Crafting an Embodied Speculation: An Account of Prototyping Methods

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ABSTRACT
In this pictorial, we show and discuss the prototyping process we undertook to craft the High Water Pants, a mechatronic pair of pants that make climate change tangible for everyday cyclists. We position the pants as an example of embodied speculation and discuss how our prototyping methods helped us craft a speculative artifact that bridged the gap between the embodied experience of cycling and speculative futures with climate change. The pictorial contributes an accounting of our prototyping methods and how they strove to connect the dual contexts of (1) how the pants felt in the present, and (2) how that in-situ feeling reflected climate change data in order to create space for cyclists' embodied speculation about possible futures with climate change.

AUTHOR KEYWORDS
Prototyping; Embodied Speculation; Somatic Design; Climate Change; Cycling

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INTRODUCTION
Climate change, while arguably one of the most pressing challenges facing society [6,20,42], and one that HCI researchers have begun to address in numerous ways [19,21,24], is often difficult to tangibly comprehend due to its generational and global scale [29,33]. In order to combat how difficult it is to tangibly grasp, we created a speculative artifact which makes climate change easier to feel at the scale of everyday life for everyday cyclists. The choice of cyclists as group to focus on arose from Biggs' personal cycling practice. She has been an everyday cyclist in Seattle, WA for the last 13 years. In recent summers, air pollution from forest fires made cycling outdoors relatively unsafe. She wondered if forest fires were being exacerbated by climate change and, if so, what other impacts climate change might have on cycling. For this reason, we began to notice that while cyclists are generally perceived as a subgroup of the population who is sensitive to issues of sustainability [16,34], they are seldom recognized as threatened by the impacts of global warming (hotter weather, heavier rain incidents, flooding, air pollution, etc. [15,26]). In order to explore intersections between everyday cyclists and climate change and make those intersections tangible, we created a wearable speculative artifact called the High Water Pants which dynamically shortens in areas of Seattle which will be affected by sea level rise 30-80 years into the future [28] (we will discuss their functioning in more detail below).

While in [3] we report on the research through design process where we frame and conceptualize the pants and their implications for design, in this pictorial, we highlight the prototyping and crafting process of the High Water Pants. We consider these pants to be an example of an embodied speculation, defined as a speculation grounded in embodied experiences, histories or practices. A focus on the process of crafting is timely as calls for more embodied speculations have been articulated in design [5,7,36], but there is still a lack of precision around how to exactly attend to embodied speculation while giving form and materiality to a concept. A detailed account of prototyping exposes, "the means by which designers organically and evolutionarily learn, discover, generate, and refine designs" [22:2]. In this case, our methods for prototyping show the triangulation of strategies used to shift between somatic feeling, the context of cycling, and speculative futures with climate change.

BRIEF OVERVIEW OF THE HIGH WATER PANTS
Although this pictorial shows a journey to the final product of the High Water Pants, we briefly describe the pants at the beginning of the pictorial to help the reader understand what our prototypes and explorations built towards. The High Water Pants work by dynamically raising in areas projected to be impacted by sea-level rise in Seattle, where seas are projected to rise 10 inches by 2050 and 28 inches by 2100 by moderate estimates [28]. They move up and down using a servo

motor which actuates using live GPS coordinates and geofences that represent future-impact areas. Using this system, when the cyclist enters a geofenced area, the cyclist's pants raise up, giving the cyclist a subtle tactile cue about an area in Seattle that will be impacted by sea level rise. In this way, the experience of feeling future-data unfolds geographically. While riding, the cyclist's tacit memories and understandings mesh with new information about sea level rise, forming a personalized, local, speculative reflection about futures with climate change. The pants bridge the territory between present and future, bending time to mediate the generational scales of climate change. They offer a way to be with possible futures, opening avenues for cyclists to imagine scenarios for cycling set in a climate-changed future.

BRIDGING SOMATIC AND SPECULATIVE DESIGN

The High Water Pants are a wearable speculative artifact for embodied speculation. They act as a research product, which is defined by Odom et al. as an inquiry-driven prototype which is of a high enough fidelity to be used robustly by a user or interlocutor [23,32]. Much like Odom et al.'s description of prototyping to develop slow technologies [31] and Höök et al.'s description of their somatic prototypes [37], this pictorial examines our thinking and problem solving as we crafted the artifact in order to explicate strategies and unpack knowledge garnered through the making an inquiry-driven artifact. This process bridged e-textile, somatic and speculative design to create a embodied speculation.

Embodied Speculation

The High Water Pants are speculative, defined as an artifact that engages in possible futures or alternate presents [1]. In this case, the High Water Pants create a space for cyclists to envision their future intersections with climate change in the present. To be more specific, however, we argue the pants—which leverage in situ experience and tangible interaction for speculation—respond to calls for more embodied forms of speculation which ground speculation in real, lived experience [5,7]. Embodied speculation is well positioned to deal with issues of climate change and feminist new materialist concepts of assemblages and collaborative survival [2,10,11,40] because they both are concerned with embodied, first-person, and situated ways of knowing about human intersections with ecologies and more-than-human actors. For example: Liu et al. [24] created a set of speculative wearables to reflect on how embodied technologies for mushroom hunting can invoke speculations around inter-species relationships and collaborative survival [40]. Due to the promise of embodied speculations for envisioning complex, more-than-human, and collaborative futures, we wanted to contribute an example of our making process to offer examples of exploratory and embodied prototyping methods.

Prototyping Tangible and Somatic Experiences

Tangible and somatic interaction design explore interactions that move beyond screens and are, "embodied, situated and connected" [38:2]. Research in this area has explained the value of utilizing first-person felt experiences [14,30], provided frameworks for observing movement in ourselves and others [25,27,41], provided methods for creating somatic designs [8,17,39], and supplied shorter examples of designing and crafting wearable, embodied technologies [13,17,18,35]. However, the prototyping methods are usually mentioned as a short case study, or discussed at a high level. Inspired by detailed accounts of the design and crafting of design research artifacts that show reflection on the crafting of critical and somatic technologies [23,31,37], in this pictorial we show our detailed prototyping process for embodied speculation, offering examples of methods and insight as we bridged in situ experiences while cycling with sea level rise predictions for Seattle, Washington. We were especially inspired by Tomico et al.'s call to, "[move] the design process from the technologically oriented 'drawing board' to a full immersion in context" [38:3]. Our methods reflect this through attempts to continually test ideas in the context of being worn while cycling.

Ultimately, our prototyping process sought to answer and bridge the gulf between two questions: (1) how to design a legible tangible interaction within the specific movement of a cyclist (a person moving through space by moving their legs) and (2) how to design a legible tangible interaction within the speculative context of the future of sea level rise in Seattle.

METHODS

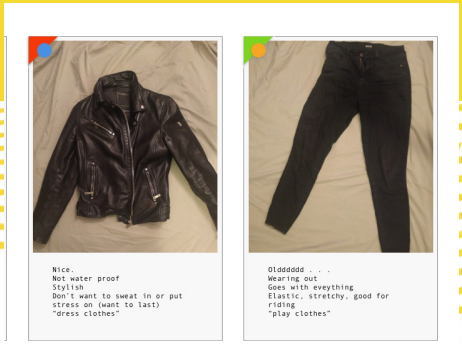
Throughout the crafting process, we kept track of our prototyping through extensive photo and video documentation and reflexive writing of medium articles and progress presentations. We used this data to conduct a thematic analysis, therefore, the methods presented are not perfectly chronological or a one-to-one recounting, but are meant to be exemplars of techniques used.

RAPID FIRST-PERSON EXPERIENCE PROTOTYPES

In one of the first phases of the research process, Biggs conducted a series of rapid, first-person experience prototypes. These prototypes focused on examining questions through use and experience, foregrounding understanding feeling from a first-person perspective as advocated for by Höök et al. [14]. We created four different experience prototypes, starting by sketching, then building the prototypes in quick and low fidelity ways. The goal was to explore connections between cyclists, the seasons, their environment and their gear. These findings were used to scaffold speculation later as we utilized gear to extend cyclists' awareness of their environment and climate change. In particular Song Hunter and Assemblage Shooter explored assemblages that cyclists are a part of as they are in motion and interacting with other entities.

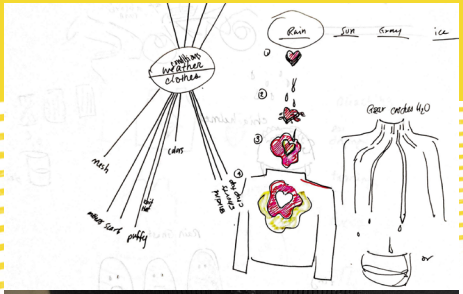
SONG HUNTER

Biggs 'hunted' songs being played by cars as she was stopped with them at a stoplight by Shazaming the songs, then continuing to play them as she rode along via a bluetooth speaker.



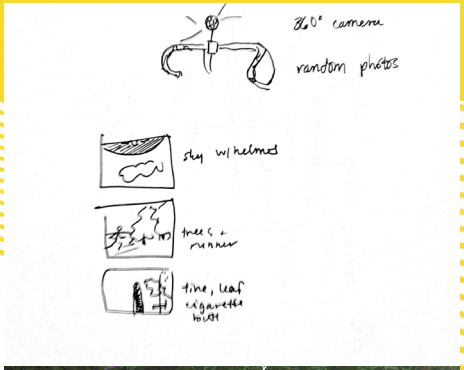
GEAR CONVERSATION CARDS

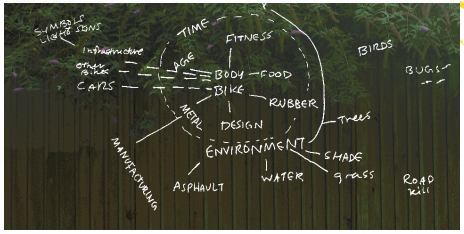
Biggs created a deck of cards to spark discussions about how she thinks of and categorizes her cycling gear.



IN THE ELEMENTS

Biggs cut a heart shaped hole into her cycling shorts and went on a bike ride to try to get a heart-shaped tan line. This reflects on exposure to the sun as a pleasure and risk of cycling.





ASSEMBLAGE SHOOTER

A bike ride where Biggs shot photos to capture mundane more-than-human actors. This exercise inspired the assemblage shooter, a camera that would take photos autonomously to capture new impressions of a ride from non-human perspectives.

INITIAL DESIGN PRINCIPLES

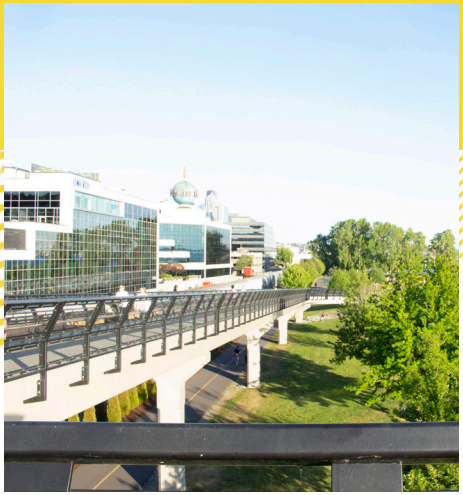
The first person explorations and interviews with 6 cyclists (which we explain in detail in [3]) led us to four design principles. In our semi-structured interviews, we discovered cyclists have a rich, embodied and sensorial understanding of Seattle's unique weather and climate, feeling the cold metal of handlebars in winter, smelling the 'moldy fresh' air of fall, and noticing cherry blossoms and migratory geese in the spring. We then dovetailed our own rapid prototypes with cyclists' everyday practices and local understandings of climate and weather to enable speculation about their futures with climate change (which operates at a global and generational scale). When prototyping the garment we wanted to consider cyclists' movement, location, gear, and bodily placement of the sensation we wanted to create.

IN MOTION

A cyclist is a person in motion, both on the bike (pedaling) and through their environment as they cover distance. We had to consider their body's position, pedal stroke, and common cycling experiences such as wind resistance and typical distances covered.

GEAR AS MEDIATOR

Garments for cycling are already designed for the specific movements and practices of everyday cyclists (chamois, back pockets on jerseys, long tails on coats). They also mediate between the cyclists and the elements (waterproof, venting, sun-blocking). We wanted to capitalize on cycling gear's inherent expression of the relationship between a cyclists body, the act of cycling and the weather, but push it into more speculative terrain.



LOCAL

In order to shift the overwhelming scale of climate change from the global and generational scales it is often discussed at to the scales of everyday life, wanted to situate our design locally. We wanted the cyclists to roll over familiar roads, favorite waterfronts, and their usual hills. This photo was taken at a popular cycling and running park along the Puget Sound in Seattle, WA.

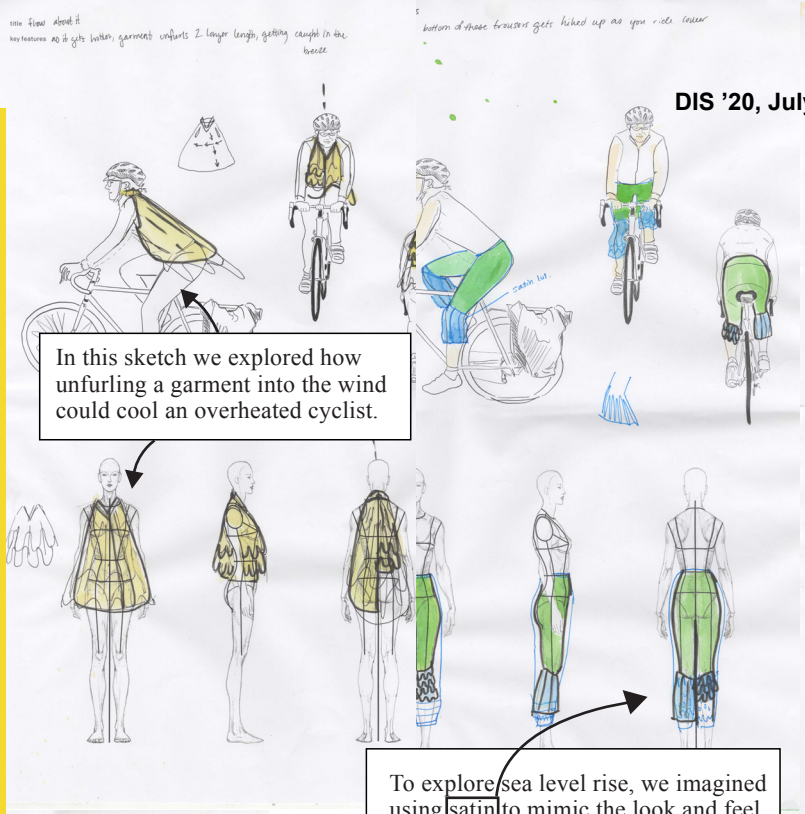
RELATION TO THE BODY

Ultimately, the garment needed to connect data meaningfully to its placement on the body as well as how the body, on a bike, had a unique potential to experience wind on the skin or swinging pant legs (to name two examples). We also had to test how different parts of the body would feel and what type of data (graduated / binary) could be felt and understood through that body part.

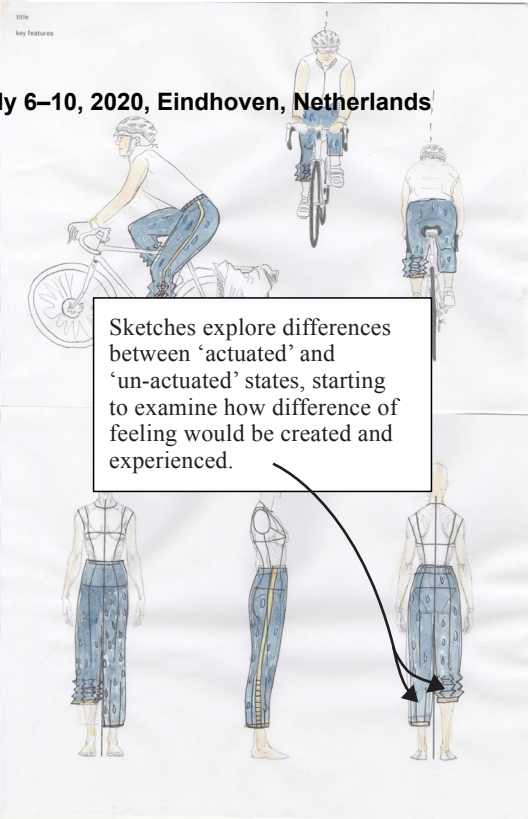
SKETCHING FEELINGS

After ideating using the aforementioned principles, we chose to create a cycling garment which could explore future climate change data through present experiences. We had narrowed design concepts down to a jersey that related to temperature rise and pants that related to sea level rise. This exercise shows how we used a sketching template as a starting point for generating a diverse set of concepts. Sketching allowed us to playfully imagine how the form of a garment would intersect with both a cyclist's movements and position on a bike as well as how the form would creatively express data about climate change in a tangible way.

To keep the context of cycling at the forefront of attention, the template included views of a cyclist on a bike to sketch over as well as a standing body shown from the front, back, and side. This exercise helped us start to imagine the forms, mechanics and ensuant feelings of garment transformations. All these sketches used material and forms to ask what form/feeling could best communicate data about a climate-related phenomenon 30-80 years in the future.

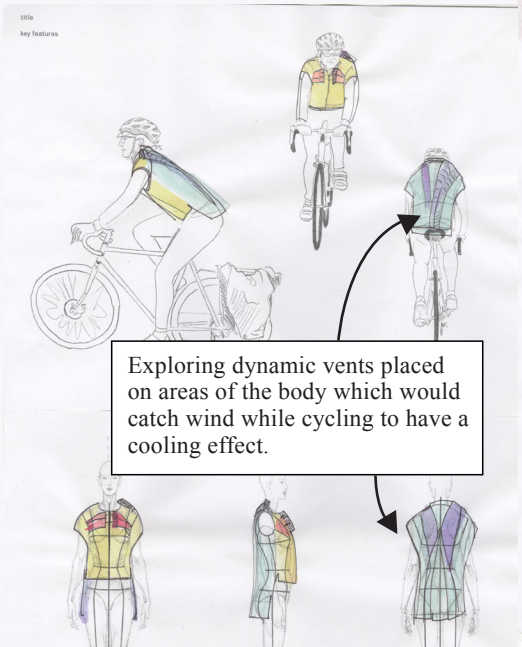


In this sketch we explored how unfurling a garment into the wind could cool an overheated cyclist.

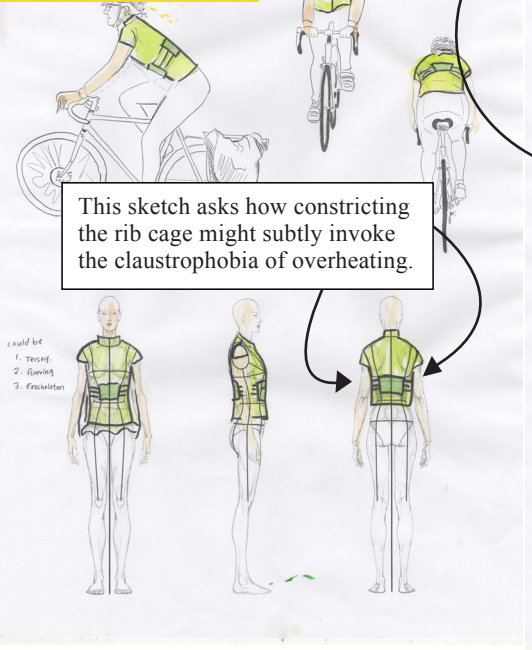


Sketches explore differences between 'actuated' and 'un-actuated' states, starting to examine how difference of feeling would be created and experienced.

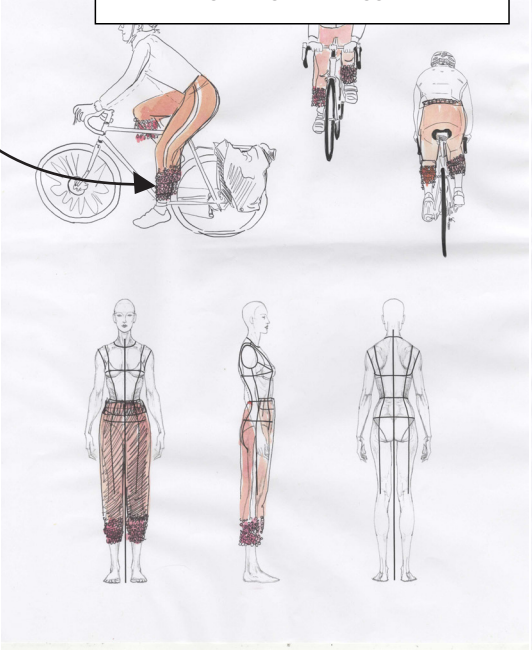
To explore sea level rise, we imagined using satin to mimic the look and feel of water by being smooth, shiny and cool, beads to mimic the feeling of cold, heavy, wet water-saturated fabric, and nitinol wire to pucker fabric like a pruney finger to represent something being waterlogged.

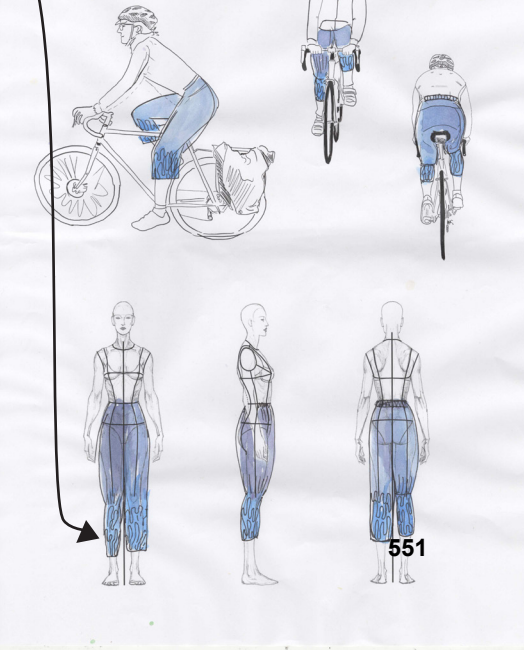


Exploring dynamic vents placed on areas of the body which would catch wind while cycling to have a cooling effect.



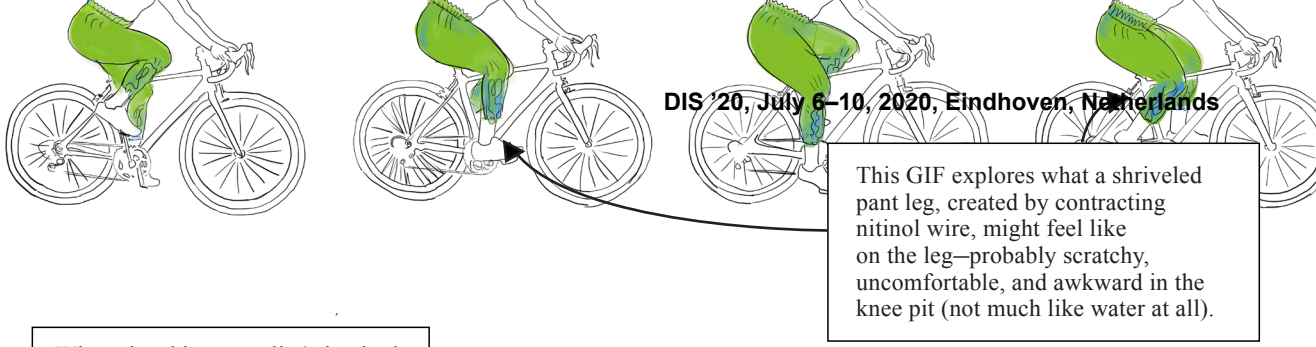
This sketch asks how constricting the rib cage might subtly invoke the claustrophobia of overheating.





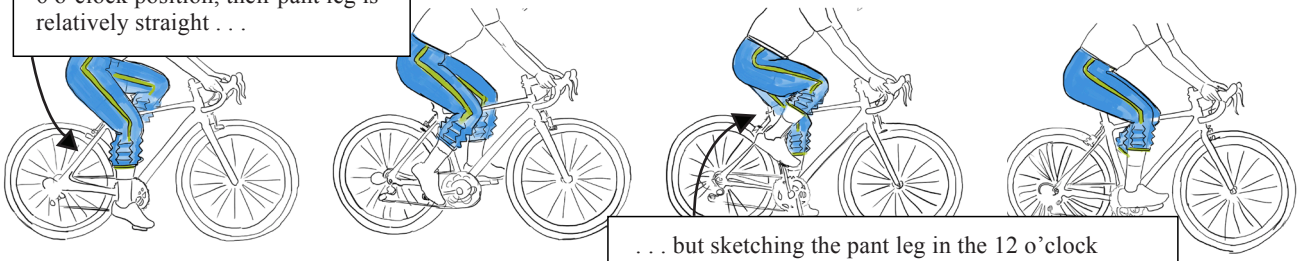
ANIMATING FEELINGS

At this point in our process we chose to focus on creating the High Water Pants. We chose our favorite concepts from the previous sketching exercise and created animated GIFs of them to help us see how different mechanical solutions and material qualities would feel within the context of a cyclist in motion. This was a low-fidelity way to explore intersections of movement, material, cyclist and experiences of climate change data. The process of sketching these GIFs required us to imagine the impact of physics and sensations of our design concepts in different leg positions on the bike as well as how clearly those sensations would translate into tangible understanding of climate change projections. These animations were also influenced by low-fidelity, on-the-bike experience prototypes explained on the next page which explore material feelings and movement in the context of riding.



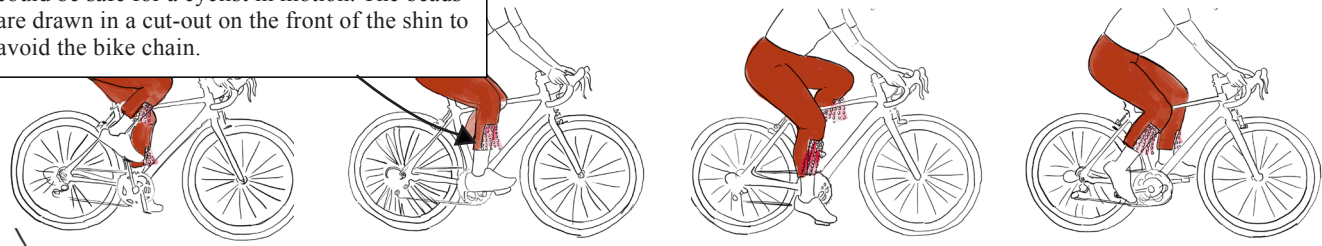
This GIF explores what a shriveled pant leg, created by contracting nitinol wire, might feel like on the leg—probably scratchy, uncomfortable, and awkward in the knee pit (not much like water at all).

When sketching a cyclist's leg in the 6 o'clock position, their pant leg is relatively straight . . .

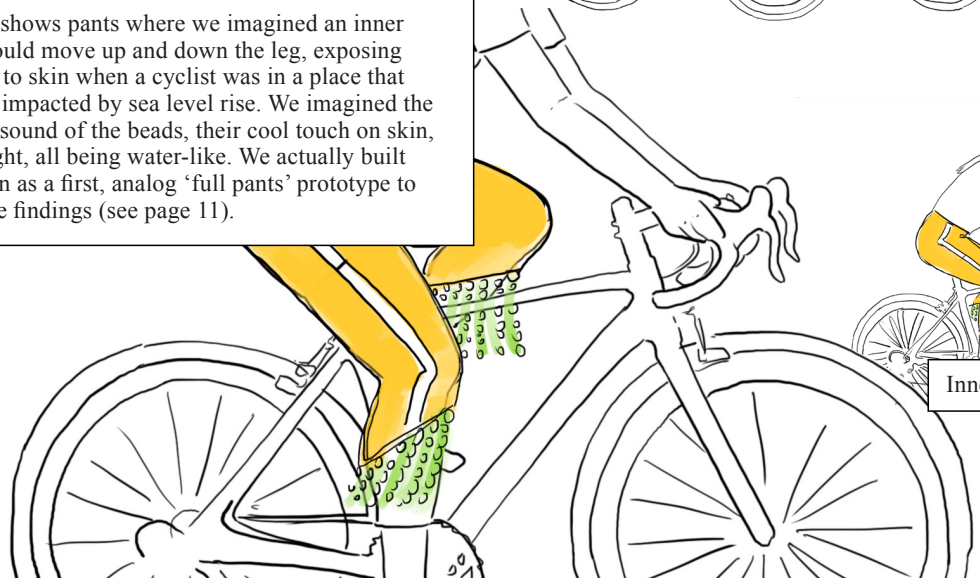


. . . but sketching the pant leg in the 12 o'clock position, we envisioned the pants (especially raised pants) had the potential to bunch into the knee pit.

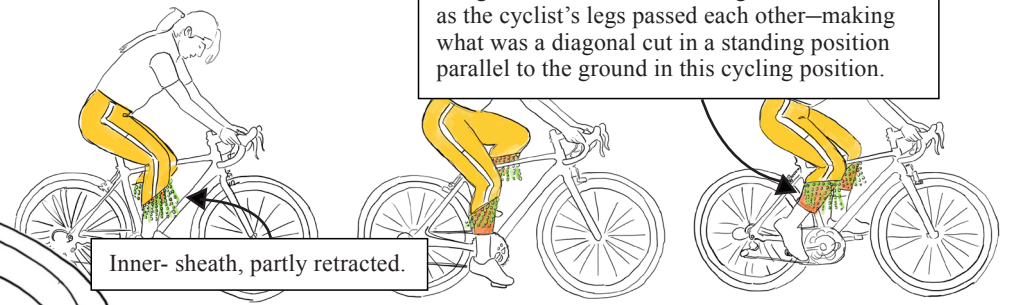
In this GIF, we were imagining both how beads could swing against the leg to feel 'sloshy' like water and also were envisioning how they could be safe for a cyclist in motion. The beads are drawn in a cut-out on the front of the shin to avoid the bike chain.



This GIF shows pants where we imagined an inner sheath would move up and down the leg, exposing the beads to skin when a cyclist was in a place that would be impacted by sea level rise. We imagined the rhythmic sound of the beads, their cool touch on skin, their weight, all being water-like. We actually built this design as a first, analog 'full pants' prototype to synthesize findings (see page 11).



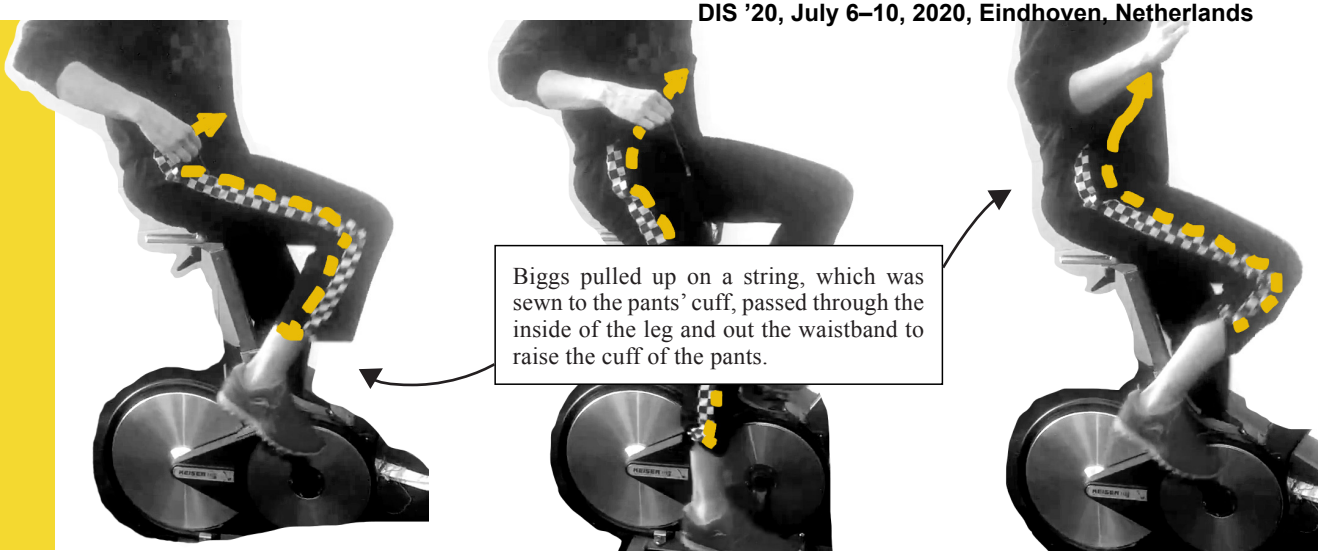
The diagonal cut at the bottom of the pant was designed to make a kind of 'high water line' as the cyclist's legs passed each other—making what was a diagonal cut in a standing position parallel to the ground in this cycling position.



Inner- sheath, partly retracted.

IN SITU TESTS OF MATERIALS AND SENSATIONS

As mentioned in the introduction, we tried to find ways even in the very beginning of our research to test ideas in embodied ways in the context of riding a bike. We conducted two very low-fidelity tests in parallel with the animated GIFs (previous page) to explore beads as a material as well as the feeling of pants raising up while riding, testing sensations and material choices within the context of cycling.



Biggs pulled up on a string, which was sewn to the pants' cuff, passed through the inside of the leg and out the waistband to raise the cuff of the pants.

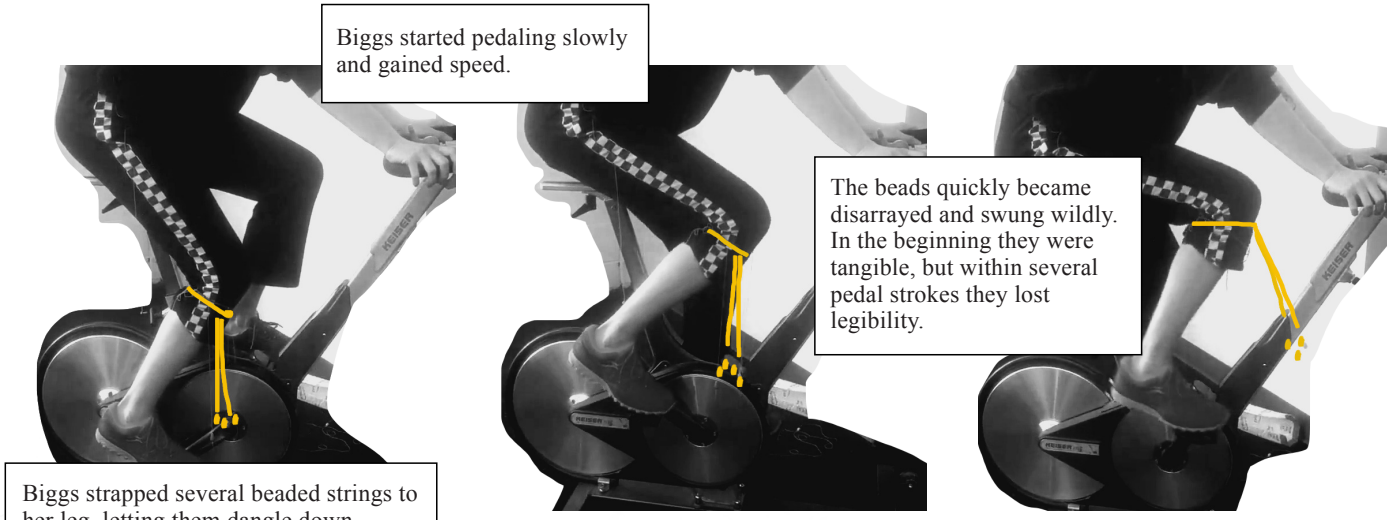
Exploring the feeling of pant leg raise

On a ride outdoors, Biggs noticed the sensation of the pants being pulled up was noticeable—the leg was exposed to more wind and colder temperatures and the pant leg brushing against the skin was in a notably different position.

However, Biggs also discovered that the leg is always changing position within the opening of the pants cuff due to the action of pedaling, and a fine-grain grasp of the distance the pant leg had traveled was impossible to discern.

Exploring the feeling of beads against the leg

Biggs captured and analyzed the movement of beads using video. By analyzing video and comparing it to feeling, we noticed the beads quickly became disarrayed and swung wildly. We discovered that beads might need to be meshed together in a more organized way to work for a cyclist riding a bike and therefore we started exploring bead weaving and beading techniques to create more organized forms.



Biggs started pedaling slowly and gained speed.

Biggs strapped several beaded strings to her leg, letting them dangle down.

The beads quickly became disarrayed and swung wildly. In the beginning they were tangible, but within several pedal strokes they lost legibility.

'FAKE LEG' MECHANICAL EXPERIMENTS

After sketching, experiencing, animating and building one pair of pants (see pg. 11), we decided to avoid the knee joint of the cyclists due to how much bulk and complexity pulling through it would add. We also decided to use a servo motor to pull up on the pant leg because it was simple, required low power so it could be powered for a long time, and required no additional drivers. To prototype our soft mechanical system, we created a 'false leg' out of scrap wood at our fab lab. We then prototyped multiple different mechanisms for ways to create tactile sensations on the rider's leg. Every mechanism sought to explore feelings generated by the mechanism and materials used and evaluate how well they would translate future data about climate change, and how feasible they would be to use on a bike.

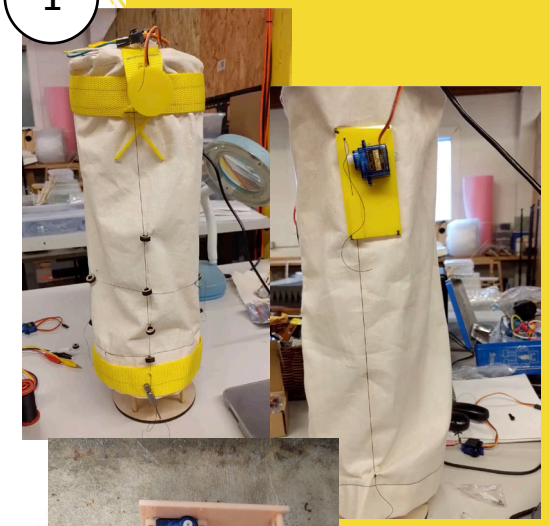
(1) Pulling
We created two different ways of pulling the pants up: a spool to extend the servo arm and a platform the servo could be mounted to and pull against (mitigating the difficulty of pulling against a soft surface of fabric). Ultimately, the simplicity of the platform pull made it robust and we chose this system for the High Water Pants.

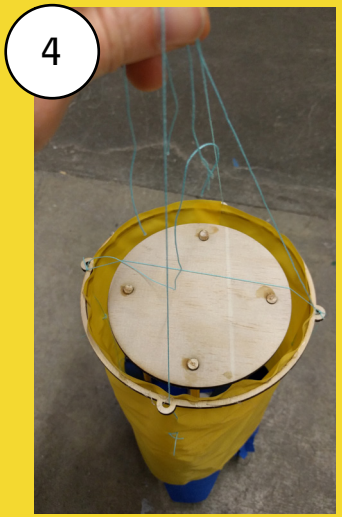
(2) Tautening
We explored tautening a network of threaded beads using a spring mechanism where the beads would get loose and sloshy to represent sea level rise and taut otherwise. We created a proof of concept for this by using the spring mechanism of a clicking pen. While this idea had merit, it was ultimately too complex to be at the scale we needed (all the way around the bottom of a pair of pants).

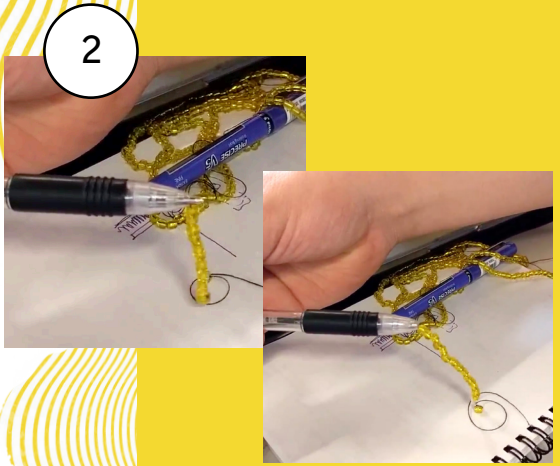
(3) Flipping
Flipping exposed different textures as a servo flipped over a piece of yellow material. In this case, one side of the material had beads and one did not. Again, this mechanism could not scale, it would require one servo motor per unit which would require too much battery power and the servos would make the bottom of the pants too heavy.

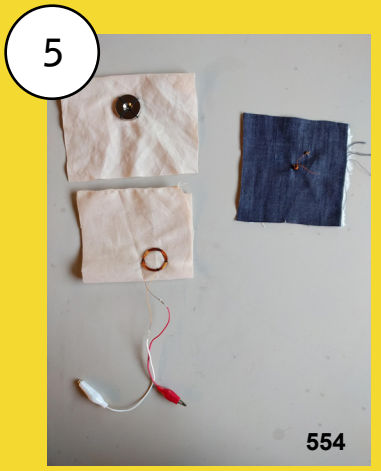
(4) Hoop-lift
This prototype sought to evenly lift a sheath up by guiding it through eyelets on a hoop. This solution we only explored in an analog format. It would have required a more complex motor that could pull more than 180 degrees and the hoop would have possibly bumped into the bike frame as it was designed to encircle the leg.

(5) Soft Electromagnets
Following a guide found on the Kobakant website, we tried to prototype a soft electromagnetic 'velcro' that we hoped could draw the pants together to shorten them via magnetism. This experiment used too much electricity and had a weak pull, meaning it was not feasible for our use case.









TANGIBILITY OF DATA AND CODE

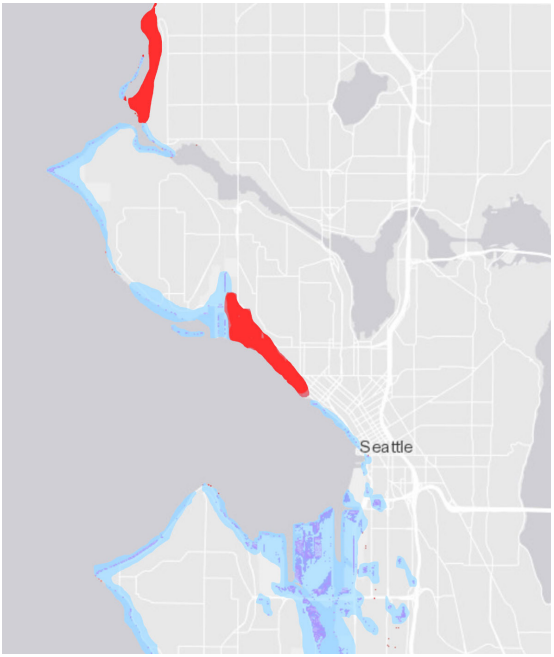
Tangible Data

When working with climate change data (data based on predictive modeling, therefore, set in the future) our goal was to choose data that worked to create tactile meaning on the body. We sought to create a meaningful sensation that represented the *differences* the data represented between the present experience on the bike and the future which the data was modeling. We evaluated which data set could tangibly communicate the difference (the time warp) but would also be interesting in the context of cycling (where you can cover geographic distance relatively quickly). We chose sea level rise because, not only would this data be place-specific in Seattle, it would also create a meaningful feeling on the cyclist's leg (the part that water might touch during a flooding incident). We also chose the data because it could be binary. We discovered in previous explorations that legs aren't able to *feel* at a fine grain of detail so we decided an 'up or down' type feeling would be most legible. Also, using sea level rise projections, either a cyclist could arguably be either inside or outside of an impact area in the future.

Feeling Code

To have a live GPS location, our code originally checked GPS coordinates hundreds of times a minute. We noticed that due to this, sometimes around boundaries, the servo would chatter and become a little erratic as the polygon detector registered the rider as flipping between inside and outside of a polygon. We actually thought this was interesting and that it might be a provocative sensation for the servo motor to flutter or oscillate at boundaries. To clarify this feeling, we slowed the rate at which the code reported GPS locations so that the servo motor's movement at boundaries would be more pronounced. This gave an exciting sensation to riders finding and exploring edges, expressing a liminality as they entered a future impact zone.

This map from the NOAA Sea Level Rise Viewer show narrow areas where sea level rise will impact Seattle (blue). *Image from https://coast.noaa.gov/slr/#*



Imagining the pants in use and under the assumption that sea level rise would impact Seattle in unforeseeable ways, we broadened the geofenced areas slightly to give cyclists more chance to reflect (blue represents proposed geofences, red represents built geofences).

The oscillation of the servo mechanism as a cyclists encounters a geofence boundary.

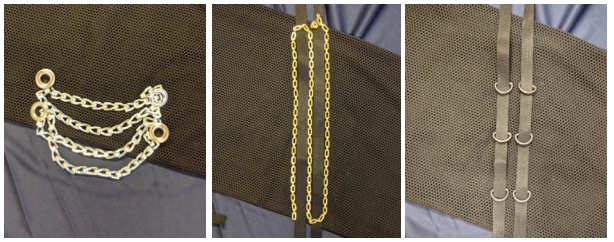
UNDERSTANDING MATERIAL MOVEMENT AND FEELING

Material Range

Part of creating feeling was also connected to the qualities of the materials we used. We explored materials continuously by shopping, touching, experimenting and procuring with a large variety of materials to explore mechanically and how they would feel on the body (heavy/cool/smooth/scratchy).

Bead Engineering

Early on in the prototyping process, we were interested in beads for their cool and heavy properties. We explored beading techniques and adding beads to the cuff of the pants. However, we slowly eliminated them because they were too heavy and unwieldy.



Material Sketches

After deciding on the final mechanism for the pants, (which was the servo-platform pulling system) we ran a series of material sketches that allowed us to quickly ideate between different types of materials and material arrangements exploring chain, d-rings, mesh and technical fabrics.

Analog Pull Material Tests

Using material sketches as a jumping off point, we chose two potential options for making a soft but mechanically feasible pulling mechanism.

These rapid material prototypes were a way to test possibilities of material and imagine different types of feelings that could be created by chain after beads proved unwieldy. Eventually we just used the mechanical idea of nylon webbing pulling up through a series of d-rings attached to athletic mesh without chain at all.

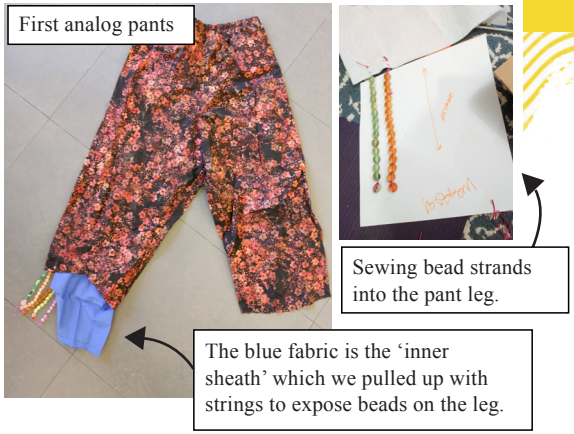
We created these sketches and tested them in an analog way by simply pulling on them by hand.

Nylon webbing is pulled up through d-rings sewn onto to athletic mesh. Pulling up the mesh slowly exposed a chain to create a cold and 'sloshy' feeling on the cyclist's leg.

This system pulled power mesh up by threading nylon webbing under reflective ribbing. However, it was too lightweight to rise and fall cleanly and seemed unlikely to evoke a clear feeling against the leg.

MOMENTS OF SYNTHESIS

On the way to creating the final High Water Pants, we created several 'full' pants prototypes that helped us synthesize the collective impacts of all of the different targeted prototypes we created. These full pants allowed us to take the pants into the context or riding a bike to explore how well they were functioning and to uncover new macro-level insights about their construction, material limitations, and clarity of sensation. In order for our embodied speculation to be tangibly meaningful, we had to synthesize our micro experiments and tests into artifacts we could experience in context and on the body.

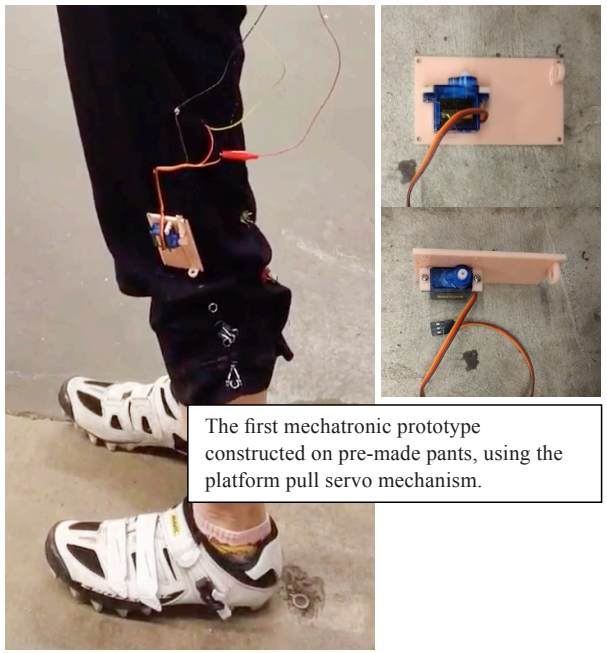


First analog pants

These pants were based on initial sketches and were fully analog. This experiment allowed Biggs to feel and experience the mechanical limitations of the design (beads are heavy and unwieldy and the sheath is mechanically unreliable) however—the beads, although unruly, felt cold and interesting on the leg.

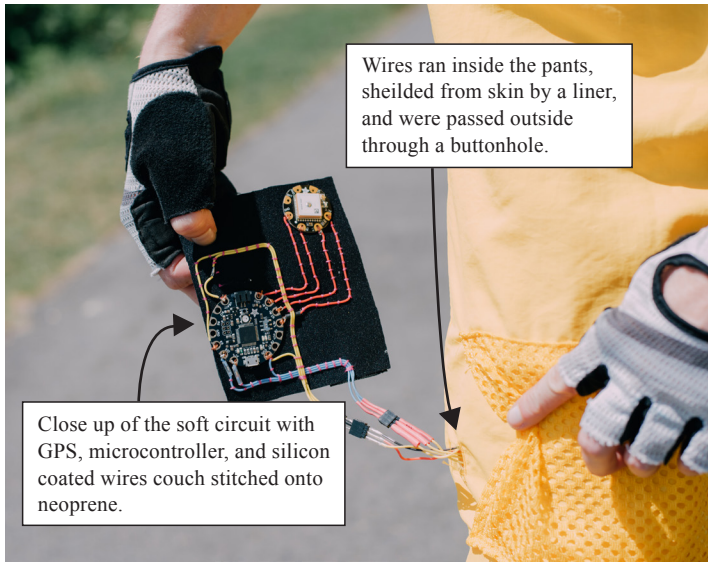
First mechatronic pants

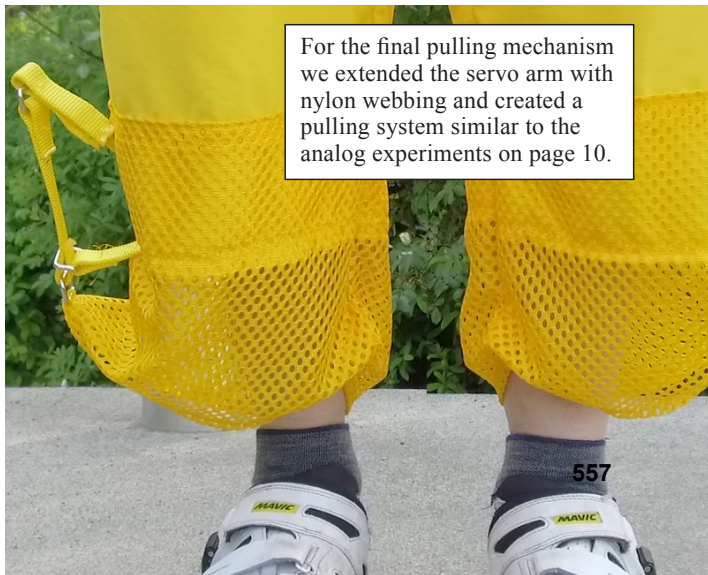
The first mechatronic pants which combined live GPS code and a microcontroller. These pants were a chorus of failures. While the platform pull mechanism worked (one success), the code was glitchy and did not yet clearly convey boundaries (we resorted to actuating them via a button to test the pants while riding). The servo arm wasn't long enough and therefore, it was hard to feel the pants lift. We tried adding beads to the inner cuff to make a more interesting feeling but they were too heavy and actually made the movement of the pants *harder* to feel. This prototype pointed out the need for further mechanical clarification, a need to attend to aesthetics (they were not very attractive), and continued work on boundary detection code.



Final Pants

These pants required a leap of faith and new, creative use of materials. They were a large improvement from the previous prototype in terms of code, aesthetics and clarity of material use. They were the culmination of many quick prototypes with materials but felt like a leap in judgement and construction which largely solved the many problems we found in the second prototype.





DISCUSSION

Through the creation of the High Water Pants, we explored multiple modalities of prototyping following a research through design approach. In the process of our crafting, we explored ways to bridge the somatic experience of wearing a garment while cycling with the conceptual and speculative experience of imagining future intersections of climate change and everyday cyclists. In the following we discuss three major implications for designing embodied speculations learned through our prototyping process: (1) how feeling can be imagined and explored through sketching and rough animation, (2) the importance of continuously testing the prototypes in context of use and speculation, and (3) the leap of faith to craft the final artifact and the pleasant surprise of finally experiencing it after many small prototypes and imagined feelings. The artifact 'became itself', in a way, with its own unique movement language and vocabulary we could never have imagined perfectly.

Sketching to Imagine Feeling

While sketching is a very traditional mode of examining the potential of design concepts [4,9], in the process of creating the High Water Pants, we used sketching to imagine movement, mechanics and sensations within the context of making future projections about sea level rise metaphorically tangible. Importantly, these sketches placed all of our concepts in the context of the cyclists so that we could continually frame ideas within the embodied experience of riding a bike. We found that sketches offered us a way to think about and see possibilities for the types of feelings garments could create for cyclists. By sketching directly over cyclists on the bike, creating an embodied context for sketching, we experienced the push-back of sketching—uncovering the complexity of building for a leg as it bends through the pedal stroke or imagining the way the wind might interact with garments on the bike. We explored tangible potential of materials, mechanics, and forms and used these initial sketches to begin to bridge the gap between the material, sensorial and conceptual aspects of the design.

Testing in Dual Contexts

Throughout crafting the pants, the two questions we always kept in mind were: 'how does this feel?', and also, 'how does this feeling make me understand sea level rise projections for Seattle?'. Inspired by Tomico et al.'s call to explore wearable technologies in context [38] and Höök et al.'s argument for the importance of first person experiences in somatic design [14] we pushed ourselves to regularly experience or imagine our prototypes in the context of cycling. However, we also had to find ways to push somatic explorations into the realm of speculation. We were dealing with a dual somatic context: both the context of riding the bike in the present and, simultaneously, the context of making predictive data tangibly meaningful to communicate futures with sea level rise.

We used prototyping to manage the push and pull between somatic design and speculative design. Our prototypes worked cyclically, for example: feelings in context (like experiencing a pant leg rising via pulling the pants cuff up with a string) impacted the type of climate change data we chose which in turn influenced the material explorations we conducted while seeking meaningful ways to tangibly translate that data. Crafting the design happened in the context of cycling, but also within the context of the larger speculative framing. This slow process of bridging tangible and conceptual/speculative contexts helped us craft an embodied speculation where cyclists experienced future data in the present through formal and tangible metaphors. This layering and leveraging of temporal contexts created space for the cyclist's own embodied speculation and reflection.

A leap of faith and 'becoming itself'

When moving from the second full-pants prototype to the final research product, we made a large jump between levels of fidelity. While in hindsight, we can see the amount of work that went into prototyping all the various aspects of the pants eventually came together into a coherent 'whole', at the time, the final product came together rapidly, surprising us with a clarity of somatic experience and aesthetic unity we had yet to see at any point in our process.

We claim this was a process of the pants 'becoming themselves' because ultimately, they ended up having their own subtle movement vocabulary [12] and took on a liveliness [2] we did not fully anticipate. The feeling of wearing the pants is a softer, more subtle experience than we imagined (although still based on our experiments and imaginings). We tried to build metaphors of feeling with beads and chains, but the final feeling and mechanism of the pants was so simple we could have never seen it from the start. In the final design, when the servo arm was raised, the feeling was mainly derived from the platform pressing the pants lightly against the outside of the calf, a subtle bounce of the servo arm, and the feeling of wind blowing on the exposed shin bone. When the pants lowered, at times, it was almost imperceptible—for Biggs, she found the impulse to look down to see the servo arm had dropped was a bit like abruptly waking from a daydream. This simple design elicited wonder and excitement as we experienced something we had previously only imagined and was therefore familiar yet totally new.

CONCLUSION

In conclusion, this pictorial explores the prototyping methods used to craft of the High Water Pants, a pair of mechatronic pants that help make the impacts of climate change tangible for everyday cyclists. This pictorial offers two contributions (1) the in-depth discussion of our prototyping methods wherein each example we offer detailed descriptions of how these methods helped bridge between somatic and embodied design and speculative design.

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