

Aggie Chang

1007563

Willem de Kooning Academy

Product Design/

Commercial Practice

Supervised by Jan Melis and Peter Kalkman

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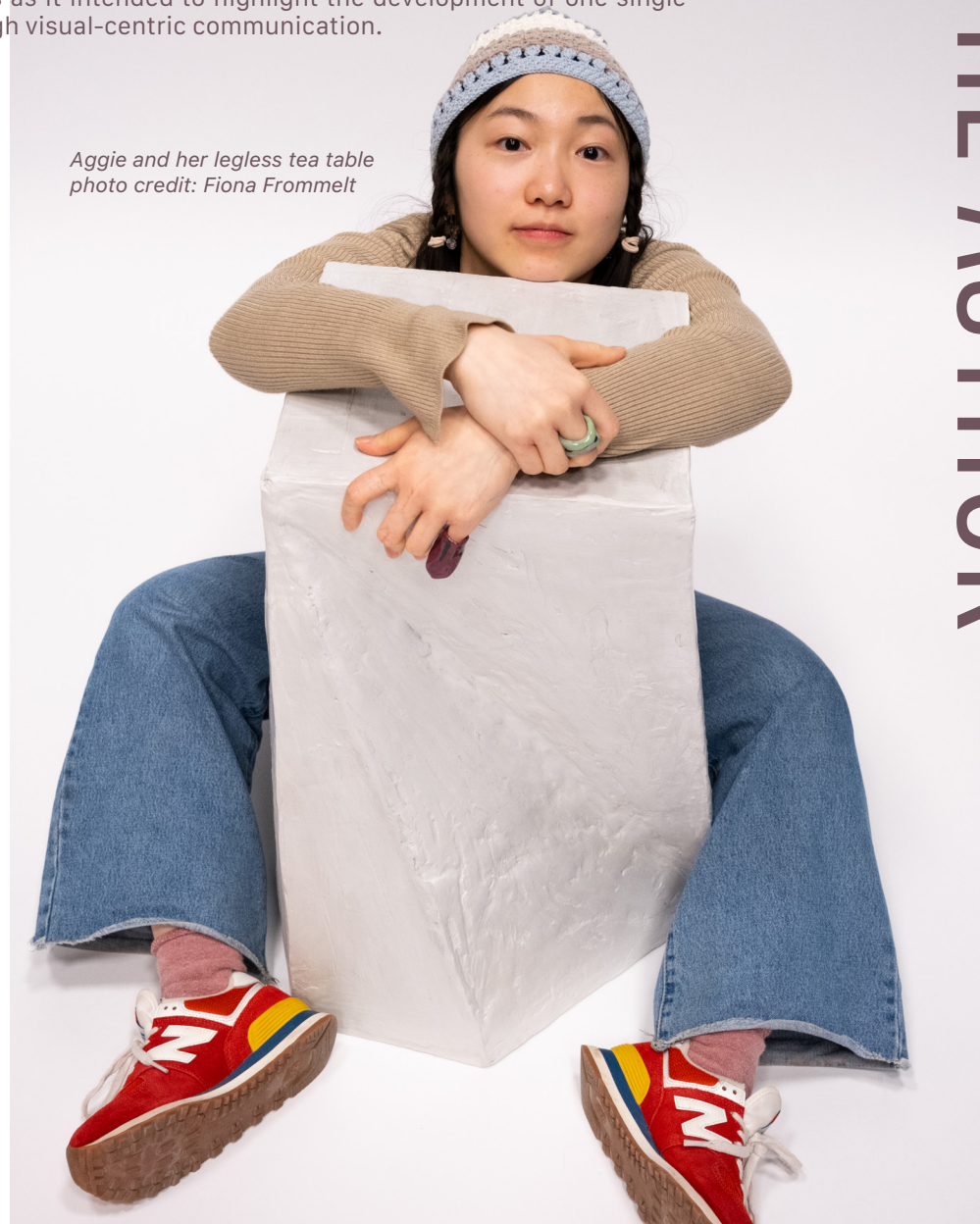
SPACESHIFT020



Aggie Chang is an innovative product designer who combines speculative thinking and scientific methods to reimagine future interactions with technology, particularly in the form of tools, peripherals and everyday systems we often take for granted. Throughout her journey at Willem de Kooning Academy, she discovers an urge to provoke reconditions on societal norms: **Does it still make sense to do things the way we always have?**

A self-initiated project in her second study year heavily influenced the form of this graduation thesis: Portfolio Magazine, created with Fiona Frommelt. Together, they pushed their institution to create a platform that truly showcased its students as the talented young artists they are. Said project evoked her love for visual journalism and defined the format of this thesis as it intended to highlight the development of one single object through visual-centric communication.

*Aggie and her legless tea table
photo credit: Fiona Frommelt*



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During the preparation of this work the author used *ChatGPT-4-turbo* and *Grammarly* in order to enhance grammatic accuracy and smoothen the flow or reading. After using this tool/service, the autho reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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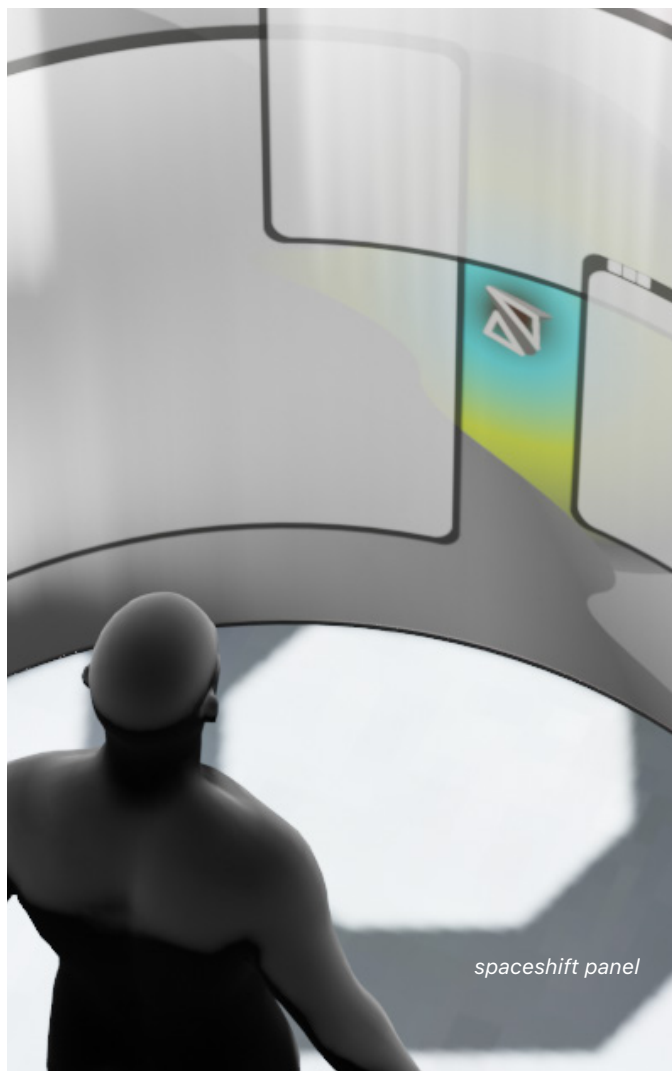
Does it come as a surprise? On average, office workers spend **6.5 hours daily** in front of computer screens (Becton). Is it hard to imagine? A high proportion of office workers experience musculoskeletal symptoms in their necks, backs, wrists and shoulders (Janwantanakul et al.). Although repetitive motion is commonly considered a primary cause of musculoskeletal injury. By itself, however, it is rare. The true concerns of such injuries lie in situations when awkward posture, position and/or forceful exertion is present (Colorado State University). The multimillion-dollar industry emphasises freeing human minds through advancing screens and smart glasses. Yet, one’s body remains stiff, arms glued to the table, and a question arises:

How can we (re)invent a peripheral to give office workers greater physical freedom in front of screens?

This thesis documents the author’s journey through contextual analysis, speculative thinking, technical prototyping, and hands-on product experience testing; a multi-dimensional learning process across understanding the cultural role of peripherals to acquiring engineering skills and refining user experience through design methodology.

SpaceShift was a speculative design project conducted two years prior to this thesis. It aspired to reinvent the workstations and their accompanying peripherals, such as computer mice and keyboards, providing office workers with greater physical freedom when handling basic digital tasks. SpaceShift consists of three key components: a large workstation with a life-sized screen and integrated storage, an air mouse and a single-hand keyboard. The panel expands the workspace, freeing the constraints of chairs and desks when accessing a computer. Meanwhile, the air mouse and keyboard provide intuitive, seamless interaction with the panel. Together, these elements form a new foundational system for digital operation.

Building on the speculative foundation of SpaceShift, this thesis — **SpaceShift020** — **focuses on reimagining computer mice and keyboards, with a primary emphasis on enhancing user experience and collecting user feedback.** Unlike most of the author's previous projects, which often prioritise conceptual innovation over practical applications, SpaceShift020 shifts towards real-world usability and iterative design.



David Kurlander, a former member of Microsoft's User Interface and Graphics Research Group, has pointed out that not only are mice and keyboards an extremely fast and efficient way of interacting with computers, but they have been at the centre of desk-top working for decades, it would take the users some time to get familiar with the new technological options (Thomas). Hence, instead of replacing mice and keyboards completely, the ultimate goal of this thesis is to evolve computer peripherals to better meet modern demands, namely, long screen time and extended working hours. In the following content, peripherals include input devices like computer mice, controllers, trackpads, and keyboards. Here it explores their potential adaptation to emerging technologies.

The project vision for SpaceShift020 can be understood through two perspectives: the surrounding environment for which this peripheral is designed and the device itself amid the rise of voice control, gesture control, and potentially mind control — technologies that aim to drastically reshape human-computer interaction. Unlike the futuristic mixed-reality environments enabled by devices like Vision Pro from Apple Inc., a spatial computer released in 2024 (Rosenberg), SpaceShift020 envisions a more accessible, human-scale screen setup. While immersive technologies may revolutionise virtual workspace, a thoughtfully designed free-standing screen with adaptive peripherals could equally provide a productive environment for office workers.

SpaceShift020 ideates its peripheral to be an extension of familiar multi-touch gestures through intuitive hardware for a wide range of users. Contrary to voice control, peripherals can support private tasks and confidential text entry essential in an office context. Despite the impressive application of fast eye tracking and pinch-select navigation in Vision Pro's system, there are notable limitations. "I do not think people realise how often we control without directly looking (at the target object)," says Marques Brownlee, a well-known consumer electronics reviewer, "With Apple's gesture control, you look at the button to select it, and if you look at the next thing you are going to do, you are no longer controlling the button" (Brownlee). Brownlee further notes that typing on the virtual keyboard is hindered by the developers' choice to only detect pointer fingers, reducing efficiency. Although alternative user interfaces promise new methods of interaction, few allow physical freedom without compromising privacy, tactility and efficiency. This transforming consumer appetite underscores the need to reimagine peripheral — balancing greater physical freedom and respecting user boundaries.

Self-Directing Learning

As part of this thesis research, the author engaged in self-directed learning, completing several online courses to acquire the necessary theoretical and technical knowledge:

Introduction to User Experience Design (Coursera) introduced foundational concepts in user experience (UX) testing and provided guidance on designing scientific methods for evaluating prototype performance. This course reinforced the author's interest in bridging design, science, and engineering technology. It covered a systematic approach to design in identifying useful and usable design criteria, conducting UX testing, and implementing test feedback. Additionally, it offered detailed instructions on planning and executing effective user research (Arriaga).

C++ (W3Schools) supported the author's understanding of programming concepts required to build functional prototypes.

For beginners and self-taught engineers, Arduino serves as an accessible entry point into technical prototyping. As an open-source electronics platform based on easy-to-use hardware and software ("What Is Arduino?"), Arduino's resources are written mainly in C++, a coding language widely adopted in hardware engineering. This course provided essential knowledge to tailor code for prototype development.

Secondary Research on the Archive of Product History and Product Variations

To develop new forms, it is essential to first understand the evolution of existing ones. This project investigates the history and variations of computer mice and keyboards to explore how user needs, technological constraints, and preferences have shaped them.

This historical review reveals that many innovative alternatives have failed, not necessarily because they did not excel beyond the existing system, but rather due to a lack of familiarity. The QWERTY keyboard, as an example, was originally designed to reduce mechanical jamming. In contrast, the DVORAK layout (1936) aimed to increase efficiency, yet failed to gain mainstream adoption due to entrenched habits and inertia (Mary Bellis). This thesis explores balancing innovation with familiarity, proposing alternatives that feel both novel and intuitively usable.

The findings are visualised in two **infographic timelines** (pages 7-10), outlining key milestones in the development of computer mice and keyboards.

Secondary Product User Review on YouTube

In the digital era, video reviews offer valuable insights into consumer perception of products and their usability. YouTube, as the leading platform of the industry, serves as a rich archive of user reactions.

Creators such as Marques Brownlee, who has been reviewing consumer electronics since 2008, provide early hands-on evaluations of products like the Apple Vision Pro (2024). These videos document first impressions, usage context, and detailed evaluations of features, such as the Vision Pro's gesture-based controls. Reviewers often conclude with personal assessments comparing the product to existing options. These insights inform the thesis by highlighting common user expectations and usability concerns.

Hands-On Research

The core of this thesis is set in a hands-on design research process, where the author engaged in iterative making as a form of inquiry. This process involved analysing research outcomes, generating concept sketches, building functional prototypes, and critically evaluating each step. This cycle of making and reflecting embodies a practice-based approach, emphasising the role of tactile exploration and material testing in knowledge production.

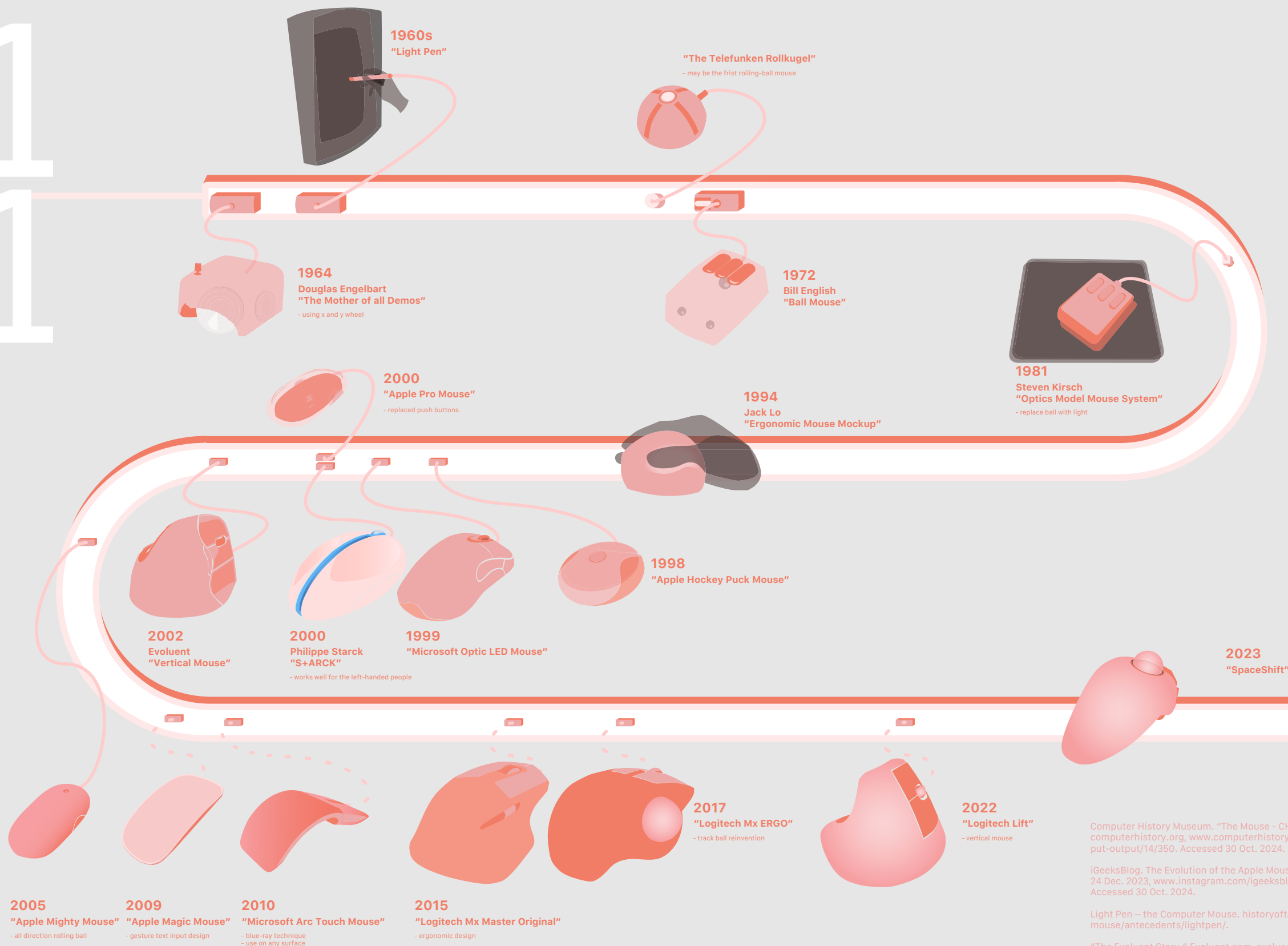
User Experience Test

The final stage of this research includes a user experience test designed to observe user interaction with the prototype.

While this is not the end of the product development cycle, it is the product's debut for an initial public evaluation. The test has two purposes: first, to collect actionable feedback for the improvement of the next prototype; and second, to assess the user's general reaction. Are the current physical and visual materials sufficient for the users to understand how the product can be used? Is the form and interface intuitive? Is the interaction positively received?

The data collected from this test provides insight into how the prototype is perceived in real-world scenarios, offering crucial input for ongoing refinement.

COMPUTER MOUSE TIMELINE



Computer History Museum. "The Mouse - CHM Revolution." www.computerhistory.org, www.computerhistory.org/revolution/input-output/14/350. Accessed 30 Oct. 2024.

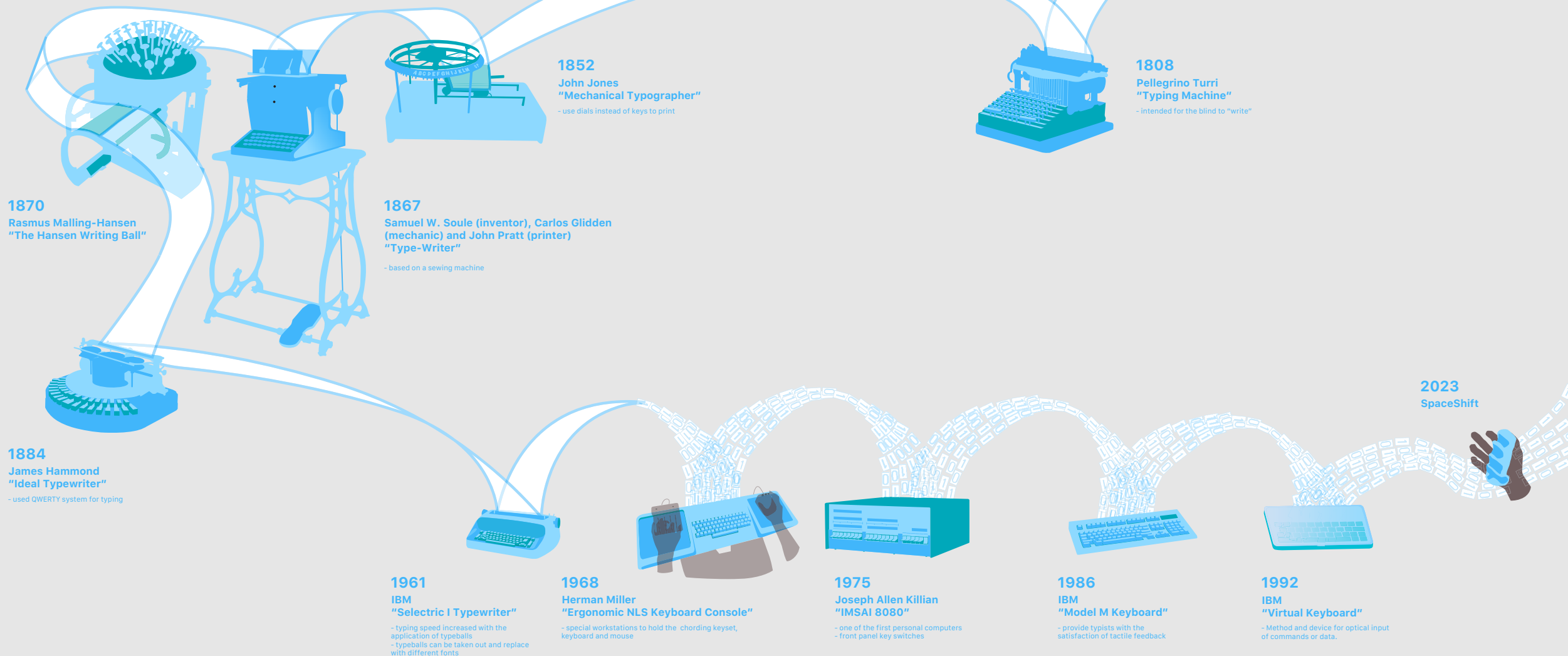
iGeeksBlog. The Evolution of the Apple Mouse through the Years!!, 24 Dec. 2023, www.instagram.com/igeeksblog/p/C10LsWFycMy/. Accessed 30 Oct. 2024.

Light Pen – the Computer Mouse. historyoftech.mcclurken.org/mouse/antecedents/lightpen/.

"The Evoluent Story." Evoluent.com, evoluent.com/about/story/. Accessed 30 Oct. 2024.

Z, Jessica. "Sutori." www.sutori.com, www.sutori.com/en/story/history-of-computer-mouse--2yUFPn6vNQBstaa2x4FTdsy. Accessed 30 Oct. 2024.

KEYBOARD TIMELINE



alker33. "IMSAI 8080 from 1975 - One of the First Personal Computers." YouTube, 10 Oct. 2010, www.youtube.com/watch?v=TDGYIUZMbUy. Accessed 2 Nov. 2024.

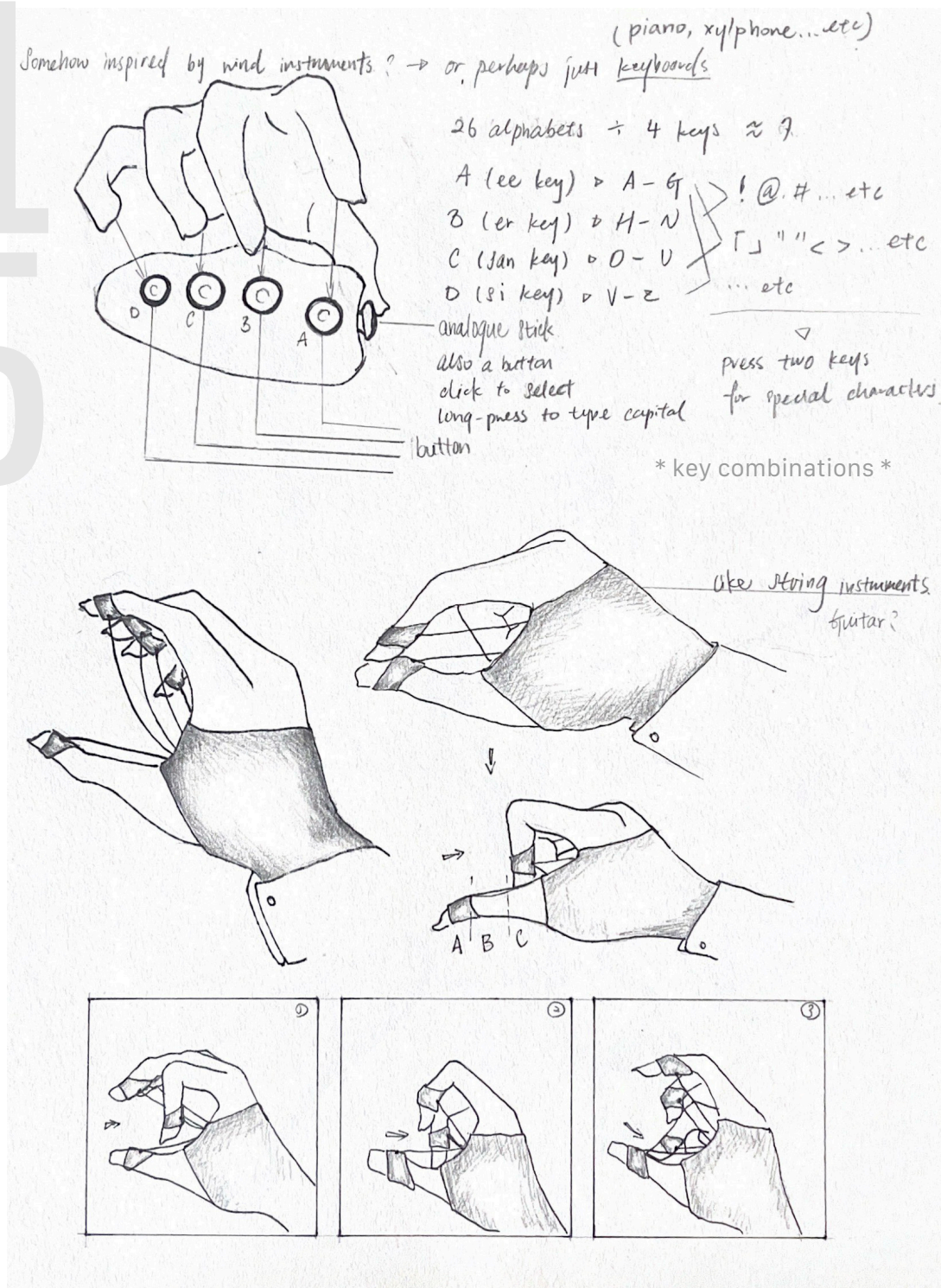
"Ergonomic NLS Keyboard Console - CHM Revolution." Computerhistory.org, 2024, www.computerhistory.org/revolution/input-output/14/350/1882. Accessed 30 Oct. 2024.
Typing Through Time: Keyboard History. "Typing through Time: Keyboard History." Das Keyboard Blog, 19 June 2019, www.daskeyboard.com/blog/typing-through-time-the-history-of-the-keyboard/.

"Hammond "Ideal" Typewriter, 1884." Sciencemuseumgroup.org.uk, 2024, collection.sciencemuseumgroup.org.uk/objects/co8633974/hammond-ideal-typewriter-1884. Accessed 2 Nov. 2024.

"IMSAI 8080 Computers — 1975 Alpha/LSI-2 Mini Restoration." Alphalsi.com, 2021, www.alphalsi.com/2021/04/09/imsai-8080-computers/. Accessed 2 Nov. 2024.

Jack. "Typewriter." DURGOD | Best Wireless Mechanical Keyboard for Gaming, Office, Mac, Windows, Android, 2 Apr. 2024, www.durgod.com/blogs/pellegrino-turri/.

Korth, Hans E. Method and Device for Optical Input of Commands or Data. no. EP0554492, 11 Aug. 1993, worldwide.espacenet.com/patent/search/family/008209311/publication/EP0554492A1?q=pn%3DEP0554492. Accessed 19 May 2025.



A computer mouse and keyboard have a well-established visual identity that is difficult to challenge. As a starting point and mental warm-up, the author sketched variations of alternative typing systems to begin breaking down this deeply rooted image.

These systems are directly inspired by musical instruments, a direction that emerged naturally from the early research into keyboard history. It revealed an implicit connection between typewriters and keyboards, prompting an extension of this realisation, the image of keyboards expanded. The term 'keyboard' spans multiple forms and functions. While the computer keyboard conveys meaning through linguistic language, the musical keyboard communicates through sound and emotion. This initial sketching exercise explores the idea of typing as a form of playing, reframing input as performance.

The image on the left features sketches primarily inspired by string instruments. At the top, a device is shown with four buttons and a joystick on the side. Each button represents seven letters; users press a button and move the joystick to select the desired letter. Pressing multiple keys simultaneously enables special characters.

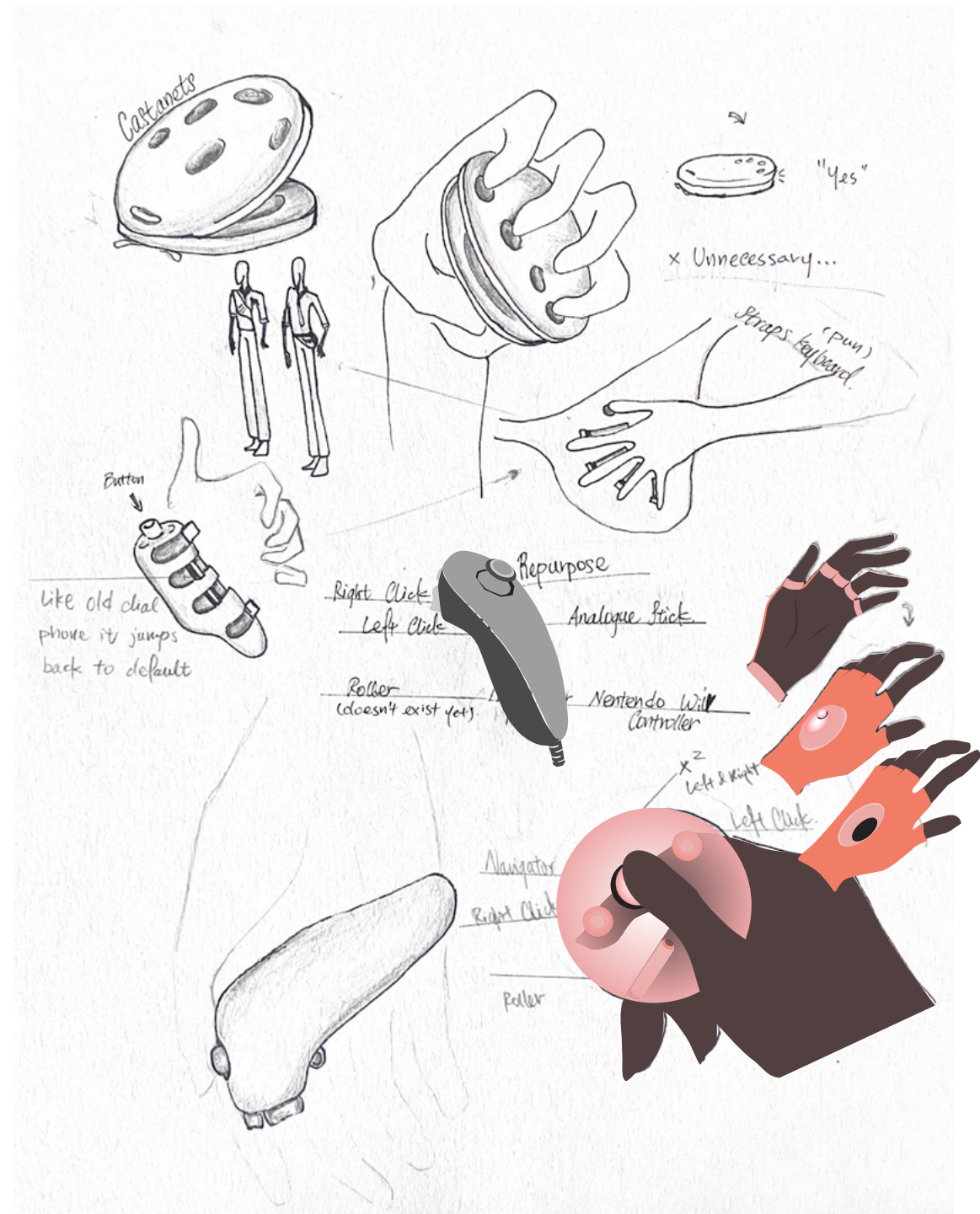
The lower image explores a system closer to gesture control. In this version, letters are distributed along strings; the user types by pulling the strings to specific positions.

The purpose of this section is not to design a practical product, but to experiment freely with the concept of typing, treating it as an open-ended design space.

The image on the right continues the exploration of input devices inspired by musical instruments. During these designs, the author gradually loosened the rigid distinction between designing a mouse and designing a keyboard, allowing the idea of interaction to take centre stage.

At the top of the image is a system inspired by the castanets. Building on previous concepts, users can lightly tap one of the buttons on the top surface and then select a letter by performing a clapping motion. In this design, the clapping gesture itself functions as a 'click', drawing on the rhythmic qualities of castanets. Below this sketch are input devices inspired by guitars. While they follow a similar principle to earlier designs, they introduce the idea of a wearable peripheral, which upholds the core concept of this thesis — physical freedom.

Combining the intuitive disc shape form of the castanet and the wearability of a guitar strap, the author arrived at the first design that feels functionally and conceptually complete. In the lower right corner of the image is **Wearable 01**: a pair of gloves, each equipped with a detachable peripheral component that can be secured on top when not in use. With four buttons, two trackballs and two scroll inputs, **Wearable 01** functions as both a mouse and a keyboard.



WEARABLE 01 PROTOTYPE



Prototype named **Wearable 01** is a 3D-printed object derived from the sketch on page 14. It was built to explore two main missions. The first was to liberate the computer mouse from its dependency on flat surfaces. By linking the trackball directly to the cursor, users no longer need to move the mouse across the surface, they simply roll the trackball with their thumbs to control the cursor.

The second mission was to investigate the potential of merging the mouse and keyboard into one single wearable input device. Drawing inspiration from musical chords, where multiple keys are pressed simultaneously to produce harmony, this prototype explores a system where strategic key combinations allow for full keyboard functionality. Just as the Shift key on a standard keyboard modifies input, **Wearable 01** enables users to click buttons and scroll through characters using the trackballs. This approach maximises input efficiency, reimagining typing as a harmonious coordination of gestures and tactile inputs.

A self-assessment of the initial prototype revealed a major ergonomic issue. When the index finger is used to press the bottom-mounted buttons, the thumb must apply an opposite force for stability. This counter-pressure disrupts scrolling and makes the action uncomfortable and inefficient. As a result, the current design is deemed unsuccessful.



2
1

how to type with wearable 01



the thumb can hardly move when index finger applies force



DEFG

2
2
2

EXISTING WEARABLE MICE

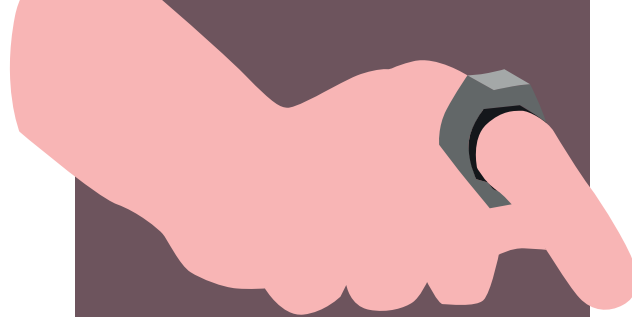


Pero: Wearable Smart Mouse Executed by Gesture

for daily tasks, office tasks

- +gesture control encourages body movements
- +comfortable material (silicone)
- +suitable for both left- and right-handed

- only mouse function
- higher adaptation barriers
- movements are not as intuitive
- still need a table surface
- no keyboard functions



The Padrone Primera

for daily tasks, office tasks

- +turn any desktop into a giant touchpad
- +easily adaptable, conventional mouse features without a tangible mouse body

- still need a table surface
- no keyboard functions

Most existing wearable mice (a few interesting designs are shown above) rely heavily on gesture control or concentrate all functions within thumb motions. While gesture-based interaction is often seen as a mainstream direction for future technologies, it can introduce a higher entry barrier and risk interfering with users' natural body movements. On the other hand, assigning all functions to the thumb creates a different kind of pressure: one that may restore conditions like carpal tunnel syndrome.

SpaceShift020, therefore, seeks a balance between gesture control and finger-based input within peripheral features. In doing so, it enables more intuitive movements, rather than adding to users' physical load.



Faddare Fingertip Control

for social media scrolling

- +small and light
- +easy to use
- +focused functions

- limited functions
- no mouse function or keyboard functions



LUPHIE R1 BLUETOOTH VR REMOTE CONTROLLER

for gaming purpose

- +good finger grip, not easy to drop
- +keys are tactful and responsive
- +nice soft rubber material on the joystick
- +return key available

- no specific keyboard functions
- gaming buttons have no use in daily scenes
- could be smaller
- too many buttons rely on the thumb

OSReviews. "REVIEW: LUPHIE R1 Bluetooth vr Remote Controller." YouTube, 23 May 2017, www.youtube.com/watch?v=acvfnFQd0XU&list=PLgVC3Th_12Auuk-0SP7FPs2-hE3HWe8jZI&index=36. Accessed 26 May 2025.

GadgetZone. "Fingertip Control Frees Your Hands, and the Screen Interaction Is Super Silky #Bluetooth Remote Con." YouTube, 8 Aug. 2023, www.youtube.com/shorts/1qqF50qRaUs. Accessed 26 May 2025.

Padrone.design. "Coolest Mouse Ever." YouTube, 28 Oct. 2024, www.youtube.com/watch?v=DtwZ0Vz0t14&list=PLgVC3Th_12Auuk0SP7FPs2-hE3HWe8jZI&index=41. Accessed 26 May 2025.

Kim, Jungmo. "Pero: Wearable Smart Mouse Executes by Gesture." Indiegogo, 2020, www.indiegogo.com/projects/pero-wearable-smart-mouse-executes-by-gesture/#/. Accessed 26 May 2025.

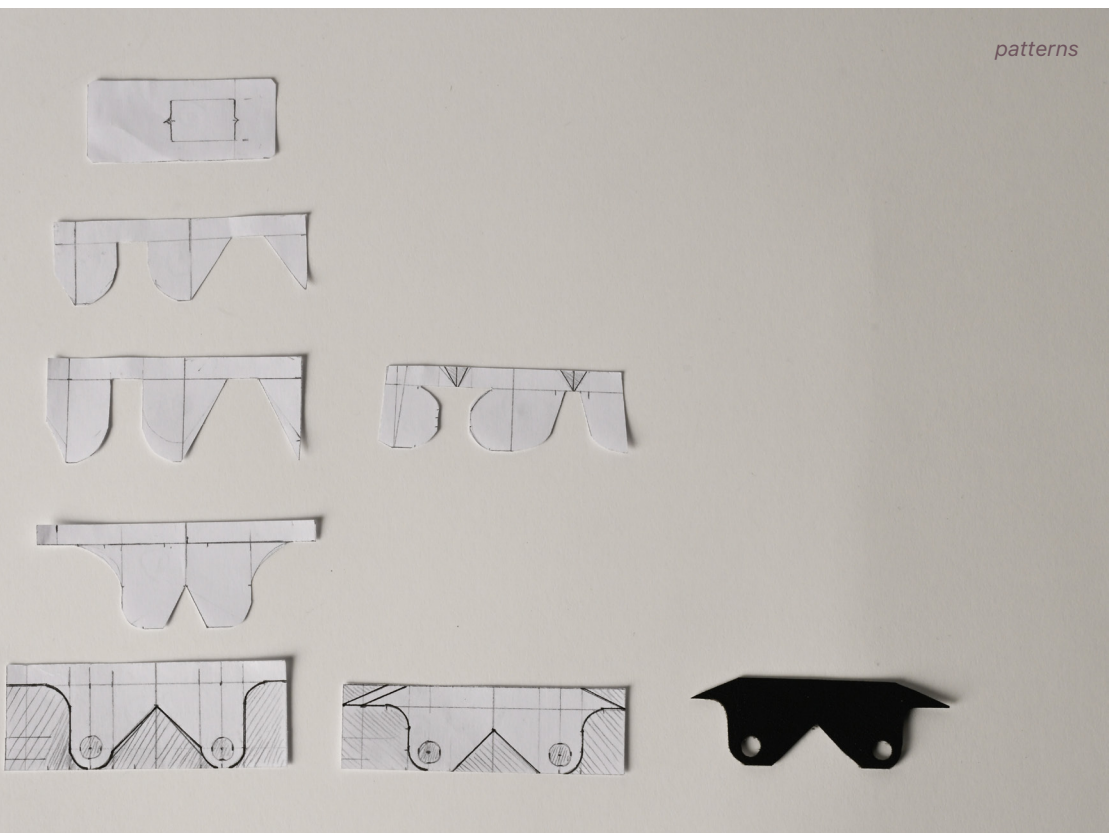
The next concept, **Wearable 02**, further stresses the wearability of input devices, with a strong emphasis on minimalism and adaptability. This iteration significantly reduces the previous prototype: instead of a full glove, the design is stripped down to a simple finger band; there is no need to cover the entire hand if the sole function is to support the device.

The number of input components is also reduced, from four buttons, two trackballs and two scroll wheels to just two buttons and two trackballs. The goal is to build a simplified system that complements existing tools, like the virtual keyboard, rather than attempting to replace them entirely. This hybrid approach creates a gentler learning curve for users, layering new interactions over familiar systems.

The trackball on the supporting hand now serves as a scroll input. The author also began considering whether a joystick could replace the trackball altogether, offering a different kind of tactile feedback.



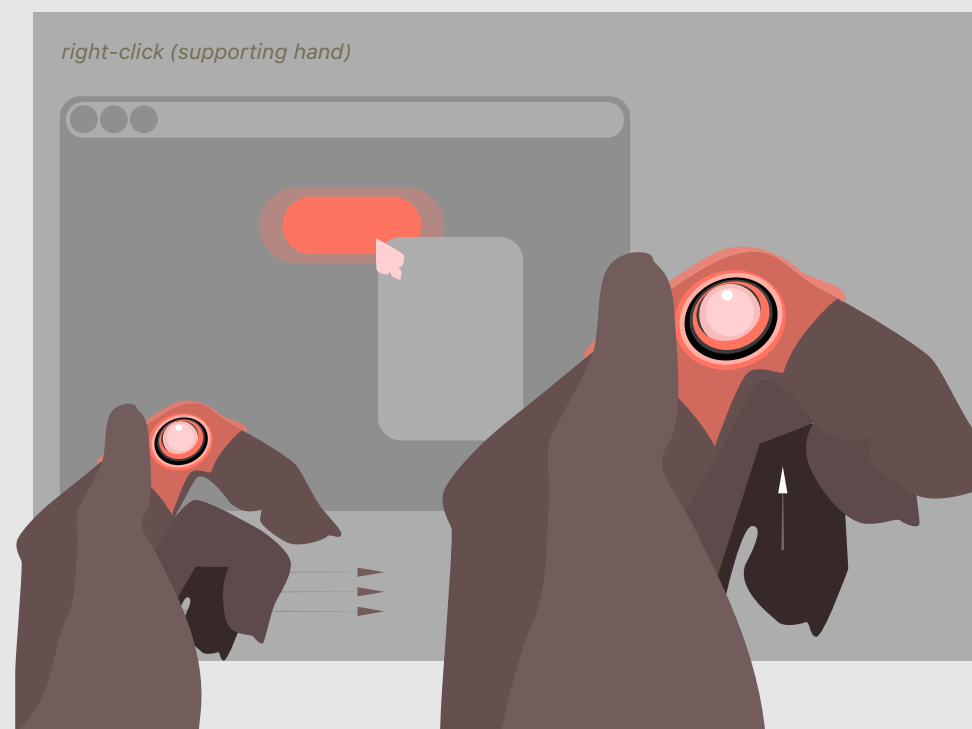
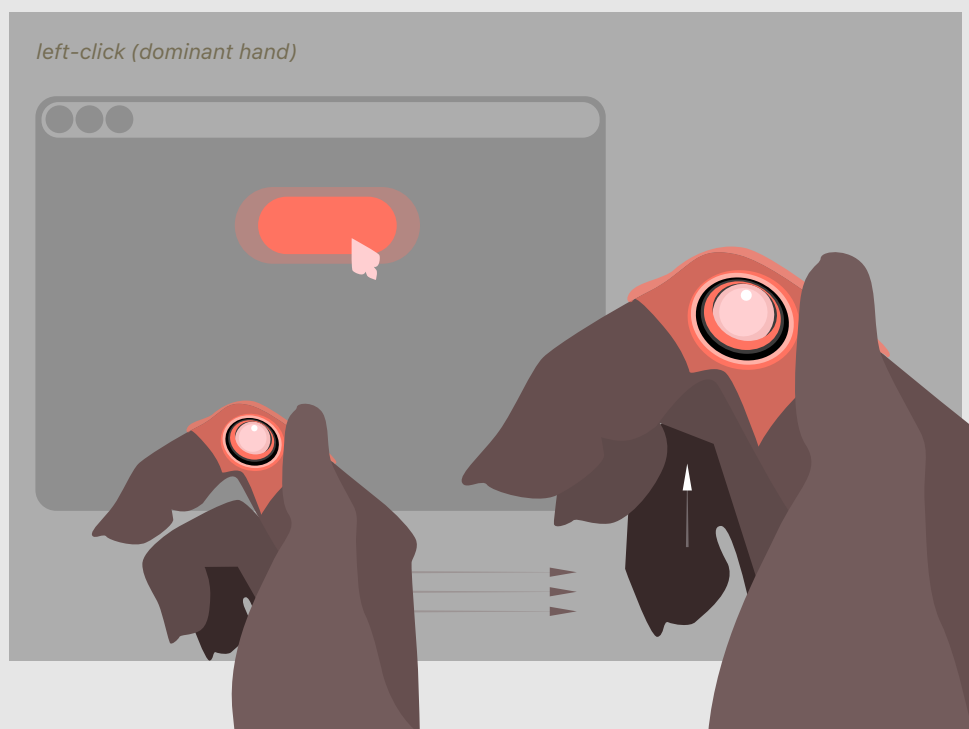
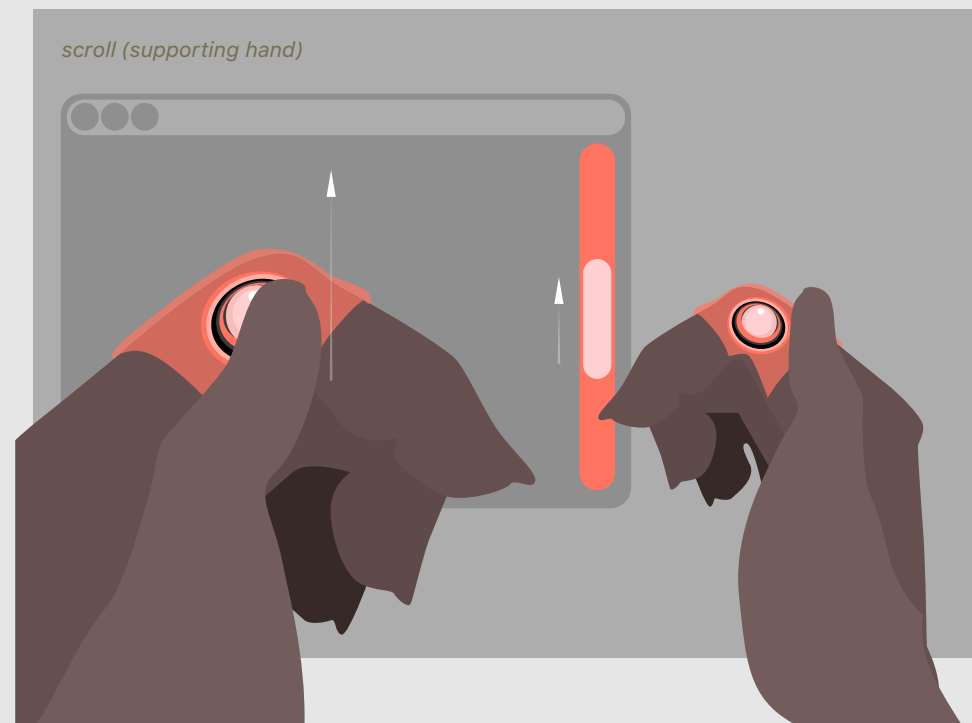
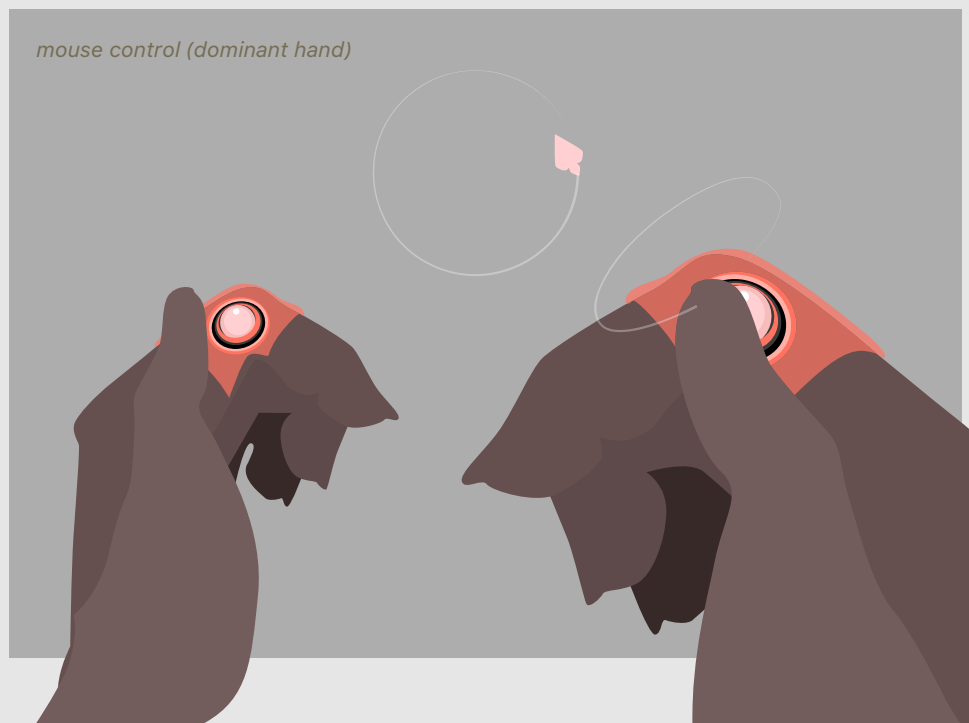
WEARABLE 02 PROTOTYPE A



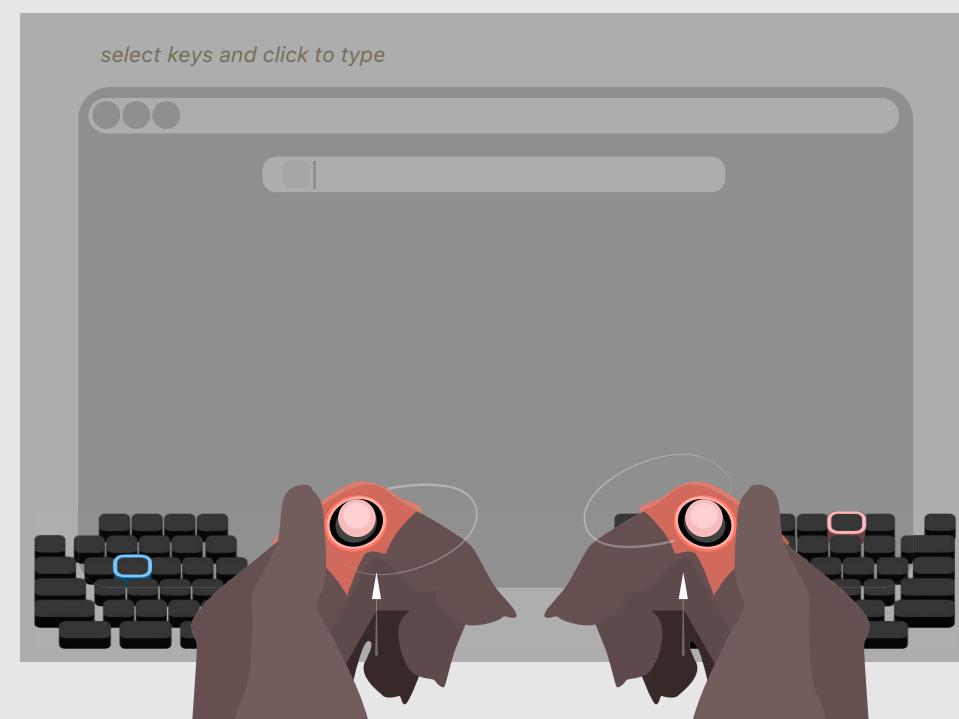
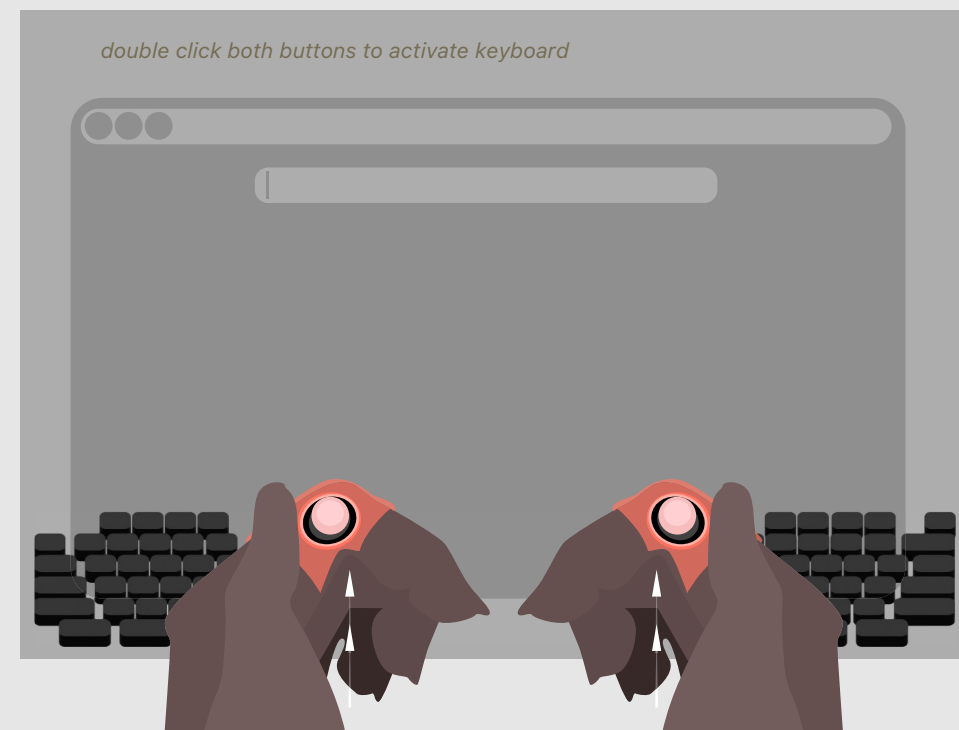
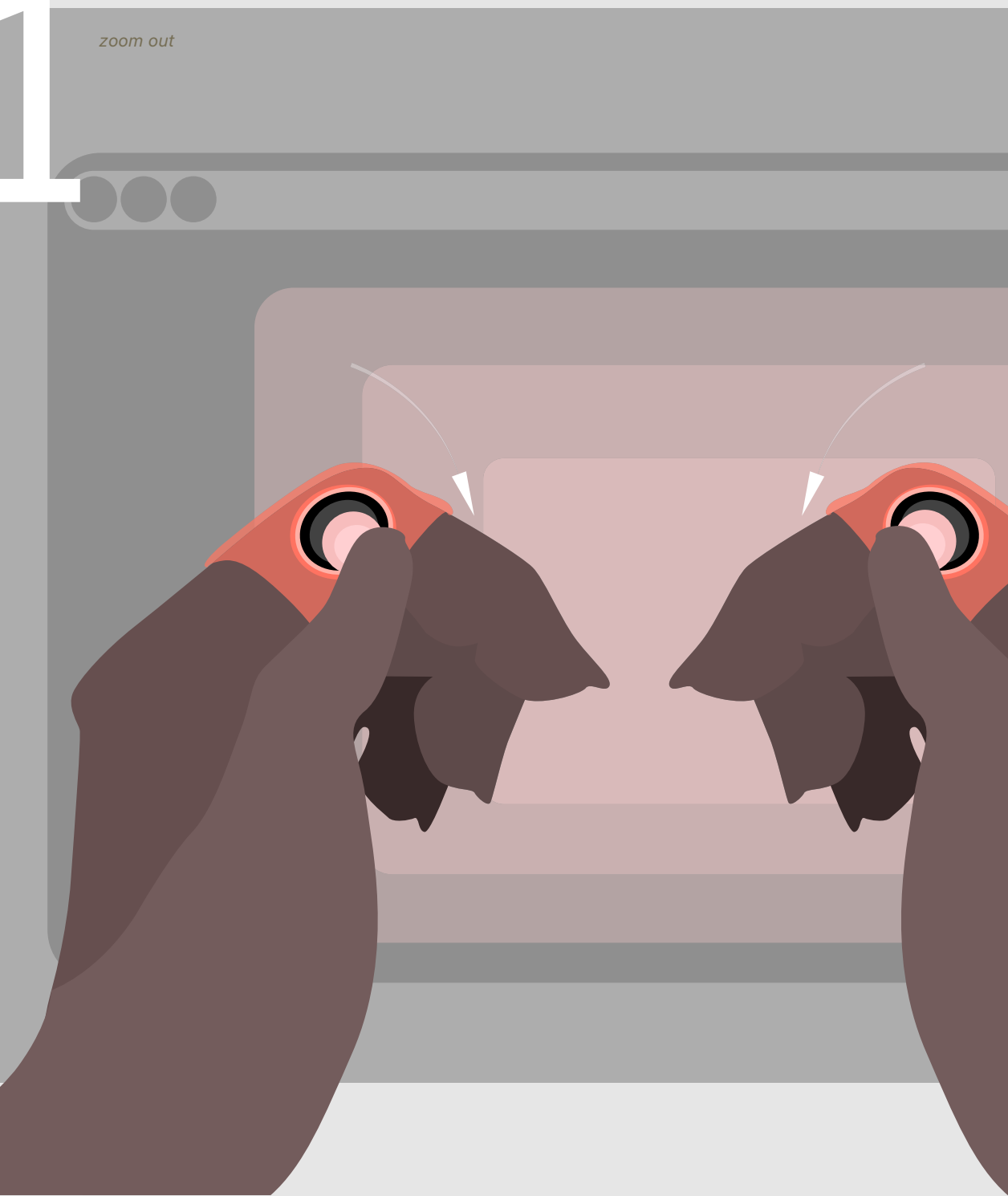
wearable 02 concept prototype A
scroll/navigate with thumb
click with middle finger knuckle



The following demonstrates how the system operates for a right-handed person, combining mouse and keyboard functionalities through hand coordination.



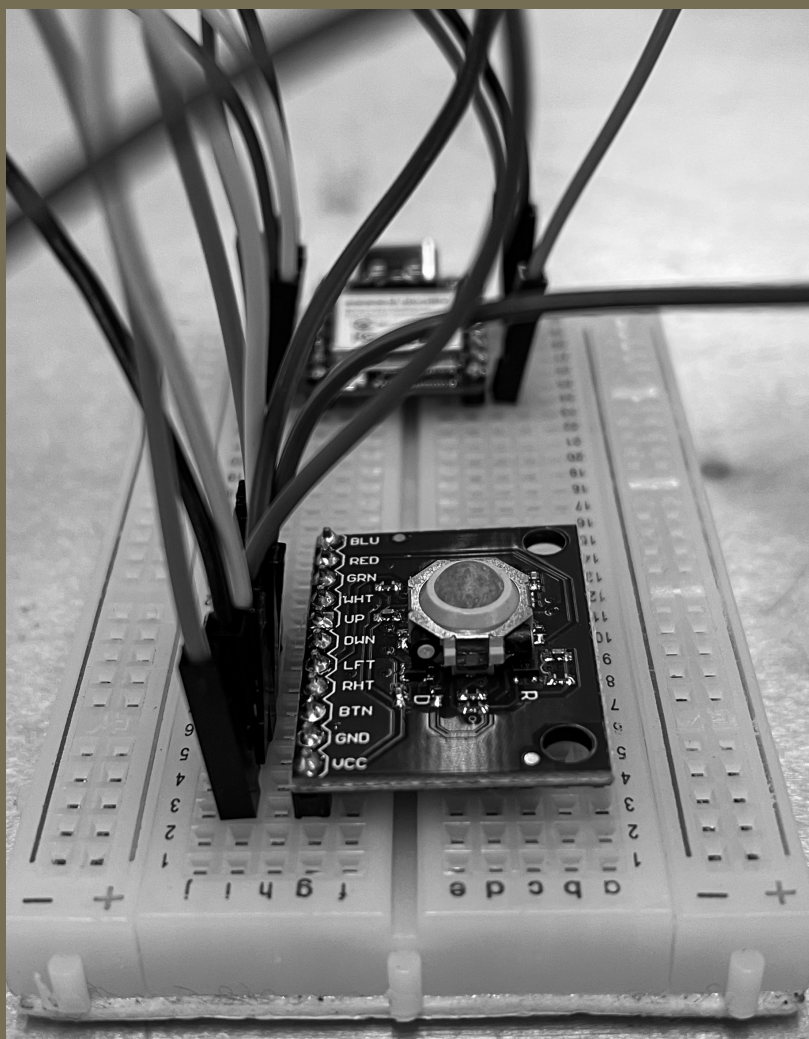
This iteration also draws from familiar trackpad gestures: for instance, users can zoom in and out by rolling two trackballs in opposite directions.



WEARABLE 02 PROTOTYPE B

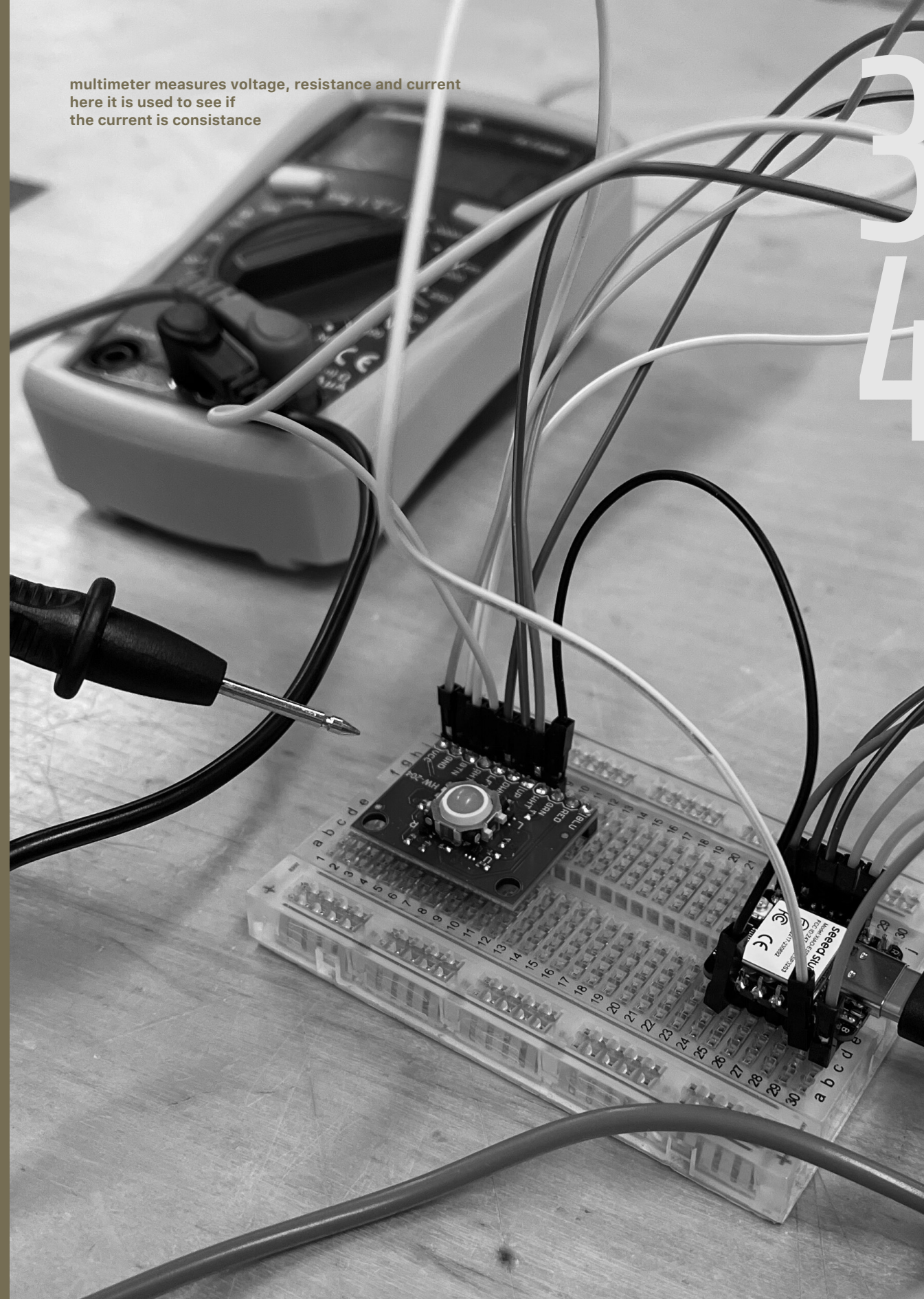
Wearable 02 is not only a refinement in form but also in function. If this prototype is to be tested meaningfully, its full capabilities must be developed and challenged on both the mechanical and conceptual levels.

The following page documents the making process of **Wearable 02B**, from technical development to functional prototyping.



*blackberry trackball
connected to central processing unit (CPU) XIAO esp32s3
with jumper wires
on breadboard*

multimeter measures voltage, resistance and current
here it is used to see if
the current is consistance



36

```
4 void setup() {
5     Serial.begin(9600);
6     pinMode(buttonPin, INPUT);
7 }
8
9 void loop() {
10     buttonState = digitalRead(buttonPin);
11
12     if (buttonState == HIGH) {
13         Serial.println("Button pressed");
14     } else {
15         Serial.println("Button released");
16     }
17     delay(1000);
18 }
19
```

Message (Enter to send message to 'XIAO_ESP32S3' on '/dev/cu.usbmodem1110')

```
Button pressed
Button pressed
Button pressed
Button released
Button released
Button released
```

blackberry trackball is both a trackball and a button

here it is ungoing a series of testing to see

- ▶ 1. if the button works
(if the program recognise when the button is being pressed)
- ▶ 2. if the trackball moves
(if the program recognise when the trackball is moving)
- ▶ 3. where is the trackball moving
(coordinates of the cursor translated from trackball inputs,
0 is not activate, 1 is activate; 1001 = up-left)

Output Serial Monitor ✕

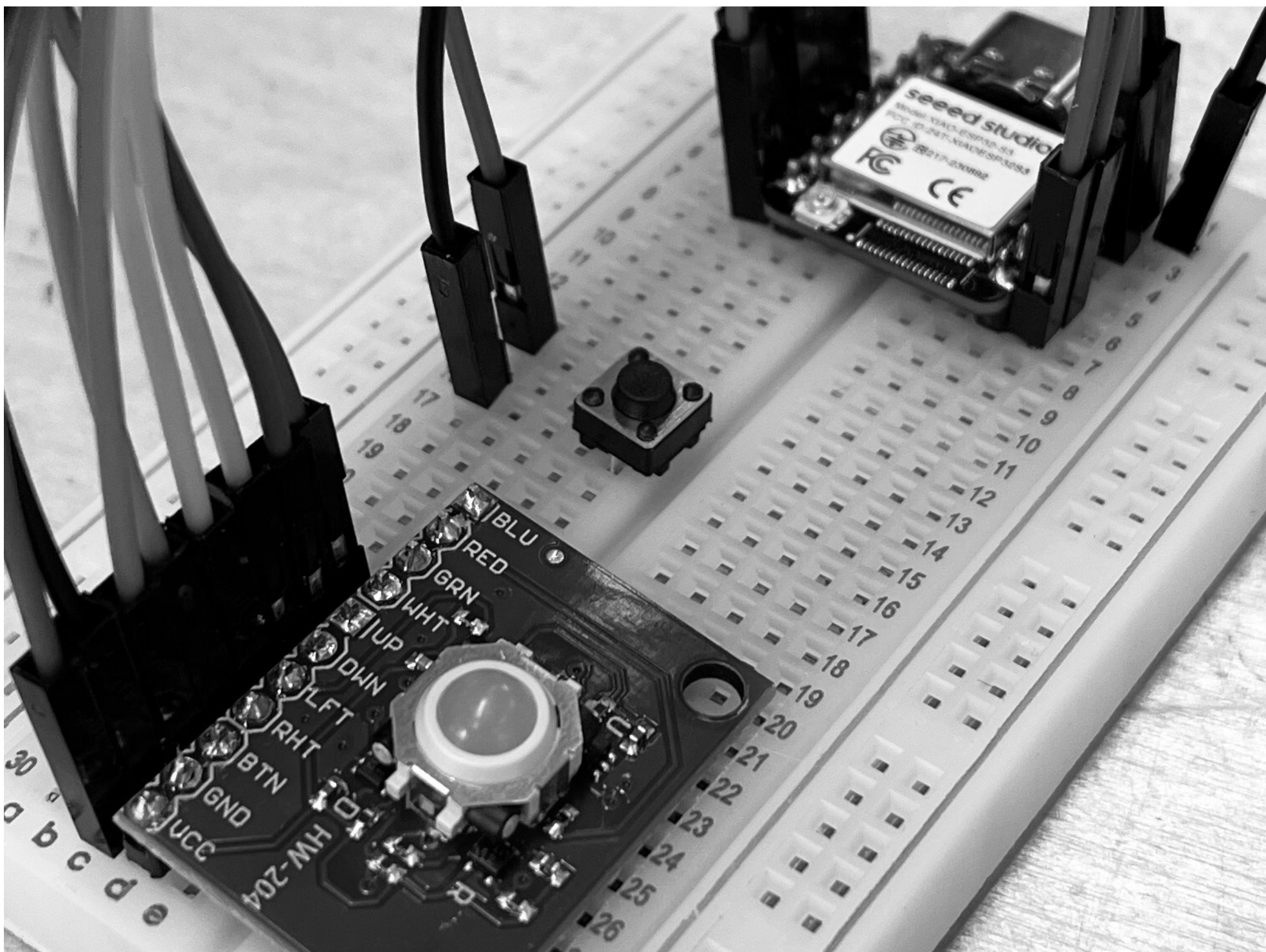
Message (Enter to send message to 'X)

```
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
MOVEEEEE  
Press  
Release  
Press  
Release  
Press  
Release
```

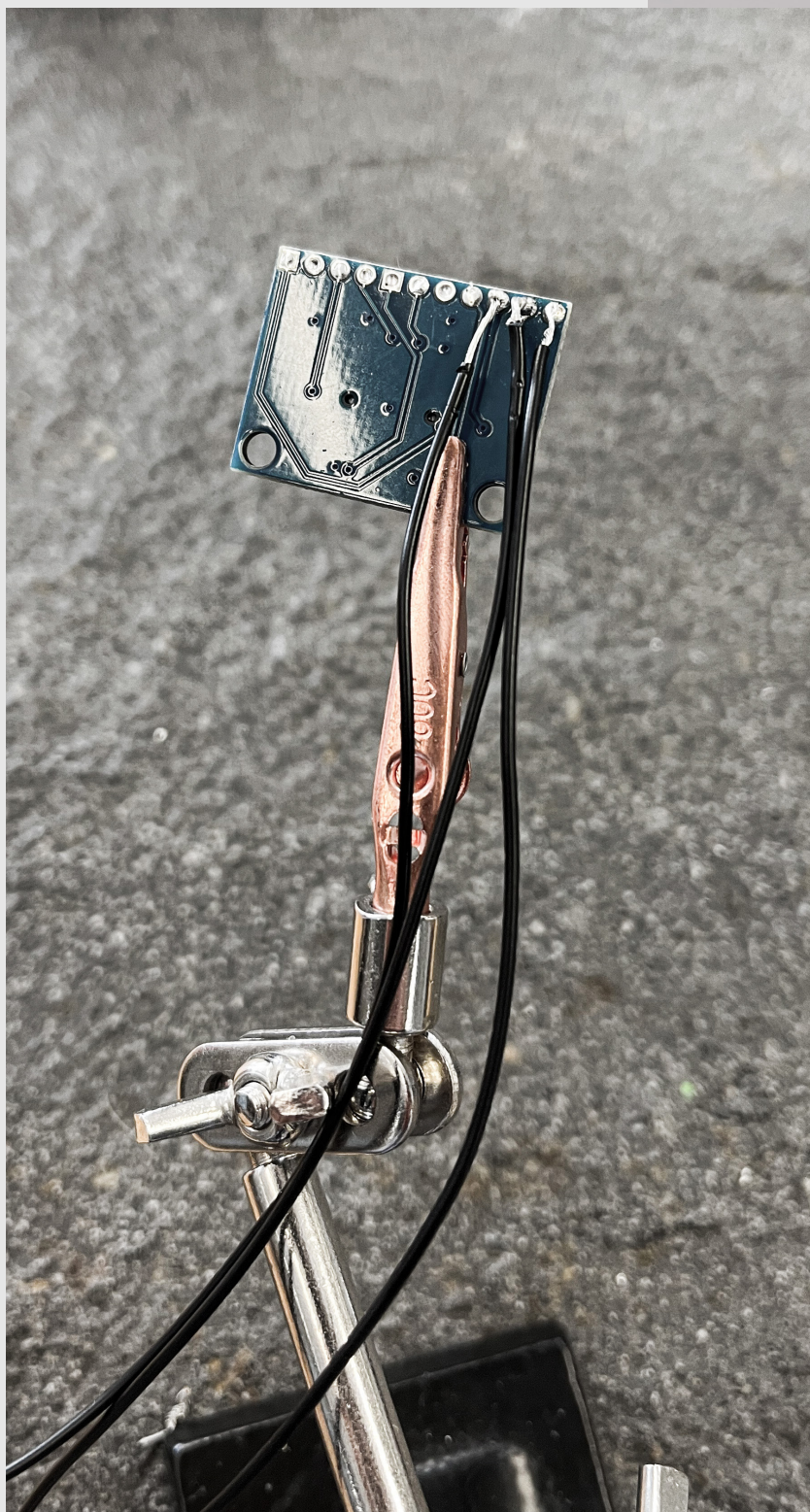
Output Serial Monitor ✕

Message (Enter to send message)

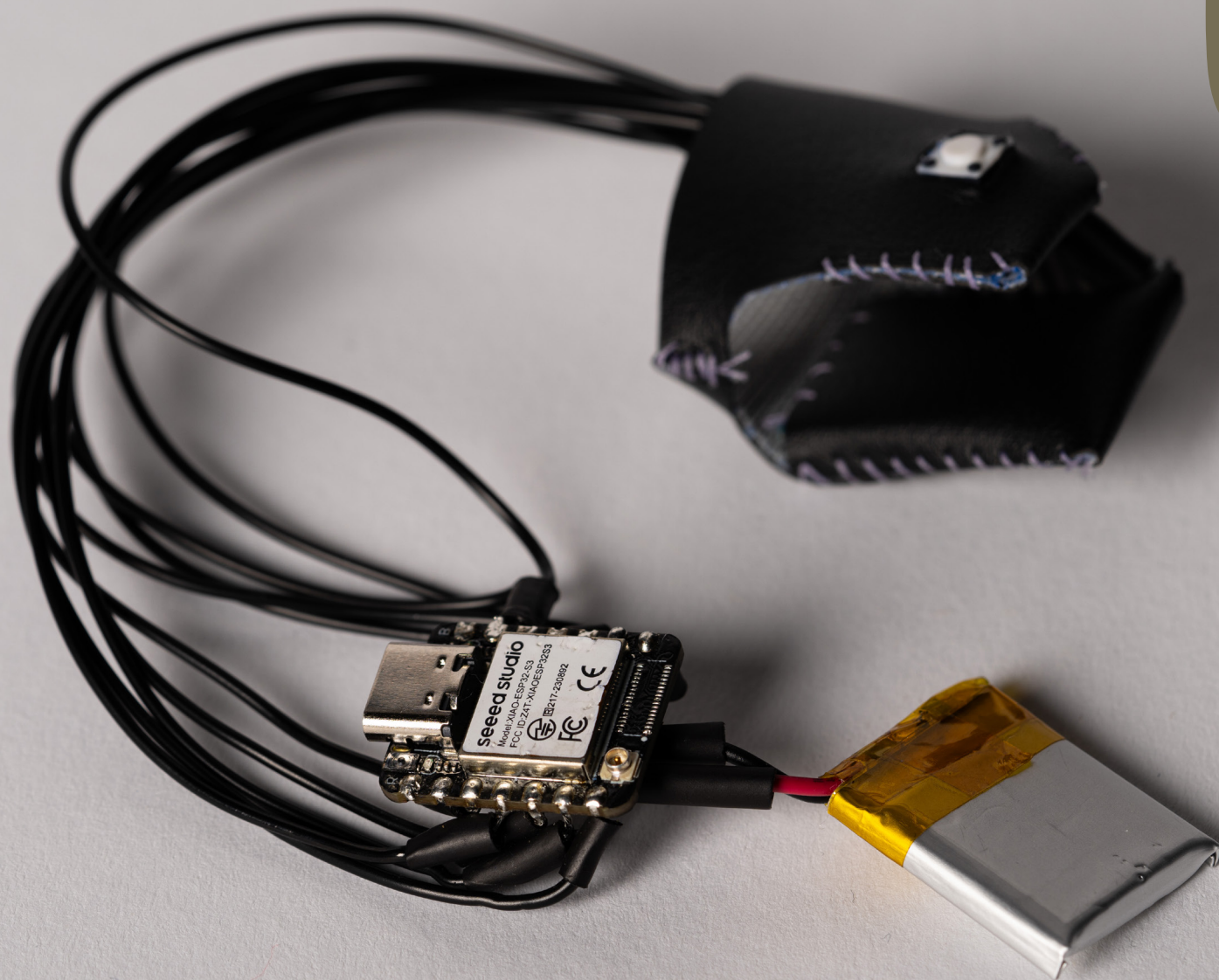
[illegible]



model from p25 + an extra button



solder to connect all parts with wires



all parts connected with wire

4+1 WEARABLE 02B



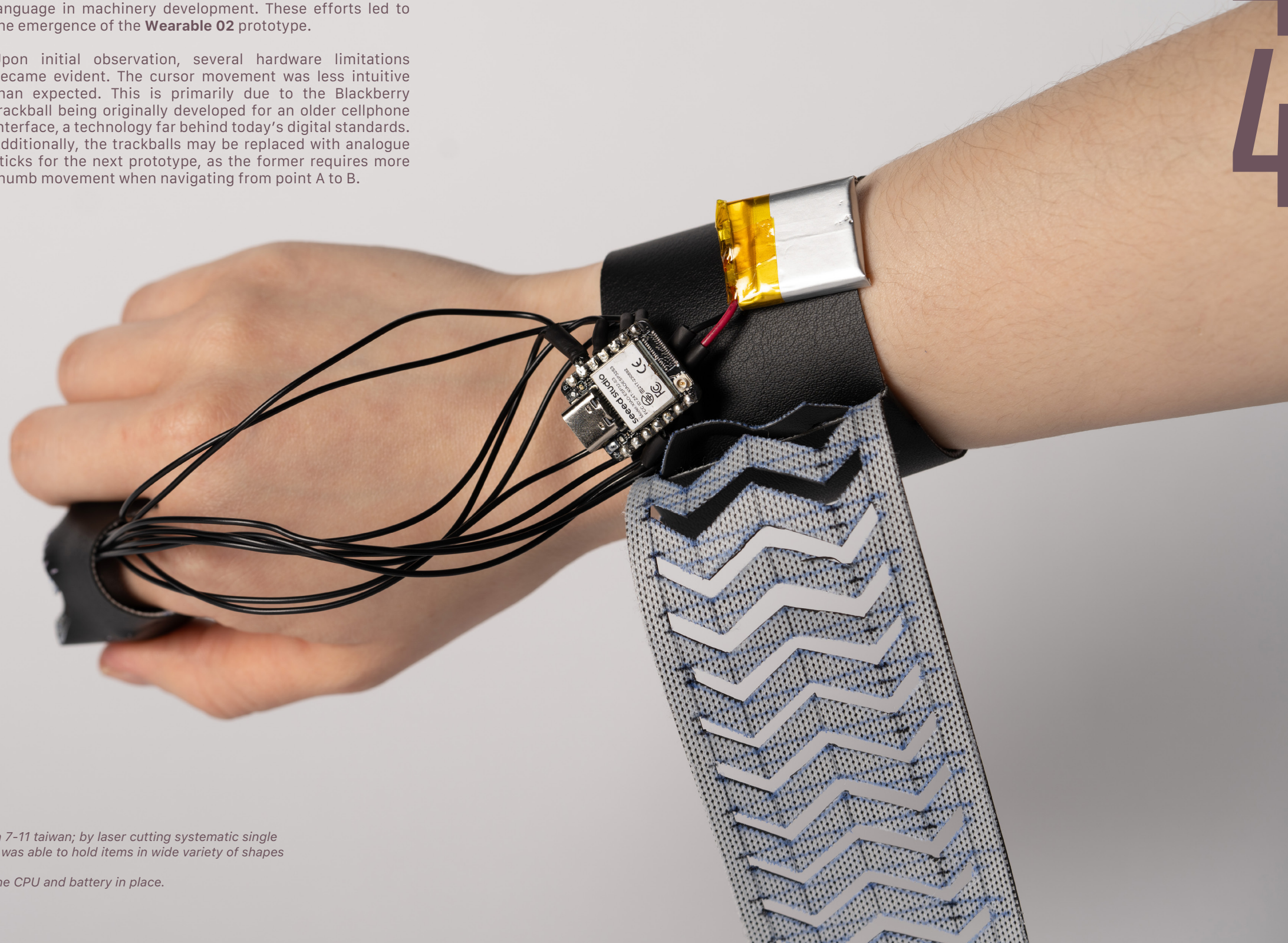
trackball navigated by thumb



*button clickable by middle finger knuckle
photo by David Andrei Cristoccea*

With limited experience and prior knowledge of electronics, the author undertook a self-directed learning process to obtain basic engineering skills. This included researching open-source DIY trackball mice, understanding electronic components and their functions, troubleshooting hardware, as well as learning C++, a commonly used programming language in machinery development. These efforts led to the emergence of the **Wearable 02** prototype.

Upon initial observation, several hardware limitations became evident. The cursor movement was less intuitive than expected. This is primarily due to the Blackberry trackball being originally developed for an older cellphone interface, a technology far behind today's digital standards. Additionally, the trackballs may be replaced with analogue sticks for the next prototype, as the former requires more thumb movement when navigating from point A to B.



inspired by the takeaway bag design in 7-11 taiwan; by laser cutting systematic single lines on a piece of blue fabric, the bag was able to hold items in wide variety of shapes

this wristband was designed to keep the CPU and battery in place.

To expand the perspectives in this thesis and bring in expert insights, the author searched for collaboration beyond the academic context. As a research method, the author actively reached out to industry-leading companies such as Logitech and 3Dconnexion, in the hope of uncovering how they approach peripheral innovation. After a series of unanswered inquiries, **Jasper Jeurens** was discovered through an extended connection. His fresh perspective on the industry offered valuable inspiration.

Jeurens is an interaction designer and design researcher specialising in Human-Computer Interaction (HCI). His work often explores the social aspect of technology, rather than focusing solely on productivity (Appendix A).

At its core, SpaceShift020 aims to expand the physical freedom of office users in front of their screens. A secondary layer effect lies in its social implications. In its extended vision, SpaceShift020 encourages users to engage more with their surroundings through this newfound physical freedom. Although this aspect could be a research paper in its own right, it is worth highlighting that the author positions her work as a support to social connection rather than undermining it. Jeurens, with his society-centred perspective, was an ideal expert to consult on this underrepresented topic.

The interview with Jeurens became a conversation about the human-computer relationship and the broader influence design can have on it. He offered a critical analysis of SpaceShift020, acknowledging both its challenges and potential, such as the difficulty of translating analogue processes into digital ones, and how a clear, mindful goal can create space for meaningful actions.

In preparation for the user experience test, Jeurens emphasised that the aim should be to observe how users behave when introduced to a new device. At this stage, the test should not be overly structured. Instead, simply handing the product to users and observing their interaction can be revealing.

The insights abstracted from this discussion had a significant impact on how the user experience test is approached in the later chapters of this thesis. Shifting the evaluation criteria from traditional UX metrics like effectiveness, efficiency, and satisfaction, to a more nuanced observation of human behavioural reactions.

Jasper Jeurens on teams call





3d printed mould for silicone



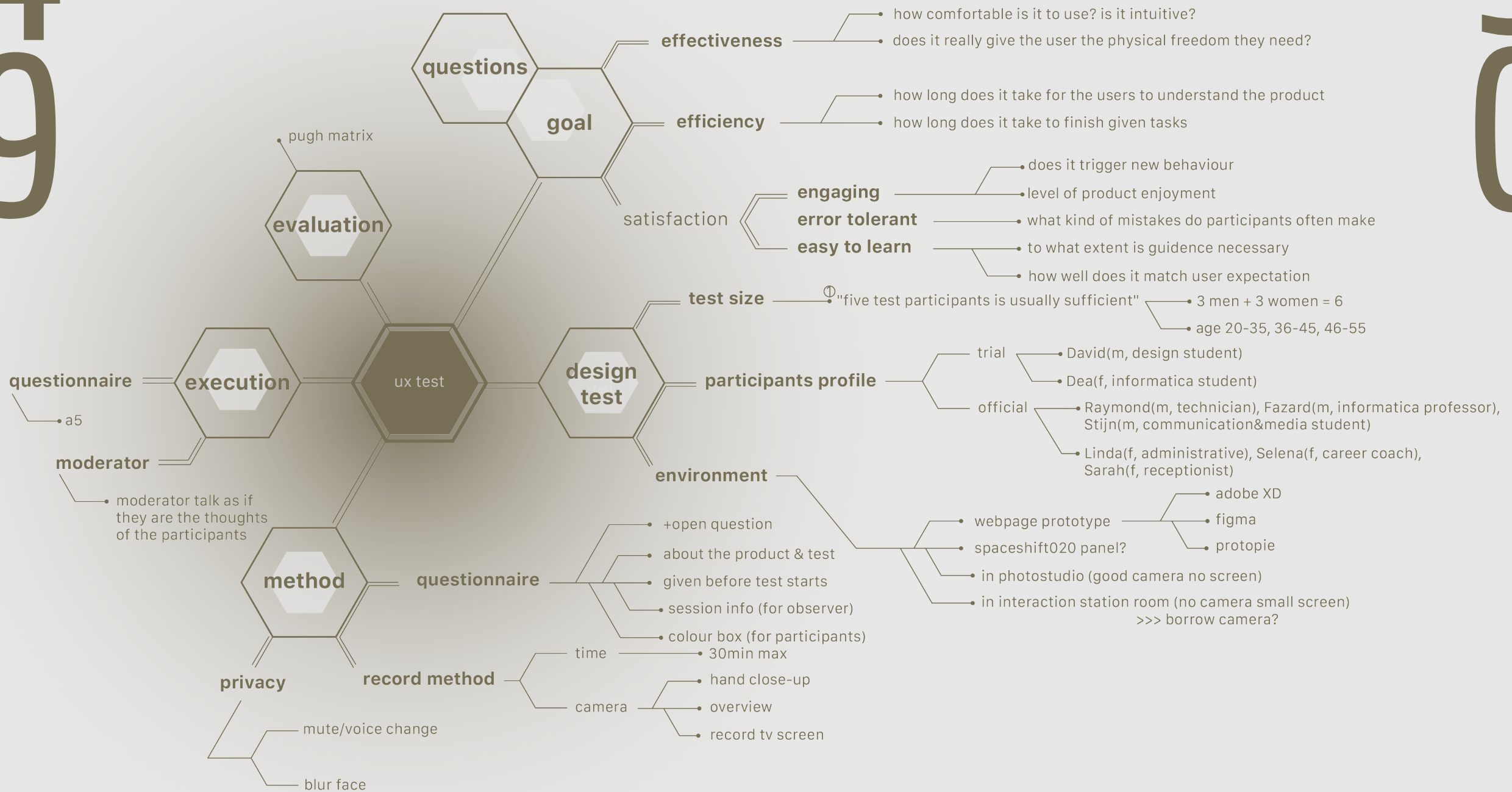
one side of the wearable 03 prototype with silicone, magnet tapes, button and joystick

Wearable 03 was developed for the user experience test and as a public-facing concept demonstration. While it is not fully functional, its purpose is to visually communicate what the final product could look like if the right technology were in place.

One of the key improvements over versions of Wearable 02 is adaptability. The earlier prototype lacked flexible sizing, which limited both the range of users and their comfort. Wearable 03 addresses this by using silicone and magnets, allowing users to wrap the device securely around their finger at their preferred tightness.

However, some technical limitations remain. The magnetic tape used in this version lacks sufficient strength to hold its shape reliably, and the joystick tends to slip out of position. For testing in the upcoming stage, additional support, such as threads and rubber bands, was added to stabilise the prototype during interaction.

46 USER EXPERIENCE TEST MAP



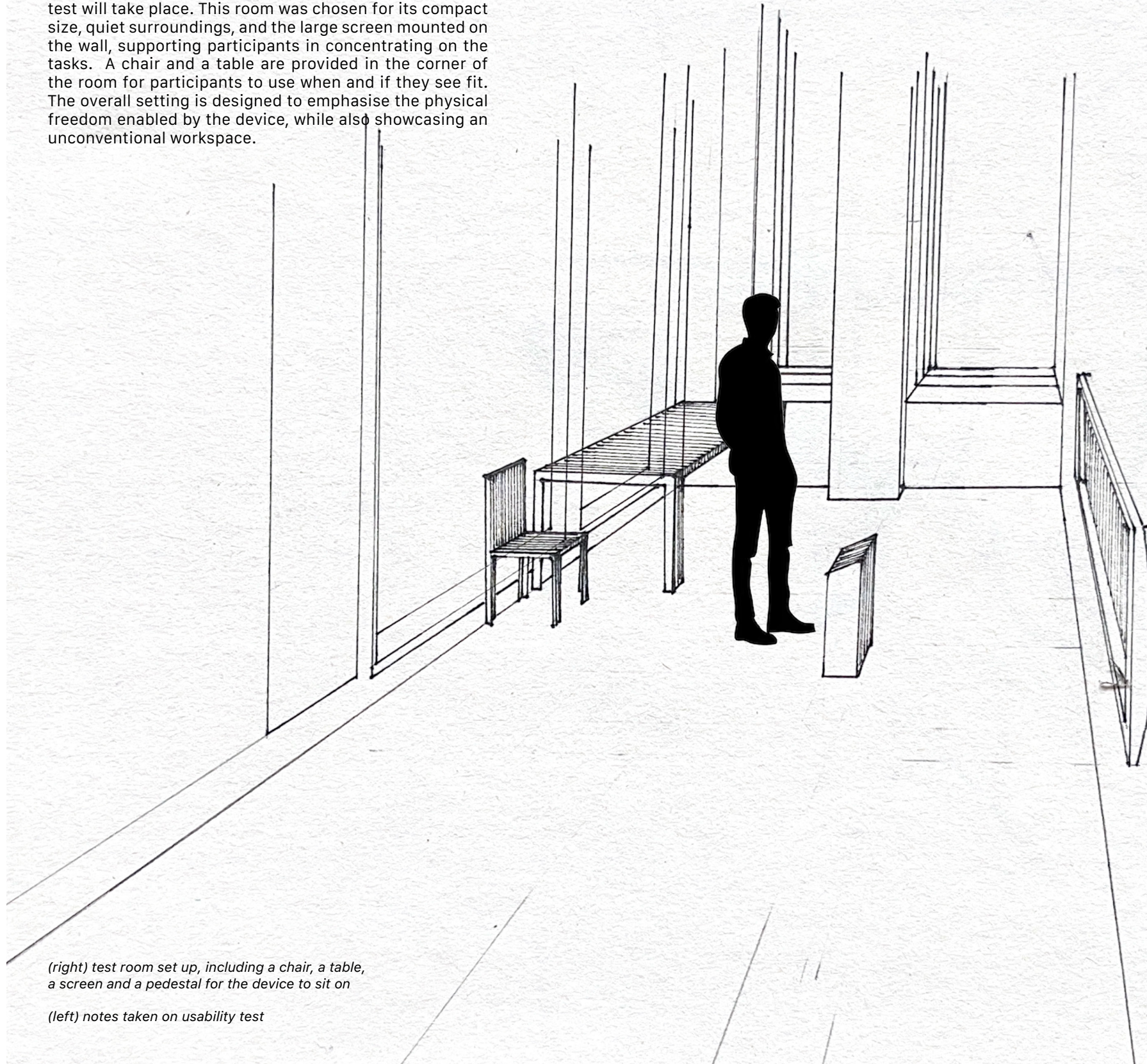
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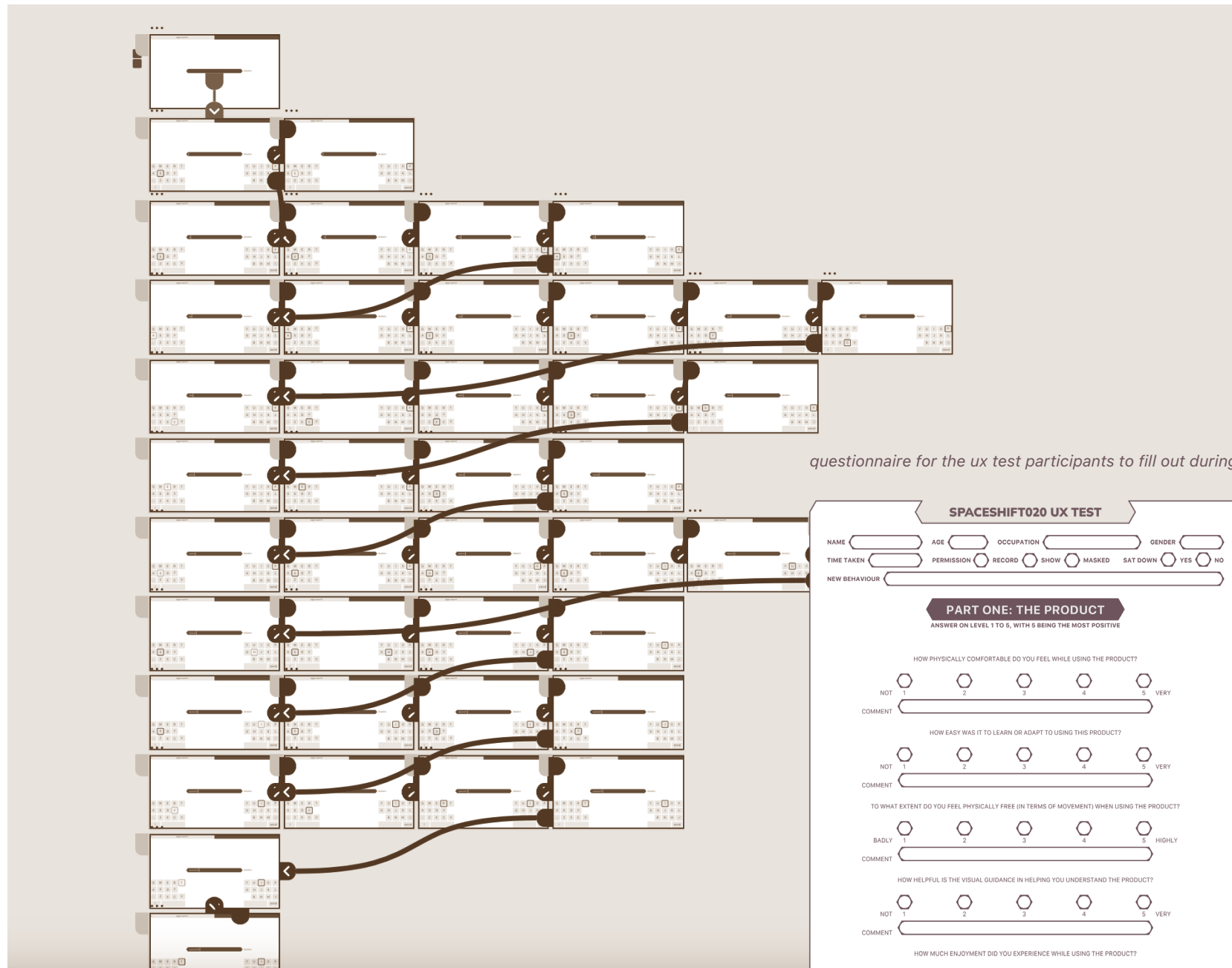
strong concept as the
the concept. If not, the

Designing a UX test is a meticulous process, it should immerse participants in scenarios where the product is meaningfully applicable. The image below illustrates the planned test environment, based on a real meeting room at Willem de Kooning Academy in Rotterdam, where the test will take place. This room was chosen for its compact size, quiet surroundings, and the large screen mounted on the wall, supporting participants in concentrating on the tasks. A chair and a table are provided in the corner of the room for participants to use when and if they see fit. The overall setting is designed to emphasise the physical freedom enabled by the device, while also showcasing an unconventional workspace.



(right) test room set up, including a chair, a table, a screen and a pedestal for the device to sit on

(left) notes taken on usability test



interface flow for the task in user experience test

questionnaire for the ux test participants to fill out during or after the test

SPACESHIFT020 UX TEST

NAME AGE OCCUPATION GENDER

TIME TAKEN PERMISSION ☐ RECORD ☐ SHOW ☐ MASKED ☐ SAT DOWN ☐ YES ☐ NO ☐

NEW BEHAVIOUR

PART ONE: THE PRODUCT
ANSWER ON LEVEL 1 TO 5, WITH 5 BEING THE MOST POSITIVE

HOW PHYSICALLY COMFORTABLE DO YOU FEEL WHILE USING THE PRODUCT?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW EASY WAS IT TO LEARN OR ADAPT TO USING THIS PRODUCT?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

TO WHAT EXTENT DO YOU FEEL PHYSICALLY FREE (IN TERMS OF MOVEMENT) WHEN USING THE PRODUCT?

BADLY ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 HIGHLY

COMMENT

HOW HELPFUL IS THE VISUAL GUIDANCE IN HELPING YOU UNDERSTAND THE PRODUCT?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW MUCH ENJOYMENT DID YOU EXPERIENCE WHILE USING THE PRODUCT?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW OFTEN DID THE PRODUCT BEHAVE DIFFERENTLY THAN YOU INSTINCTIVELY EXPECTED DURING THE SESSION?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

PART TWO: THE TEST
ANSWER ON LEVEL 1 TO 5, WITH 5 BEING THE MOST POSITIVE

HOW CLEARLY DID YOU UNDERSTAND THE SCENARIO IN WHICH THE PRODUCT WAS USED?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW CLEAR WERE THE TASKS PROVIDED DURING THE SESSION?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW OFTEN DID YOU FEEL PRESSURED OR OVERSTIMULATED DURING THE SESSION?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

HOW APPROPRIATE DID THE SESSION LENGTH FEEL?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

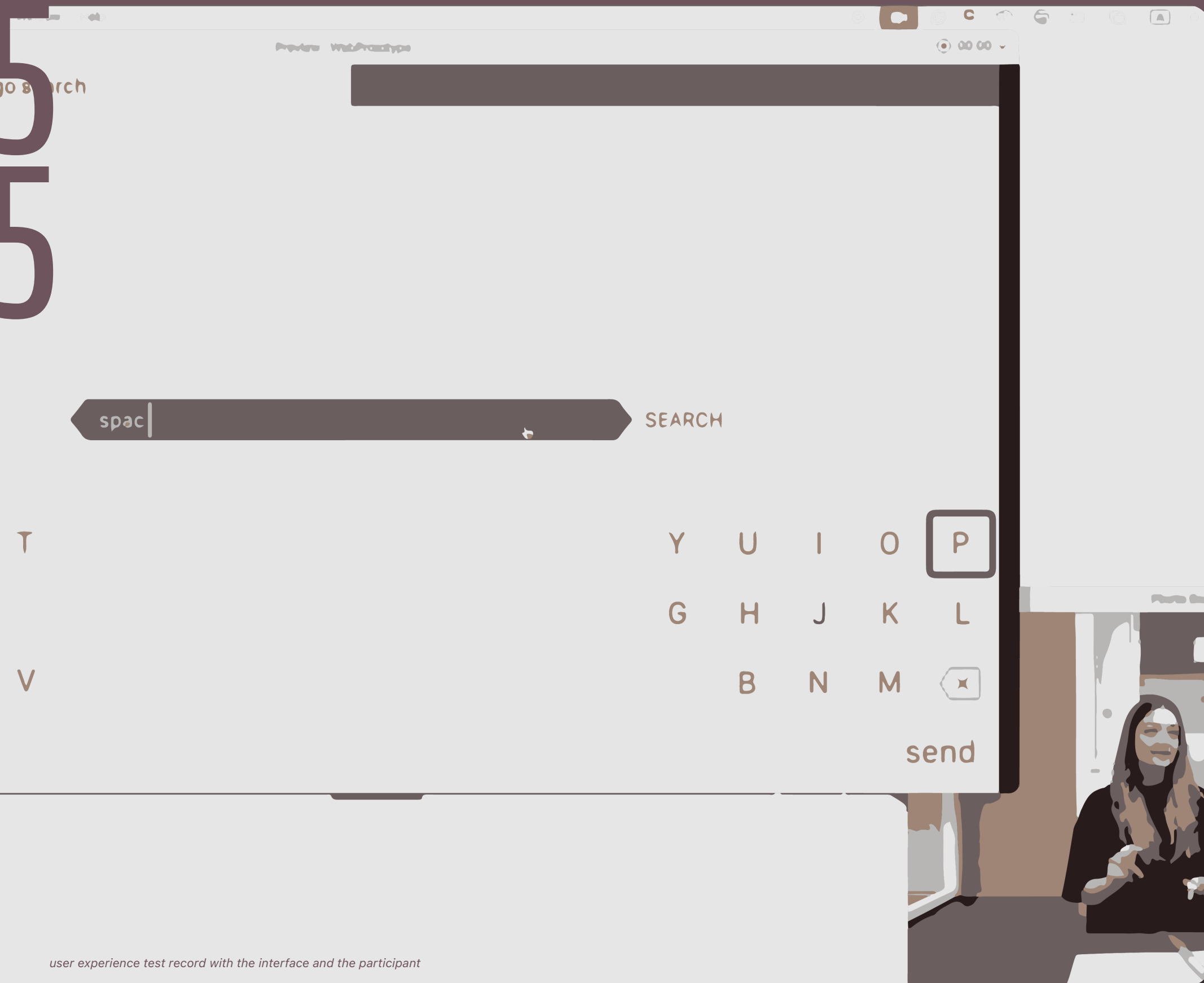
COMMENT

HOW ENJOYABLE WAS THE OVERALL TEST EXPERIENCE FOR YOU?

NOT ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 VERY

COMMENT

DO YOU HAVE ANY ADDITIONAL FEEDBACK YOU'D LIKE TO SHARE?



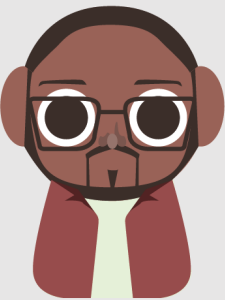
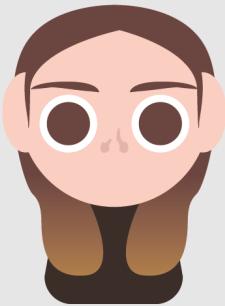
user experience test record with the interface and the participant

Beyond the physical environment, the digital atmosphere also dictates participants' understanding of the novel scenario. This is especially the case with SpaceShift020, where the computer interface plays a crucial role in its experience. Since Wearable 03 is not a fully functional prototype, additional support was necessary to help participants envision its intended capabilities.

Three key preparations were made for the test. First, a carefully drafted moderator script (Appendix B), designed to maintain a neutral tone, facilitate smooth communication, and ensure all critical points are addressed ("Resources for Evaluation"). In the test, the moderator acts as the inner monologue of the participants, guiding them step by step through the tasks.

Second, a visual interface was required for participants to interact with. Made with Adobe XD, as recommended by Jeurens (Appendix A), a task flow was built to simulate the intended experience of using the device.

Lastly, a questionnaire was prepared to collect basic participant data and feedback. It is designed to be quick and easy, since the primary focus of this test remains the observation of emerging user behaviours. Participants were informed that the session would be video recorded for research purposes, and their consent was documented through the questionnaire.

							
dominant hand	left	right	right	right	right	right	right
gesture (their pov)	half- unbend fingers 	fist + index finger pointing 	L shape hands 	unbend fingers 	half- fist position 	L shape hands 	bend fingers 
	relax on lap	hanging on edge of table	on table	hover on table	relax on lap	lower palm on table	holding up in the air
time taken to finish the task	00:08:30	00:07:45	00:05:50	00:06:10	00:06:20	00:05:30	00:06:20
comfortability							
adaptability							
physical freedom							
visual guidance							
enjoyment							
instinctivity							

feedback table for the product



comments

i wasn't sure which way was up/down and left/right

i can imagine gaming with them

need time getting used to new device

features are easily understandable

could wear it as an accessory

matched well with my movements

loved trying a simpler version of an everyday gadget i use

made perfect sense

i only had issue with my supporting hand when pressing the button

i was just talking about my carpal tunnel from working on laptop, so this would be a nice solution

enjoyed :)

-

it was lightweight which felt easy to use

felt like i was wearing my rings

it was very clear

i would love to play an arcade game this way

maybe the placement of the buttons (need some adjustment)

lightweight and comfy

the tutorial was very clear

it felt light and not too tight

clean communication and images

it was interesting to use the prototype, something different

i had to get used to use my supporting hand

this could also help people with bad mobility in hands/arms

the click-hold is not comfy, it's a workout

The 2025 SpaceShift020 user experience test revealed seven distinct hand positions and gestures across seven participants. These participants came from diverse cultural backgrounds, including Moroccan-Dutch, Albanian-American, Saudi Arabian and various Asian heritages.

The initial plan for the test was to include a broader age range, ideally targeting individuals with office-based professions. However, following the interview with Jeurens, the testing approach shifted. He argued that the most urgent objective at this stage is to observe how people interact with a new device, and not necessarily who (Appendix A).

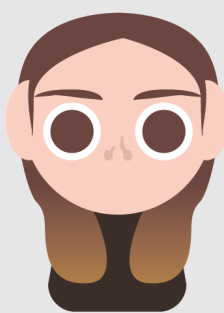
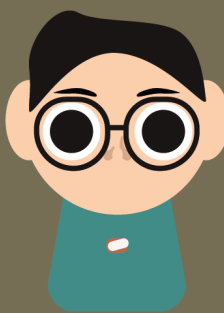
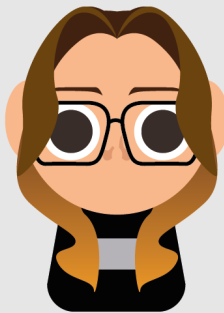
This revised direction proved valuable. Although less diverse in age, the participants provided a wide range of critical feedback and reflections. Interestingly, while some perceived the device as a potential solution to carpal tunnel syndrome, others feared it could be the cause. If the latter holds, it would suggest that the intended sense of physical freedom is yet to reach the users.

Through direct observation, the author suspects that this issue lies in the design and placement of the buttons on the Wearable 03 prototype. The current button positioning appears to trigger awkward hand gestures that may contribute to discomfort. Additionally, the buttons' lack of sensitivity requires excessive force to activate, prompting comments such as: "Clicking feels like a workout" (see above).

While the device is meant to allow free interpretation in how it is worn, there remains an ideal way to interact with it. Of the seven positions recorded during the test, only two closely align with the intended use. The next prototype should therefore address two key changes: first, more sensitive buttons and second, to fix button and joystick placement to subtly guide users toward the optimal way of wearing the device.

Participants responded positively to the UX test. While the session was originally planned to be more formal and structured, a relaxed atmosphere ultimately helped participants feel more at ease, leading to greater openness and patience throughout the process. This shift in tone proved beneficial, resulting in richer and more authentic feedback.

However, the earlier sessions took longer to complete, partly due to the moderator’s lack of practice. Future UX tests could benefit from more rehearsal beforehand to ensure smoother facilitation and a more accurate time measurement.

							
understand product scenario	●●●●●○	●●●●●○	●●●●●○	●●●●●○	●●●●●●	●●●●●●	●●●●●○
understand the task	●●●●●○	●●●●●●	●●●●●●	●●●●●○	●●●●●●	●●●●●●	●●●●●●
pressured or overstimulated	●●●○●○	●●●●●●	●●●●●●	●●●●●○	●●●●●●	●●●●●●	●●●●●●
length of the session	●●●●●●	●●●●●●	●●●●●○	●●●●●●	●●●●●●	●●●●●●	●●●●●●
experience enjoyment	●●●●●●	●●●●●●	●●●●●○	●●●●●○	●●●●●●	●●●●●●	●●●●●●
comments	-	straight forward simple everyday actions i would normally take i felt comfortable +the product is lightweight sufficient time to understand everything great new experience	the coordination with another person while figuring out the controls was a little challenging, but managable for a prototype :)	-	-	to type and find things is clear only (feel overstimulated) when i click double instead of once it was (a) perfect (length) fun experience, unique	-

participants feedback for the ux test

How can we (re)invent a peripheral to give office workers greater physical freedom in front of screens?

By examining the evolution of common office peripherals — the computer mouse and keyboard — and by exploring multiple design iterations and user experience tests, this thesis proposes an alternative mode of interaction between human and computer.

SpaceShift020 is fundamentally about the harmony between hardware and software design. It is the strategic use of limited components, joysticks and buttons, that enables the compactness and flexibility central to its wearable form. Wearability, in turn, is the key to restoring users' physical freedom.

This thesis registered the solidifying of SpaceShift020's core concept; the next challenge is bringing it into reality. Wearable 02B stands as a subtle but concrete proof that SpaceShift020 is no longer speculative fiction, but something within reach. Creation is an ongoing iterative process, but in the short term, the focus is on completing the next functional prototype, **Wearable 04**, registering its design patent, and presenting the work to Jasper Jeurens and his team.

In the longer term, the vision is for SpaceShift020 to become a brand of its own, offering a suite of products that build on this foundational peripheral.

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Jasper Jeurens "I am an interaction designer by trade, but also a design researcher. The interaction design field is multidisciplinary by nature. Within this broad industry, Human-Computer Interaction is my field of expertise, which deals with the interface between humans and computers. The technologies my team and I would design are often specifically for social context or sensitive social context.

The main ideology behind my design stems from the phenomenon in which societies push for a kind of digitalisation to achieve more efficiency and all the opportunities that were promised. This movement then comes with some serious downsides. My reflection on this rather destructive trend is that perhaps we should look at technology from a different perspective—a more socially friendly one, as opposed to design with a purely functional mind.

Regarding your project, I see you are trying to combine what is technologically possible and what would be the most desirable way to work, which is already a good start. "

Aggie Chang "Yes, a few of your projects are interesting to me because I am juggling between the principles of 'are we designing technology for humans' or 'are we optimising the possibility of technology', if the balance is tilted towards the latter, then humans are taken out of the equation. As a creator who wishes to take a more technological direction, I find myself in a moral dilemma as I come to understand that current technological development does not sustain humanity. That is not the direction I wish to go. The vision I have for SpaceShift020 encompasses more than just physical freedom; it also encourages a form of physical interaction with one's surroundings. I do want to emphasise the social part of this project. Could you advise me on how you normally proceed on this topic?"

Jeurens "I think you are on the right track when you design with the aim to empower humans to interact more with their physical surroundings in a workplace, to go beyond what constrains them in the current setting. Such as 'they are bound to the surface', I think that's what you called it. In that way, you could argue that the technology enables and enriches the existing social situation or context, and it is good to focus on this theme.

The question is, what can you do with it? What does it make possible? Keep in mind that you are designing something that digitises a big part of our analogue system, and that is difficult, because you would lose a lot of context in the translation process. Now, if you create something that enables new opportunities, then this process becomes meaningful, which could be the case here.

Have you been able to do any tests with users to see how they interact with your product? "

Chang "Yes, I am planning on it. I am now doing research into usability tests through books and online lessons. I will do two small trial tests first and move on to the official tests. I want to see if my product matches my anticipations. "

Jeurens "I think what you need goes beyond usability testing. Traditionally, this kind of test helps you measure how efficient and effective your design is, for example, the best seating position or the most readable interface. You then collect and learn something from the data, but that is not all you want to learn, right? You want to learn how your device impacts the current practice and what kind of behaviours arise from your technology. That is not what we considered 'usability testing', but more 'user testing' or 'user

experience testing'. How you label does not matter too much, what matters is being aware of how you measure your task. You can do careful measurements, or you can just strap your project on some people, ask them to do whatever it is that they normally do, but now with your device. "

Chang "That's a good point. It is logical to make it more accessible to see the raw interaction, but then they are likely not familiar with the product?"

Jeurens "Users might need some help or time to get accustomed to the new device, before finding out how they could use it. It's like a technology probe. "

Chang "What is a technology probe?"

Jeurens "It is similar to culture probes. The cultural probe is a kind of research technique in which you create a work package with designed tasks and send it to your participants for them to undergo the process on their own terms without you being present. This is an open-ended research method that usually happens in the very early stage of design as a contextual inspiration. A technology probe is exactly the same concept, but instead of giving tasks like 'take daily pictures of your surroundings', you could ask the participants to 'use the device in your own practice'. You could then find out how they use it or misuse it, or what other use cases you were not even thinking about. "

Chang "Thank you very much, that was very helpful. From what I told you about my project, do you have any concerns, or is there something I need to consider?"

Jeurens "The freedom aspect of your project resonates with me. It sparks my imagination as more freedom of movement would allow different ways to work. I can imagine it might even be more relevant to design practice or design practitioners because they might suffer more from being bound to specific places than others. Regarding other concerns, I would need to use the device to find out more. "

Chang "I made a functioning prototype, but it is not ideal bc of the hardware limitation. I plan on making a second one, and hopefully that one will work. I am also considering making a simple interface to pair with it. I am wondering if you have any sort of advice on which program I could use or what's the easiest way to make a website prototype. "

Jeurens "Basic prototype tools are Adobe XD or ProtoPie. These are software programs that allow you to mock up things easily. If it is too difficult to program, you could also fake something or apply a Wizard of Oz type of approach, where you simulate behind the scenes. In that case, you could also use PowerPoint. "

Chang "And do you have any tips on how to balance human-computer interaction? Is there a sort of criteria I need to consider? "

Jeurens "It depends on the type of technology. As far as screen-based interaction goes, there are some pretty thought-out heuristics. You can find some articles on Nielsen Norman Group. There's kind of an authority on the subject in the field, and they present some heuristics, patterns and principles that are universal to apply, especially when it comes to the usability part of things. "

Chang "Thank you so much for your time. Would it be possible to contact you if I have more outcomes? "

Jeurens "Yeah, sure! Happy to give feedback. I think it's an interesting project. We could also arrange for you to come here and present your project within our research group (at HAN University of Applied Sciences), so you could collect some more opinions."

Chang "That would be fantastic, thank you so much."

Hello and welcome to the trial/official usability test for SpaceShift020.

SpaceShift020 is a reinvention of office peripherals — including computer mice, keyboards, and controllers — designed to give users a greater physical freedom in front of the screens.

The purpose of this usability test is to evaluate the product's effectiveness, efficiency and overall user satisfaction.

During this session, I will act as your internal monologue — guiding you step by step through the test using spoken instructions. You will be following my instructions to finish a series of tasks. Before the session starts, you will receive a questionnaire sheet; this questionnaire can be filled out during or after the session is conducted. If you wish to fill out the sheet during the session, please raise your hand as an indication to pause. A table and chair are provided in the corner of the room. At any point, if you wish to make use of them, please feel free to pause the session.

You will start by reading through the questionnaire. Meanwhile, I will help you put on the device and get familiar with its function. The actual session takes about 10 to 15 minutes, and you will have some time to finish the questionnaire at the very end.

Before we start, the following session will be video recorded for research purposes and possibly presented during the Willem de Kooning Academy graduation show. If you do not feel comfortable, the video and audio could be masked. Please state your permission and preference on the questionnaire. Please note, there is also a chance that the record won't be shown at all.

Finally, you have the right to decline any question or end the session at any time when and if you feel any discomfort.

—record—

Now, before we start, could you please state your name for the record? And are you left-handed or right-handed? That hand would be referred to as your dominant hand during the session, and the other will be your supporting hand.

Now, the following are your internal thoughts. Please follow along by physically acting them out with the device:

"I am curious about SpaceShift, so I decided to search for it on Eggo. While thinking, I move the mouse clockwise with my dominant thumb on the joystick in circles while thinking. "

"It is my first time typing with this new device, so I will go slowly. I tap the search bar using the knuckle of my dominant hand's middle finger to click the button at the back of the device — the keyboard appears. The S key is already selected, so I click the button on my left hand. "

"Next is P — it's already selected. I click with my right hand."

"I move the left-hand joystick to the left to reach A, then clicked it with my left hand."

"I now push the left joystick right and hold it until I reach F. I release, then push the joystick downward to reach C. I click with my left hand. "

"Now that I understand the system better, I begin typing faster. Left-hand joystick short left, up, up to E. Left click. Then, short down, then left to S. Left click. "

"Next, right-hand joystick goes short left, left, left, down to reach H. Right click. Then short right, up to I. Right click. Left-hand joystick right, right to F. Left click. Up and right to reach T. Left-click. "

"*SpaceShift* is exactly what I want to search. I'm done typing. I double-click the buttons on both hands at the same time with my middle finger knuckles to disable the keyboard. I know this action toggles the keyboard mode."

"I push the joystick on my dominant hand to the right to reach the search button. Dominant hand click. "

"The same hand, I move the joystick in the left-up direction to the first link. I click with the same hand again. Ooops — wrong link. I press both joysticks rightward to go back. I know this action toggles the back and forth function"

"With my dominant hand, I push the joystick downward to reach the second link. Click. "

"I scroll all the way down by dragging the joystick on my supported hand downwards. Then I scroll up a little with the same joystick. A sentence in bold catches my eye. I want to copy it, so with my dominant hand, I push the joystick rightwards. Release when reaching the start of the sentence. Then press and hold the button on the same hand and push the joystick right, then down. I release the button to finish the text selection. I click the supporting hand's button to open the dropdown menu. I push the dominant joystick downwards to go through the options and stop at copy. Then click."

"I want to zoom in on the picture. I move the mouse to it by dragging the dominant joystick left, then release. I push both joysticks outwards to zoom in on the picture and then both joysticks inwards to zoom back out. "

"Lastly, I want to rearrange the tabs. I push the dominant joystick up and release. I press and hold the button on the same hand and push the joystick to the right. Release. "

Congratulations! You have completed the session. Thank you very much for your participation. Please take a few moments now to complete the rest of the questionnaire. If you have any questions, feel free to ask.

I would like to express my sincere gratitude to my supervisors, Jan Melis and Peter Kalkman, for their continuous support, thoughtful guidance, and constructive feedback throughout this journey. A special thanks to Boris Smeenk for generously sharing his practical knowledge and support the development of the functional prototypes in this thesis.

I am also thankful to my tutor group for their inspiring thoughts and ideas, which helped me push through every obstacle along the way.

Last, a big, big thank you to my mother, Pheobe Chou, for her unwavering belief in me and her words of wisdom whenever I need them. Thank you, Mom.