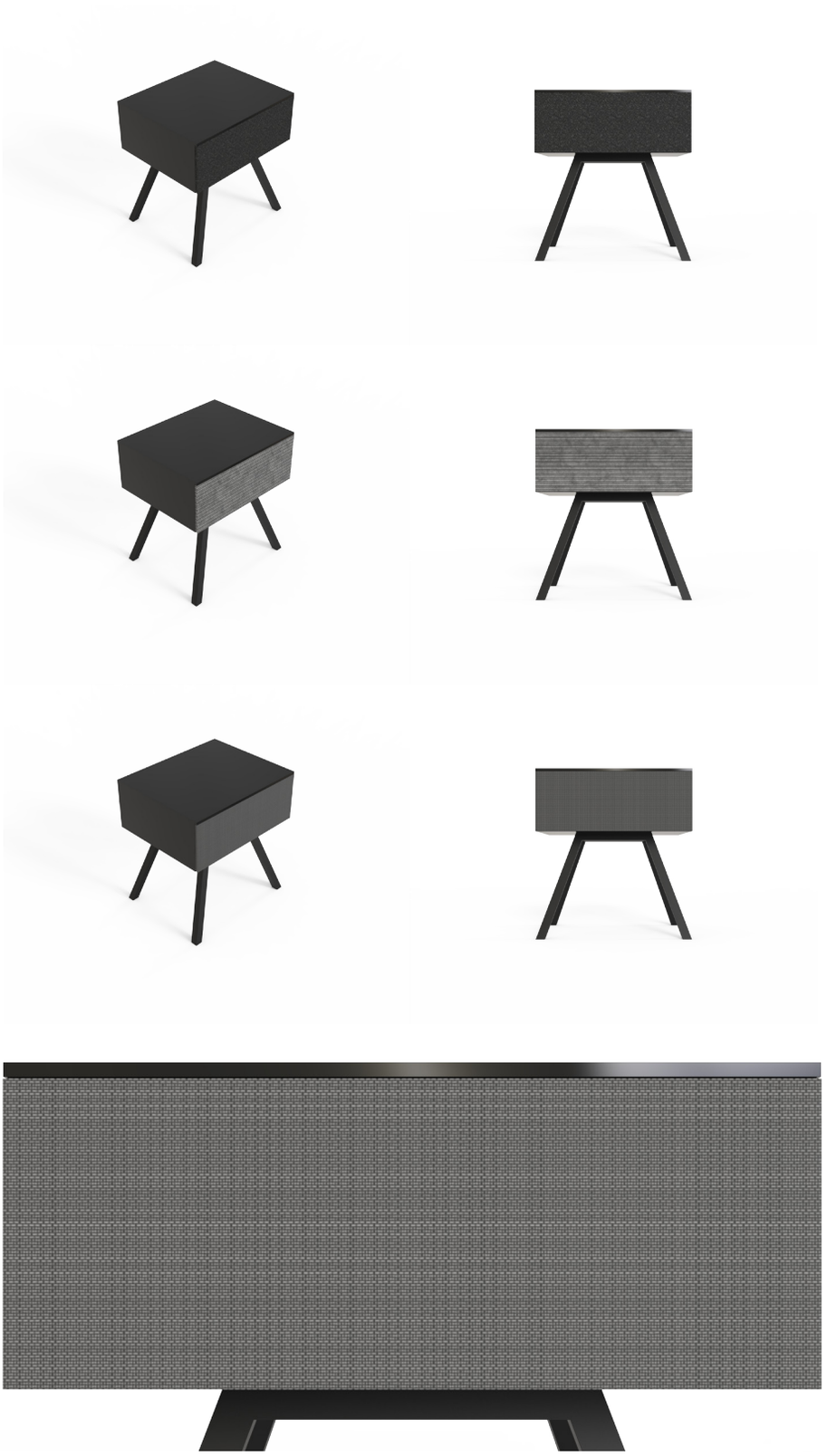


Figure 5.38. Development Sleeve Renders. Black hard shiny plastic body & legs, asphalt drawer (top), black hard shiny plastic body & legs, grey knit drawer (centre), black hard shiny plastic body & legs, grey fabric drawer (centre & bottom).

Refinement

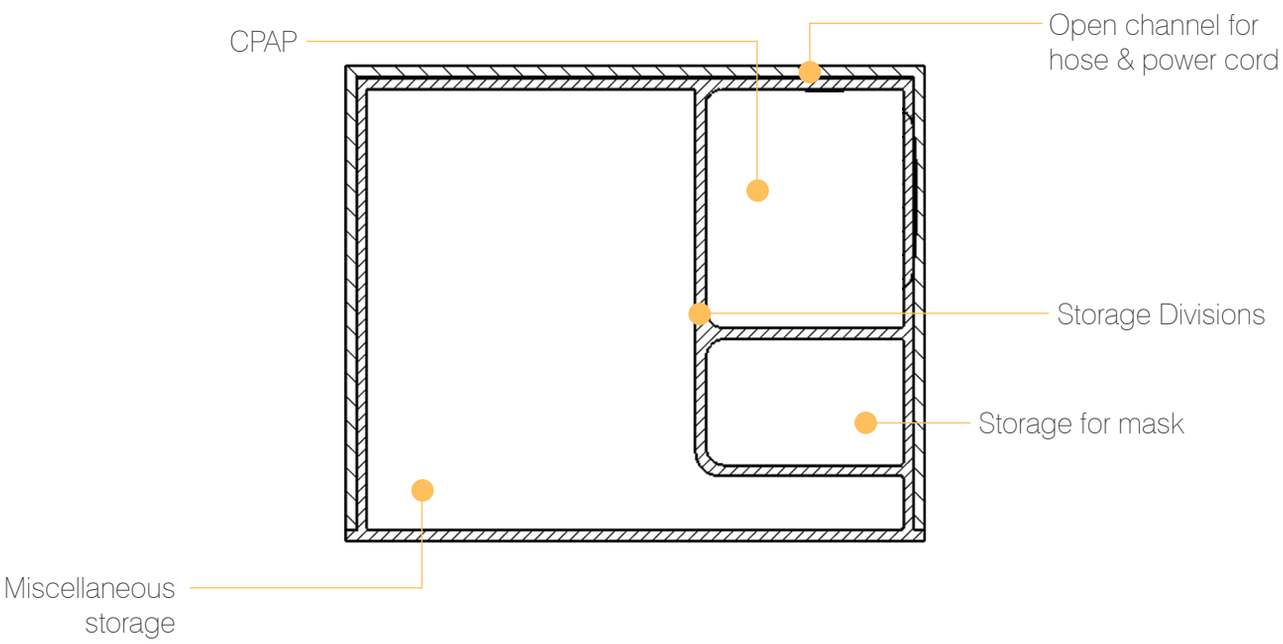


Figure 5.39. Barry's Sleeve Drawer Touch-Points. Shows the where important parts and design details are on the sleeve.

Figure 5.39. shows access points and essential design features of the sleeve. Extruded storage division lines are sized to the size of the CPAP, to ensure it does not move around when the drawer is being used/opened. The open space of the sleeve's drawer is added storage space for miscellaneous or personal items. A small opening channel in the back right corner of the drawer allows the power cord and hose to be fed through for use.

Measurements of the size are noted to give a sense of the size. The height depth of the drawer is slightly larger than usual to enable the CPAP to fit inside so that it does not catch against the sleeve when the drawer is being pulled out. The drawer detail (Fig 5.40.), shows the angle under the edge of the drawer, which allows the hand or fingers to be put underneath, where it can bed pulled open (Fig 5.41.). A pull/slide draw used in this design as it allows for easy access to all aspects of the CPAP for use. This Sleeve was prototyped using cardboard (Fig 5.43.) as it was too large to be 3D printed. However, this allowed the scale and proportion of the Sleeve to be shown with the CPAP sitting inside of it. Figure 5.44. shows the Sleeve in Barry's bedroom on the left side of the bed.

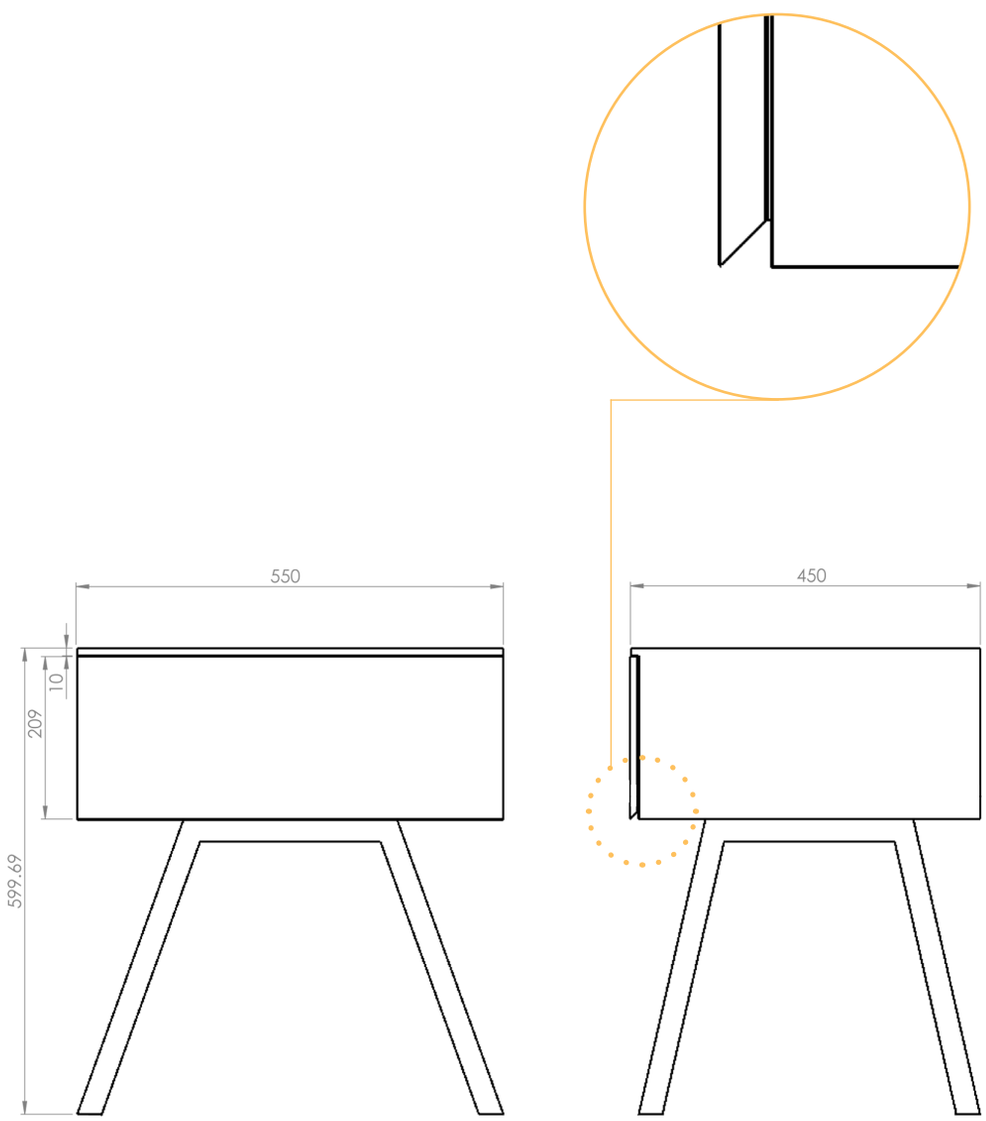


Figure 5.40. Barry's Sleeve Details. Front & side view showing the overall structure and size of the sleeve. Close-up section shows the drawer edge detail.

Figure 5.41. Barry's Sleeve Access Drawer. Isometric renders show the draw of the sleeve being pulled out to reveal the CPAP inside.

Figure 5.42. Barry's Sleeve Isometric Render. Shows the overall materiality of the designed sleeve. Black hard shiny plastic body, black powder coated legs and black hard rough plastic drawer.

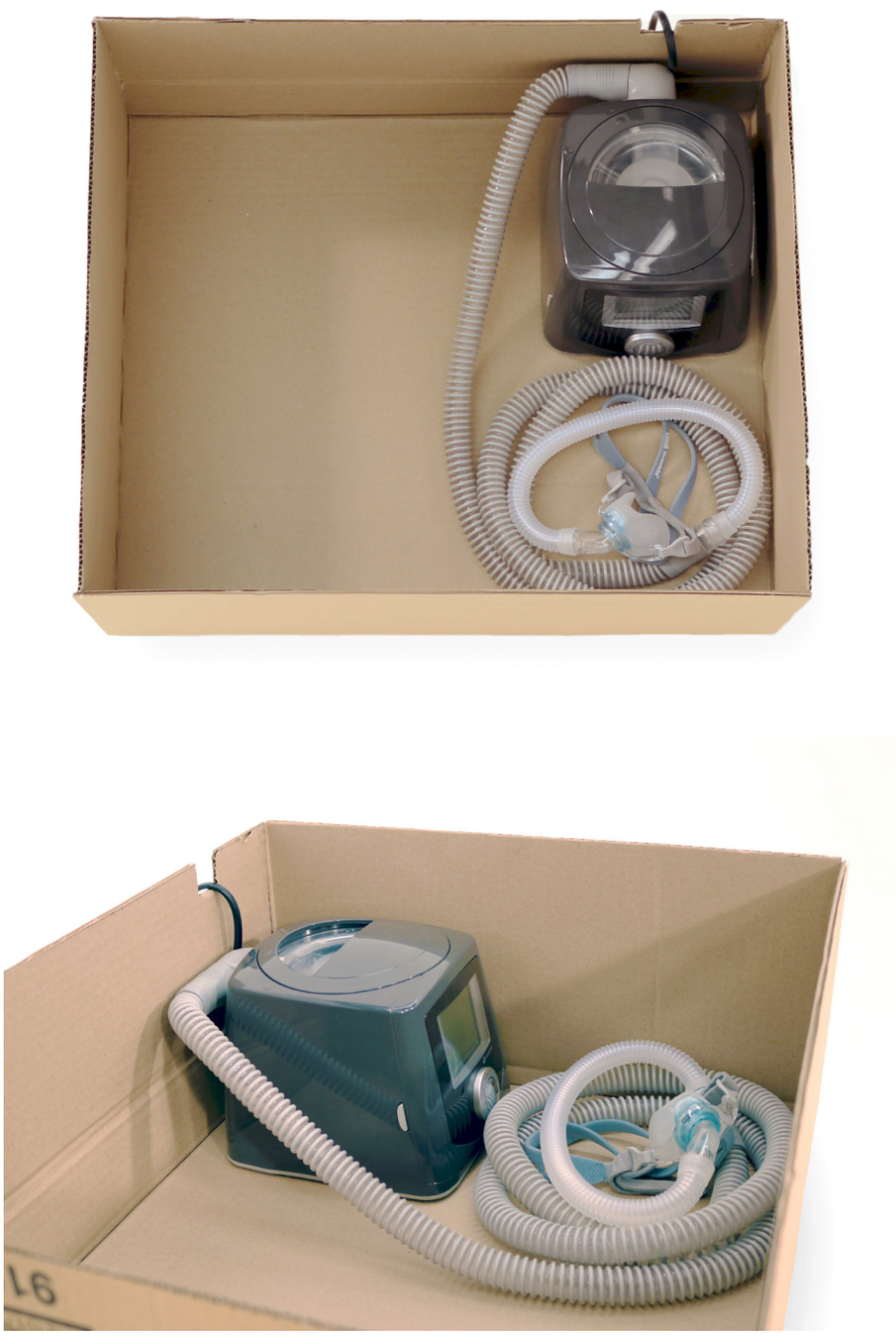


Figure 5.43. Barrys's refinement Sleeve, cardboard prototype.

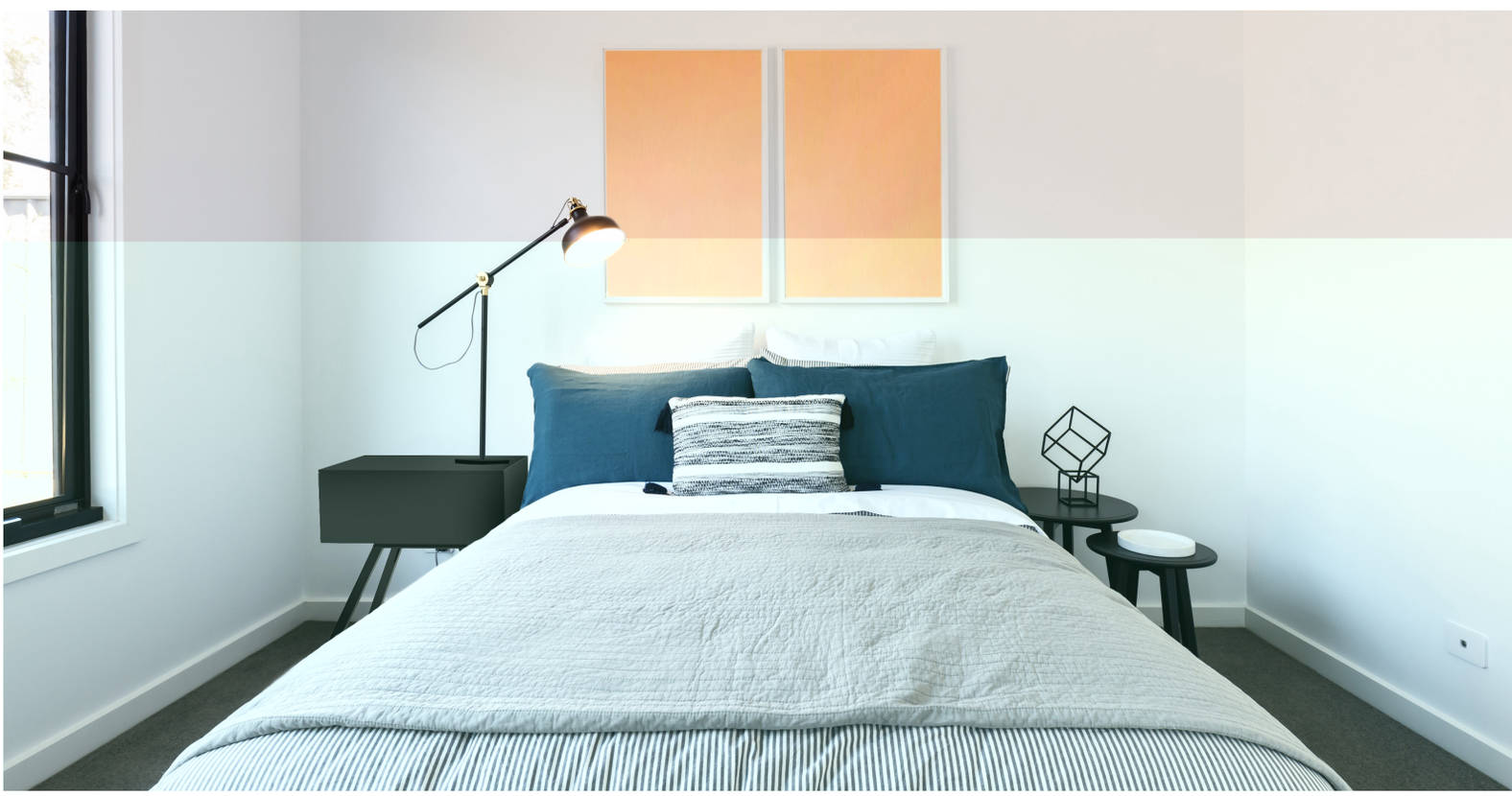


Figure 5.44. Refined Sleeve in context. Barry's Bedroom

Tom

Figure 5.45. Photo of Tom's Bedroom.

Figure 5.46. Sleeve Ideation Sketches.Tom.

Concepts

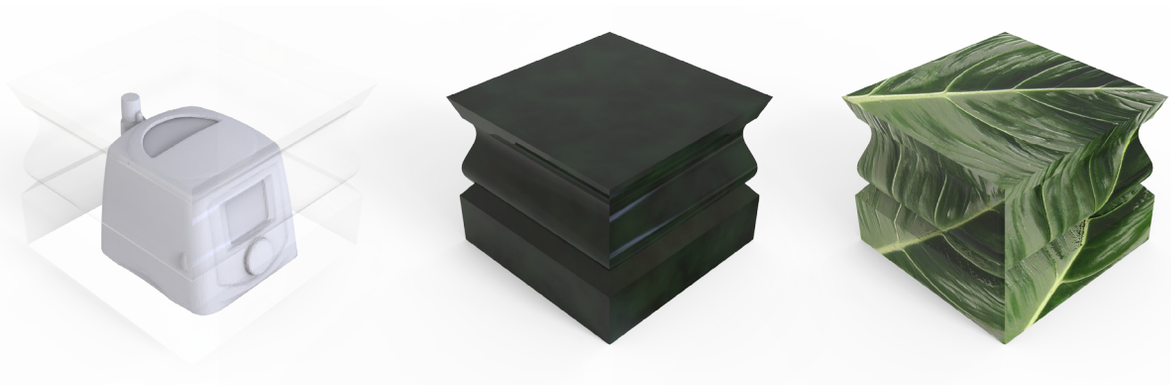


Figure 5.47. Architrave. Clear glass with CPAP inside (left), dark green granite (centre), leaf print on hard shiny plastic (right).

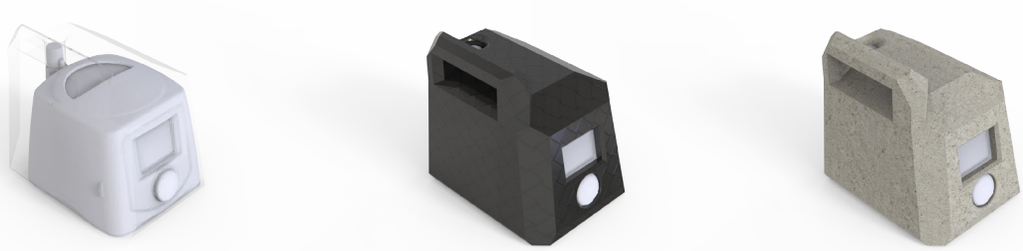


Figure 5.48. Chambered Brick. Clear glass with CPAP inside (left), carbon fiber (centre), concrete (right).

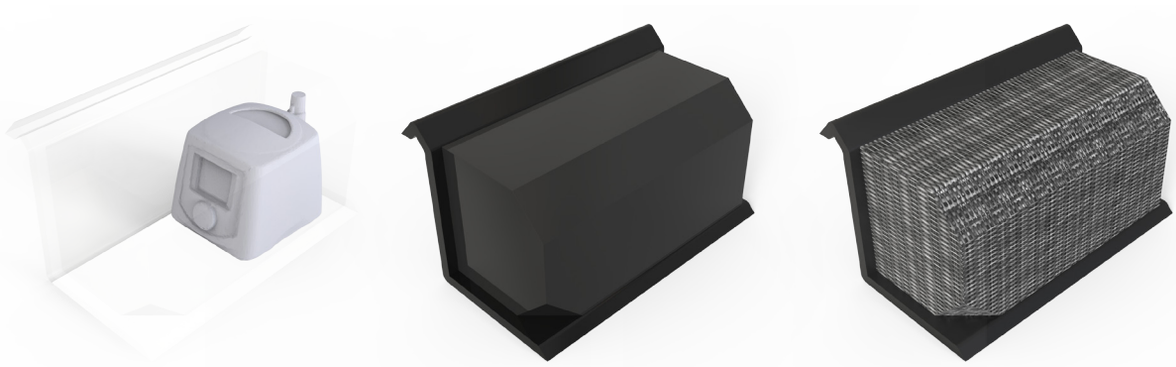


Figure 5.49. Rectangle Box. Clear glass with CPAP inside (left), black hard rough plastic frame, black hard shiny plastic body (centre), black hard rough plastic frame, grey wicker body (right).

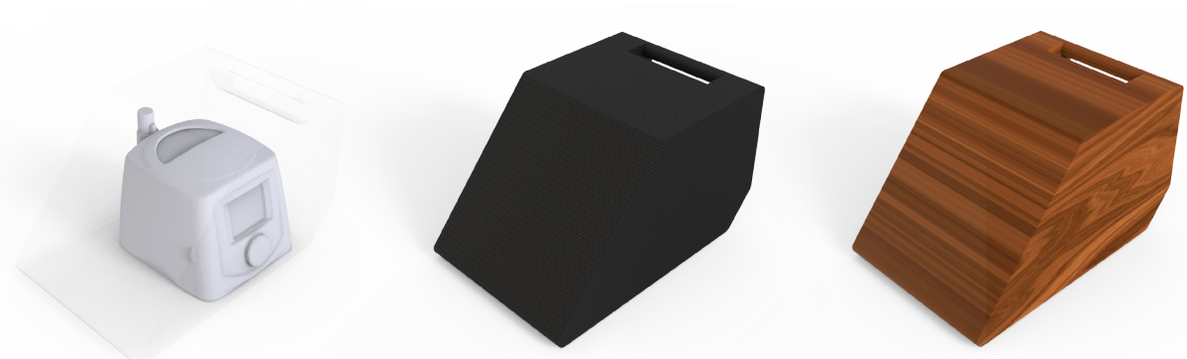


Figure 5.50. Angled Box. Clear glass with CPAP inside (left), black nylon fabric (centre), walnut wood (right).

Figure 5.51. Simple Skin Print. Print applied to the simple skin sleeve was extracted from Tom's Dairy. All are rendered in hard shiny plastic, black (left), white (centre), forest green(right).

Concepts were created with the intention and purpose to fit under the bed. The chambered brick, rectangle box and angled box sleeves (fig 5.48. - 5.50.) all have handles so that they can effortlessly be pulled out from under the bed and accessed for use. The chambered brick (fig 5.48.) is fitted to the front surface of the CPAP, where the menu screen and selection dial is accessible from the outside of the sleeve. The architrave sleeve (Fig 5.47.) focuses on creating separate storage for the CPAP and reflects the style of the bedroom through the form of an architrave. A simple skin (Fig 5.51) was also styled and personalised for Tom; though the use of the sketches that had been drawn by daughter Amelia in his diary (chapter 004 of this thesis).

Tom's developed sleeve builds on the under-bed concepts. Similarly to Barry, Tom's developed sleeved was CAD modelled through a series of regular extrusions and drafted angle cuts. Figure 5.52. & 5.53. show the exploration of materials through a range of hard and soft textiles, as well as the use of monochromes and natural woody browns.

Developement

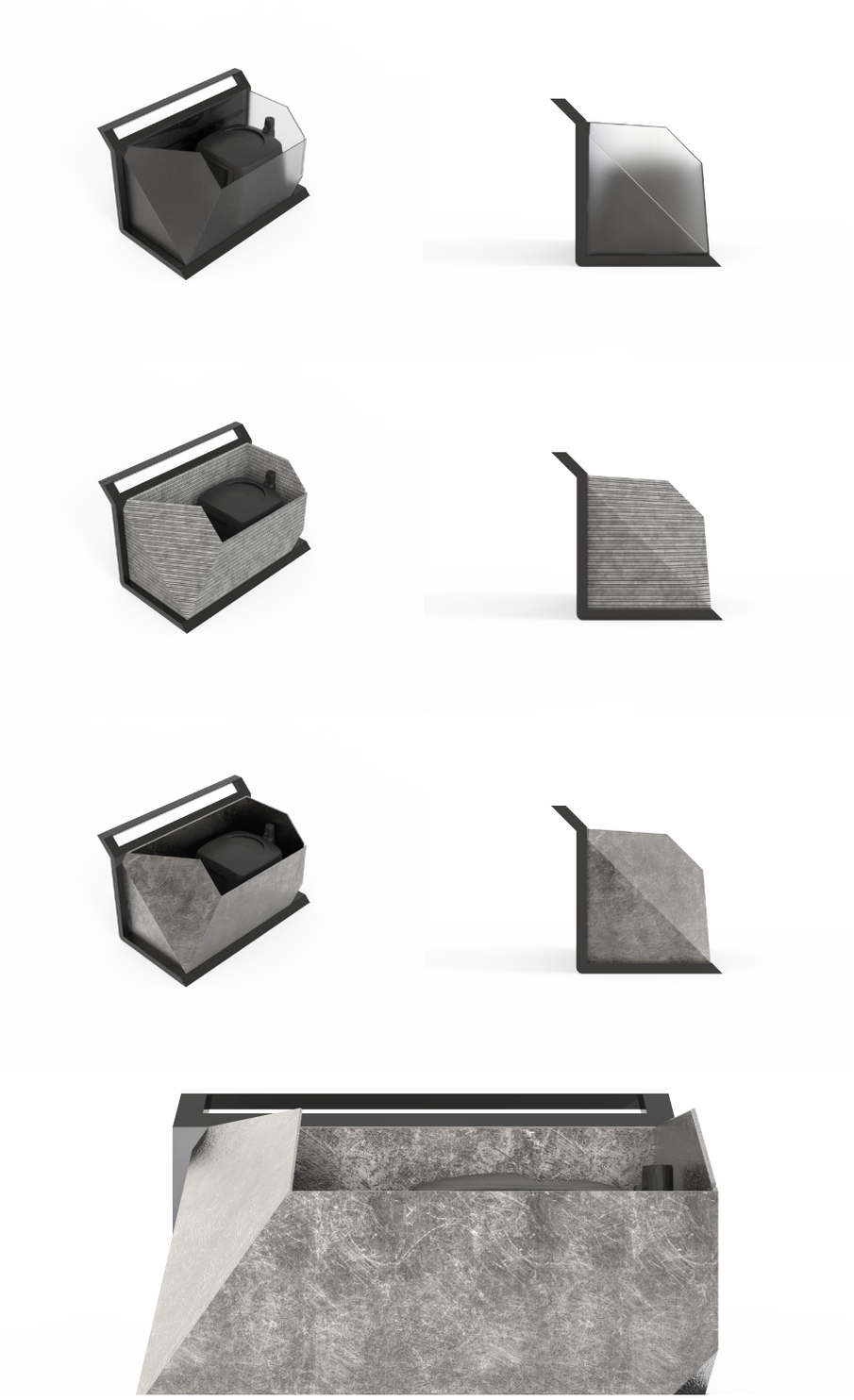


Figure 5.52. Development Sleeve Renders. All frames in black hard shiny plastic. Frosted glass (top), grey knit (centre), ultra scratched steel (centre & bottom).

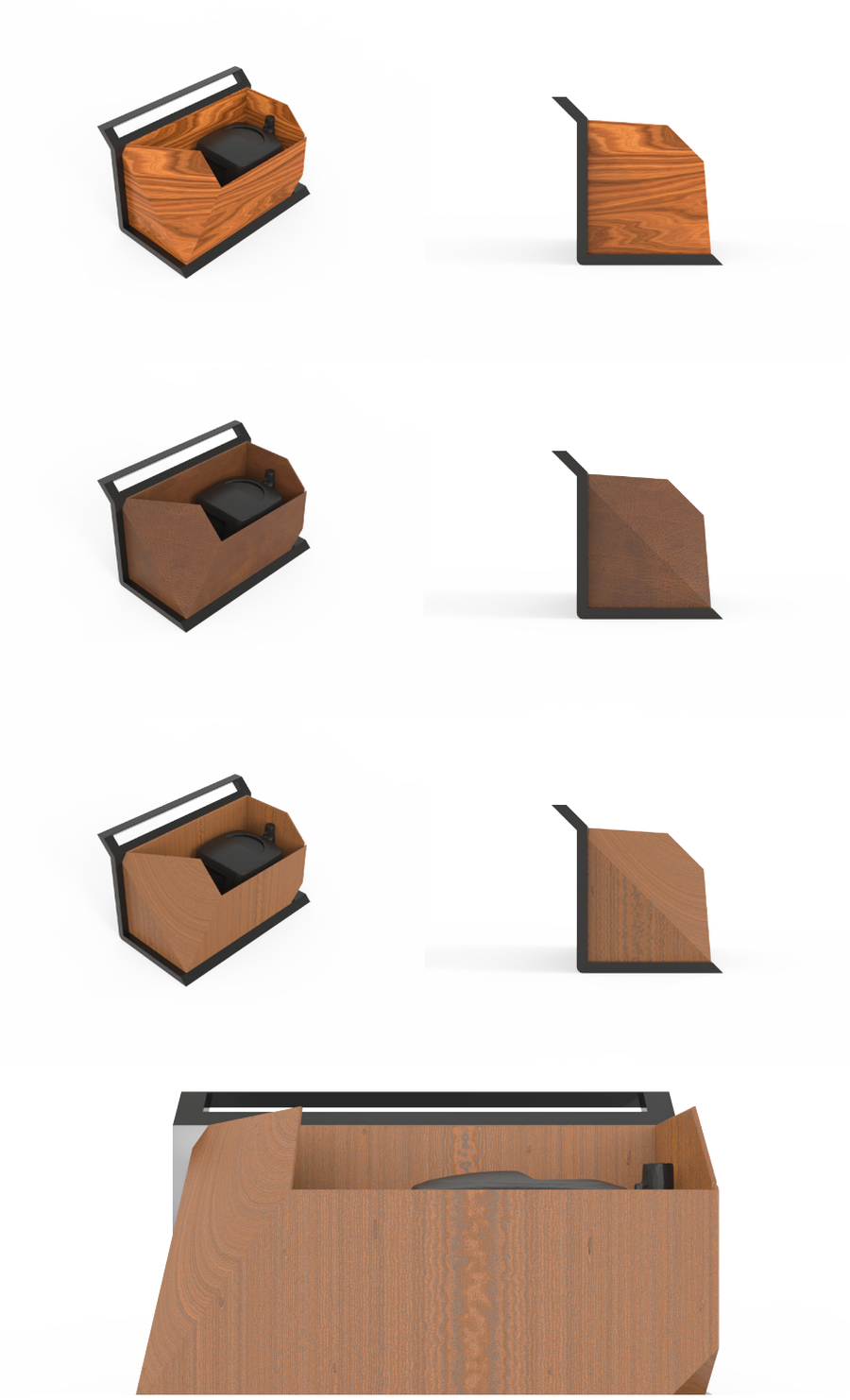


Figure 5.53. Development Sleeve Renders. All frames in black hard shiny plastic. Walnut wood (top), brown leather (centre), procedural wood (centre & bottom).

Refinement

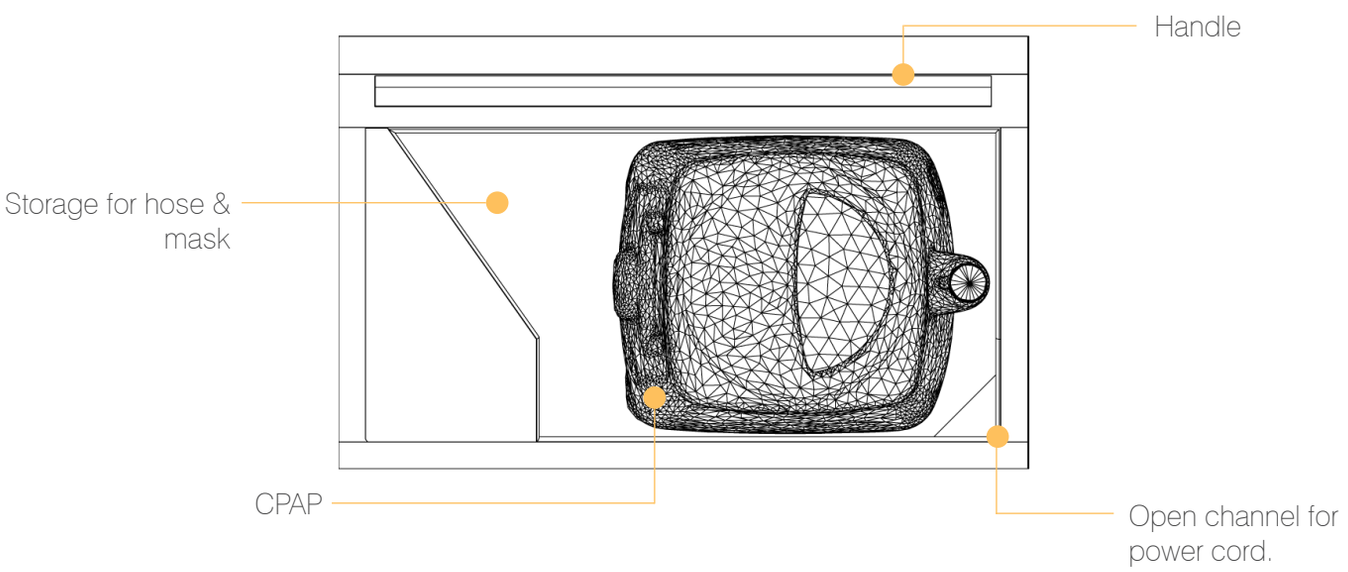


Figure 5.54. Tom's Sleeve Touch-Points. Shows the where important parts and design details are on the sleeve.

The diagram (Fig 5.54) shows access points and essential design features of the sleeve. The sleeve body is left open for quick, secure storage and access to the CPAP; however, the faceted body keeps loose stored items, such as mask and hose, contained. Figure 5.55. shows a close-up detail of the open channel for the power cord, allowing it to be fed through the guided cut for use. The CPAP is also seen in the front view of the sleeve, showing the form and size relationship between the CPAP and sleeve.

As soft fabrics and woods were prominent in the environment, leather was chosen as it provides colour with the reflects others in the space and adds further depth of textiles to the room through the harsher texture of the material (Fig 5.57.)The curved edge at the base of the black frame allows the sleeve to be easily tilted and pulled out from under the bed (Fig 5.56.). Tom's refined Sleeve was prototyped using cardboard (Fig 5.58.) as it was too large to be 3D printed. This allowed the scale and approximate fit of the CPAP to be seen physically when placed inside. Figure 5.59. shows the Sleeve in Tom's bedroom peeking out from under the bed on the left side.

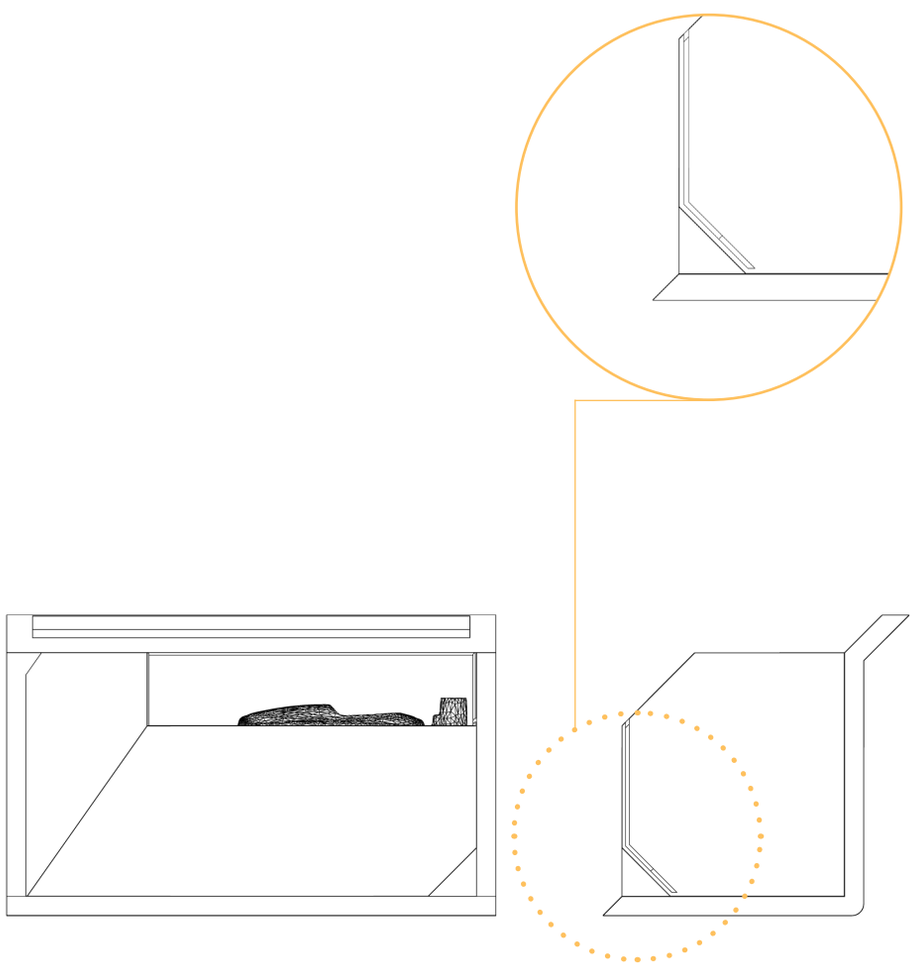


Figure 5.55. Tom's Sleeve Details. Front & side view showing the overall structure angles of the sleeve. Close-up section shows the cut out open channel for the power cord.

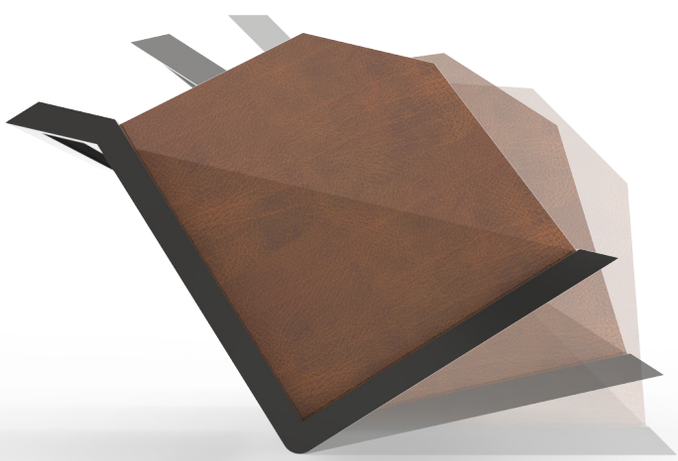


Figure 5.56. Tom's Sleeve Side Movement. Layered renders show how the sleeve tilts on its curved edge to pull out easily from under the bed.

Figure 5.57. Tom's Sleeve Isometric Render. Shows the overall materiality of the designed sleeve. Black hard shiny plastic frame and brown leather body.

Figure 5.58. Tom's refinement Sleeve, cardboard prototype.

Figure 5.59. Refined Sleeve in context. Barry's Bedroom

Reflection

In this chapter, it was found early on, through the rendering of the simple skins (Figure 5.4 - 5.6), that having a simple skin with a material change was not a big enough aesthetic change. Part of the problem is that the touch points were still visible (as they had to be accessible), and this made it difficult to change the form of the sleeve. The front face of the CPAP would have to match with a coinciding face of a sleeve, and this would force some of the visual qualities from the CPAP device to remain. Hence the sleeves took to storing, covering and hiding the device. This also enabled a broader range of potential design possibilities for the sleeves (Fig 5.60.).

Sandra's refined sleeve fit into her bedroom environment through utilisation of visually feminine qualities, through curved form and reflects the space through the use of light colours and precious metal/ceramic materiality. The sleeve is small enough to fit on a side table and has enough space inside of it to store her hose and mask on top of the CPAP. Although some of the side table surface space is taken up by the sleeve, the lid/bowl on top of the sleeve's body allows her to place other objects such as books, jewellery or keepsakes.

Barry's refined sleeve adds another piece of furniture to his unfinished space; adding more storage and enabling him to hide is CPAP away if wanted. The form of the sleeve is slightly contrasting in terms of the square space; however, this adds further depth of form and visual interest to the bedroom. Shiny/glossy black finishing of the sleeve reflect other furniture and colours within his environment.

Tom's refined sleeve utilises the space under his bed and keeps the device within reaching distance. The handle on the sleeve allows it to be pulled out from under his bed easily when access is needed. The open top also enables his hose and mask to be quickly chucked in or tidily packed away without visually impacting his bedroom. While the frame is hard shiny black plastic to match the other furniture in the room, brown leather is added to create further textural depth to the environment.

The sleeve concepts created show some of the overall variation possible, while development and refinement designs hone in on this through material and detail variation. These show the potential possibilities of aesthetic change which allow the sleeved CPAP to fit into their defined environments visually. 3D printed, and cardboard prototypes have shown the size of the proposed sleeves. It can be said that the volume that the sleeves add to the CPAP device is very noticeable. However, this slight disadvantage should be outweighed by the dramatic change in the visual aesthetics that this process can offer. The Criteria has been met through exploration of designs, renders, photographs and 3D printing.

Criteria

Design Process Phase 3

The designs must retain the CPAP's function.	Designs allow acess to the CPAP device.
Designs should change the current visual appearance of the CPAP.	This is shown through concept, development and refinement renders.
Designs should fit into the environment's aesthetic in which it is being placed.	This is shown in context photographs.
Design should be specific to each narrative.	Sleeve design are based on information gained from narratives.

Figure 5.60. CPAP & refined Sleeves. CPAP, Sandra, Tom, Barry.

Conclusion 006

Conclusion

The Suitable Machine proposed the question, Can 3D printing enable the personalisation of CPAP devices so that they can aesthetically fit in specified home/bedroom environments? This has been investigated through background research, which showed the gap in information regarding current applications of large-scale 3D printing and the future applications of Mass Customisation. Research into democratisation allowed a broad view of personalisation showing the design field's subscription to democratisation. While research into healthcare at home showed that there is no relationship between the appearance of medical devices being used in the home environment and the aesthetic style of the home environment. Thus the background research made it clear that the function of the device needed to remain intact, as the CPAP device technology provides required therapy for a chronic disease. Ensuring the designs did not change the CPAP technology's function while granting patients the ability to personalise their devices, to the style bedroom environments, led to the resolution that a cover could allow the augmentation of the CPAP's aesthetic. The conceptualised Sleeving process created allowed a digitally accurate and fitted cover to be created and materialised; the Sleeve enabling aesthetic changes to the CPAP while keeping the device's function intact.

The sleeving process was tested through the aesthetic exploration of a generic object, a glasses case. This produced a number of renders and CAD models that accomplished the production of digitally defined and physically fitted Sleeve. This proved that digital accuracy and aesthetic change was possible through the Sleeving process allowing it to be applied to a CPAP device. Narratives were then developed and used as a method of storytelling, producing information that informed the Sleeve designs and enabled variable idea generation. Initial render explorations of 'simple skin' Sleeves revealed that aesthetics were only able to be changed through material variation, as they still kept the approximate form of the CPAP due to it being a fitted cover. Concepts and developments were then designed to house the CPAP device, rather than tightly fit, to allow the full customisation of the Sleeve. The resulting concepts and developments focused on the exploration of aesthetic qualities, to show the potential possibilities of the Sleeving process. 3D printed and cardboard prototypes of the refined sleeves showed the volume that would be added to the CPAP device. This physical exploration made it clear that the volume increase was also important to dramatically change the CPAP's aesthetic.

As this thesis promotes aesthetic possibilities that can be created through digital data, defined styles and 3D printing, further research is required to test the function of the CPAP device with an added Sleeve. Additionally, research should be carried out into the Sleeving processes the real-world application, to investigate how patients or users would create their designs. For this real-world application, it is suggested that a program/website is produced, where the patient could upload an image of their designated environment. The creation of a programmed algorithm could identify aesthetics and styles from images and use these to create the Sleeve designs. Thereafter the patient could make any additional adjustments to the generated sleeve if required; enabling them to have control over what value they are creating, while keeping the aesthetic style of the sleeve specific to their environment.

This research established the ability to change the aesthetics of a CPAP device through a Sleeve, enabling the personalisation and visual fit of the device to a bedroom environment. It also provides a basis on which further research and designs could be developed, a continuation of Sleeving for CPAP devices; or the Sleeving processes application to other medical devices or generic products. This thesis concludes by questioning future products and the growth of 3D printing as a viable manufacturing method for personalisation that is driven not by the designer, rather the consumer in collaboration with digital algorithms.

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List of Figures

All other images were produced by the author.

Appendix

A. Design Audit Tables

Bedroom

Bedroom — environment.

	Comments/notes
Shape/form /style	Soft edges contrasted with sharp corners and chamfered edged hard wood furniture.
Materialities	linens, wool, cotton, faux fur, wood, glass, ceramics, chrome knitted blankets, threaded fabrics, rugs, thick blankets
Size/weight	large room, quite open. ~~none~~ clutter free. — adding additional objects throughout can be cluttered.
Sounds	still → proper movement, ~~soft~~ rustle of fabric. whispers, sliding drawer — no consistent humming.
Touchpoints	Side table, bed, door, lamp.
Interface	phone. call.
Colour and light	Soft, bulky greys & whites - nothing to harsh. 60w ~~lamp~~ lamp soft enough for night reading.

Overall visual quality	simple, relaxing, easy to look at, not excessive.
Movement/disassembly (cleaning/replacement/movements of parts)	
Accessibility	Large room doors for optimal movement. and ~~easy~~ easy use.
Storage	wardrobe, side table drawer, top & base shelves. ~~Flat~~

CPAP

ICON Auto plus - Sensawake CPAP

	Comments/notes
Shape/form	Box, no completely flat surfaces apart from base. - slightly bulged on all sides to appear softer. - lip/draft angle at bottom front? filleted edges a above.
Materialities	plastic everything, selection button however does have soft metal & polished metal finished - drawing attention to it. Clear perspex for the front screen, & clear plastic for water chamber so patient can see inside.
Size/weight	water chamber - 420 ml. 2.2 kg. (160 x 170 x 220 mm)
Sounds	29 DBA Bed partner can hear humming of machine (but can sleep through this). Problem occurs when partner is close to the user as mask sound is not as soft. - Attach sound polution chart/diagram.
Touchpoints (buttons, handles, opening)	- turn identification dots on top of the cpap seem unessesary & are ugley. - water container pulls out easily. - buttons are rather small, this may be a problem for people without good grip. - good spring resistance of button, however no solid click. - attach diagram
Interface (screen data; USB - doctor only)	- A few different settings that are accessible, currently have to refer to booklet to work out what each is. flickering/blink of presure number when turning outer wheel & beeps lightly → create a sound digitally instead. Being adjusted is difficult to look at, Brightness can be adjusted; the blue color is a little harsh
Colour and light	

→ typeface is clear & easy to read, however some icons that appear are hard to see. Dots for each setting are small & there is no way to differentiate them until they have been selected.

Could this be change to yellow night setting hue?

very medically

Overall visual quality	looks clean, however not super slick or modern, would compare it to a box shaped vacuum cleaner (less noise). Does not really fit into a peticular style group & is very deroid of character
Movement/disassembly (cleaning/replacement/movements of parts)	There are a lot of parts, figuring out which ones have to be cleaned requires referall to instruction book; these instructions are slightly tricky to understand due to letter to part indicators - diagrams for this are on another page that has to be flicked back to.
Accessibility	filling water container may also be difficult depending on tap; due to support structure at top of container.
Storage	- I have storged on side table as I do not have room under my bed. However my side table already has a light, note book & jewlery bowl on it & CPAP takes up 1/4 of this surface space

May be tricky for some people to open due to the size of the top grip/handle.

Side note - mask instruction booklet in different languages is alot. reduce this problem by printing separate booklets.? cost will increase, however patients wont be as freaked out.

→ CPAP tube is difficult to manouver in the dark & gets caught on bedding & objects on side table.

B. iPhone Cover Case Study

Findings

Planned obsolescence plays a large part in creating an environment in which the desires and wants consumers lead them to see the value in these luxuries; perception of ownership and value can affect this tendency to purchase. The research suggests that people cover their phones for many reasons, device protection, added value, the context of the device and the extension personal of style. These personalisations can have cognitive, social, and emotional effects on the user as this type of personalisation can be used to improve aesthetic, distinguish oneself, create ease of use or create a feeling of control or ownership. This case study shows the sheer number of iPhone covers available; it is a saturated market with hundreds and thousands of options that allow consumers to personalise their iPhones. There are also many different ways of personalising devices; this could be through picking the colour or material of the cover, adding personal imagery or purchasing a case with an artists work printed on it. The cost of these is also mostly variable with some costing under a dollar, and others with unbelievable price tags of up to six thousand US dollars.