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Master's Thesis
Academic Year 2021

Byuuro: A Smart Surface for Remote Workers Employing Vibrothermal Stimulation and Affective Materiality

Keio University
Graduate School of Media Design

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A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

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Abstract of Master's Thesis of Academic Year 2021

Byuuro: A Smart Surface for Remote Workers Employing Vibrothermal Stimulation and Affective Materiality

Category: Design

Summary

Nowadays, our lives are inseparable from technology. While it has enabled convenience, many industries have also been on a decline as a result. In early stages of this thesis, I paid particular focus to the traditional craft industry. While innovation techniques incorporating new manufacturing methods and combination with interactive technology have been employed to innovate the industry, a problem at large of physical product consumption being taken over by digital and tech products persists. The thesis considers the intangible values traditional objects possess, with its deep consideration to natural, and ergonomically-positive object interaction and material, and how it can be insightful to how technology can develop to be more natural to humans.

Design research methodologies were employed in several stages exploring tactile qualities of material, studies looking at user latent needs. Preliminary observational studies performed on work behaviors and fidget habits have pointed towards our decrease in touch points with objects that give pleasure and positive mental stimulation. The devices we are adapting to have yet to be natural for our prolonged use; with negative effects on our health such as compressed nerves from prolonged postures, eye strain and more. This issue only intensified with our life changes in COVID-19 as the continual use of devices have become the dominant way to fulfill social needs besides mandatory work needs.

HCI research in the last two decades has identified these issues and researched ways of making GUIs more natural with topics vibrotactile haptics, tangible interfaces, skin-based haptics, multi-modal interactions, affective sensing and wearable technology emerging. While many of these studies look at the effectiveness of task

performance, they do not highlight as much the mental stimulus and ergonomic effects of tactile variety. Compiling findings from psychology, neuroscience, psychotherapy, commercial product, and human computer interaction literature as background, the thesis seeks whether tactile variety achieved through the incorporation of augmenting our desk top surface can improve the telework experience of remote workers

To better understand the type of work users' perform and pain points of remote work, a participatory workshop was conducted exploring vibrotactile cues in combination with added somatosensory textures. A final concept of Byuuro was developed incorporating all findings looking at the effects of vibrothermal stimulating and calming effects' impact on remote worker's work-from-home experience,

Keywords:

remote work, technostress, affective technology, vibrotactile technology, thermal-haptics, soma design, tactual interaction, affective materiality, mental wellness

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Now I look back, there has been a lot more to this journey than this output. I learned about methods of conducting research from amazing professors and participated on projects in three countries, from service design, industrial design, traditional crafts, venture projects, and more. I have met so many talented individuals, who are professors, classmates, and friends whose perspectives have enriched me as a learner, designer and individual. Friends from 2018 Fall batch, who harbor so much warmth, your virtues, your dedicated attitudes and positive attitudes have made me grow, and made me aim for the better. I will always treasure the precious times we had and how learning together made me grow and understand my strengths.

The last part of this journey has been a crazy one and I am incredibly thankful to my friends who have given me hope and support throughout the lonely time. Michi, thank you for always being a pillar of strength and a role model guiding me. To my family, thank you for always silently supporting me and watching over me, wherever I go. I am thankful to my friends Dianne, Haru, Qing, Alicia, Lilly, Shirley for always supporting me and giving me words of encouragement. I have also enjoyed the wonderful company of Iris, Rui, Lang, George, my Media Studio friends and GID mates on so many steps of the way. Last but not least, to those who have advised me, including my participants, members of the July Project, and the Vancouver Hackspace mates, your attitudes have inspired me in this research and during the hardest times, propelled my way.

Chapter 1
Introduction

1.1. A Working-from-home Economy

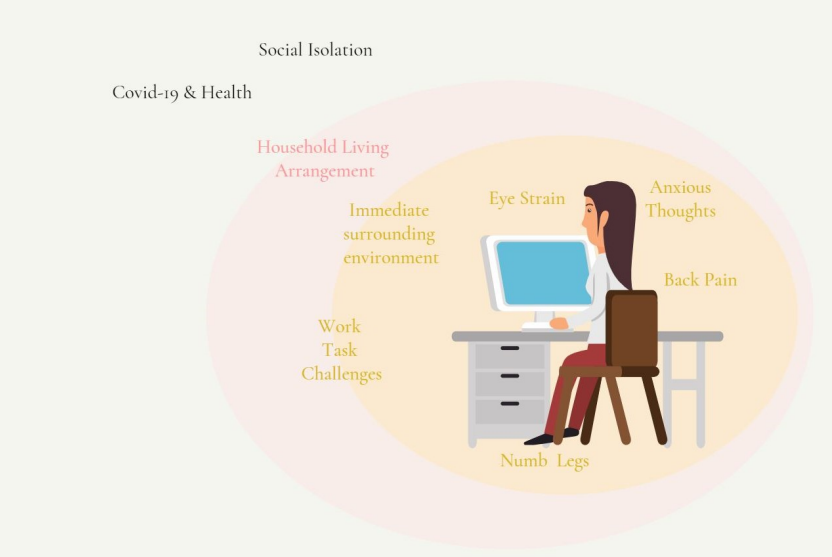

Figure 1.1 A case of remote working (Source: Self)

In the last year and a half, our life has changed drastically. In the ongoing pandemic, for many people, lives have become synonymous with activities we perform within the square feet of our homes. With the onset of the Covid-19 pandemic, as a means to reduce the spread of the air-borne pathogen, governments and healthcare experts around the world call for changing lifestyles in response to the Covid-19 pandemic. [1] The development resulted many industries directing their workers to virtual work-from-home. While some aspects of previous in-office work by and by migrated productively with remote communication and touch-less

technologies, for the individual worker, the adjustment meant an absence of touch and physical contact that highlights their critical importance in human life from school to hospital to care facilities. [2]

Looking around our desk and the computer screen you view this thesis from, like the illustration in Figure 1.1, a home-office for full-time remote workers can be lonely, especially for people who live alone. We no longer have those natural exchanges of ideas during breaks, quick questions thrown at the cubicle over to troubleshoot a hiccup, the hums of Mike behind you to accompany your arduous tasks. Reports indicate just as much, with significant numbers of worker reporting dissatisfaction with mandatory remote work and major issues including isolation, lack of engagement and suffering of connections. Academics are also concerned of the impacts of remote working for existing experiences of **technostress**, which involves stress users encounter with **application multitasking, constant connectivity, and information overload** with the increase demand of **information and communication technologies (ICT)**. [3] Our drastic shift to performing extended hours of work using digital tools has only been around since around twenty years ago. A reduction of visual information may be one answer. Statistic taken from 2020's case of the U.S. labor force indicated as high as 42 percent of workers conducted full-time work-from-home, 26 percent of the statistic are workers in essential services, and 33 percent were not working. [4] This is a significant portion of the population conducting telework and economists forecast this working-from-home trend to continue post-pandemic. [4]

The experience of work-from-home seems not to be the same for everyone. Reports indicate many factors affect the experience and whether their home-office feels like a bleak cage without any engagement, or a peaceful sanctuary away from office drama. [5] An understanding of what types of workers suffer this reduction of engagement, what kinds of interventions are useful, and under what circumstances individuals can benefit from perhaps a stimulation of their senses is explored. For the isolated remote worker, can surrounding objects, surfaces, and environment create sensations that make them feel engaged? With isolation and decrease in engagement being a large part of life in the "new normal", perhaps our workstations can be augmented to supplement the lack of surrounding stimuli in our at-home work environments. For this, the researcher studies technology capable

of such affective effects, and pleasant non-audiovisual stimuli that can supplement our home computer-work positively.

1.2. The Role of Objects Today

Objects are one of the things that surround us. With work-from-home, what become of the objects surrounding us? How has the development of technology shaped the role of objects around us? What must become of these objects surrounding us? what are the reasons for which we choose to keep certain objects? What are things we touch - things we fidget with, desk objects, food-related items for the typical user. The number of objects we are touching have reduced significantly in modern times. Many interactions we would have physically in person, and interactions with objects have become digitized and the few things we touch everyday become limited to food preparation. This has been ongoing since the 1970s, when digitalisation started to be more widely adopted. [6]

Figure 1.2 Techno Stress (Source: https://online.king.edu/news/technostress/)

Along with industry digitization, scholars have noted the lack of research on wellness with the adaption to the increase use of ICTs. [7] This change is relatively recent, only in the last 30 years have digital devices pervaded the lives of the regular consumer. With this, we may also be subjected to **technostress**, expressed to be stress experienced by end users in organizations as a result of their use of ICTs. The onset of technostress can be attributed to the increase in

information intake. [7] A notable concern on the impact of remote-working on top of technostress experienced by the large populations of workers adapitng to ICTs have been raised by Molino et al. [8] As we develop machines even further, we may need to consider more the importance of *Calming technology*, where technology adapts to user's needs and limit the user attention it takes up to the periphery. [9]

Considering the case of the remote worker, further consider one who lives alone, in a work day with only surrounding objects. Figures on the U.S. labor force in the last year has seen a shift to a work-from-home economy with 46 percent of the workforce engaged in remote work. [4] How can we perhaps improve technology further to tackle technostress and the negative experiences of remote work?

1.3. The Case of Traditional Crafts

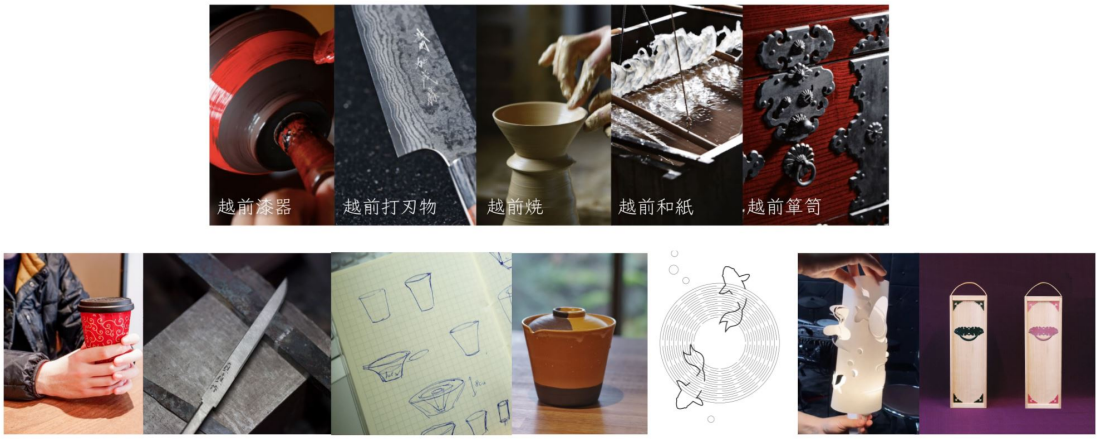

Figure 1.3 *top row:* 5 Crafts of the Echizen Region Echizen Japan *bottow row:* New campaigns and products developed with craftsmen in 5 crowdfunding projects, 2019 (Source: Self)

An original motivation of this research is rooted in the project findings and personal design explorations the author gained as a part of the Echizen Traditional Crafts Future Project.[1] The project was a crowdfunding venture of products developed with the use of new technologies, targeted-marketing techniques,

1 http://echizenjapan.com/

and brand new story-telling campaigns as a way to improve sales and open new business streams for Fukui Prefecture's traditional craft industry. The project found it was difficult for even novel crafts to rely on crowdfunding to improve sales, and marketing still weighted heavily, similar to any other consumer goods. The techniques and their artistic principles, form, have withstood history and in researching humans' crucial development and need for touch experiences, the author found potentials of leveraging traditional crafts' intangible aesthetic values in alongside the application of somaesthetic design approaches in HCI.

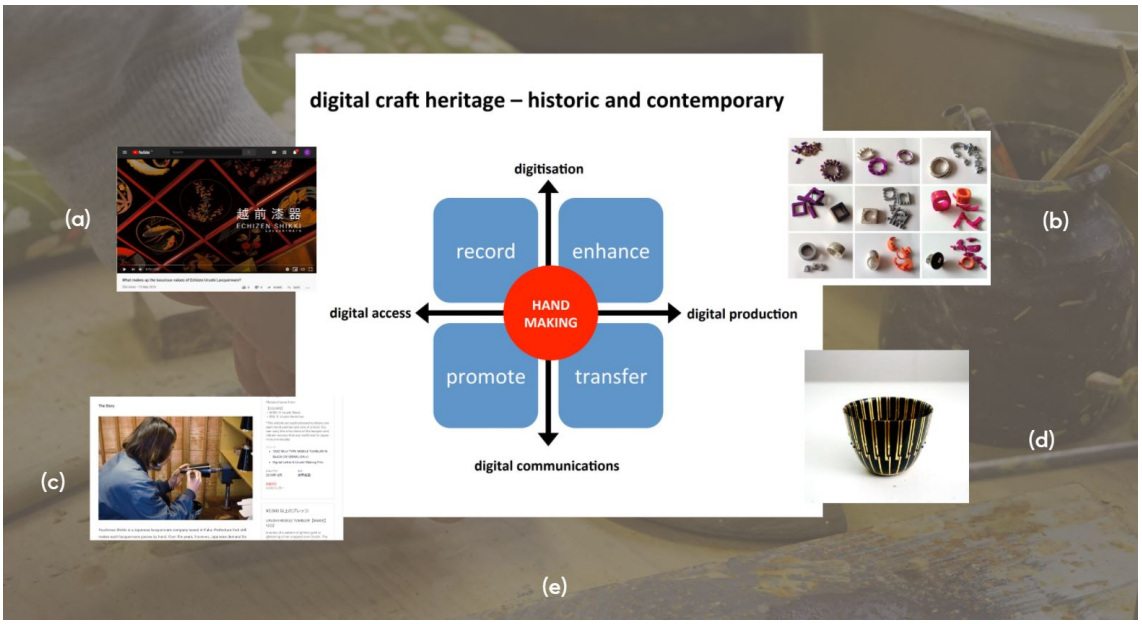

Figure 1.4 (a) Video documenting urushi craft (b) Jewellery developed using rapid prototyping techniques, Friedman, 2015 (c) Echizen Traditional Craft Crowdfunding Project Kickstarter page, 2019 (d) Youichi Sakamoto's Craft Circuit, 2018 (e) The Use of Craft Skills in New Contexts. Woolley, 2015

Woolley discussed four key directions the innovation of traditional industry has taken, namely, *record, enhance, promote, transfer*. [10]. In Figure 1.2, the author inputted examples of the four strategies. (d) showcases a hybrid craft, Craft Circuit by Youichi Sakamoto developed as a part of the Kogei Hakathon.[2] This types of technique combining technology-craft are called Hybrid crafts, and have

2 https://craft-tech.org/craftcircuit

been seen to be developed in the HCI field. However, these products usually take on installation type form and don't necessarily become a large source of further production craftsman can take on. Strategies to re-purpose attributes of craft and furthering the knowledge of modern products that support modern needs is something this thesis further explores.

New combinations of tech+traditional craft artifacts have grabbed attention as art pieces and as novel designs, however it can be argued the method only creates a marginal sales improvement in the overall industry and the reliance of marketing as any other consumer product of the landscape has not changed itself. Today, we are ever the more consumed by digital devices with our adaption to new digital tools in order to perform remote work. Seeing how we are interacting with more and more digital devices and less with analog objects, I explored a perhaps counter-intuitive, reverse survey of our object interactions. Can the tangible, tactile aesthetics, and experiential qualities of traditional crafts inform us on how we perhaps interact with objects in the future?

Figure 1.5 Byuuro Calming Pad Prototype(Source: Self)

1.4. The Byuuro Concept

We introduce the final concept of Byuuro, a haptic-based accessory to enhance existing remote worker's desk-based work-from-home experience. The aim of Byuuro is not for post-work stress relieve, which are offered by various body-engaging entertainment platforms, sports and exercises, but rather, as an added stimuli (and non-audiovisual engagement) to users who are occupied with extended digital interfaces use. Target users are users who experience stress and dissatisfaction in lack of engagement and new stresses in their work-from-home situations.

1.5. Expectations of this research

The largest reason for initiating this project, and the design approach taken by the author is first, to try to gather interdisciplinary perspectives in understanding the future of traditional craft materials and materiality, its role in our daily lives and how material qualities are experienced by users.

Secondly, the author takes these explorations also to understand the role of affective materiality on user experience in the future of computer interfaces, adding to the research on positive technology and towards understanding how HCI can improve existing consumer electronics interfaces and decrease technostress.

The author looks at literature from multiple fields to understand how they influences our understanding of product design and interaction design, and synthesize them in understanding how they may shape current ideas and future trajectories of digital and physical products. As the thesis studies both form, physical material and the incorporation of actuators in conjunction, the design of Byuuro has taken on an iterative process with the two explorations influencing each other. A large focus of the thesis explores materials' affective qualities and its relevance in application for products today. A soma design method, which will be further explained in the literature review, is undertaken in part, and the author explores sensorial qualities of various material, including their interaction possibilities. An effort to understand individuals' solo working habits, and objects they interact with was also extended through naturalistic observation methods and user interviews. The author gains insights into individuals' work-from-home experiences and learns of

how pain points, work routines, and the change in home office environment effects their subjective mental wellness.

The process taken by this thesis has been aligned with Hook's somaesthetic approach. The framework has served in understanding design in a affective to designing for teleworkers who live alone. Incorporation of touch based affective qualities of materials, both non-augmented and augmented material on affecting human emotions. The goal of this research is to understand how soma aesthetic factor in understanding the design products and interactions in future trajectory. The author takes on a user-centered approach and explores solitary workers and their working habits, to understand latent needs associated with object interactions. To understand real users' reception of a soma-based, A participatory approach was utilized in the work.

Research Objectives

The author hypothesizes that an increase in somatosensory stimuli (tactual variety) in combination with haptics stimuli can serve as a tool for individuals conducting work-from-home in physical and social isolation to regulate emotions and improve their perceived mental well-being

- Additional Scope 1: Explores the affective experience objects and its role of object interaction in remote-workers
- Additional Scope 2: Understand how workers are effected by the change to work-from-home and explore their latent needs with considerations to the reduction of surrounding stimuli and the impact of technostress

Contributions

This thesis makes contribution as of below:

1. The thesis examines the use of soma design approach to understanding and designing for remote workers and demonstrates the somaesthetic understanding of interaction can be applied to the use of haptic technology for mental wellness alongside work

2. The work examines stress from a holistic understanding of nuanced work contexts of individuals, the categorization is also a novel strategy that would be useful in interviews and discussions with unfocus groups

3. The findings suggest haptic actuation, with nuanced understanding of its somaesthetic value, can be applied to improve mental wellness enhancing at-work experience

4. It examines remote methods of conducting user research and findings indicate a useful case of remote video interviews for in-situ scenario evaluations

5. Examines diverse materials' affective qualities and evaluated these for using alongside computer-based tasks

1.6. Thesis Structure

This thesis consists of 5 chapters. In previous sections, we laid out the contexts and motivations behind this thesis and our approach to tackle the issue from a multi-disciplinary lens. Chapter 2 outlines theories from multiple disciplines. Knowledge from the soma design approach, product design theories on material interactions, neuropsychology theories, product case studies, and HCI research are accumulated to form the foundation of relevant background. The body of reference also positions the opportunity for design, and guides the design development. Chapter 3 outlines the various studies conducted in the design process. From material exploration, user research, qualitative research, co-creation processes, each explorations influence the steps further taken in an iterative way, and insights supplement the wide scope of fields reviewed. Chapter 4 details a workshop study evaluating the Byuuro experience prototype and findings that amounted to the prototype's further development. Lastly, the concluding Chapter 5 discusses insights gained from the body of studies and details next steps in store for testing attributes of Byuuro, and more undertakings for future development.

Chapter 2
Literature Review

To understand the background of my study, literature review surveying the affective qualities of material, our sensory experience, health perspectives on isolation and mental health, and lastly intervention methods and existing research on affective in the HCI field are surveyed. This chapter tries to understand our surrounding object's affective quality on users surveyed through various disciplines, as an approach to understanding the role of traditional crafts' and analog products' tangible experience, in its form and material qualities, how they effect us we look at theories on object affordances and different disciplines' studies of object interaction. The chapter also looks at how sensory experiences effect our emotions. A deeper look at remote-working conditions with Covid-19 and HCI interventions are also visited.

2.1. Theories on the Affective Quality of Material

In the field of design, architecture and design research, conversations around how we perceive, interact with and our relationship with objects and environments are perpetually discussed. The Theory of Affordance, a concept looking at the various uses objects perform for users traces back to James J. Gibson. In 1984, the discussed Affordance as a material or object's intrinsic potential of use based on its properties and while relative to a user's capabilities, is independent of the actor's ability to perceive it. [11] We commonly use a tea towel to wipe counters, but we can also perceive its potential use when something catches on fire and we need to snuff it out. To understand the role of objects today, where digital devices dominate, what are the affordances underlying non-tech objects in this scope?

Material research, which studies material properties and performance, over the

years, have also developed from a primarily functions and properties-based engineering perspective, to branching out to nuanced understanding and libraries and toolkits of expressive-sensorial material directories to encompass interdisciplinary perspective for product development with sensorial, This development was essential to understanding the role materials plays to the relationship between user and object. As the way proudcts are designed become more human-centered, the way they are produced involves more actors, from designers, to users, product are no longer as designer-centric, and the incorporation of users in these discussions n design education [12]

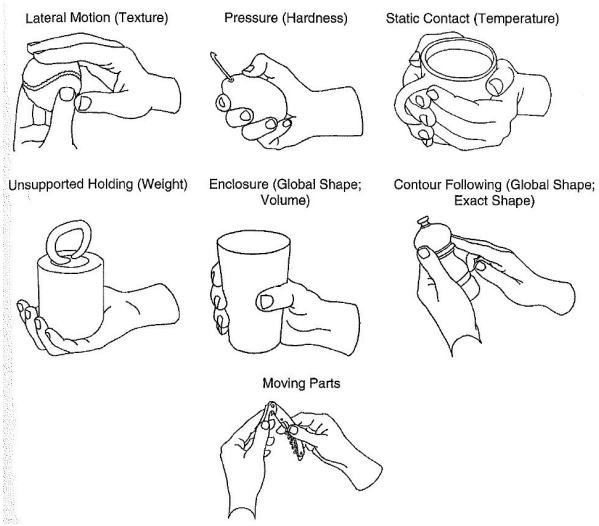

Figure 2.1 Klatzy's haptic exploratory techniques (Sonneveld and Schifferstein, 2008)

Besides looking at object properties from a material, temperature, form point of view as other scholars and theories have outlined, Sonneveld described a framework understanding users' motivations performed with objects. The quality of materials have been studied properties elicit emotional responses. In the "Tactual Experience of Objects", Sonneveld and Schifferstein introduced surveying and experiencing object with the perspective of tactual experiences. The skin is capable of sensing **Light Touch**, without skin being deformed, such as the sensation of clothes, **Pressure**, touch that deforms skin and maintained touch, **Vibration**, examplified by when hand strokes a texture, **Cold and Warmth**, **Itch and**

Tickle, **Physical Pleasure** [13]

From somaesthetic understanding, craft artisans can be said to have cultivated high soma appreciation, for they have honed artistry that requires sensitivity to the curves of their hands, and how their limbs wield tools to create a precise, intended step. However, to the consumer, these experiences are less noticeable, and in today, can be said to have been forgotten.

In design, designers have tried to create toolkits users can understand design perspectives by. How we talk about objects and their sensorial properties have been outlined as a chart of *expressive-sensorial characterization of material for design* in the Materials in Products-selection (MiPS) tools [14].

Whether emotions can be mapped consistently to physical and sensorial qualities of materials was studied in the Physfeel project. Through the project, researchers wanted to develop a toolkit to qualify the "the enchanting, relaxing or tactile qualities of a material" which designers often discuss with one another but have found difficulty translating to engineers or users. [15] Researchers, with the development of 32 material cubes, this library of textures were evaluated with participants on the affective and non-affective qualifiers. The study found cubes evoking softness and elasticity to be linked with happiness, and cubes evoking thermal qualities linked with sadness. This indicates a consistent link participants have with certain textural cues and emotions experienced. However, the analysis also notes that "emotional associations of a material cannot be fully understood in isolation from the cultural totality of the whole material in its context of use." [15] In the exploration of a luminescence smart material in Light, Touch, material scientists evaluated diverse materials were evaluated for its affective properties to employ in healthcare product design with an aim to make consumers feel better, monitor or improve their health or increase comfort' [15].

2.2. How Our Sensory Experience Affect our Emotive States

Our somatosensory and proprieceptive system are in charge of perceiving pain, tactile experiences, social touch and to perceive our location in our surroundings. The system consists of our skin, the human body's largest organ, and many

types of specialized nerves cells that detect different information located from our fingertips to the inside of our guts. For this thesis, I was interested in the systems responsible for perceiving affective touches, and that in most understandings traces to C-tactile fibres that are generally associated with social touch and detecting moving touch. If you imagine a one point contact with a wall, or any item, it may not register long enough for us to detect what the object, or person is. Where as social touch is recognizable for its continuous, moving, factor, and the C-tactile fibres we find on the skins with hair perceive movement, it is able to detect lateral motion, such as how wind passes by or social touch. On the surface level of our skin, are nerves that detect contact, when we place our fingers on our keyboards, the can register the contact with aluminum. nerve cells navigate information, and proprioceptors detect spatial orientation. [16]

2.2.1 Somaesthetic Appreciation

In the 1990s, an approach of understanding our perception in a recognition that all actions we perform are processed through the felt body was introduced. This sensory medium was referred to as the **soma** and literature described a perspective in regarding it as "living, sentient, and purposive". [17] The school of thought exposes the lack of consideration on aesthetic qualities of interaction (i.e. of the soma) in existing theories of embodiment and cognition. Researchers suggested that intrinsically, all our experiences are embodied and that further emphasis on the aesthetic and sensorial quality of our perceptive experience is necessary.

In a series of studies in 2015, a concept of *Somaesthetic Appreciation* was coined by Hook, Jonsson, et al. Somaesthetic appreciation emphasizes evoking the use of our "immediate access to our perception and experiences of and through our bodies". An emphasis on the consideration of somaesthetics in design practice, interaction theories, and Human-Computer Interaction has been outlined by Kristina Hook in "Designing with the Body: Somaesthetic Interaction Design". [18] In her works, the scholar introduces a Soma Design perspective, a lens of designing interaction in consideration of theories of movement and Shusterman's somaesthetics as well in order to design in a holistic way. The scholar fortifies a need to consider the soma, criticizing how previous frameworks of design focuses "almost entirely on the mind, and ignoring almost entirely the body". [19, 20] A full-body guided

thermal actuation were employed in *Soma Carpet*, a body-sized mat for users to use in the therapy lying down, guiding heat to the user's own somatics.

In Jonsson et al's work, heat was explored as a design material to reinforce body awareness through the Feldenkrais training, a body scan meditation technique. [21] The study looked beyond HCI's application of heat for its material aesthetic quality and experiential quality for interaction design. The authors point out several themes from their studies. First, heat may be better functioning than touch or vibration for drawing users towards an inner awareness to the experience of their felt body, for vibration or touch is felt as an 'external' stimuli, the heat on the skin were perceived by participants to be considered 'inside' the body. Subtlety was expressed to be important in creating unobtrusive experience and was stated to be achievable through slow changes in temperature, allowing heat to lingering and transfer on the skin slowly. For theses reasons, the study recognized a suitability in the properties of thermalhaptic cues in "slow and reflective forms of interaction", as cited by the authors. Heat as a actuation medium transferring to enclosing materials resulted in the softening in the surrounding foam, altering the experience of that material.

2.2.2 Body Awareness

Body awareness also supports the Soma Design perspective and a healthy level of body awareness in adults has been to promote wellness. Body awareness is an underlying mechanism of many therapy techniques, and practitioners have stated it as an inseparable aspect of embodied awareness and our interaction with the environment and the world.

Body awareness is a combination of exteroception (input experience on the body surface) and interoception (perceptive experience from within) the importance of touch, and body experience has been noted interoceptive (internal) sensitivity, body awareness. Typically in neuropsychology, it is studied with patients and as a form of treatment. Recent study also suggest healthy degrees of body awareness to promote holistic health in adults. [22]

While thermal cues have been explored as a potential sensation-modality, majority of works in the HCI field look at the use of the stimuli for representing information. For example, in the Thermal Bracelet, several variations in numbers

of Peltier heating elements were applied looking at its use for spatio-locating. [23] The study showed heat allows for quicker detection compared to vibrotactile cues in a wrist-based wearable. In HeatCue, Brolin applied thermal stimuli to different body areas for body awareness therapies. [19] The study found heat can be used to effectively guide the body to focus on the inward response, and the actuation can provide a desirable subtle, intimate, and welcoming sensation in the guided therapy. [19]

Both the somaesthetic appreciation and body awareness perspectives challenge our existing methods of creation with consideration of body and mind together, towards felt experiences. In the context of the pandemic, we see a large population in isolated individuals in atypical environments and alienated from our natural social culture. As body awareness therapies have been practiced clinically as a relaxation method, HCI explorations on the use of haptics for these practices can perhaps be employed to help users suffering from isolated remote-work as well.

2.2.3 Disruptions on Somatosensory Experiences

Studies around disruptions on the somatosensory system has revolved mostly around sensory deprivation, sensory processing disorders, and physical impairment. These studies are conducted in medicine and psychotherapy revolving around individuals with these conditions and impairments. Among

A study recorded the routines of new Latin immigrants to North Carolina and used video recordings as discussion devices for discussion about changes in environment. The study found participants to experience “sensory dissonance” everyday with change in environment. The research concluded the studies stating “harnessing sensory experiences to mitigate negative mental states is an innovative development that merits further exploration” in the field of occupational therapy. [24] This sensory dissonance may also be used to understand the sudden reduction can also be seen with the case of isolated remote workers in Covid-19. discussed as disruptive, can also be considered traumatic for many.

2.2.4 Sensory Grounding

Sensory grounding is a therapy technique that tackles feelings of anxiety by directing our thoughts and perception to sensory experiences. In the HCI field, several cases of healthcare interventions based on interactive technology have been researched, some of the studies have also been commercialized to physical products people can use. An example is the MIT-developed SqueezeVest that achieves sensory grounding through actuated force to give patients a sense of security. [25] Weighted blankets are also examples of products employing this principle.

Tactile therapy is a related concept and have been employed by designers to develop products to help patients with anxiety, PTSD, ASD, and Alzheimer's. Some such as Paula Lorence's *Taktil Objects*[1] and Aurore Brard's *Moving Memories*[2] take form as beautiful objects with attention to physical form and material selected that promotes users' soma experience. Tangibles and haptic technology have been applied in research to facilitate patient-therapist understanding. [26]

2.3. Effects of Fidgeting on Cognitive States

Fidgeting has been found to support cognitive states and our thought processes are engaged with embodied cognition in the form of fidgeting. Studies have explored toys to facilitate cognitive processes by engaging hands in repetitive movements that can promote memory and creativity, becoming 'unconscious focus tools'. [27] [28]

Karlesky and Ibister started looking at fidgeting, studying secondary tangible stimulation alongside computer-use. Several studies on the project were conducted looking at the use on tools on promoting productivity, creativity. In 2014, they developed Fidget Widgets, a set of interactive fidget toys and surveyed their use to promote of productivity and creativity. (Figure 2.2) [29] In reviews of the prototype, experts raised It has yet to be tested with users in-situ of working desk space. [30]

1 https://www.dezeen.com/2018/10/15/paula-lorence-tactile-objects-children-autism-london-design-festival/

2 http://aurorebrard.com/moving-memories/

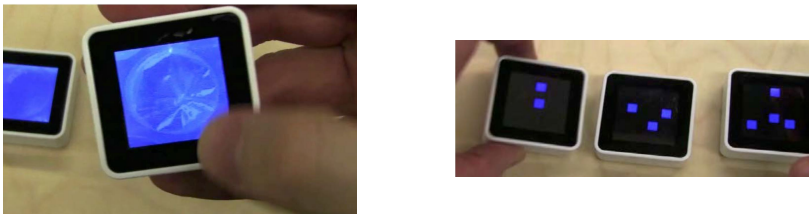

Figure 2.2 Fidget Widgets - *(left)* Infinite Bubble Wrap, *(right)* Virtual Newtonian worlds (Source: Karlesky and Isbister, 2014)

"It seems the mindlessness of these activities is somehow intimately connected to repetition," were noted by Karlesky in their review of their blog where fidgeters are invited to upload things they are fidgeting with. From the collection, Karlesky noticed people discuss these interactions with sensorial descriptions such as squishiness, seem to be soothed by the widget's "evocative" sensations. The scholar expressed Under Sonneveld's framework, the actions of fidgeting can be allocated to playing, exploration. Persons with ADHD, and in the Autism spectrum can have a phenotype for sensory stimulation and expresses them with hard-to-control fidget activities, also referred to as stemming. In the series of studies on fidgeting, findings show the experience can vary in demand for individuals, and they facilitate cognitive functions for most. These objects also have ulterior function in providing soothing experiences. Many toys leveraging these sensory qualities are also marketed for stress-relieving qualities. However, the stress-reduction claims in the market of fidget toys are seldom explored. [3]

The understanding of how our interactions and sensorial qualities with these widgets may help us understand. Fidget widgets explore alongside computer work and author Karlesky expresses lessons from research on fidgeting may be leveraged to understand the "huge, not yet well-understood opportunity to re-examine the design of our digital interactions." [27]

3 https://www.themuse.com/advice/18-stressrelieving-toys-thatll-fit-on-your-desk

2.4. Covid-19 and Remote Working

There is no doubt the Coronavirus pandemic has impacted our lives greatly. The mandates to stay home have resulted in the reduction of public activities, changing our surroundings and with whom and what we interact. In terms of work, at the beginning of the pandemic, however, reports regarded this new shift positively as workers enjoy increased flexibility and personal time with reduced commute time. However, after a prolonged period of mandatory work-from-home, new surveys have shown the many nuanced issues with the new normal and problems such as lack of engagement, isolation poses as significant unresolved issues faced by teleworkers globally. [5]

I look at reports on this divide to understand how the change in work environment has impacted the individual worker and more precisely, the isolated remote-worker living alone. Reports indicate subject experience can differ how individuals experience work-from-home and one can see how pre-existing workplace struggles, and or new pain points effect different types of workers. In the Steelcase 360 report on world remote work surveying workers from ten countries, satisfaction have divided response and the range in individuals' subjective experience are cited to play a major role for the divide. [5] Five distinct types of remote-work experiences were summarized to explain worker attitudes. In the categorization, the groups **Relieved Self-Preservationist** and **Autonomy Seeker** who have had struggles previously with hostile office environments and controlling management found peace and freedom in their home office. its important to consider how these types of reflects the attitude on remote work. Pre-existing workplace struggles can impact how workers perceive mandatory work from home, and can explain why in early reports, remote work were reported to be viewed largely positively.

For groups such as the **Overworked Caretaker**, **Frustrated Creative Networker** and **Isolated Zoomer**, the change gave rise to new struggles. 41 % of workers are reported to be dissatisfied with their work-from-home experience, details of decrease in engagement, communication issues, work-life balance contribute to that. Workers are reported to encounter "challenges associated with repetition, lack of variety and sensory deprivation." [1] I argue that the prolonged isolated remote work can be considered sensory deprivation. The sudden change of environment to many teleworkers brought on by the pandemic has hugely altered

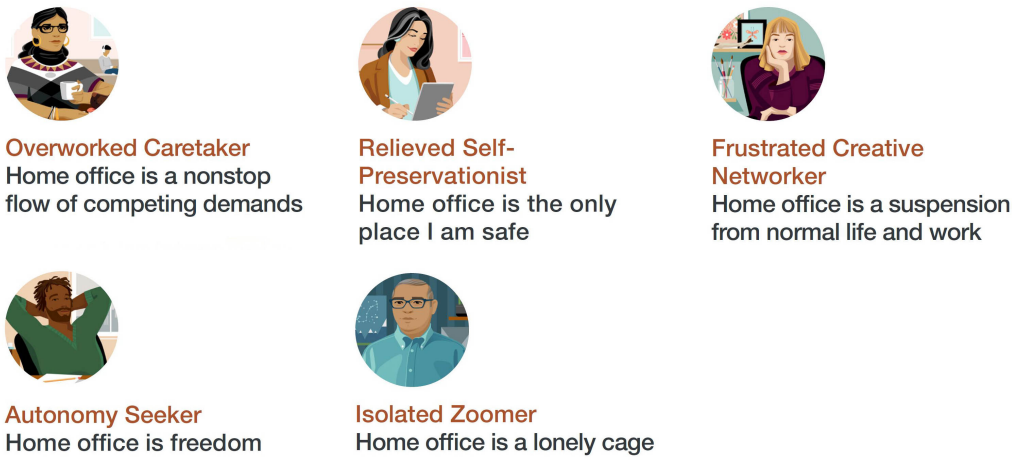

Figure 2.3 Five Patterns of Work-From-Home Experiences (Source: Steelcase360 Global Report)

people from their normal states and can impact negatively their subjective well being. [2] For individuals living completely alone, without adequate resources to improve their living situation for suitable home-office. Imagine that on the large scale of. The Isolated Zoomer in Steelcase's report is the group that suffers from these issues.

Pre-pandemic, documentations on recommendations for isolated working environments such as the Antarctic station, have emphasized the need of having workers occupied with hobbies and activities to mitigate isolation. Facilities housing these workers often incorporate these accommodations in the environment. [31,32] The typical office worker, however, were found unprepared to adjust sufficiently in a holistic way. In reality, many also don't have the means to. For instance, it was reported only 24% of US workers surveyed were able to install ergonomic chairs for their home office. [5] Workers also don't necessarily have living arrangements designated for long term work-from-home or ability to change that situation financially either.

These lack of adequate home set-up can impact workers physically, especially with the increase of screen-based activities. Digital eyestrain and back pains can further worsen the issue. [1] Scholars also theorize the adjustment to Zoom-based work for essential communication also means new workload and stress factors

for many. [33] Molino et al highlights a crucial need to study and find solutions to the pain points of remote work, how and why technology creates stress in users, especially for those dealing with **existing technostress** and subjected to **information overload**. Without a clear work-life boundary as that of an office where surrounding cubicles empty out daily when the clock hits 5, workers may also struggle with work-life balance and a feeling of a need to be perpetually connected. [34] Furthermore, with pandemic restrictions, screens became not just for work but also necessary for socialization, communication and entertainment.

While exercises, meditation practices, breathing techniques are recommended ways of coping with these changes, frustrations from the change in engagement impacting work for the *Frustrated Creative Networker* type of workers continues to impact the solitary work space and won't disappear with calming therapy techniques. [1] For these workers, perhaps surrounding objects and technology can be leveraged to provide solutions to more immediate affecting our immediate surroundings when we experience stress.

2.5. Interventions Tactics for Isolated Work

2.5.1 Telepresence Technology

While now used to refer to the video tools most remote workers need to facilitate meetings, before the pandemic, telepresence technologies were developed to facilitate distanced socialization. The understanding of existing telepresence technology can be taken to survey technology used to engage users and can be employed to help isolated users in their confined environments.

Projects in HCI research have leveraged various actuators to engage users sensory modalities in ambient experience, haptic experiences facilitating social communication. The AGNES ambient system looks at visual, haptic, stimuli to create affective experiences. The system is then applied to facilitate affective social touch through surrounding stimuli. [35] A system creating force sensations to represent hugs have been explored to connect distanced partners in the HugMe. [36] Research has also looked at stroking interactions, and fabric-based sensors for affective touch interactions, in delivery and for object sensing. [37]

2.5.2 Robot Pets to Tackle Loneliness

Touch interactions to prompt affective touch in users have also taken the form of robots, specifically, cute furry devices embodying pets. Further, many instances can be seen in HCI research and on the market for the purpose of combating loneliness, such as Qoobo, and Nene. [38, 39] These robots react to users strokes and the furry device reacts with interactions such as tail-wagging, or shivers, imitating a real pet companion.

While these robots tackle loneliness, they require the adoption of a habit for users initiate to establish these human-robot interactions. This interaction of soft textures and similar actuated response may be leveraged further to affect our emotions with the incorporation of sensing technologies measuring user affective states.

2.5.3 Entertainment Engaging the Senses

To mitigate boredom and monotony, games, videos, and other digital entertainment are popular methods people opt for to engage their senses and mitigate feelings of isolation. In recent years, researchers have looked to further create more immersive entertainment by developing technology to create multi-sensory experiences. Amongst these, haptic actuation have been implemented to make these media contents feel more real by creating movement, and feedback users can feel through our somatic senses, to further immerse the user. In VR research, researchers are using haptic technology to accompany or audiovisual VR contents to deepen the experience of contents multiple modalities. These studies have also looked at how users perceive haptic actuation. In Disney Research's work, researchers studied the semantic values of vibration with a development of a library of haptic 'effects' called Feel Effects. Vibration patterns in a chair were paired with descriptive movements and the appropriateness of pairings were evaluated with users to explore appropriate creating immersive haptic experiences. [40] The same type of vibration actuator featuring low frequency audio signals have also been used in the designs of a mood-regulating furniture. The Kan.ka furniture by Chandra features various musical patterns for giving users full-body soothing effects. [41]

Thermalhaptics have also been used to deepen the immersion in VR horror games, using cold sensations through Peltier devices to induce senses of unease in users. [42]

2.5.4 Affective Haptics

While we are most familiar with haptics in the form of notification buzzes on our phones, the HCI field has been exploring the use of haptic technologies to display, deliver, and exchange information in our touch modality. In consumer electronics, we are familiar with haptics in how it is employed to represent information. Our smart phones, smart watches, computers, and tablets are becoming more and more sophisticated in how they use haptic-tracking, which are the use of sensors to sense how our fingers navigate information on these devices. Commercially, we have devices that mobile device UI, smart watches, massage products, and sensory therapy products. Research on the affective use of vibrotactile patterns have taken form as direct-on the skin bands in Good Vibes and findings show vibrations can give positive affective experiences. [43] In Hornbaek's work, evaluations of qualities of vibrotactile cues were assessed. The perception of parameters: *motion, granularity, bumpiness*, were found to effect user emotions. [44] In studies on VR-MIP (virtual reality and mood-induced procedures) for therapy, the incorporation of tactile stimulus (artificial grass) has been found to improve the relaxation scores for users experiencing the VR therapy technique. [45]

In recent years, we have seen the emergence of IoT technology becoming a part of home appliances, and singular units that learn about users and service us, making our lives more convenient. The sensing technology is regarded as affective technology, and has taken the forms of smart watches and devices that monitor our health. With new attention on VR healthcare, education, entertainment, the representation of through tangible and embodied means has surged. Surveying on a macro scale, the rise of attention to simulated, artificial sensations, while useful, attention to experience of individuals such as mental wellness alongside these advancement (such as towards positive technology) are paid less attention on. The understanding of vibrotactile technology in creating pleasant arousals can be extrapolated from these studies and applied to mental health application.

2.6. Summary

Working alongside digital devices takes up large portions of the remote worker's day. With the coronavirus pandemic, the work-from-home setting also for most indicate a significant decrease in external stimuli such as interactions, found in an office environment. We surveyed HCI research that employs multimodal technology for telepresence, entertainment and affective haptic. While studies have evaluated haptic as a modality for the bilateral display (the sensing and display of user emotion levels as information) in therapy settings, they are yet to be implemented alongside work for work-related stress facilitation purposes. For work-from-home users, working in isolation can feel like being 'stuck' when one encounters stress without body-engagement and external stimuli engaging them. Furthermore, technostress have been shown to be a major issue with our perpetually increasing long hours of digital use. For this, it is important to look for ways to improve technology in how it must address its impact on user mental wellness and overall steer the development of consumer electronics towards positive technology. With an understanding of affective properties of material and textures, we can infer that the a tactual experience alone has been shown to have be able to influence user emotions. We may be able to leverage these affective properties in technology if textures are experienced in tandem with haptic experiences and such stimulation may create subtle functions to improve remote workers' daily experience of digital interfaces. This direction may also point to how analog materials can be used in design and as a part of positive technology in the future to highlight more of their affective qualities (besides just functional qualities).

Chapter 3
Concept and Design Methodology

3.1. Design Concept Overview

The design process of this project undergoes various research methods in surveying the materials' affective qualities and the application case for work-from-home users. While mental health products often appear as commercial products they seldom go through research. In this section we explore whether objects and material in conjunction with affective haptic technology can be a source of stimuli in improving remote workers' work-from-home environment.

We look at the future potentials of materiality implementation on computer-work spaces and explores the affective quality of textures, vibrohaptic stimuli, and thermal haptic stimuli on perceived measures of mental well being. Affective technology are becoming ubiquitous, and emerging devices capable of measuring biodata. The use of smart analytic revolving around biodata and health have also become widely accepted and popularized. The affective therapeutic effects of haptic experiences have yet to be leveraged in conjunction with material and in work-settings. We introduce the use of added somatosensory stimulation to improve users' sense of well-being, tackling remote-working and the issues arisen for stressful moments. User-centered design was important throughout the design development.

In the later development of Byuuro, we pose the *Isolated Zoomer* and *Frustrated Creative Networker* type groups as extreme users and try to dissect the issues they encounter, considering pre-exisitng technostress. A key feature of technostress is how it distracts our focus, lowering productivity, and the cycle can make the working experience even worse. The Byuuro concept takes an interactive surface-based touch therapy that uses haptics to raise body awareness. Our approach

tries to understand the therapeutic qualities of materials on our target users.

The aim of this research is to understand application of haptic technology, the relevance of material variety scenarios for solitary workers. Through broad exploratory stages researching themes related to stress, motivation, remote work, and existing usages of haptic and affective sensing, we were able to delineate settings of stress patterns users experience and understand attributes of our system that can improve their home office.

3.1.1 Design Process

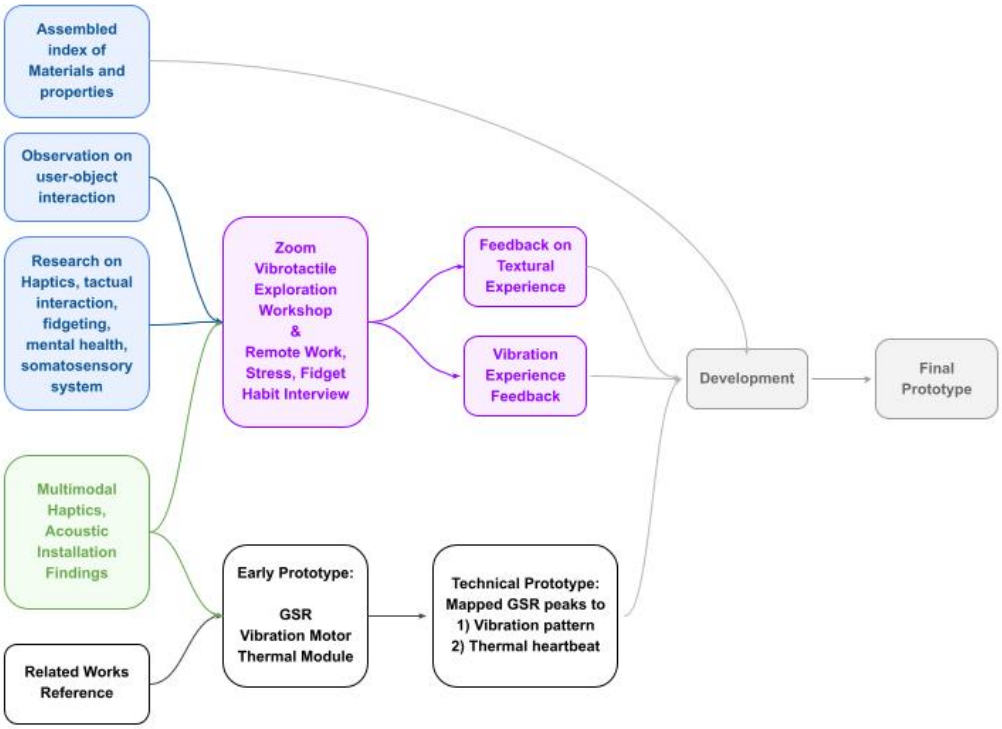

Figure 3.1 Design Development Stages (Source: Self)

The development of the concept took on a multi-stage process, and a body of work around various themes in human-object-interaction using multidisciplinary

research processes were developed as a result. User-centered design philosophy was important for each step and process alternating between participatory co-creation and designer-centered development were adopted.

To begin, exploratory studies were conducted in two directions, object-material exploration, and user needs research. Throughout the study, an ongoing material index was developed evaluating the designer's own perceptive experience of diverse materials, noting their affective qualities and their room for interaction. Observational studies were conducted to understand user's natural interactions with objects in work and study contexts. In following steps, we took on a latent-needs approach and looked at the application of our concept to users who could benefit from the interaction and interviews with students and remote workers on their work spaces ensued. With the onset of the pandemic, the study zoned in on the new remote work paradigm and assessed how remote workers may benefit from our proposal. The final assessment of Byuuro was conducted in Zoom workshop with 6 participants from Japan and Canada.

3.2. Understanding Users

3.2.1 Naturalistic Observations on Solitary Workers

Nowadays, we spend hours looking at screens for work and tools for daily life and they take up large portions of our waking hours. Consumer are also purchasing more devices and digital products that aid their screen-based work with the demand of screen-based work and time spent increases. To understand realistic users' interactions with objects while they conduct work or study, naturalistic observations were conducted over a period of a week in public libraries and cafes around Central London. Observational subjects were individuals performing solo computer-based work continuous for more than half an hour. The study observed user habits in this scenario, including, but not limited to, stationary used, duration of use, how stationary are interacted with, fidgeting habits, notes of distraction, user behavior while focused and user behavior while distracted. The technique was chosen over interview-type methods because the aim was to study individuals' behavior and interaction with their surroundings and objects during concentrated

work. The method was suitable as it does not make users feel self-conscious while working nor does it disrupt their work. Self observation by the researcher was also conducted. specifically, the Experience Sampling Method has been noted to be useful for understanding changes in motivations, moods or subjective well-being as it occurs, was also used to understand effected when behavioral changes occurs. [46] The researcher tried her best to conduct work as normal as she could and recorded self-habits and change. Interesting insights into how subjective-well being is effected by surrounding stimuli were found.

It was found the quality of touch, such as duration and how much sensation is registered can effect the effect on concentration. It is interesting to further investigate how actions that make us distracted and actions that facilitate concentration. When people are engaged in concentrated cognitive loads such as reading, studying, reflection, and information processing, they are seen to be still. They also engage with minimal touches and very few interaction with objects.

Items we hold for longer, and bi-directional pressure *felt weight and active touch* (applied pressure) are experienced include touching water bottles, our own bodies, and using pen and paper to write. Individuals who conduct work that involve producing, such as in the tasks of writing e-mails or creating, are found to fidget. Natural fidget gestures involve active touch outside of our focused field of vision. These people who're busying their hands typing or scribbling are found to fidget often; twirling their pen, touching their faces, tapping on their laptops. In fidgeting, repetitive interactions were done to promote focus.

Typically, objects we touch when working alone are minimal. Most interactions only involve static touches and are limited to laptop computers, water bottle, phone, pen, and paper. In the author's own examination, in static touch on computer-based surfaces, no more information beyond a neutral temperature can be felt in the fingertip in typing actions.

The observational study proved to be helpful in understanding realistic contact with objects. Computers and phones, that provide information, are interacted with in static touches and the contact are short-lived. However, users can be seen to rest their palms on laptops surfaces mid-task and while thinking, and becomes a substantial continuous contact. While working, most information we are processing is delivered only visually, and it can be deduced that the touch

modality is seldom interacted upon. As we physical type work are replaced by automation, speculated that information type work will increase in the future.

Our interactions with objects and how we touch things in these environments, like holding objects or placing our fingers lightly on our key pads is in the background subtly affecting our cognitive processes. When we fidget, the repetitive motion we are in helps us focus.

Some fidgeting actions done out of feeling distracted can create a calming effect and help focus, for example touching hair slowly. An awareness of the felt experience of the action, and a slowness of the experience can aid in creating the contemplative space. Hearing white noise also helps focus in this same sense.

3.2.2 Interviews with Users on Desk-Top Accessories

As an accompanying study to the observational study, semi-structured interviews with users in regards to realistic buying habits of desktop accessories were conducted. Seven undergraduate and graduate students at Pratt Institute were interviewed for the segment. Themes from the interviews indicate students, who perform large amounts of ICT-based work have Some themes from the interviews: From literature review, users do no infer soma without training, and somaesthetic qualities rarely crosses the regular user's mind. Even students in product design interviewed do not necessarily prioritize or put soma aesthetic qualities of objects as consideration when purchasing products for desk-top use. Objects purchased for long-term use and keep can be summarized to prioritized by qualities of: trust-worthiness, reliability, and nostalgia.

3.2.3 Semi-Structured Interviews with Remote Workers

After understanding users' object-interactions when performing work individually and their purchasing. The author conducted semi-formal one-to-one video interviews with persons working from home with the aim of understanding how work experience has changed in the context of Covid-19. Furthermore, the interview was aimed at understanding whether individuals interact more with objects and whether tactile sensation in at-home setups differ than in public.

However, the author soon found a difficulty in discussing tactile sensations and

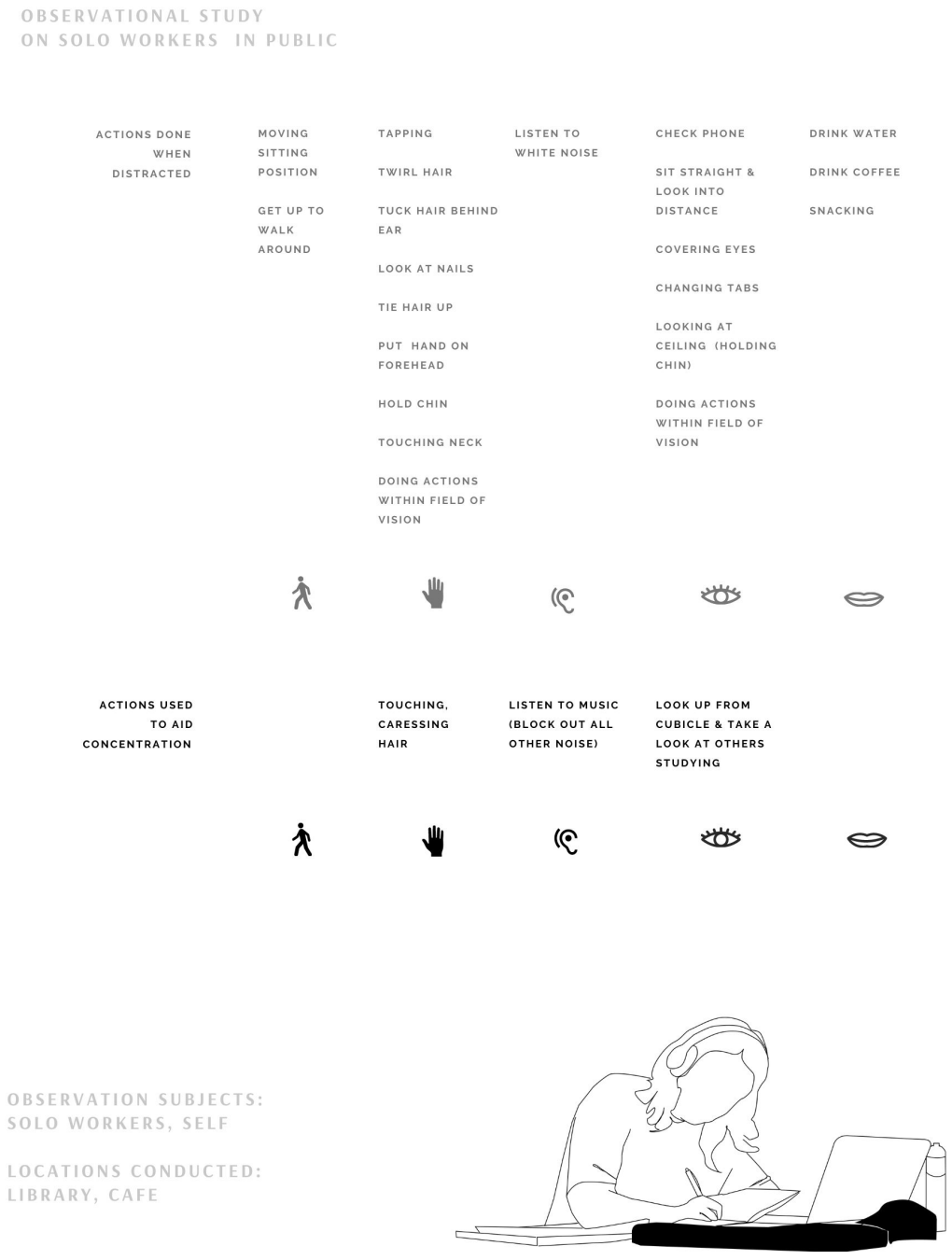

Figure 3.2 Observation notes on actions performed by solo worker in public work spaces (Source: Self)

we found remote work was highly subjective to users' work requirements, work content, level of social interaction in and outside of work, and more factors. In the workshop, we asked participants in a pre-survey and in-workshop interview about stress, remote work challenges, and stress-relief methods and how surrounding affect their mood.

3.3. Affective Properties of Materials

3.3.1 Material Properties Study and a Material Index

The preliminary stages of the project adopted a soma design approach and was centered around the designer's own experience on material affective qualities. As the project revolves around materiality, understanding materials at large, how we perceive how to interact with materials and what they afford was another important factor. The approach was aimed to understand interaction possibilities and properties of materials. Throughout the project, an ongoing index of material

Figure 3.3 Sample from Material Index (Source: Self)

and textural experience were collected. The collection begun with a focus on found surfaces and objects made with craft techniques, and next, found objects that can be held and experienced through haptic exploration methods were reviewed. Appendix A displays a portion of the index. The analysis of each interactions were described based from the Sonneveld's Tactual Experience Guide, the MiPS tools and Klatsky's Exploratory Procedures. [13, 14, 47] Qualities, affordances, material

names were collected and evaluated from a subjective experience point of view to assess the experience of diverse materials.

In interacting with a diverse number of surfaces and objects, the designer found a linkage of certain ranges of weight and smoothness in contour following to the feeling of security and trust. Certain temperatures combined with graininess, evokes emotion of comfort. From an direct experience, we do not gain much information from light fingertip touches, except temperature, which becomes prominent. The interaction the researcher conducted with materials are explicitly out of typical object contexts, but the aim explores both the intended soma experience and afford.

3.4. Concept I: Indicia Stamp Set

Indicia is a stamp concept exploring object interactions that promote mindfulness. The design features a set of weighted design objects shaped so our hands can comfortably wrapped around them.

Figure 3.4 Indicia concept (Source: Self)

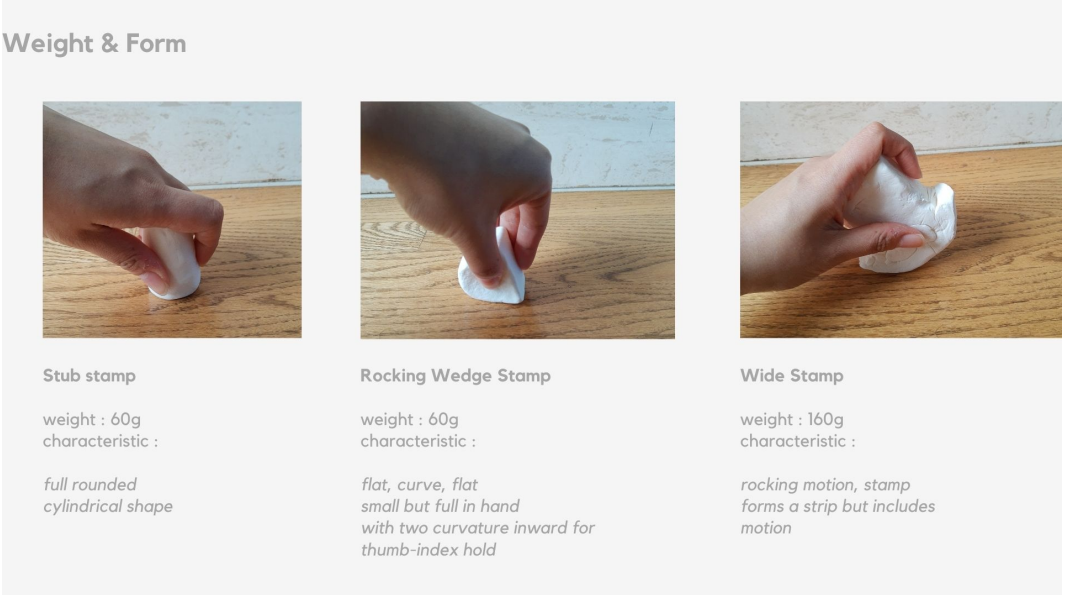

Figure 3.5 Developing multiple sizes, form, and weight (Source: Self)

The design draws on the understanding of remote workers' routines and reduced tactual interaction with objects. Further, in literature review on understanding of digital eyestrain, working posture, and hand-wrist physical ailments such as carpole tunnel, the design acts as an intervention to these problems workers face.

The concept acts as an accompanying stationary set that can be used during breaks during work routine. Creating a mindful active experience and physical outlet that is a soothing tactile-wise and playful. The concept is developed from research on fidget toys, stemming activities, froebel's toys for sensory awareness development, hobby-crafts, and an exploration of physical forms. The review covered the hands-on experience with hobby-crafts, exploring the tactual interaction qualities these activities arouse. The final design is inspired by the stamp craft. Stamp, which in children's stationary takes the form of a wooden or plastic object with carved rubber layer actually takes on many different form across different cultures. The development is inspired by the use of Japanese *inkan* and its rocking motion when performing the act of stamping. The stages of development drew inspiration from the approach of viewing objects through tactual interactions outlined by Sonneveld. [13]

Figure 3.6 A closer look at existing fidget products, studying their qualities and affordances. *left* bubble popper fidget toy *right* schylling nee doh (Source: Self)

The author was concerned with the similarity of to concept to existing fidget toys. An issue the author was the requirement for users to incorporate to their intimate desktop tools. Training to incorporate touch therapy as a strategy to ease stress is also necessary. Similar reviews on fidget based designs have pointed out the need survey user connection with these tools.

At the time of the research timeline, new fortified social restrictions to prevent Covid-19 spread signaled difficulty in testing the unique Indicia forms. Henceforth, the project reoriented to employ method of testing the interactive and physical mateirality that would be accessible to distanced users. The researcher became interested in the adaptation of affective haptic research to a responsive desktop service that adds pleasant sensations to improve mood and would also be capable of responding to user emotion states.

3.5. Concept II: Byuuro Fidget Surface

With the built understanding of interaction possibilities of various materials, and affective haptics employed in HCI, therapy, and entertainment fields, the author developed the Byuuro blotter concept. The Byuuro desk pad presents a computer-desk accessory that employs affective technology and haptic actuation to measure and respond to user emotion states. As diverse textures can afford different ex-

periences with various affective qualities, the researcher hypothesizes the use of multi-materials in a smart fidget surface would add stimulus and improve the experience of work-from-home computer users. The design accompanies users who have difficulty adapting to new work-at-home regimes and experience a bubble of isolation such as the *Isolated Zoomer* and *Frustrated Creative Networker* types of workers. [5]

Shown in Figure 3.7, the author developed ideation sketches exploring the form in which Byuuro can take. Brainstorms on different forms, multi-materials, pleasant ergonomic surfaces for the palm, materials with pleasant sensation that allows for fidgeting were considered in the process. The accumulated material index, Physfeel material toolkit, and Material District library swatches were referenced to develop the concept. The stage also considered ways haptic actuators may be Incorporated.

The use of vibrotactile actuators are common, however they are seldom used for at-work situations. Shape shifting technology could be referenced to support the ergonomic form to create moving stimulation. In consideration of the use of such intervention alongside work, the author decided on the use of vibrohaptic actuators that can be hidden and out of sigh and create relative subtleness that doesn't disturb the arms so much.

3.5.1 Technical Prototype

Concurrently with the development of the Byuuro concept, the author has worked on the implementation of technical parts. In the sketch development, ideas were selected on their feasibility with technical elements and whether appropriate actuators can be embedded in the design. The form of surface textures that can be experienced, including how density and conductivity of the material were looked into.

Ultimately, to produce the full Byuuro system, biodata sensors capable of processing user stress levels in needed. Recent studies using biosensors to evaluate stress levels, galvonic skin response has shown to yield more stable data on stress compared to amaylase and less expensive to administer. [48] The method also allows for continuous measurement that is non-intrusive and have been found to predict high stress [49] The sensor measures the conductivity between the skin

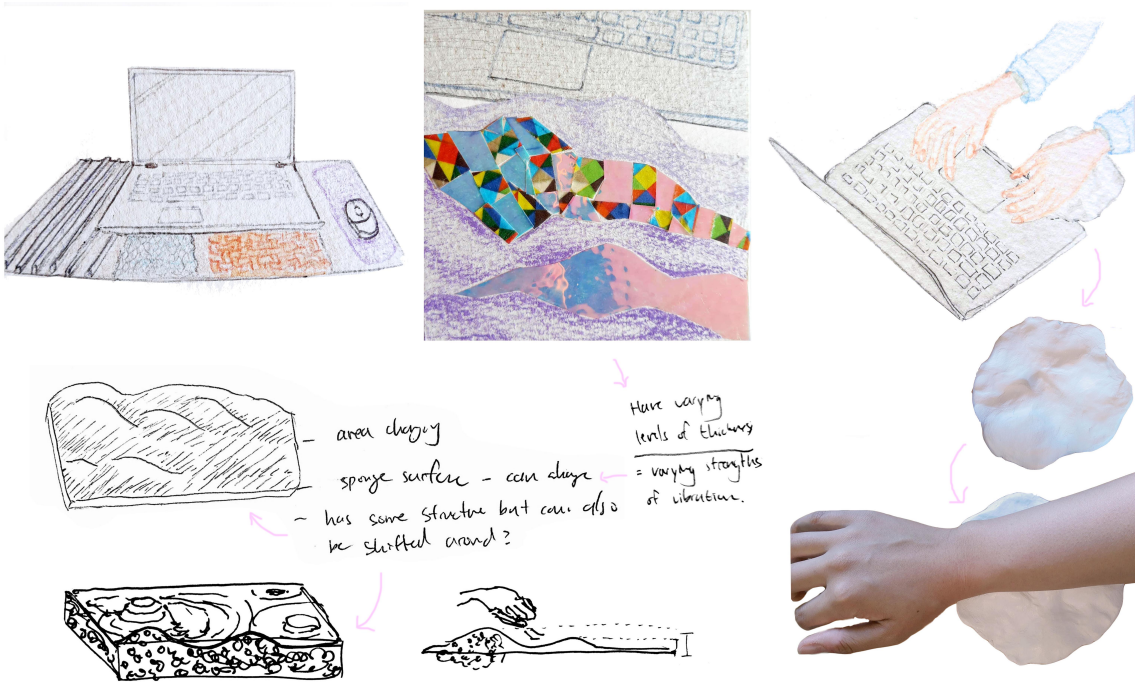

Figure 3.7 Initial Concept Sketches (Source: Self)

top left, middle: multi-material surfaces would allow users to use for fidgeting and gives multiple types of stimulation *right top, bottom*: a small wrist-sized device that has give and can shift-shape to give user stimulus, and form model sketch *bottom left:* Extended developments of Byuuro fidget surface

that produces sweat, which has been studied to be a stable physiological data. In many implementations, the fingers and under the feet are used, the palm area is a underused area, but has been researched to equally measure a relatively stable understanding of stress and was selected as putting actuators on the fingers can be cumbersome for during-work applications.

Localized haptic have been explored for the wrist in the form of bracelets and wristbands, in the back, the back, around eyes, and on the neck have been explored in [23, 43] The envisioned placement of both actuators are in a deskpad form underneath computer devices.

Figure 3.10 illustrates the concept and technical schematics. An Arduino Uno is used to store the code of the input and output. In the current prototype,

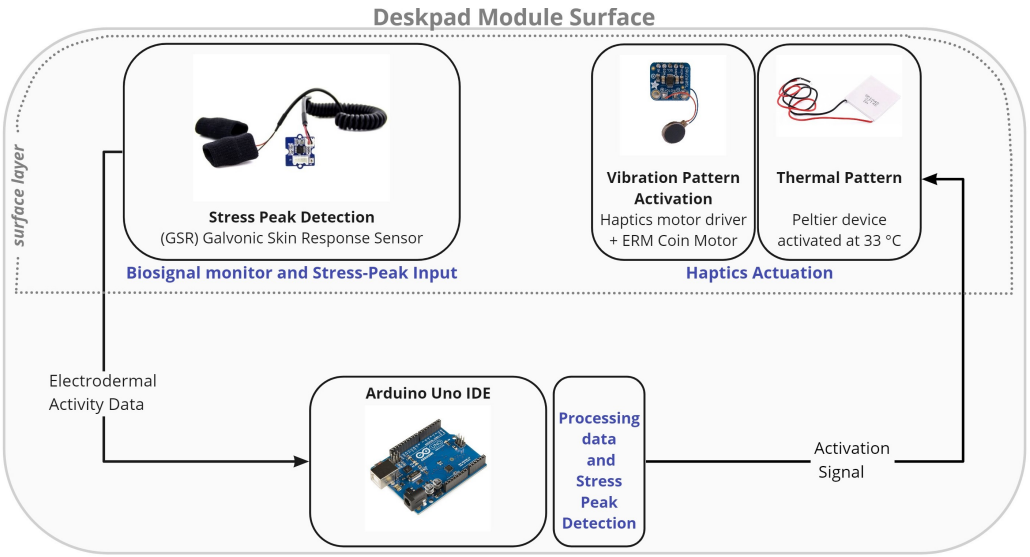

Figure 3.8 Technical Prototype Schematics

3.6. Experience Prototype

We hypothesize the use of haptic actuators underneath a surface with varied textures can stimulate remote workers and raise body awareness as a method of coping with stress in remote work environments. The prototype adopts a **participatory**

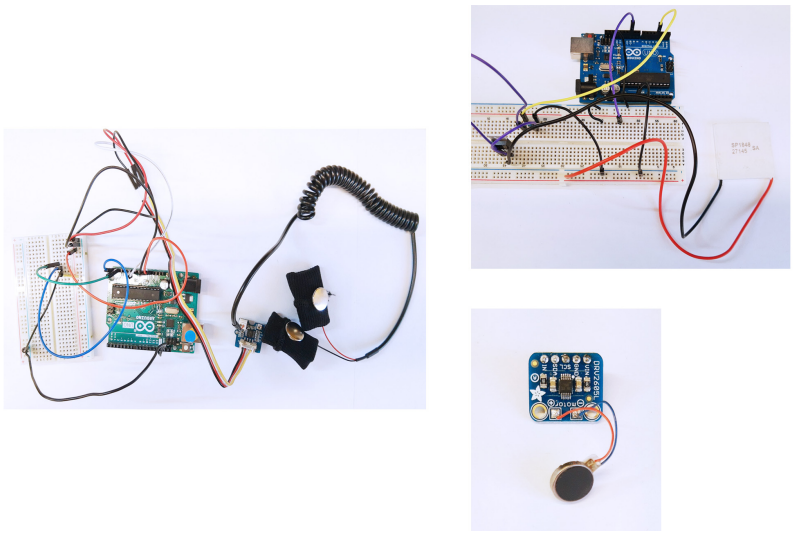

Figure 3.9 Technical Prototype Elements. *left:* galvonic-skin-response Sensor Unit, *right-top:* peltier heating generating module, *right-bottom:* haptic controller and vibration motor (Source: Self)

co-design strategy with participants through Zoom workshops. The methods features instructing teleworking participants to set up a simplified version of the Byuuro concept to evaluate its use right at their at-home office computers.

Sensova Application

The researcher developed a lo-fi prototype participants can arrange from home. Participants were asked to set up stimuli at their desk space, consisted of a vibration massager app, Sensova. [1] The experience prototype delivers a simplified version with only vibrotactile actuation to gauge users' experience of diverse textures (soma experiences). As we were unable to develop a delierable thermal experience in the prototype, only the vibrotactile sensation was tested. A simple vibration pattern was chosen with the intention to enable conversations about vibration actuation in combination with textures and their perceived pleasant level.

1 Sensova Vibrator Application https://apps.apple.com/ro/app/sensova-vibrator-ai-massage/id1546196440 https://play.google.com/store/apps/details?id=com.vibrator.sensovaome and place over the vibration

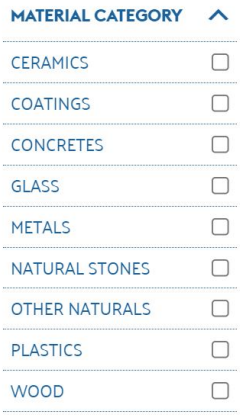

Figure 3.10 Material District Categories (Source: materialdistrict.com)

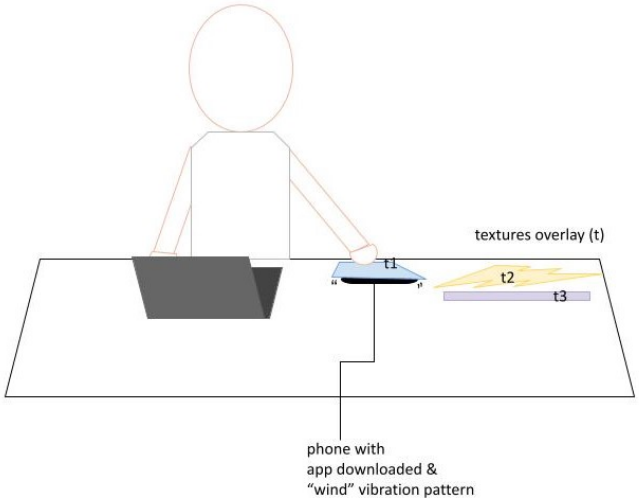

Figure 3.11 Instructions on setting up the textures (Source: Self)

The *Wind* pattern from the application was selected and was consistent in use with all 6 participants and along all textures. The pattern consisted of a 1-second vibration, 2 second interval, In comparison to the *Heartbeat* pattern, which has shorter intervals and faster pulses, the *Wind* pattern with longer resting intervals was selected.

Material Selection

The categories of material to prepare was based on material library classifications as shown in Figure 3.9[2]. Also, textures typically not found in consumer electronics were chosen, as we wanted to explore users' perception of diverse materials in conjunction with computer interactions. This included materials often found with traditional craft, such as bamboo, wood and ceramic.

Participants were instructed to collect at least four items with a rough size of 5" by 5" and a thickness of 2" that fit the categories of Rubber, Bamboo/ Thin Wood Material, Ceramic, Sponge or Fabric they like, Decorated / Ornate Surface. Additionally, at least one surface or item that may not fit the size requirement but

2 Material District https://materialdistrict.com/material/

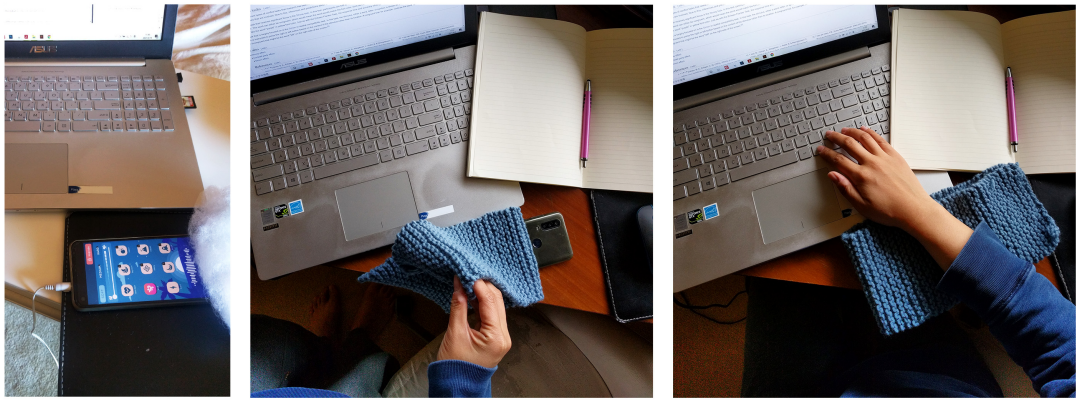

Figure 3.12 Participants were instructed to open the Sensova App and use the *Wind* pattern selection, they were to cover the phone with different material set-ups and have each stimuli under the wrist and forearm during the e-mail task (Source: Self)

they perceive as pleasant. Participants collected items from around their homes as close to the instructions as they could.

Chapter 4
Implementation & Evaluation

4.1. Overview

To evaluate the concept, an experience prototype was developed to gain insights from users and validation method was through six 2-hours workshop sessions conducted with 6 participants. The workshop tested the desk-based accessory concept and surveyed users' holistic work-from-home experience to understand their stress, coping mechanisms, and in what situations a haptic-based stimuli can be useful. Evaluation of the concept was done through a comprehensive analysis of users' experience prototype feedback, in-workshop interview, survey responses, and their Self-Assessment Manikin ratings. This chapter discusses the study design, findings from the study, and further development conducted by the researcher.

Several aspects were surveyed in the workshop that were considerations under the Byuuro design:

1. Understand users' living conditions, social activities, subjective wellness and points of stress they experience in work from home and points for proposal to intervene

2. Understand users' existing coping mechanisms to different types of stress, the effectiveness of existing strategies

3. Survey user evaluation of the use of Byuuro alongside work and as a potential tool for stress relief

4. How textures that encapsulate the vibration effect the reception of vibration

5. User's perception to the affect qualities of diverse materials in conjunction with vibration stimuli

6. How users perceive the concept proposal as an intervention to stress they may experience in their work-from-home set-up

7. Whether the use of multiple textures add interest and usefulness to the experience

8. Whether users have existing use of fidget and stress toys and how the proposed concept compares

"I think its good for de-stressing and relaxing from problem-solving tasks"

4.2. Study Design

The study was designed as one-on-one Zoom workshop-interviews with participatory aspects (asking participants to gather a set of textures), and the use of an experience prototype that simulates the Byuuro proposal. The users were instructed to set-up the prototype and experience it along with three scenarios: while writing an e-mail, while closing their eyes and resting, and while fidgeting.

A brief with instructions and a pre-workshop survey was set out. Actual workshop consisted of the use of an e-mail task, the Self-Assessment Manikin, and semi-structured interview segments throughout. At the end, discussions about stress, work-from-home experience, and the experience prototype were discussed and a post-workshop survey sent out.

4.2.1 Pre-Workshop Survey

The pre-survey is attached in the Appendix. Before workshop sessions, the author wanted to gain a holistic understanding of participants' experience with remote work, which was important to understand in what ways Byuuro may help different users. Questions asking about contributing factors to work-from-home stress they may experience such as the social disconnectedness, living arrangements, lifestyle and work changes due to Covid-19, self-ratings of subjective mental wellness,

and stress relief methods were asked in the survey. A 5-point Likert scale was used to assess individual's level of agreement to statements on subjective mental wellness. [50] The last segment of the workshop touches on the responses and the researcher discussed them along with the prototype experience.

5 Types of Work Categories

Recognizing the variation in job content across occupations and its implications on situations and intensity in which stress arises [2], we asked participants to allocate the ratio of their work week in accordance to 5 work categories and rank them in stress elicited. [51] The categories are from Adobe's creative career resource column and were used to gain insights on the types of tasks users perform that affect how they perceive their work-from-home experience. For example, for work heavy on communication (*reactionary*)tasks, the migration to telework may effect workload and difficulty.

- Reactionary - Including responding to messages and requests – emails, text messages, slack communication, messages on other communication platforms.
- Planning - Type of work when you decide how to allocate time to get things done, including scheduling and priority-allocating, developing systems for running meetings etc.
- Procedural - The administrative/maintenance work we do just to keep afloat: making sure that the bills are paid or updating a deck for a presentation, or tracking old outbound emails to confirm that they were addressed/solved.
- Insecurity - Looking at certain statistics related to work, repeatedly checking what people are saying about you or your output.
- Problem-Solving - Work that requires our full brainpower and focus, developing new systems, developing a new business plan, writing an article, or brainstorming the features of a solution. Whether you're working solo or as a team, you're leveraging creativity to find answers.

4.2.2 Workshop

The workshop flow is illustrated in Figure 4.3. The workshop itself lasted 1 to 1.5 hours, as the interview length varied. However, while the pre-survey was designed for participants to fill several days in advance, most participants filled the pre-survey and post-survey along with the facilitator during the workshop time and added to the total length of the study.

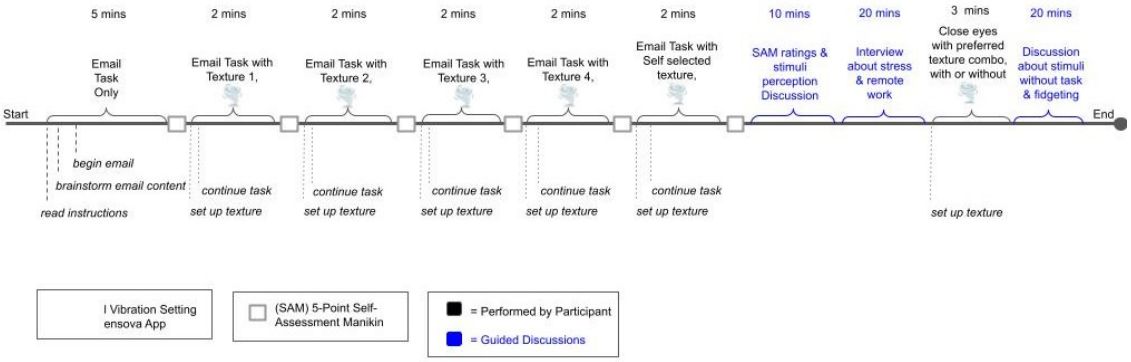

Figure 4.1 Workshop Flow

The workshop begins with the users setting up the experience prototype tool, Sensova and putting their gathered materials on their laptop side. Participants start the e-mail task that simulates a working type situation. After performing the task for 2 to 3 minutes, the participants were interrupted and asked to assess their valence-arousal-dominance ratings based on performing e-mail using the self-assessment manikin. Subsequently, users were asked to set-up the *Wind* vibration stimuli with the textures in series and to continue the e-mail task. After 2 to 3 minutes with each texture, users were to rate the SAM Manikin. A discussion about the experiences and reasoning for the ratings ensued.

In the last segment of the workshop, users uestions were also to prime participants on imagining stressful situations Users were asked about stressful scenarios while conducting work, referencing their answers from the pre-survey and prompted to imagine the use of the vibration+texture stimuli when stressed.

Simulating Stress Experienced while Working

We asked participants to performed tasks to simulate two types of modes in the session. Participants were asked to perform an e-mail task and at the end simulating a work-time break with the closing of their eyes. The first task simulated a working task using an e-mail assignment sourced from an English lesson resource.[1] Participants start with the e-mail task only and were asked to rate the Self-Assessment Manikin on writing the e-mail. Next, participants continued their e-mail with the stimuli setup.

Self-Assessment Manikin

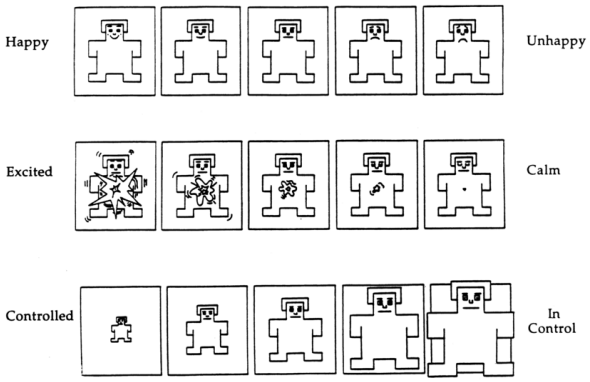

Figure 4.2 The Self-Assessment Manikin

The Self-Assessment Manikin was used as a tool to gain users' emotional self-assessment in reaction to gathered textural stimuli and added vibration. The measurement is based on visuals of three scales: pleasure, arousal and dominance. [52] As participants will be continuing the same task while going through various change in experience, the measurement that allows participants to give quick evaluations was chosen. The PrEmo Emotion Measurement Instrument and Semantic Differential scale were also considered, however, rather than understanding specific descriptive emotions each texture elicit, the author wanted

1 Formal or Informal E-mail Exercise, MacMillan Business English. http://www.businessenglishonline.net/resources/email-english-worksheets/

to survey how participants' perceived happiness, arousal, and sense of control changes dependent on the various attributes of textural stimuli. [52, 53]

4.3. Findings

The evaluation was conducted with 2 male and 4 female participants (mean age = 26.5; with a standard deviation of 3.27, students, workers with full, part or hybrid remote work schedules). The pre-survey and interview formed the understanding of participants' situations. Overall, the prototype was an perceived as an interesting addition to work task. The use of the SAM measurement allowed participants to reflect on their emotion upheavals and they were able to describe in great detail how each material in conjunction with the vibration actuation made them feel.

Figure 4.3 Materials gathered by P1 to P6

In Figure 4.3, materials gathered by participant can be seen. While the author hypothesized that diverse textures and multi-material can offer unique levels of comfort, added stimuli and fidgeting affordance for users to be more engaged and improve their body awareness, workshop feedback indicate there are specific

qualities that make a set-up calming, or stimulating. Fidgeting was also found to be a distinct experience from calming or stimulating effects.

Participants enjoyed the idea of having a context-aware affective tool to improve their work-from-home experience. For a calming setting, participants outlined low intensity and comforting material attributes that affected their experience. Added vibration was also found to have a potential in making participants stimulated and concentrated for some work tasks. With data collected from the workshop and analysis on participants' SAM scores and qualitative feedback, the author gained valuable insights to developing the service attributes, form of an improved Byuuro prototype.

4.3.1 Participants' Remote Work Experience

All 6 participants were under city-wide lock-downs that restricted outings, social gatherings, and in-person activities at the time of the workshop. This meant all conducted their work and school entirely from home (none conducted partial or hybrid work or school at the time).

In interviews, everyone expressed to feel a decrease in engagement, met new communication issues, and to suffer work-life balance in their remote set-up. The lack of environmental stimuli in their home office, including coworker or classmate interactions, movements in the environment, noise, wind, and movement that are a part of natural work environments. For workers, while they had the option of improving home-office environments, upgrading work computers and computer accessories took priority and limited space at home made further adjustments difficult.

- "We're basically looking at these screens all day, I do feel that it contributes to the screen fatigue." (P3)
- "I realized that because of me sitting in front of the screen, reading, reading and reading, that's the only task that I do...It was very mundane for me, I didn't like working [like that]." (P6)
- "I definitely feel that I'm less disciplined and more laxed" "Remote work requires me to be really self-disciplined...and I find that I'm not really[able to be]"(P2)

Anxious Thoughts and Low Moods: Some participants expressed the reduction of external stimuli meant when they experience stress, there are fewer surrounding distractions to deter them from their anxious thoughts. The tendency to be stuck in negative thoughts and new found experiences of low moods and stress at home were a pain point. Participants also noticed the impact of extended computer-use on their mental and physical health.

The below table illustrates participants' basic information and the context of their work & study situations.

Table 4.1 Participant Backgrounds

	Age	Occupation	Living Arrangement	Covid-19 Situation	Struggles
P1	32	videographer	alone	lockdown	loneliness
P2	25	undergraduate	solo, family closeby	lockdown	lack of motivation
P3	27	highschool teacher	alone	6-ppl social bubble	
P4	27	part-time student	share house	6-ppl social bubble	social relationships
P5	22	grad student	alone	lockdown	
P6	26	grad student	with family	total lockdown	remote school communication

4.3.2 The SAM Evaluation of Textures+Vibration

In the workshop, all participants except P5 scored the Self-Assessment Manikins while performing the e-mail task. Conditions assessed include a task-only condition (shown as a grey bar), and a condition for each of the texture+vibration experience set-up (different colored curves). The change in scores for each types of stimuli were compared to the task-only and analyzed.

Overall - Most participants' valence score (perception of pleasantness) increased when using the vibration alongside sponge and fabric materials. In general, with thin textures, vibrations were felt as more intense, and with thicker textures, the vibration was felt to be muffled. Overall, the sponge was the most preferred texture for its amount of give offered and level of malleability that accommodates for the movement of users' wrists when typing. Layered soft fabric, cushions, and sponges all created a form that has the positive preferred attributes of give, softness, and interaction possibility (meaning offer flexibilty to adjust to users'

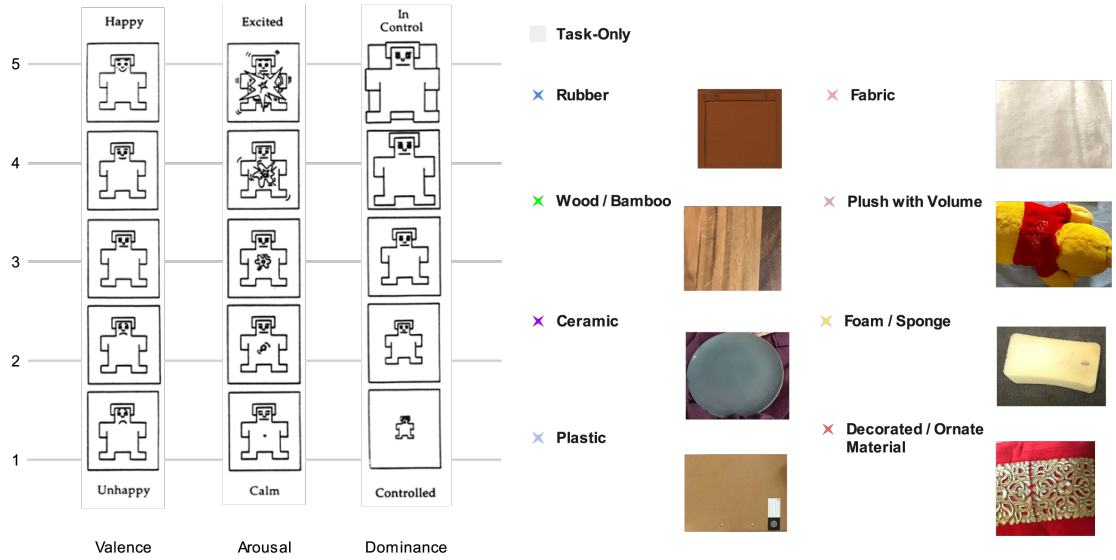

Figure 4.4 SAM scale and categories of participant-collected textures

arm movements and any applied pressure).

P1 - Perceived vibration as pleasant and valence scores improved when all stimuli were introduced. Size and stability of texture for the wrist effected her SAM rating significantly.

P2 - Felt the *Wind* pattern to be too intense and loud stand-alone on the phone. The vibration would permeate to his bones. P2 also found wood cutting board particularly unpleasant due to its rigidity and lack of give that further made the combination with *Wind* painful to his wrist. Sponge, mask, and console textures improved his pleasantness ratings of the felt vibration. P2 said the flexible, cooling, and smooth qualities of the mask fabric and multi-material console with vibration gave him a calming effect.

P3 - Size and thickness of the materials affected the overall experience. A material that adequately transfers the vibration to the skin yet isn't too strong was preferred. With large materials absorbing to much of the vibration and soft fabrics, which are usually nice on the body, are imagined to become tedious and lacking in support for the day-long wrist-support use, the sponge was chosen as the best.

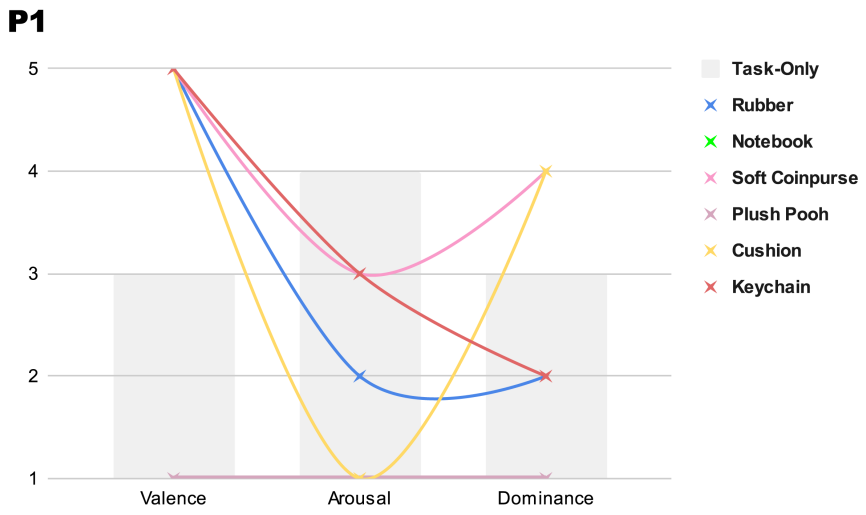

Figure 4.5 P1 SAM ratings of task-only and various texture set-ups

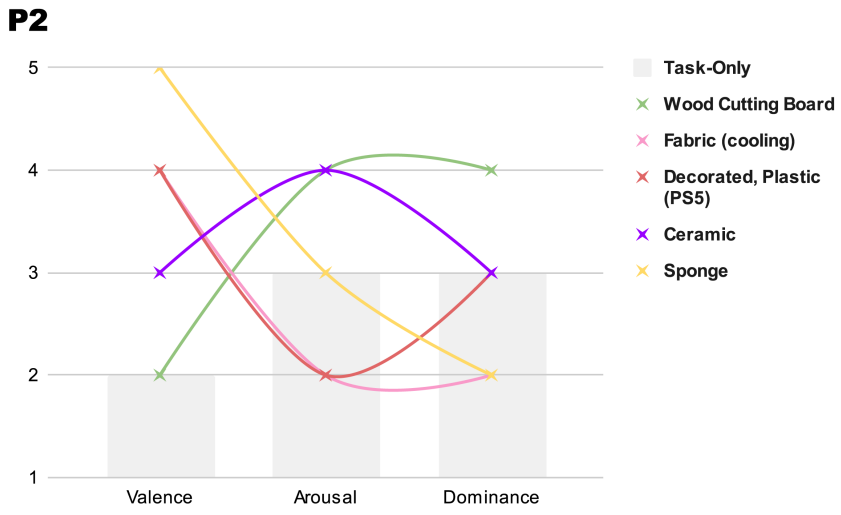

Figure 4.6 P2 SAM ratings of task-only and various texture set-ups

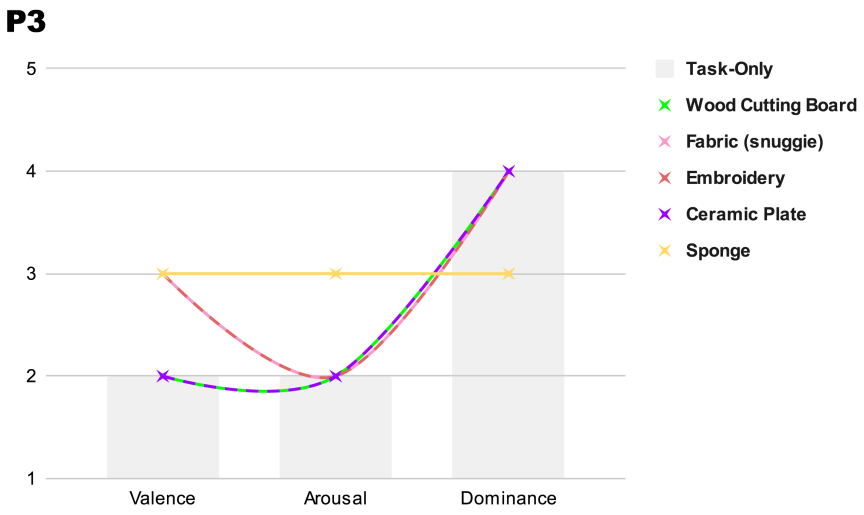

Figure 4.7 P3 SAM ratings of task-only and various texture set-ups

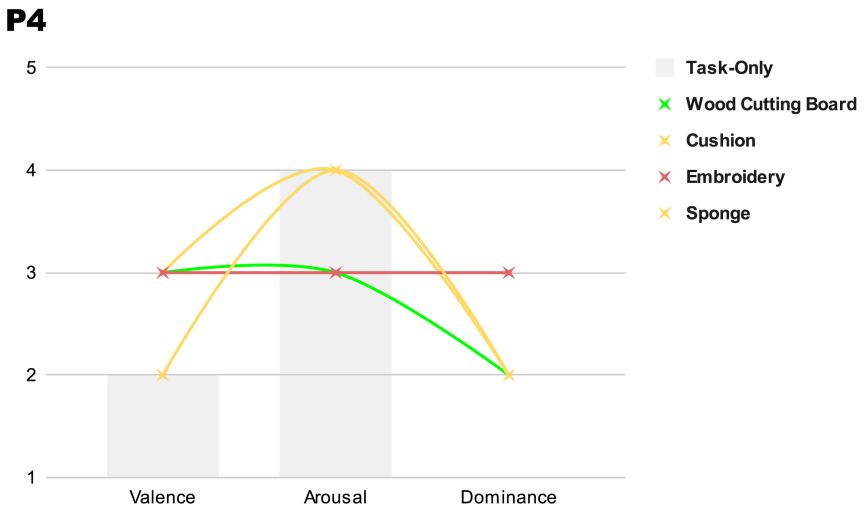

Figure 4.8 P4 SAM ratings of task-only and various texture set-ups

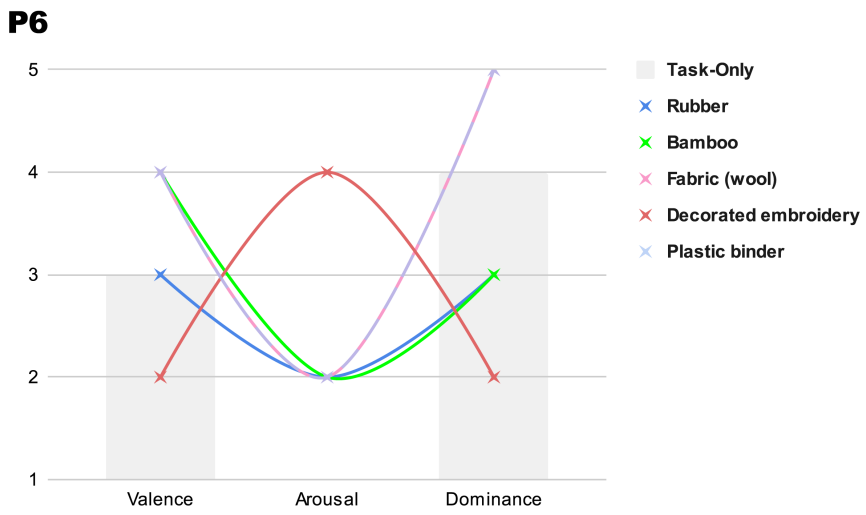

Figure 4.9 P6 SAM ratings of task-only and various texture set-ups

4.3.3 Vibration Evaluation

User's suggestions on vibration stimuli:

- Variability in patterns would be more pleasant and improve the overall experience. Natural patterns that are" non-repetitive but has a logic to it" such as sea waves were mentioned
- Most participants got used to the vibration after five minutes, however, the *Wind* pattern was found to be too intense and similar to notification sounds. The noise was also loud and the experience felt like a separate task demanding attention
- Interest in location adjust-ability of the sensation was raised. Both to other areas around the arm and palms and other body parts such as behind ears and back were mentioned
- One participant raised an interest in experiencing the stimuli as a heartbeat (embedded in thick soft material) and for the system to take adjustable forms to use either as a surface or for a substantial hug-able device

4.3.4 Calming vs. Stimulating vs. Fidgeting

Fidgeting:

Participants differentiated between the use of tactile stimuli for fidgeting versus relaxation. During discussions and closed-eyes rest, participants gravitated to small textures with give or elasticity to fidget with. The characterization of the act is divided. While in some, it is playful and elicited happiness, in others, it is characterized by compulsion and is neutral in affect. During the e-mail task, fidgeting was not performed, and in the activity, passive vibration was more paid attention to. "because of the rating... [I realized] fidgeting might not make you happy, it might give you a sense of control"

Use of Set-up While Resting:

Participants were asked to close their eyes and choose their most preferred texture combinations with or without vibration. Half of the participants chose with vibrations. The task was a simulation of breaks taken in between work. Overall, for half that chose vibration, they explained the texture chosen in combination made them feel calm, a sense of security, they got used to the vibration and it felt like a massage. Others voiced the pattern's strong intensity may be a reason they opted it out. This segment in the workshop tried to look at the use of textures and haptic actuation for rest and fidgeting, however most indicated in the post-survey that they rarely close their eyes to nurse eye strain during the day. Rather, when fatigued, they look at greenery or take naps, indicating the use of Byuuro for closed-eye rest scenarios would be atypical to users' existing habits.

The Experience of Multi-materials

When asked to experience multiple materials together along with the vibration, participants expressed the experience of multiple textures at the same time distracted one from another. Participants seemed to prefer one cohesive texture that encompass the pleasant attributes for this use scenario over using multiple materials. Besides, the incorporation of more haptic interactions (various patterns and actuation) would further diversify a material's felt experience. This diversification of patterns aroused the participants' interests more.

Figure 4.10 Participants fidgeting with stimuli during closed eye rest scenario

4.3.5 Work & Types of Stress

The categorization was selected as it creates a standard across tasks students and remote workers conduct. For example, a problem-solving type work may look like writing assignments for a student and developing a presentation for an office-worker, both types conducted by students and workers alike but in different amounts and specificity. This type of work would differ from communicating with co-workers or instructors, and these tasks may be impacted differently with distance.

Reactionary type tasks were ranked the highest in terms of stress elicited. It was voiced that communication difficulties, including struggles with relationship and replying to messages can stay on the mind. The ranking was followed by problem-solving and insecurity type work. The author further interviewed each participant about the tasks they perform for work and study and factors that impact stress, as well as how they cope with different types of stress.

Circumstances under the pandemic generated new types of stress for many. For example, in reactionary tasks and planning type tasks, the distance meant a difficulty to gauge when to schedule their personal life, hence work-life balance suffers. P6 also expressed needing to plan meetings around many different time zones and have new work in responding with others' who reside and respond in different time zones. Remote work added a new layer of unpredictability to communication tasks. Participants also voice for these unpredictability to give them anxious thoughts, difficulty planning, and anxiety around reactionary tasks. Users expressed a subtle, non-intensive vibration may help calm these anxious thoughts.

Participants expressed procedural tasks when repetitive and they don't feel like

doing them, and they pile up, stress can arise. The vibration was expressed to create a nice stimulating sensation that was interesting, and might make such tasks more enjoyable.

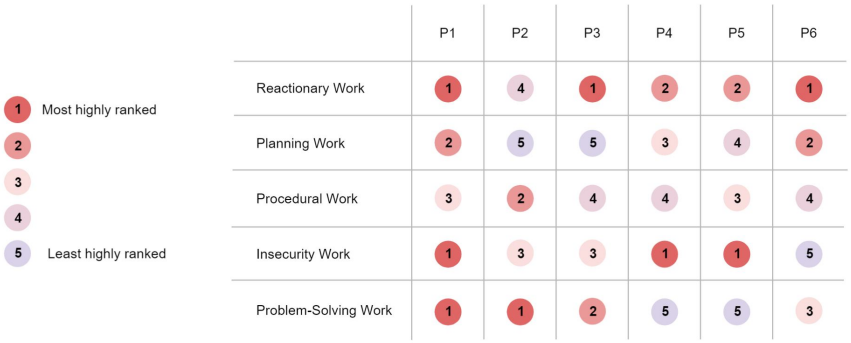

Figure 4.11 Participants Ranking of Types of Work that Elicit Stress

Table 4.2 Types of Work and Stress Experienced by Participants

Type of Work	Tasks Participants Perform	Stress Elicited	Existing De-stress Methods	Unresolved Pain Points	
Reactionary	- responding to others' problems - dealing with relationship with management or co-worker - responding to company news - communicating issues - replying to emails - scheduling time remotely	"dynamic stress because it's unpredictable" "worry about social connections...that call to my attention on my phone" "different time zones...common time... disrupts my day" "stress planning [around other people]" "things don't go as well as you think"	"put my phone out of sight and focus on whatever I need to work on" "going for a walk after, that helps me process it and [feel that] I'm done for the day." "I'll talk to my friends...to not think about stress from my day"	- hard to disengage - because it's connected to other people, there is insecurity, uncertainty and inability to control	
Planning	- waiting for external confirmation in order to plan - planning around other people's schedules - scheduling personal deadlines	"no idea what's gonna happen next, kind of anxiety inducing at this moment" "it can be hard to know in which way you should be doing things" "sometimes I'm unable to finish something in time...I'll be doing it until 3am...and my body is impacted"	"being able to finalize and make a decision will relieve the stress" "take a break from worrying"	- continues to be outside of their control - difficulty in concentrating and managing time remotely that requires self-discipline	
Procedural	- repetitive, predictable administrative work - marking assignments	"if it gets high volume, then it gets kind of stressful" "it's because I'm bored of it, it's one of those tasks you put off...you procrastinate"	"take a break" "do something more fun and exciting" "changing my environment"	- when it's boring and you procrastinate and there isn't ways of making it fun	
Insecurity	- gauging feedback from project members - repeatedly checking for feedback				
Problem-Solving	- problem-solving and making decisions for exceptional cases - school work and assignments - tasks that require solution	"if there were unexpected situations...the fact that you have to pass judgement...can generate stress" "stressed from not having come up with the solution, lacking inspiration for some reason" "when I find it difficulty proceeding I feel stressed"	"engage in other tasks [which does not require] as much mental focus" "find inspiration or look at examples" "take a break from working or thinking" "doing something procedural"	- out of inspiration or don't have examples - difficulty making decision in unexpected situations	

4.3.6 Body Awareness

After the workshop, participants were asked about how the experience effected their sense of body awareness, which was defined as "Body Awareness: " *An overall concept to the awareness between body and mind. It includes body consciousness, body management, and deepened body experience. The concept also concerns the relation between one's own body and feelings, and the perception of the body as "me".*

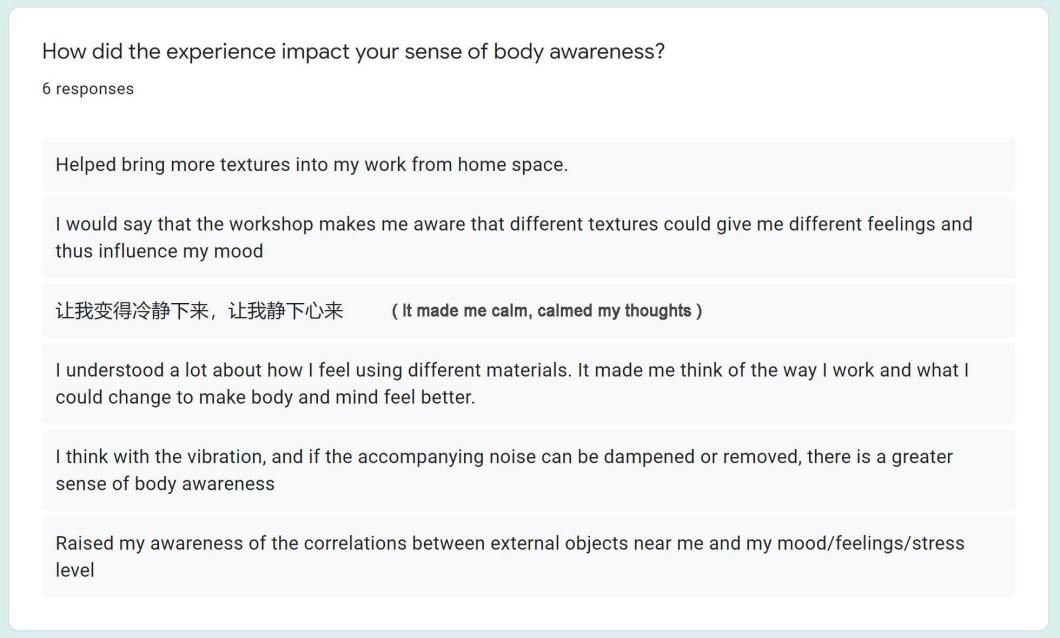

Figure 4.12 response to body awareness

In the initial survey and during the workshop interview, the topic of work-from-home impacts on physical activity level and body engagement were discussed. Participants expressed that city-wide restrictions have prevented their usual outings and physical activity level and expressed extended computer time made their body numb, made they feel physically fatigued. For students that don't have a set 9-5 work schedule, remoteness gave rise to new scheduling and communication workloads. Needing to make time for virtual meetings, and the difficulty to adjust to full remote learning made keeping up with physical activities difficult.

Participants are aware of their own need for physical engagement and actively try to fit in more walks in nature d the method was also expressed to be a crucial stress-relief method. However, activities performed still low compared to in-person work and school. With less opportunity for this life balance, some try to add in physical aspects to computer routines such as brainstorming using sticky notes and taking all notes on paper. Participant 6 expressed to feel more motivated after a task that involves physical engagement, however, it was noted that an exercise like that are only performed around once a month, the regular day of work still consists mostly of still computer-based work. To supplement physical engagement in the screen-heavy remote work, participants voiced tendencies to opt physical writing over digital organization or note-taking tools. The was expressed to insight body engagement, however most expressed it would be more effective

4.4. Summary of Feedback

4.4.1 Experience of Material

Temperature conductivity, stability of surface, comfort level, were aspects participants noticed that affected their valence, arousal and sense of dominance ratings, as well as their preferences for each experience. Participants' preferences for the vibration were also affected by the size, thickness, density (sound conductivity), comfort level, and malleability of textural surfaces.

4.4.2 Byuuro Use Scenario

Combining thematic analysis from the interview, data on the self-assessment-manikin ratings participants gave and change from their rating of the experience of doing the e-mail task by itself. We derived two settings when users perceive use in the experience for a desk-based setting including *type of work conducted, type of stress experienced, state users wish to be in.*

Use of Stimuli for Stress:

One is for moments of stress accompanied by anxious thoughts, or when encountering difficulty in problem-solving work. Participants found vibration over soft

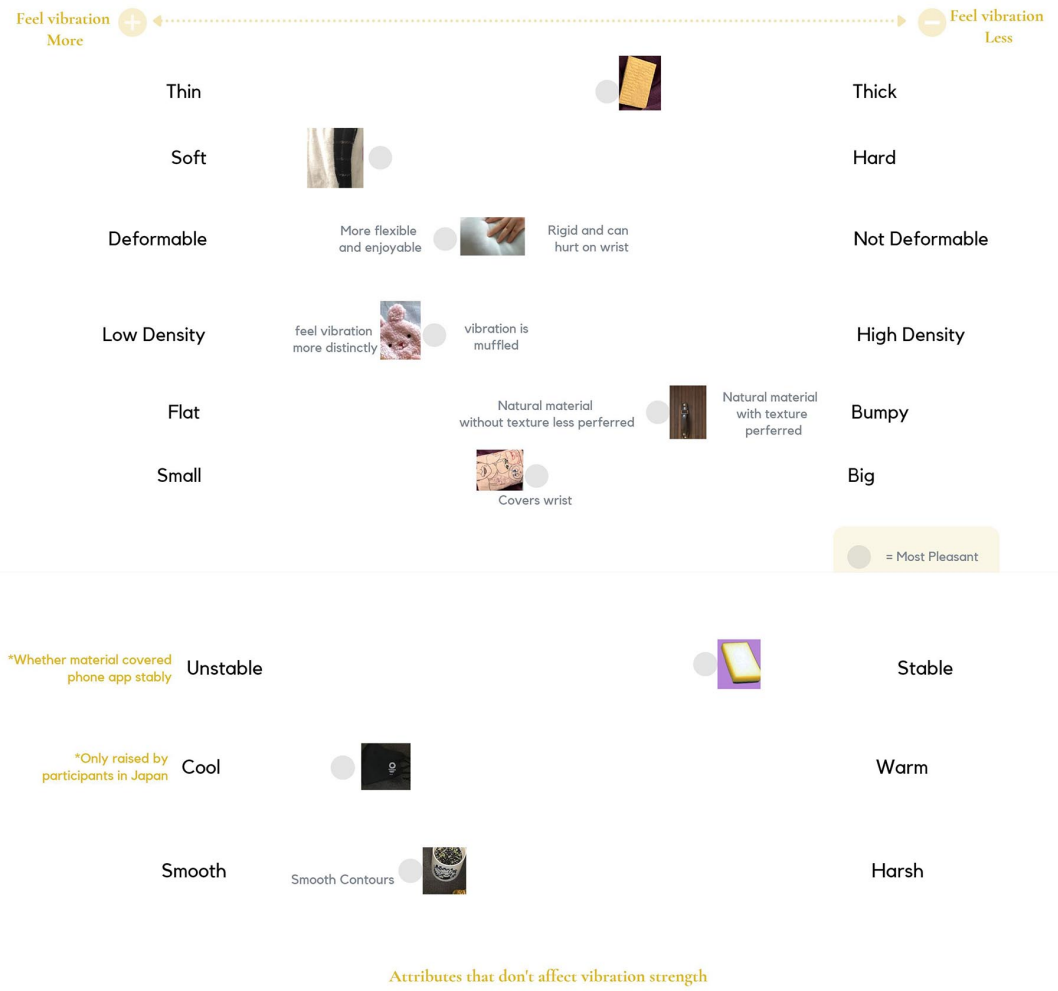

Figure 4.13 Textures attributes affective pleasantness of experience

surfaces to bring about a calming effect, and expressed it could distract them in a good way. Attention to material thickness was noted by everyone. Thickness in soft material was noted to make vibration more enjoyable and cushioning would be nice for long-hours.

"I think its good for de-stressing and relaxing from problem-solving tasks" (P4)

Use of Stimuli for Concentration:

Several participants referred to the stimuli as "something new" that adds interest to their desk set-up. The same participants suggested they would find the stimuli useful to help them focus when performing repetitive tasks, such as procedural tasks.

Byuuro for Grounding Effect:

Participant four expressed "grounding effect" to be potential mode for Byuuro. For P4, when asking about the use of the vibration for calming or stimuli, the participant explain she finds the useful for raising body awareness, and such stimulation are needed when she wants out from a immersive state. Cases such as after spending long concentrated hours writing, or when engaged in imagination, after a while, she finds herself wanting out. Usually she would switch to mundane tasks for the effect, but she foresees Byuuro vibrations to be useful for this need as well.

4.5. Byuuro Calming Pad Development

We take the feedback proposed by participants after evaluating the experience prototype and combine with the technical prototype that had on-going development. More sketches were made around interest points raised by workshop participants such as a wearable-type bracelet form, a full-table size sensation, an adjustable and portable type of from were explored. For the consideration of prototyping and current feasibility for combining with technical elements, the researcher decided on a simple form that allows one set of vibration motor and peltier element to be embeded the technical prototype and combination with the surface textures were

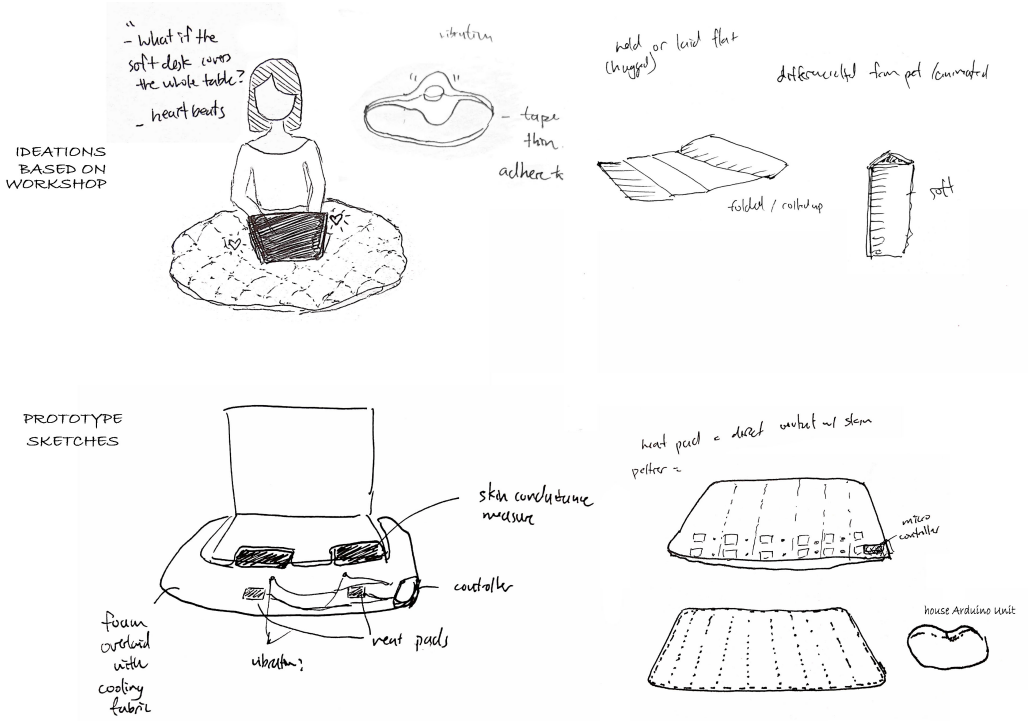

Figure 4.14 Byuuro updated development sketches

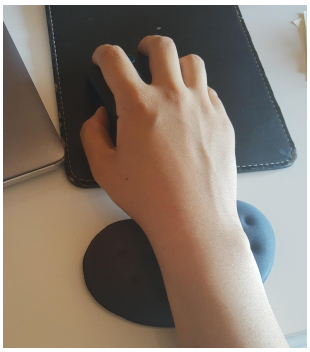

Figure 4.15 Product test of workshop participant-mentioned Ergonomic Memory Foam Wrist Support Cushion

taken into consideration.

The design is refined with feedback on the use case of a calming pad to tackle stressful work situation rather than create a stimulating situation. The system includes the use of a series of vibration cues and thermalhaptics actuation. More sophisticated and 'natural' feeling vibration pattern that user raised was also developed. Thus far, the prototype application looks at stress alleviation, specifically electrodermal activities are found to map to stress and an incorporation to the palm area allows for stress detection and haptic actuation in the same unit.

Users' insights on their own fidgeting observations echoed previous found on design observations.

Figure 4.16 Part of the prototyping process

Prototype Elements and Features

- A foam base was chosen as all participants found the sponge to be pleasant and calming. it was noted that for long hours of computer use, a texture with give that adjust to their wrist and is ergonomic for long-term rest is favored

- A fabric that is cool to the touch was sourced as participants indicated the foam can store heat, and overall in the study, textures that are cooling on immediate contact were regarded as pleasant

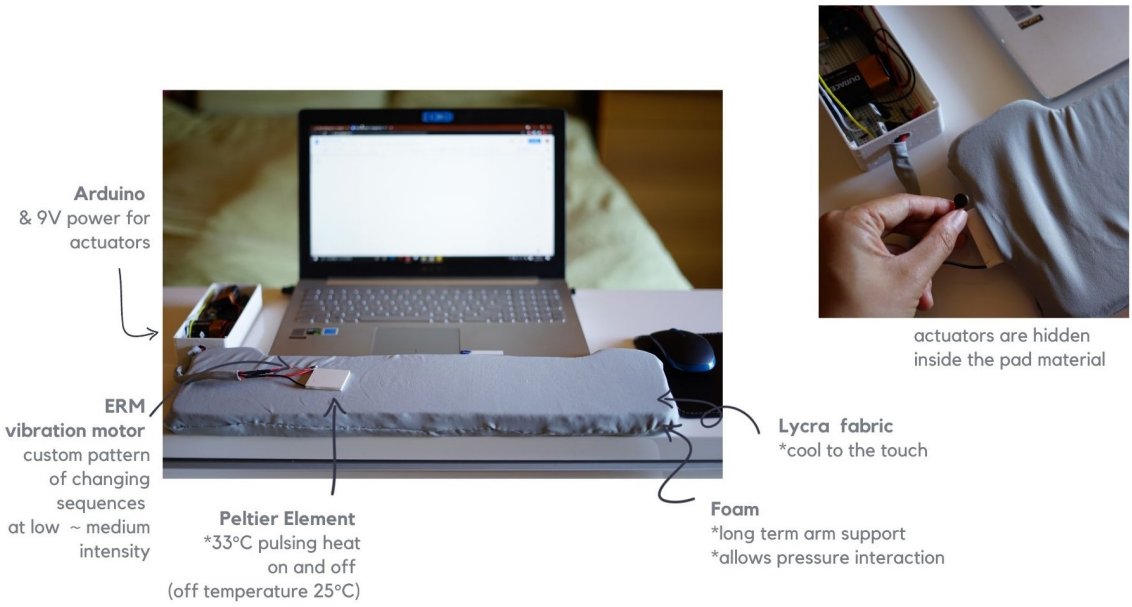

Figure 4.17 Byuuro Calming Pad Features

- A neutral color fabric was also chosen with similar tone to consumer computers as not to be distracting
- One peltier element controlled with a Mosfet programmed to have the gate turn high at 33 Celcius for 7 seconds and off for 6 seconds
- wo buttons programmed for the selection of thermal actuation, and vibration actuation respectively

Chapter 5
Discussions and Extensibility

5.1. Validation of Concept

The validation of the concept is based mostly on qualitative feedback from the testing of the experience prototype on six participants. All six users affirmed to be experiencing senses of isolation and new stress that are hard to relief in their work-from-home environments. Most participants were optimistic and interested in the use of the Byuuro accessory concept to aid the lack of stimuli in their current home office. The result from the evaluation indicate Byuuro can provide valuable interaction to users in isolated work from home situations. First of all, the participants' feedback on their personal stress factors alongside various work types were useful in understanding how haptics can be applied to improve concentration or to calm emotions and perform at-work emotion regulation and stress facilitation. The method also allowed users to give insights to material attributes that create pleasant experiences in combination with vibrotactile actuation. The feedback also inspired understanding to areas that are meaningful for further development.

When asked the most preferred stimuli combination, with or without vibration, half of the participants chose to incorporate vibration. The concept of mapping the experience to stress levels was well-received overall and several expressed they could envision Byuuro helping them with their daily recognition and facilitation of emotions. In an isolated situation, such an experience was raised as meaningful, as blurring of work-life boundaries means it can be harder for us to recognize our own emotions, and further, less opportunities to naturally express or facilitate them.

The study also found materials to provide affective functions in influencing users' mood, echoing related work findings. The use of non-intense vibration with

pleasant materials can improve user's subjective enjoyment of tasks, calmness, and improve sense of control and potentially help ground users when involved in deep thoughts they don't want to further engage in (such as the case of anxiety, intense immersion, or negative thoughts).

Users evaluated a lack of necessity on diverse material in such a surface, instead having one cohesive material allows them to concentrate on the sensation more. Rich feedback on considerations to take into designing the vibration stimuli were also received.

Sensorial properties described from the tools illustrated in Kesteren et al. were utilized in the evaluation criteria of the surface. [14]

With a projection in the continual proliferation of the Working-from-home trend, findings from this thesis and topics dicsussed The use of employed in interactive technology and entertainment may be used to facilitate emotion for computer desktop settings at

There is projected continuation of the Working-from-home trend.

5.2. Limitations

Use of SAM in the Workshop

A limitation to the data from the SAM ratings include the difference in experience setup. As participants did not evaluate the exact same material for each material category, there is a lacking in standardization for the test. To mitigate this, the author conducted in-depth qualitative interviews with each participant on the experience of each material. The use of the SAM tool however, prompted users to evaluate the affective levels of pleasantness, arousal, and dominance not typically articulated in words and enabled rich discussions on detailed sensorial qualities experienced in each set-up. The diversity of the material also gave way to insights on evaluation of attributes and how they affect user as seen in Figure 4.13.

Participants were asked to rate the Self Assessment Manikin on a 5 point scale and during the workshop two participants rated mid-point scores for the closed-eyes evaluations. The 5 points scale did not allow for significant discernment between the experience of various materials in a way as nuanced as participants provided in the qualitative interview. Because of this, the interviews were relied on

heavily to understand the user ratings and the interviewer sought out descriptive and experiential details of each set-up.

However, the use of the manikin allowed on the 3 qualities of experience, which was helpful as a guide alongside the discussion. Users distinguished between situations in which stimulation versus pleasantness are useful as a result. In future work, the use of of a 9-point SAM scale would likely provide more nuanced feedback. Furthermore, a more detailed explanation of the SAM at the beginning of the workshop session may be useful for participants to familiarize with the scale ratings.

Materials Evaluation

Although the author offered participants to purchase materials and offered reimbursement for them, participants chose to look for items around their home rather than purchasing new material. It may be due to the cutting back of in-person shopping with the pandemic restriction making the collection of equivalent material unfeasible. With this, it is important to understand differences in materials effected the SAM data and analysis were weighted on sensorial descriptors much more heavily as a result.

5.3. Next Steps

5.3.1 User Trial

With the new iteration and prototype, a future step is testing with participants in controlled settings to see how target users respond to heat and vibration patterns alongside computer-based tasks. We plan to recruit study participants for the same target group as the workshop study (workers conducting at least part time work-from-home or students who spend extended periods of time performing solitary study). In the updated iteration, three buttons are implemented in the design to allow user input, one button activates a five minute **vibration pattern that varies in intensity and speed**, following workshop feedback. A second button has a **pulsing thermal pattern** generated by a peltier module.

Participants will perform the e-mail task continuous in all three conditions.

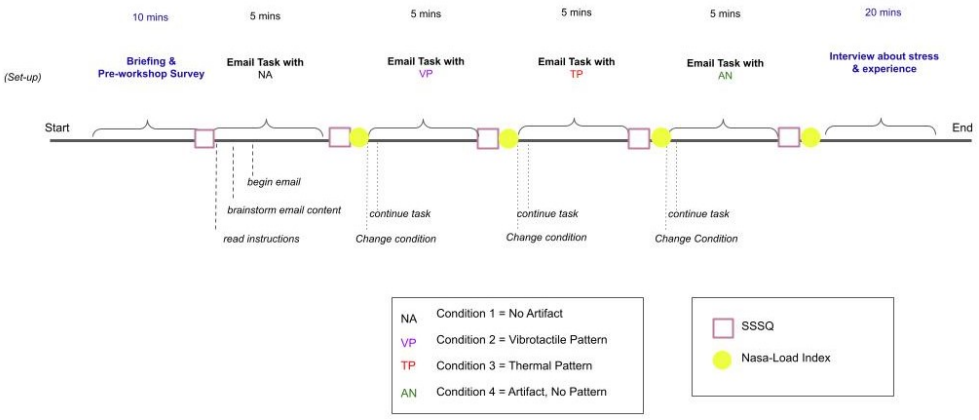

Figure 5.1 Rough user trial experiment session plan

After two minutes under each condition, they will be instructed to press another button for the different condition. At least 15 seconds interval will take place between the use of the conditions as studies have advised the experience of thermal cues may be effected by the *thermal adoption effect*. [23]

After a set of test on Byuuro updated the incorporation of **Galvanic Skin Response** sensor is also necessary to fully test the device in use and survey how users find the device along with their regular work. [49]

5.3.2 Service Design

Feedback from workshop participants indicated several directions that can be taken to develop Byuuro further into a service. Users suggested having select-able modes and bio-sensing modes can make the system adapt to different uses. Many suggested subtle nature-derived patterns, such as ocean waves, would be pleasant and enjoyable. The design of this interface and the number of modes select-able can be further developed.

Interviews with participants paved our understanding of the tasks they perform in remote work, types and roots of stress that arises, and their personal routines for coping. The data can form the basis of future work in developing Byuuro to provide guided patterns to help different types of tasks and tackle different types of stress.

Users also suggested the system can accompany existing ambient services built to accompany remote works, such as ones simulating cafe environments or nature. Participants expressed the vibrothermal cues can be non-distracting additions to improving these audiovisual-based experiences. The haptic stimulation can neutralize the load on visual information with are often already heavily loaded with our dominant tasks. This can allow us to immerse in a virtual environment services without overwhelming our audiovisual modalities

Byuuro can also be used to provide rich music-like haptic sensations if further incorporating small piezzoelectric haptic actuators that use audio signals. This can allow for the experiencing of sophisticated music-like patterns on the body directly from one's desktop. A future potential is also online libraries for haptic patterns where sound artists and haptic designers can design therapeutic calming experiences for the haptic modality users can enjoy.

5.4. Extensibility

Remote Participatory Workshop

The session from home allowed participants to reflect and discuss their work routines and pain points by directly referencing their work-from-home environment. Participants were comfortable interacting with the setup and had no trouble describing how each texture, in combination with vibration, made them feel; as well as how slight differences in texture (i.e. fabrics differing in fibre lengths) elicited a difference in their subjective affective response. Compared to a controlled setting in typical research facilities, in the understanding of users' work habits, a remote workshop featuring the use of experience prototypes were found to be effective for understanding users' subjective experiences and the sessions informed the application of material for improving mental wellness greatly. The use of this type of remote workshops and set-ups may be useful for specific context-based participatory research in various research fields.

Use of the E-mail Task

The workshop evaluated participants' reception of vibrotactile with somatosensory stimuli on e-mail tasks (which are categorized by participants for reactive-type work and problem-solving-type work). Reactive and problem-solving were the two most highly ranked task type in stress encountered, and most participants voiced to feel stress from the assignment as the task felt like work. The participants who voiced this were also ones who ranked Reactionary type work as the most or second most stressful in the pre-survey. The use of the e-mail task was shown to be a good representation of typical tasks performed at work, and users that are stressed by reactive and problem-solving type tasks found the assignment similarly stressful. This shows potential in using this type of assignment to evaluate stimuli under reactive and problem-solving type work.

Designing with Materials

The workshop surveyed interactions with objects users who work from home take on during their working and studying hours. This thesis explored added affordance to materials by activating materials through the incorporation of actuated vibration and heat. Overall, actuation and the exercise brought users to consider materials' affordance beyond visual aesthetics, raising awareness of the subtle material qualities that affect their interaction with objects and their own bodily felt experience.

5.5. Future of Working-From-Home

In recent years, we have seen the digitization of ninety percent of our industries and the increase of demand for digital skills has shifting how we work. expected. [6] With Society 4.0 and the implementation of wide automation and AI that supersedes the manual and service work-force, workers opting for high digital jobs with more resiliency are expected. [6] As large population spend more hours working digitally and technostress seldom addressed, workers may find the same issues encountered as large working populations still experience under the Covid-19 pandemic. [4] Furthermore, work trend reports predict future offices will shift to

a flexible hybrid format, signaling the pertinence of this issue. The explorations of Byuuro have shown that work-from-home users with limited outings found affective materiality to engage their somatic senses and add a new dimension to their computer-based work experience.

Byuuro can accompany remote work in creating stimulation for these workers. Students are another user group where individuals perform long hours of solo computer-based work heavy in problem-solving type task. For at-home or solo studying, Byuuro can also accompany these users and detect stress signals continuously to provide direct feedback that would improve user moods without needing active user-directed interventions.

The proposal of this thesis and findings on the use of affective material and haptics for affective purposes can be further extended to the design of consumer technologies toward positive and calming technologies. The final prototype has also been demonstrated conceptually to be useful for users. With further development and tests, Byuuro can be a sophisticated accessory that reacts and adjusts to remote-working needs. Adopting biosensing would further highlight a future potential of such technology to monitor and guide our mental health in consideration of our cognitive load and mental health levels while we perform work digitally.

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Appendices

A. Material Index Example

B. Interview Work Desk Objects Notes

C. Byuuro Evaluation: Pre-Workshop Survey

D. Byuuro Evaluation: In-Workshop Email Task Worksheet

Figure A.1 A portion of the Material Index

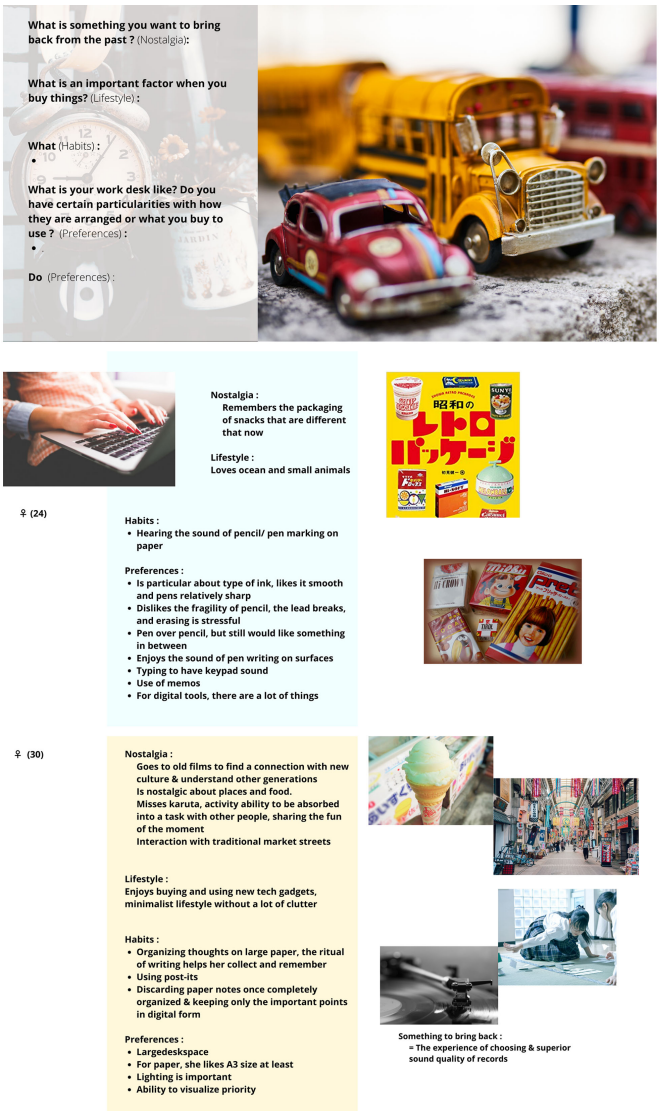
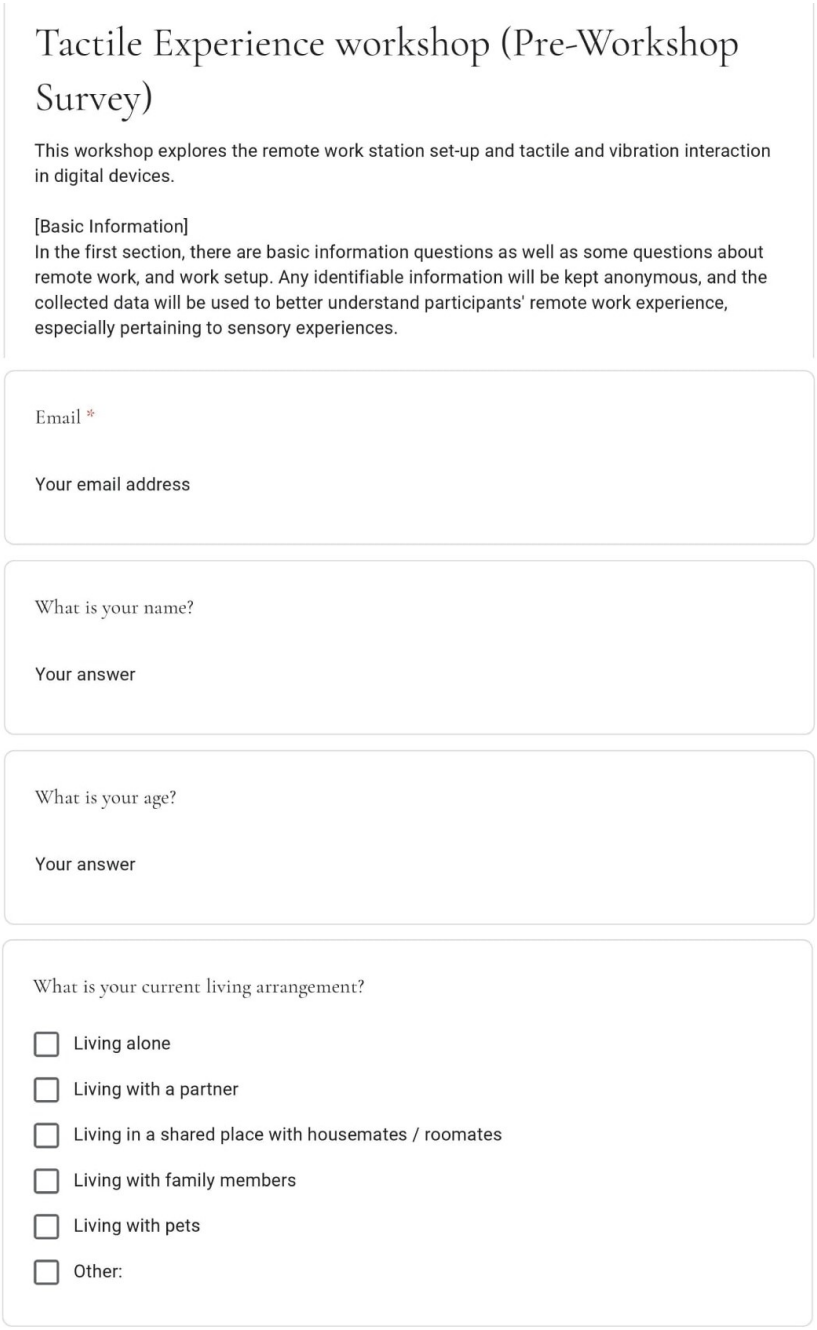


Figure B.1 Work Desk Objects and Nostalgia Interview Notes I

Figure B.2 Work Desk Objects and Nostalgia Interview Notes II



Tactile Experience workshop (Pre-Workshop Survey)

This workshop explores the remote work station set-up and tactile and vibration interaction in digital devices.

[Basic Information]
In the first section, there are basic information questions as well as some questions about remote work, and work setup. Any identifiable information will be kept anonymous, and the collected data will be used to better understand participants' remote work experience, especially pertaining to sensory experiences.

Email *

Your email address

What is your name?

Your answer

What is your age?

Your answer

What is your current living arrangement?

- [ ] Living alone
- [ ] Living with a partner
- [ ] Living in a shared place with housemates / roomates
- [ ] Living with family members
- [ ] Living with pets
- [ ] Other:

Figure C.1 Pre-workshop survey page 1

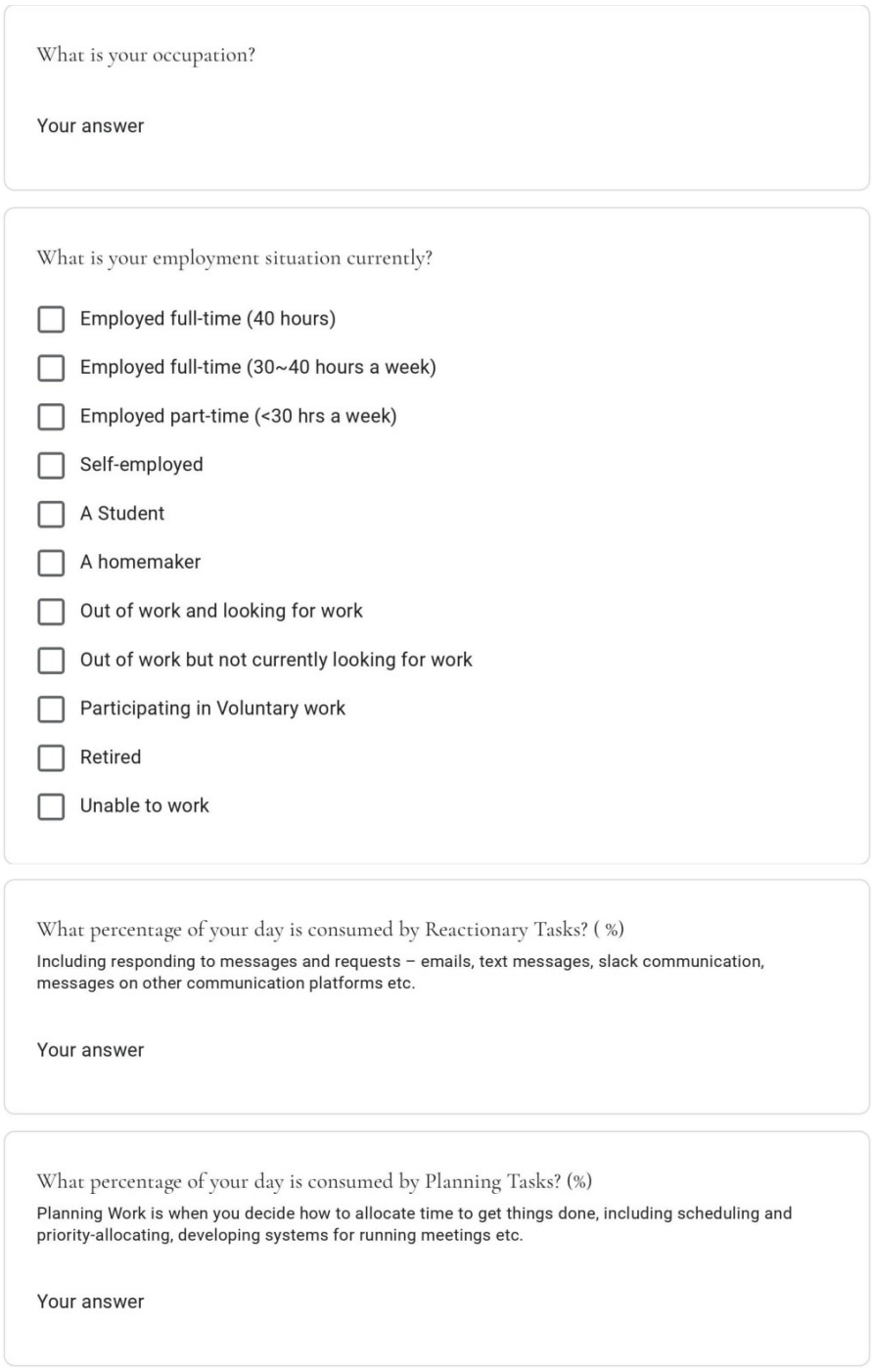
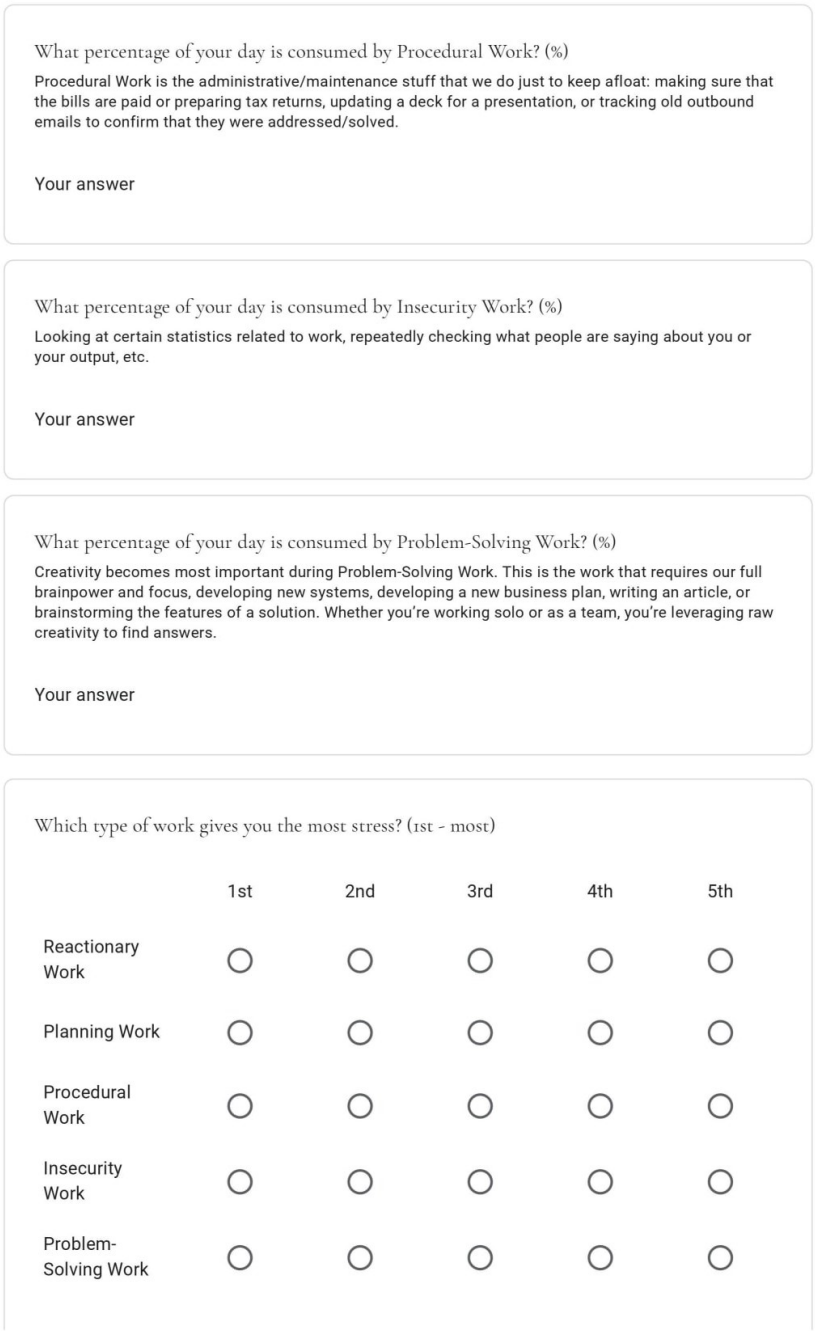


Figure C.2 Pre-workshop survey page 2



What percentage of your day is consumed by Procedural Work? (%)

Procedural Work is the administrative/maintenance stuff that we do just to keep afloat: making sure that the bills are paid or preparing tax returns, updating a deck for a presentation, or tracking old outbound emails to confirm that they were addressed/solved.

Your answer

What percentage of your day is consumed by Insecurity Work? (%)

Looking at certain statistics related to work, repeatedly checking what people are saying about you or your output, etc.

Your answer

What percentage of your day is consumed by Problem-Solving Work? (%)

Creativity becomes most important during Problem-Solving Work. This is the work that requires our full brainpower and focus, developing new systems, developing a new business plan, writing an article, or brainstorming the features of a solution. Whether you're working solo or as a team, you're leveraging raw creativity to find answers.

Your answer

Which type of work gives you the most stress? (1st - most)

	1st	2nd	3rd	4th	5th
Reactionary Work	○	○	○	○	○
Planning Work	○	○	○	○	○
Procedural Work	○	○	○	○	○
Insecurity Work	○	○	○	○	○
Problem-Solving Work	○	○	○	○	○

Figure C.3 Pre-workshop survey page 3

If there are other types of work unlisted, can you explain the category and the % of time it consumes? Where does it fit in the scale of how stressful it is?

Your answer

Example of photo of desk set-up

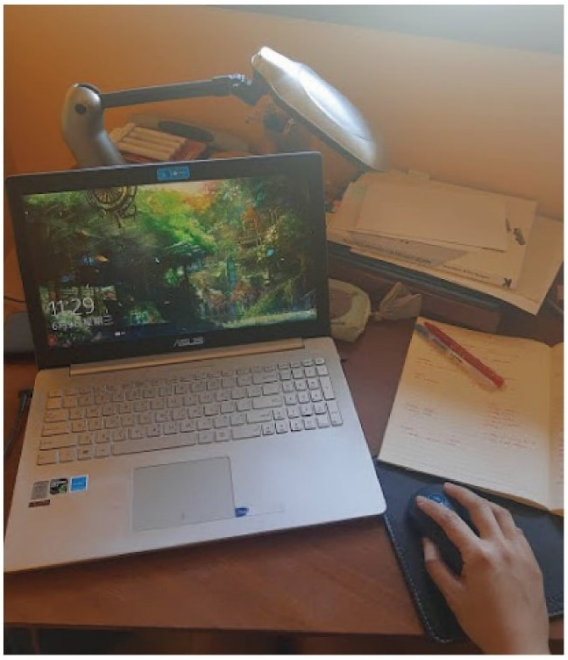


Figure C.4 Pre-workshop survey page 4

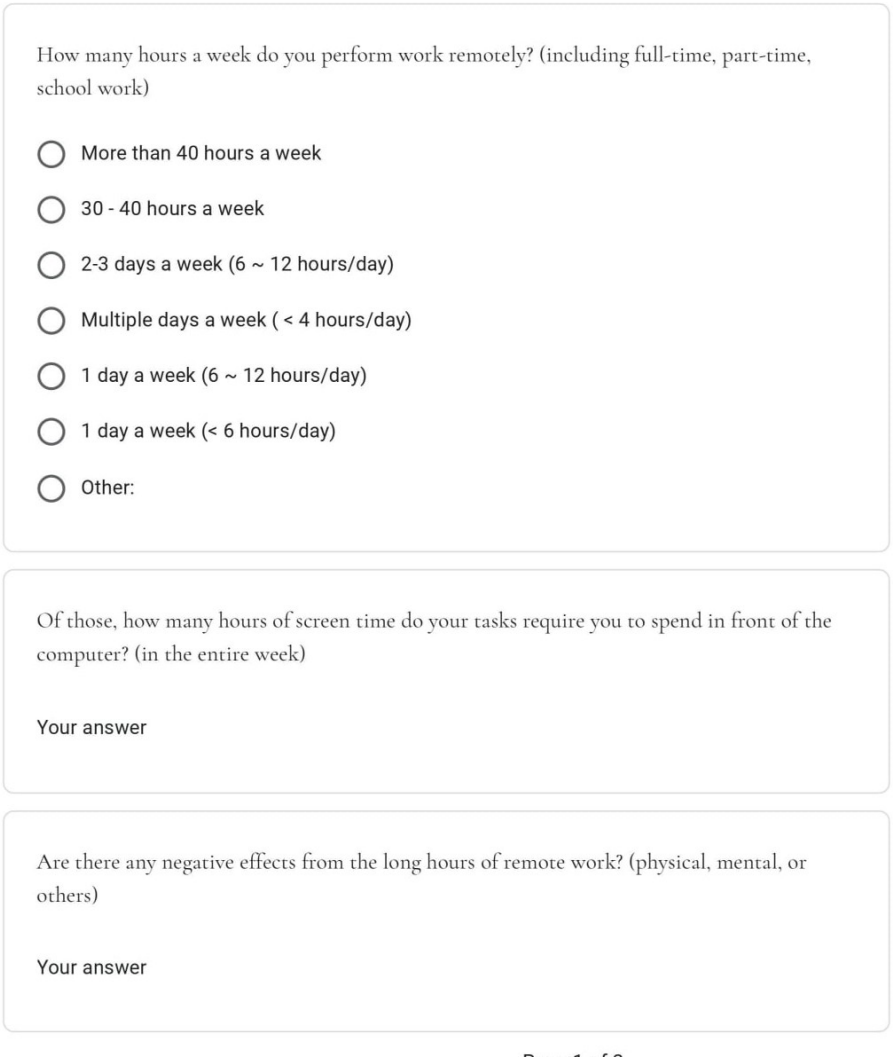


Figure C.5 Pre-workshop survey page 5

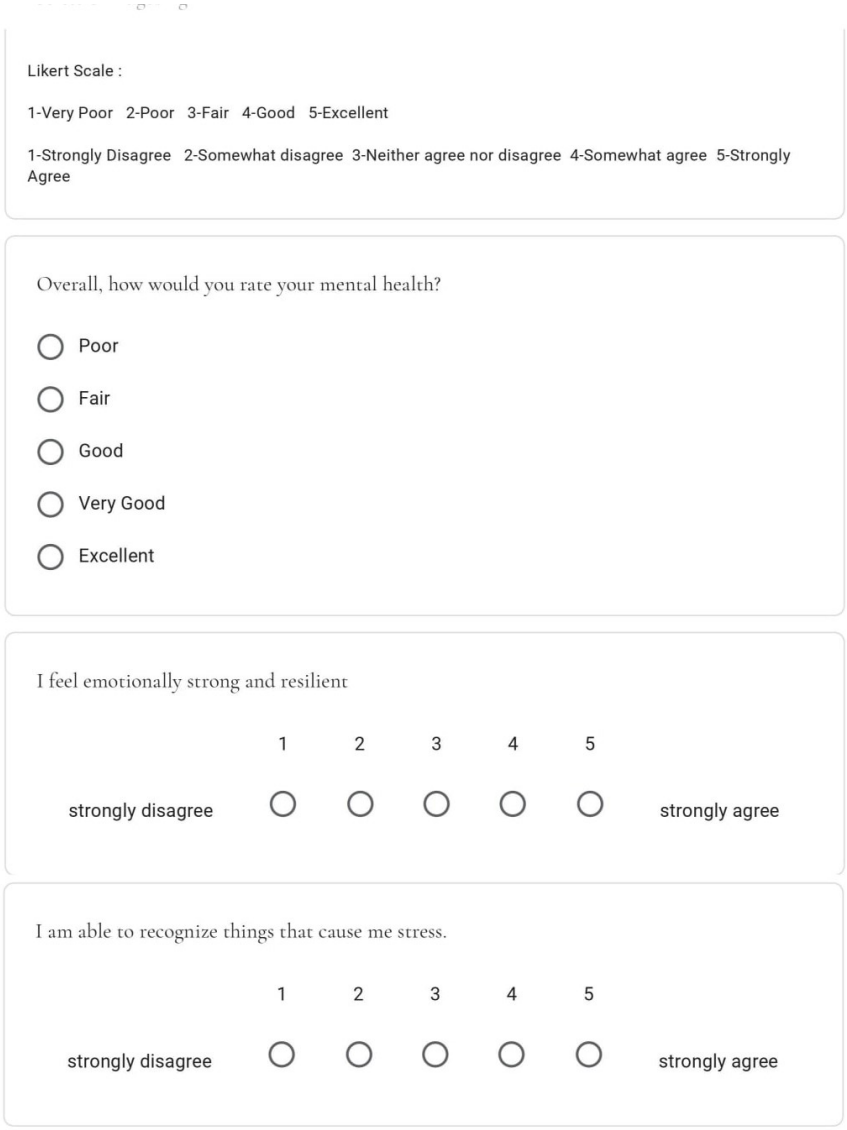


Figure C.6 Pre-workshop survey page 6

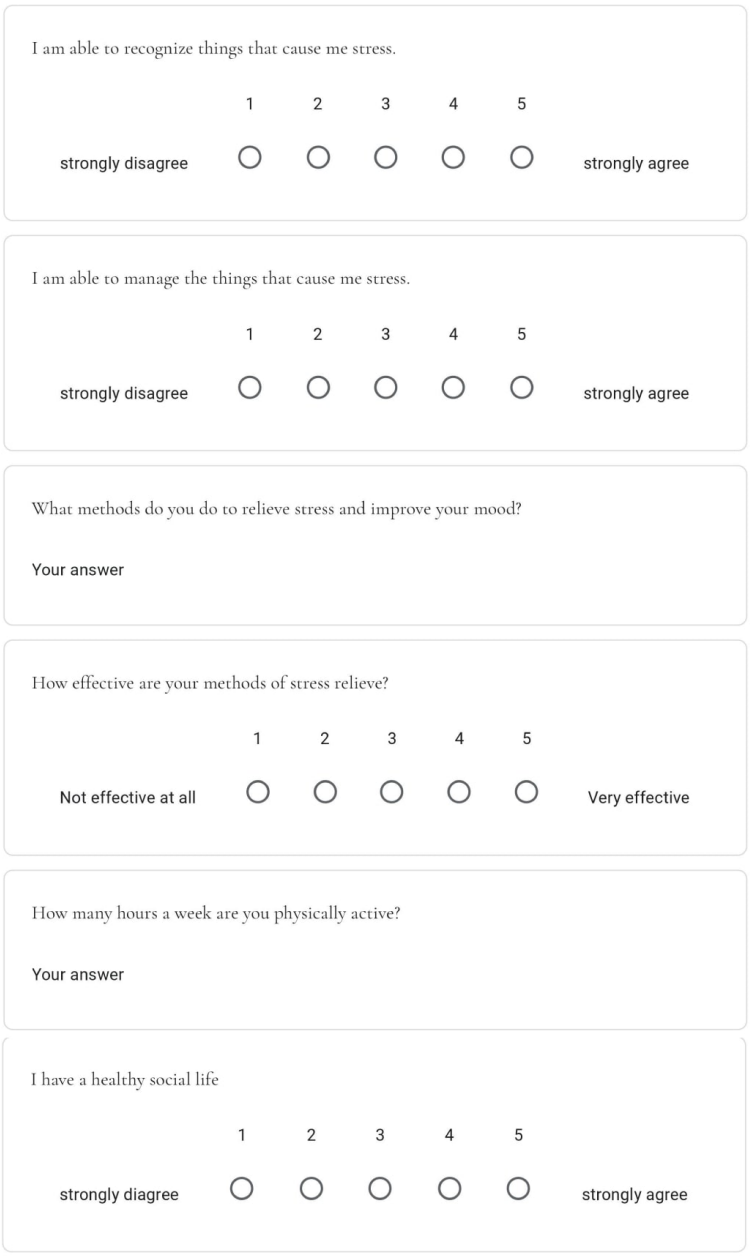


Figure C.7 Pre-workshop survey page 7

Figure C.8 Pre-workshop survey page 8

What type of tasks are you performing when you fidget?

- ◯ When I'm thinking
- ◯ When I'm reading/ studying
- ◯ When I'm stuck on something
- ◯ Other:

Fidget Toys

Do you use fidget toys? What is your experience with them?

e.g. How old were you when you used them? For how long did you use them? Do you use them now? Are they more decorative art objects or do you actively use them?

Your answer

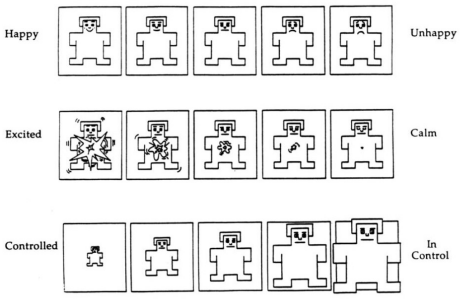
Thank you for answering the Pre-workshop survey!

Figure C.9 Pre-workshop survey page 9

Please give a rating of the task so far: e.g. RowA 1 ; RowB 4 ; RowC 3

(Only Email) 1 4 3

1 2 3 4 5



Material #1

Material #User Selected 1

Material #2

Material #3

Material #4

Figure D.1 Worksheet page 1 - E-mail Task

Please draft an email with the following instruction:

(there will be some interactions in the middle of the task the interviewer will ask you to perform)

Write to a customer to tell them that the product/service they want is not available at the moment.

Prepare the situation using the questions below. The information can be real or imaginary.

- What is your company's business? What products/services do you offer?
- What is the particular product/service that you normally offer, but is not available at the moment?
- Why?
- When is it going to be available again?
- Who is the customer that you are writing to? Why do they need your product/service?
- Are you going to promise any action, give additional information, offer help, or simply say that you will tell them when the product/service is available again?

Figure D.2 Worksheet page 2