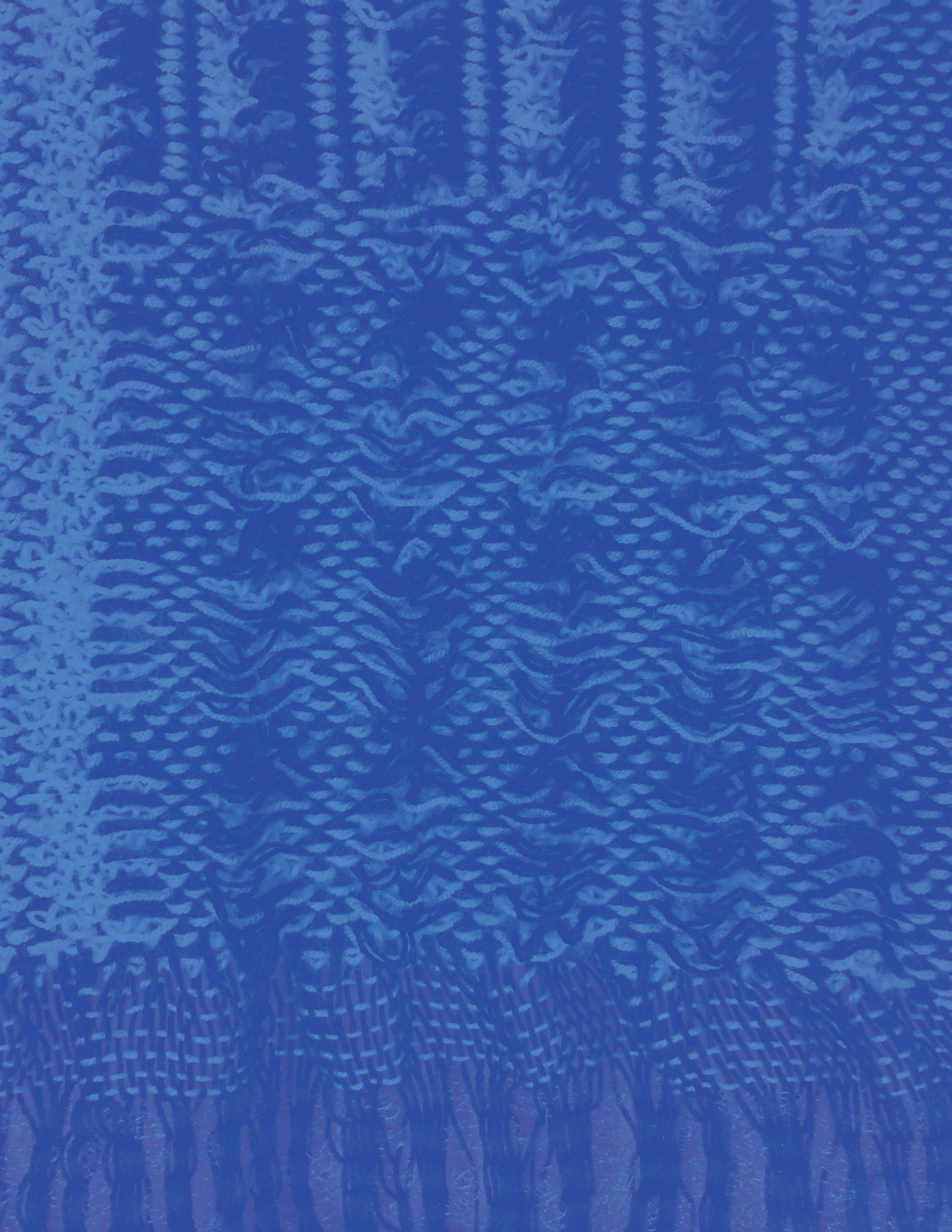


The Experimental Weaving Residency

Unstable Design Lab + Sandra Wirtanen

A Materials-Based Research Grant from the Center for Craft

"being able to integrate material and design knowledge into the process from the beginning. Often times, even in textile-based research, the design process is skipped entirely or conducted in a later phase after developing the technology. In some cases the opportunities to utilize the textile material in an effective and meaningful way are missed, which may have a negative effect on usability and user experience later. An open, collaborative process with a more holistic approach to engineering, design, materials, fabrication, and Human-Computer Interaction is powerful for testing and gathering ideas that could potentially result in research around
multiple fields."
Sandra Wirtanen, Textile Designer

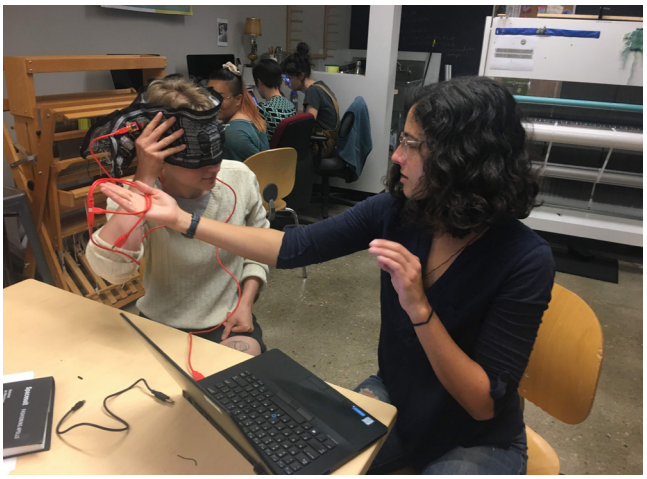
"the opportunity to shed the structure of the engineering design process and begin making without a clear picture of what the product would be. Sticking to the typical requirement-driven design produces functional technology, but it loses the benefit of organic development there is room for within the artist's process."
Allison Anderson & Katya Arquilla, Aerospace Engineers

"a greater knowledge of the capability and possibilities of textile structure that could be leveraged for novel smart textile interactive projects and the kind of design tools and supports that might need to be created to support this work more broadly. While we still remain novice weavers, we cultivated a much better sense of how we could approach our own testing and prototyping practice in moments where we didn't have access to expert knowledge."
Laura Devendorf, Design Researcher

Establishing the Experimental Weaving Residency

As technology researchers continually look towards the integration of "smart" digitally enabled or responsive components within traditional material domains they are increasingly turning their attention to the arts and crafts domain for inspiration and collaboration. However, as technologists approach these domains, they tend to engage them within specific capacities, often (un)intentionally emphasizing the romantic, poetic, or primitive associations of craft to create thought-provoking juxtapositions between the technological "new" and the craft "old". In other cases, they aim to bring technological "expertise" to the craft "amateur" particularly when we use craft as a platform for women and non-westerners to become introduced to more technical concepts and techniques. We began this residency with an aim to demonstrate to technologists how art and craft practices could be understood as technical in their own right.

With generous support from the Center for Craft, the University of Colorado at Boulder's ATLAS Institute within the College of Engineering and Applied Sciences, and Deptartment of Information Science within the College of Media, Communication, and Information, we developed and announced an "experimental weaving residency" in an attempt to bring a working textile artist into our research practice. On one hand, our residency was a chance to expand our own thinking and approaches to smart textile development. On the other, we were confident that it would give us evidence through which to highlight the value and technical competency of craftspeople to practices of technology and innovation. In addition to publishing our findings from the residency within academic " venues", we are publishing this text to bring awareness to the growing community of craftspeople interested and willing to pursue research. Furthermore, we reflect on our own experience to provide insights to institutions who might be interested in hosting similar programs.



Sandra Wirtanen specializes in weave structures, and to her the loom and act of weaving represent an infinite space for creative and technical exploration. She is a newly graduated Designer from Aalto University and currently based in Helsinki, Finland. Making tangible prototypes is her method to create and do research. During hands-on work, she processes new ideas and information and transforms them into physical objects. Lately she has been focusing on embedding technology into the aesthetics and function of textiles. As a passionate collaborator, interdisciplinarity is in a key role in my future visions. Through my work, I aim to communicate a worldview that is conscious, human and sensory.

sandrawirtanen.com

Unstable Design Lab uses design as a way to generate theory and things. Design is political and we develop working technologies to help people imagine alternative futures with alternative politics. We think its okay that the world is a messy and unpredictable place. Instead of building technologies that help us know more and do more and predict more, we explore technologies that help people become beginners, see things differently, and form new relationships with people, environments, and things. In doing so, we often trade control for cooperation, the individual for collectives, and productivity for humility.

unstable.design

The Unstable Design Lab is Laura Devendorf, Steven Frost, Mikhaila Friske, Sasha de Koninck, Shanel Wu, Jolie Klefeker, Ruth Hunsigner, Katya Arquilla, Nathalia Campregeur França, Rona Sadan, and Lea Albaugh

The Engineering Challenge

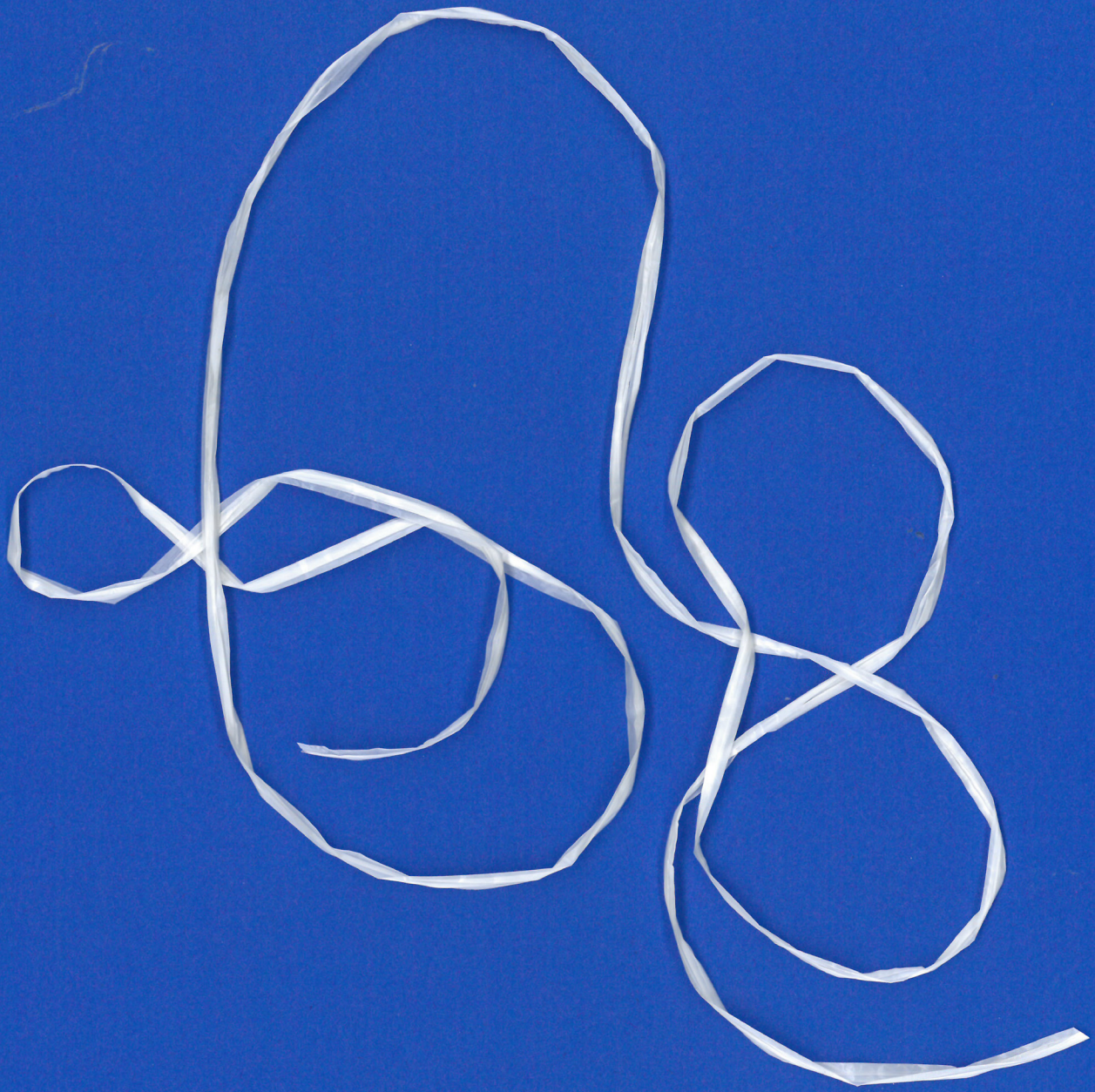
Over the course of the residency, Katya Arquilla and Sandra Wirtanen developed a project concept that was of mutual interest, based on their individual backgrounds and desired future work. The focal point of collaboration was a headband that sensed muscle actuation of the forehead. With each heartbeat and muscle twitch, the body produces electrical signals that can be mapped to motion, emotion, and intent with the use of simple electrodes in contact with the skin. These electrical signals can be sensed using processes of "electromyography" (EMG), where conductive electrodes are placed on the skin, acting as a conduit carrying the electricity in the muscles into a computer system where it can be measured and analyzed. The muscles in the forehead, such as the frontalis muscles (located above the eyebrows, in line with the pupils), can indicate surprise, fear, or sadness, depending on which other muscles are activated simultaneously. The engineering challenge, then, was to develop a textile integrated system capable of sensing the frontalis muscles in comfortable and technically robust ways.

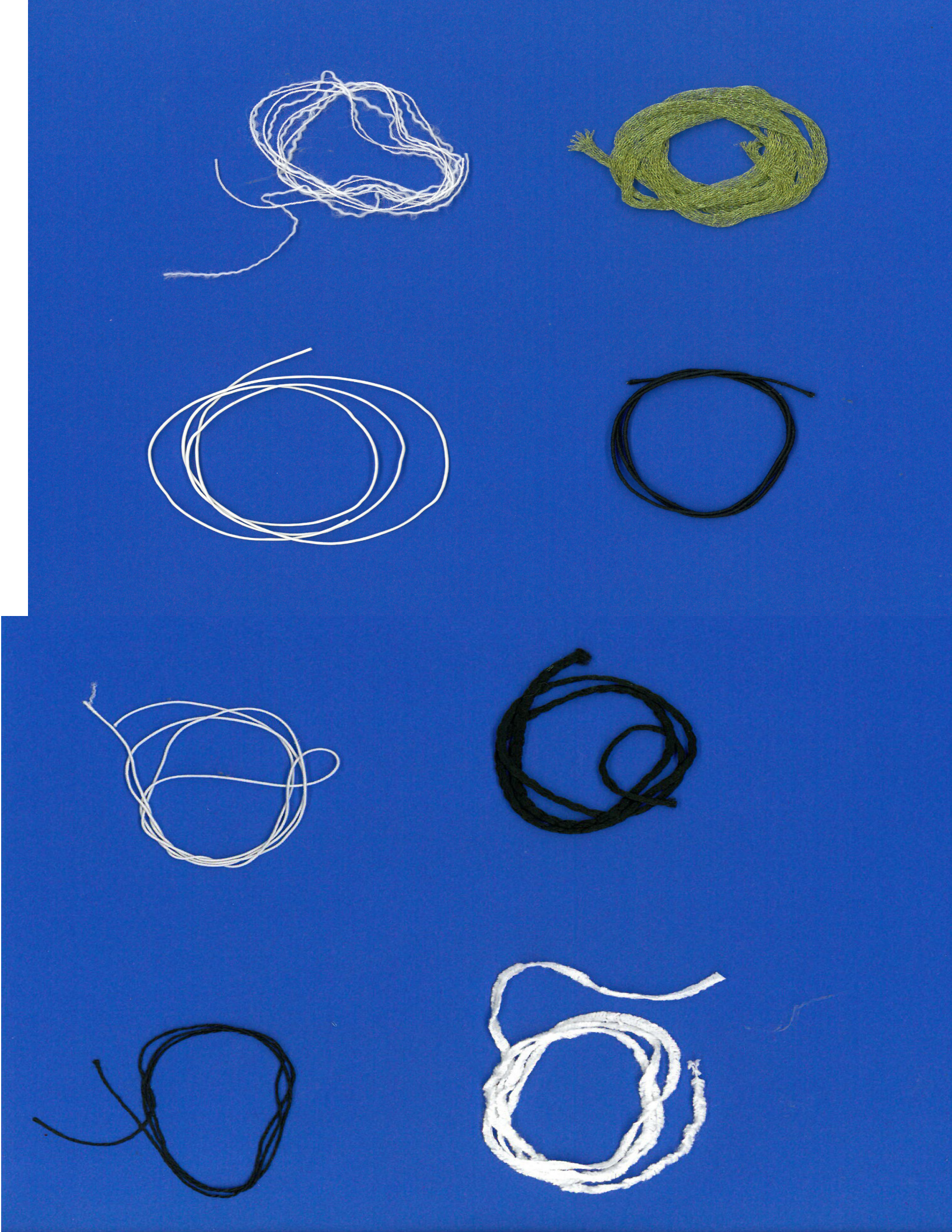
System design began by mapping out the required elements for an EMG circuit to detect activation of the frontalis muscles. Two electrodes are required for each muscle, with an additional electrode at the top of the forehead to act as the ground. The system is run using an Arduino Pro Mini microcontroller, which had to be integrated into the headband as it was woven. For the first iteration of the design, the Katya laid out the circuit and its necessary parts, and Sandra incorporated them into the weave structure by mapping out in a diagram the size of each component and its necessary connections.

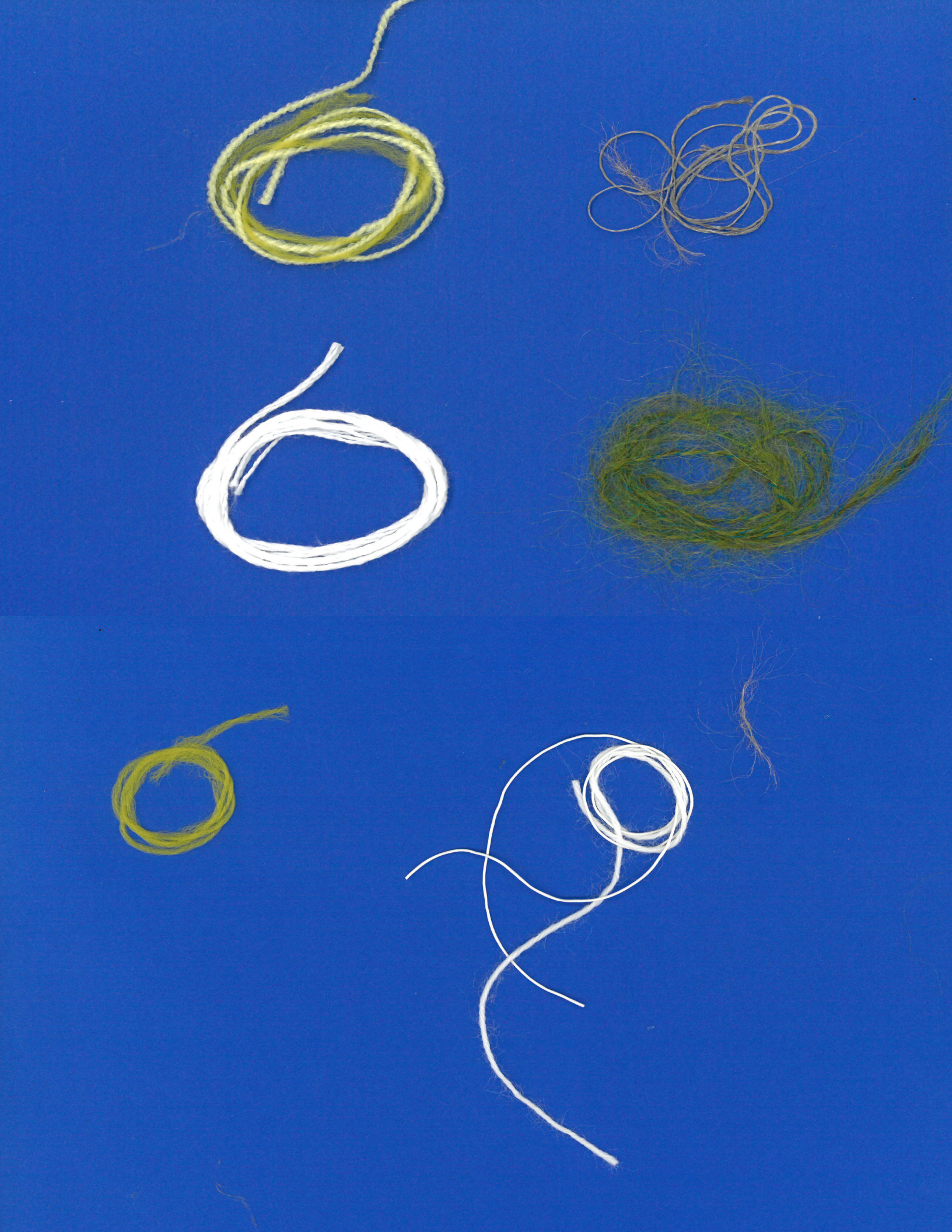
Primary Engineering Collaborator

Katya Arquilla received her undergraduate degree in astrophysics at Rice University. For her Ph.D., Katya plans on developing wearable sensor systems and processing the data from them to quantify the connection between physiological signals and psychological state. This technology will lead to earlier and more accurate diagnoses of mental illnesses such as depression and post-traumatic stress disorder (PTSD) for a wide range of patient populations.

MATERIALS



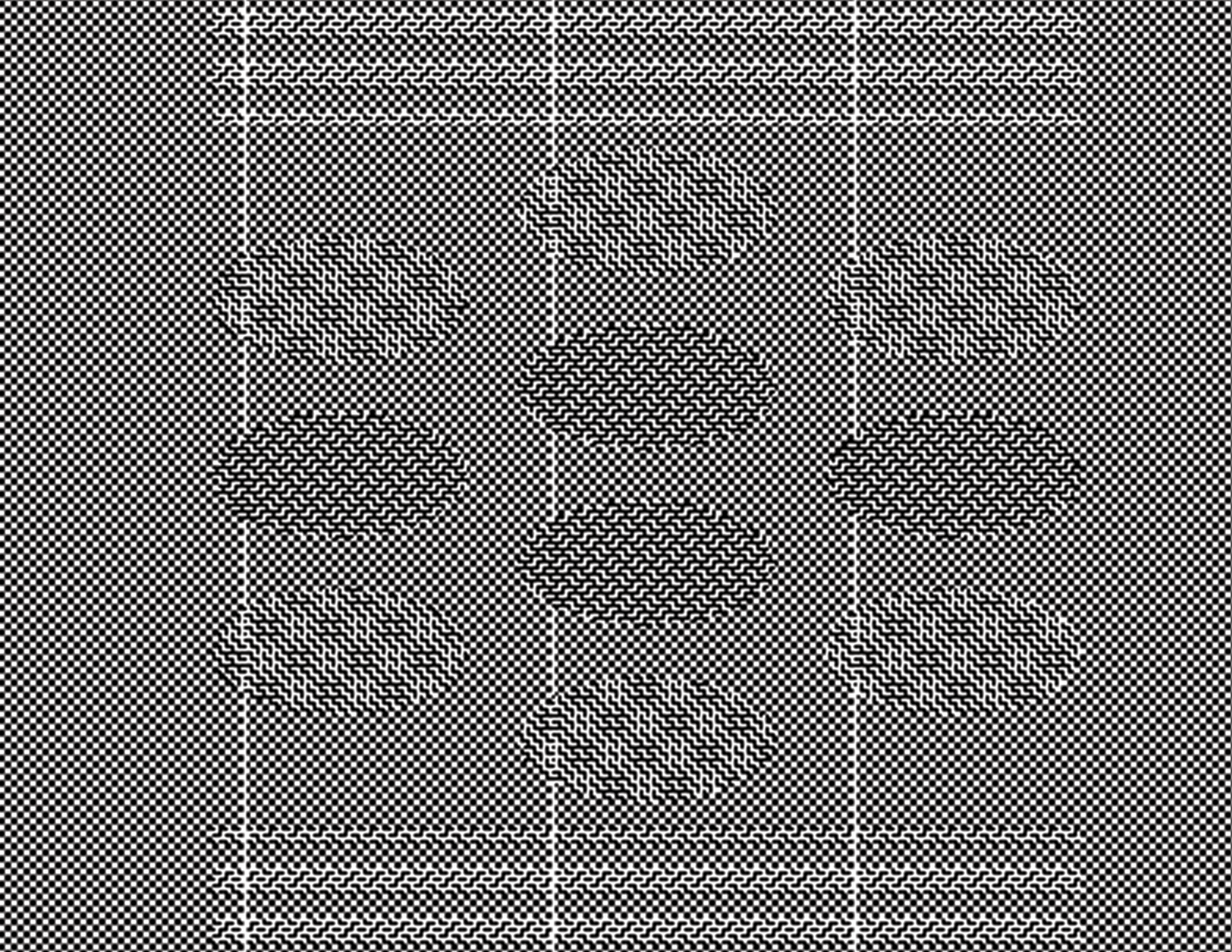




STRUCTURES

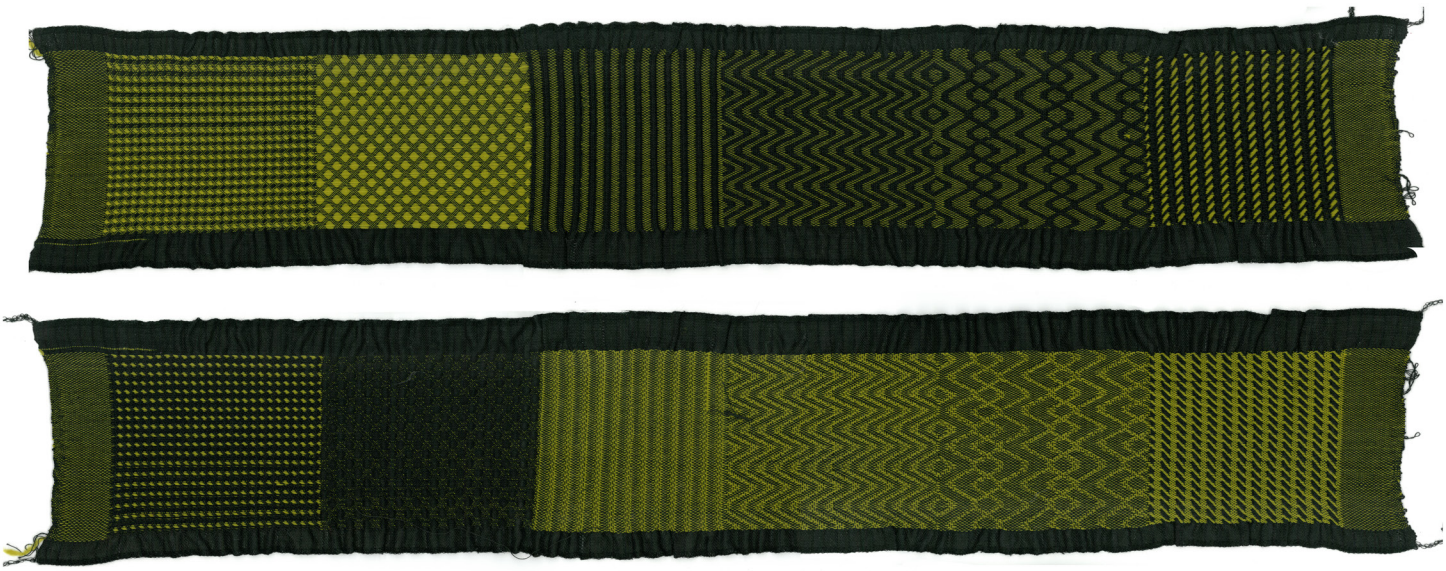
From Technology to Textile Structure

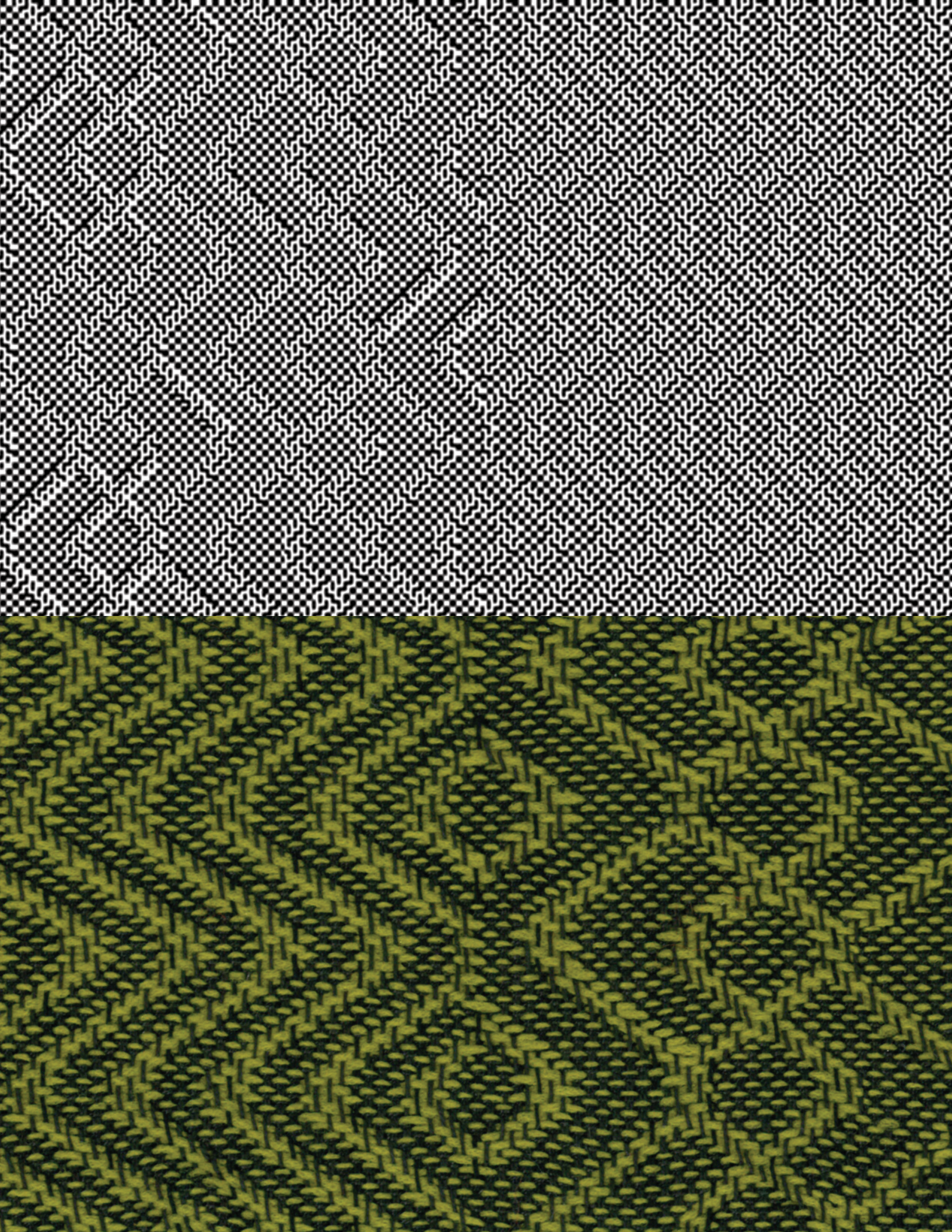
One of the primary design challenges with wearable sensors is the need to minimize noise from the sensor by limiting movement against the skin. The traditional engineering solution to this problem is to make the electrodes sticky. Commonly used gel electrodes have an adhesive backing that sticks to the skin and keeps the electrode in one place. Yet, this adhesive can impact comfort and irritate the skin and does not provide a solution feasible for most daily contexts. When we opened our process to Sandra, we began to consider how fabric structures and materials would enable the materials to sit firmly on the skin, hopefully eliminating the need for gels. We turned to an investigation/integration of two woven structures specifically: elastic ribbing and double weaving pockets. The idea was that integrating elastics would push the fabric against the skin while the pockets would add additional support and pressure.

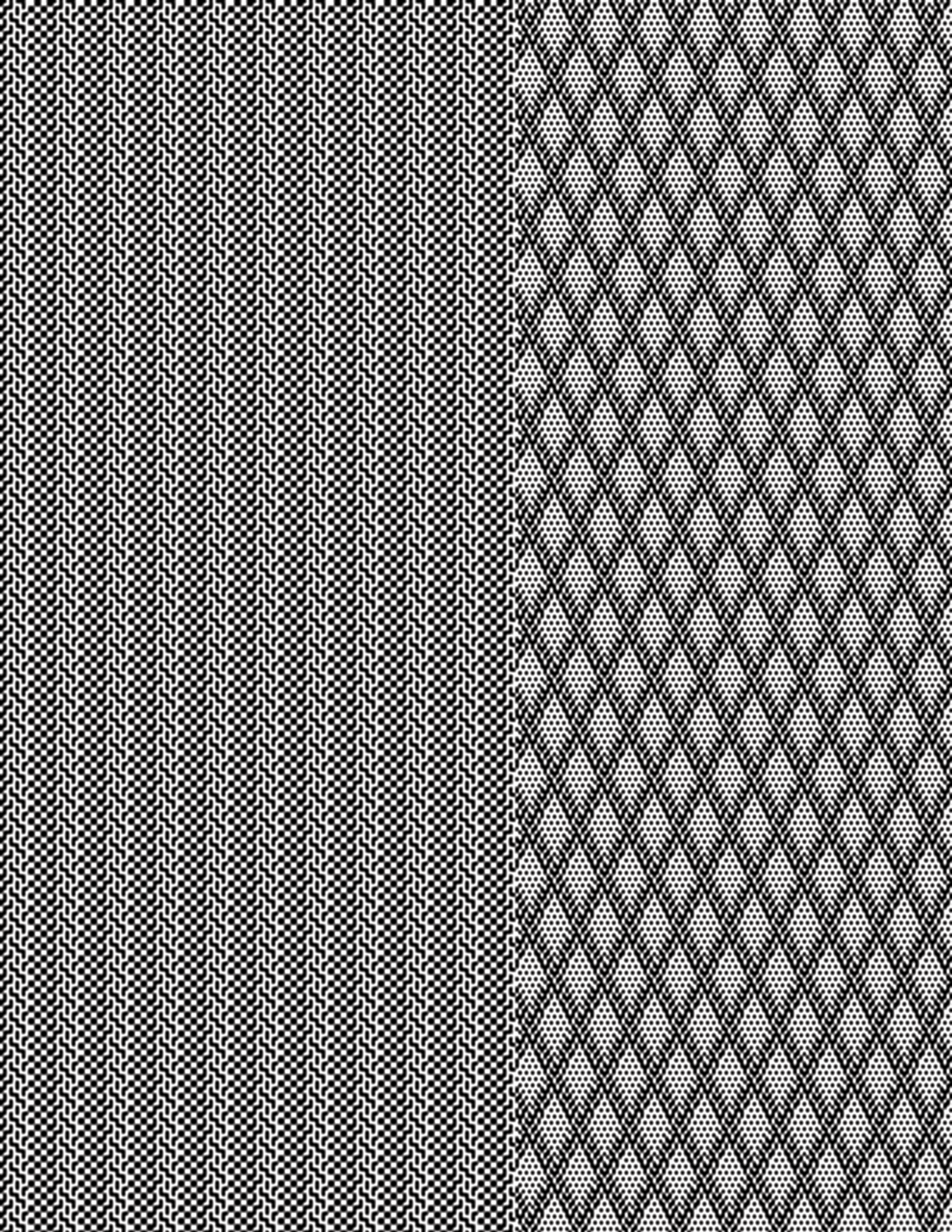


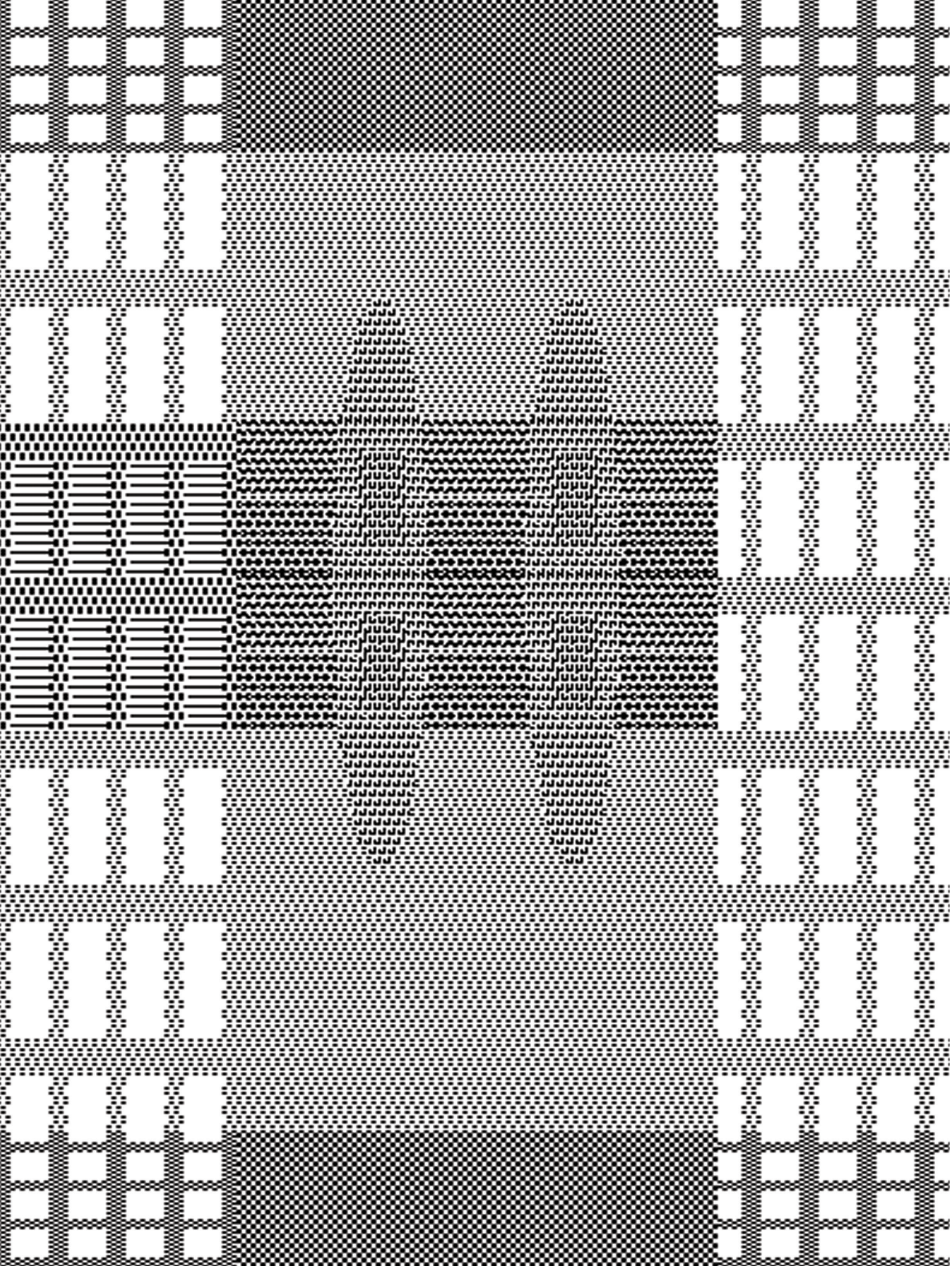
Elastics

Our elastic structures utilized plain woven cotton on one side. On the other side, Sandra integrated satin woven elastics (e.g. a stitch in which long lengths of elastic "float" over the width in regular intervals). While two layered, the structure was bound together across the width of the fabric, meaning that every nth yarn on the top layer was attached to every n^{th} yarn on the bottom layer. Because of the properties of elastics and cotton, this caused the plain woven, non-stretchy layers, to pucker up and create ridges when the elastic was at rest. When pulled, the plain woven sections would become flat and limit the elastics for over stretching or breaking.





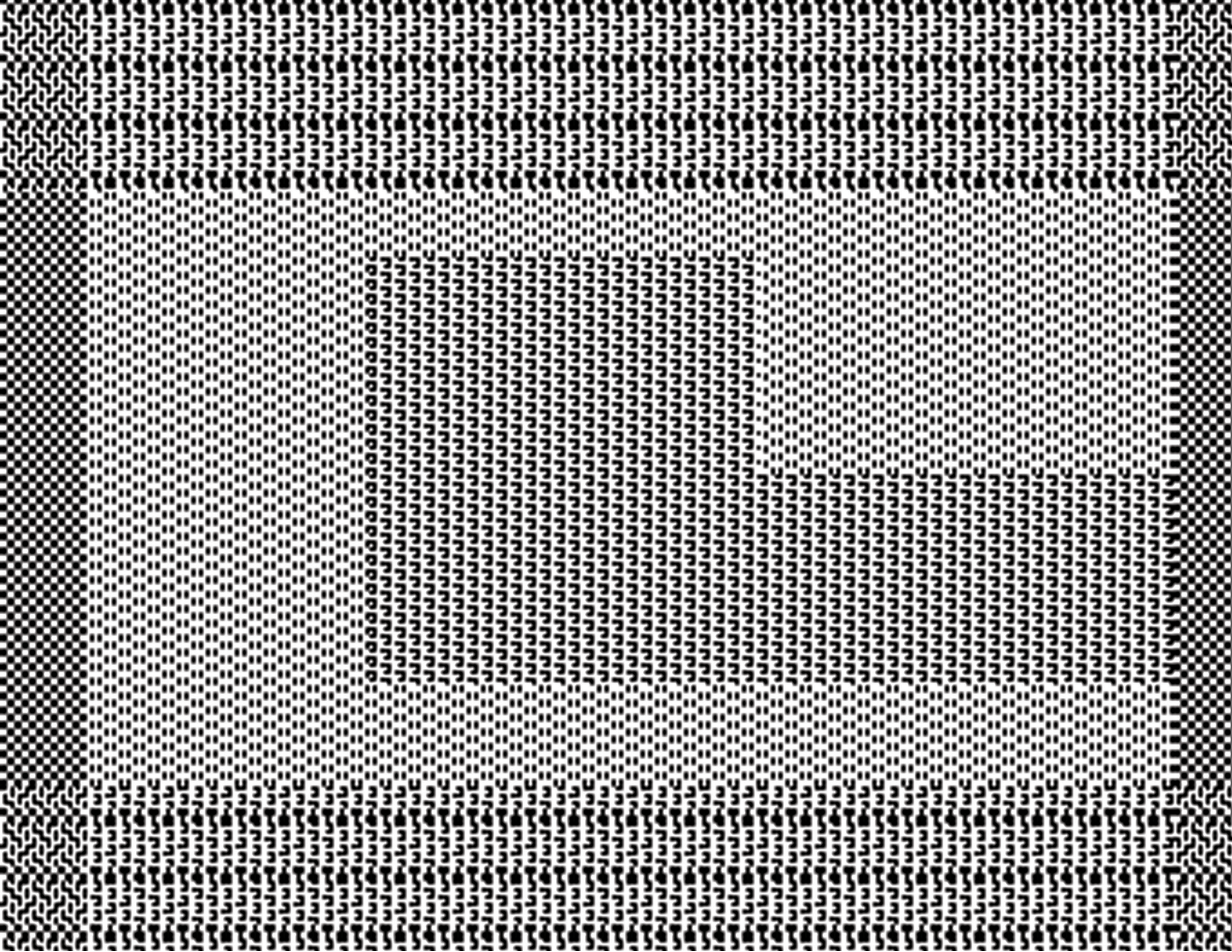




Pocket Structures

To reduce sensor noise, we integrated the electrodes atop pockets that would be filled with a shape conforming material.

Katya and Sandra evaluated several material and pocket shapes, and integrated an electrode pad by weaving silver coated yarn on one side of the pocket. The padding served the dual purposes of keeping the electrode against the skin while also shielding the conductive elements from other components in the headband and effectively disguising them on the side that does not contact the skin. This design inspired a second padded pocket concept for storing and concealing the microcontroller. Sandra inserted the hardware (an Arduino Pro Mini) into a padded pocket during weaving to completely encase it in the fabric structure, limiting its ability to shift and move and providing a comfortable, wearable solution. Furthermore, by integrating the microcontroller into the fabric, instead of attaching it on top, we could keep it close to our electrode pads while keeping it hidden from view, limiting noise resulting from long signal wires.



Rethinking "Technical" Knowledge

One of our initial barriers to including craftspeople in our collaborations on "hybrid" or digital-physical projects is the assumption that they will not be able to contribute to the core "technical" knowledge. Yet, in this experience, we began to see contributions coming from the "technical" weaving skills, the deep knowledge of materials, structures, weaving and the emergent effects when blended together. These competencies are just as important as the ability to code or debug a circuit.

Aside from addressing the problem at hand, conversations between all the authors inspired visions of new materials that we desired but did not have. These included materials that would shrink or swell with moisture content, materials that could be woven non-elastic and then treated with an external stimulus (UV, low heat for a duration) in order to become permanently stretchy. In this way, including a craftsperson perspective not only helped the engineering/design collaborators develop new pathways towards interactive objects, but also offered need finding exercise for identifying new textile specific materials that could influence a broader range of "smart" systems.

When we recruited for our residency, and judged the applications, we felt strongly that the person we would select should have a baseline understanding of digital technology in order to productively collaborate. We looked for evidence of this knowledge in the use and integration of "smart" materials, physical computing hardware and circuitry, and/or the development or integration of computational design tools into their practice. In this capacity, we considered technical knowledge as awareness and comfort with "non-traditional" practices, explicitly casting technological development as something (new) coming to be integrated with textile craft. This had the practical effect of applicants being scored more highly if they had some experience with these techniques. While we would have preferred to look at every application more closely, the size of the pool required us to develop scoring techniques that we could use to effectively narrow the candidates.

While the "technical" scores had the least effect on an applicant's overall score (e.g. knowledge of weaving and our appreciation of their concept and style were primary factors in scoring) the size of our applicant pool resulted in several of our top candidates having the highest possible scores. This suggests that ultimately, our judgements of technical competency did make an important difference in who we considered. The implications of this decision became clear to the organizers when attending an event on feminism in the university which highlighted that all requirements for technical knowledge, in any domain, necessarily skew the applicant pool towards applicants that come from more wealthy, resource, and

opportunity-rich contexts. This mimics the argument of the "pipeline problem," where lack of diversity in selection is explained by the lack of diversity in the selection pool. This gave the organizers cause to reconsider the competencies relevant to technological work. Despite understanding this from an analytical level, the organizers were still concerned how the residency could even take place if traditional notions of "technology" were not evidenced in an applicants prior work. Yet, in the weeks of collaboration to follow, the organizers were able to understand and reflect on their own biases.

The complexity of the textile challenge as demonstrated in this project case study helped us appreciate the vast knowledge of Sandra. At the outset of our project, the organizers anticipated this finding, but they underestimated the magnitude of its truth. While the organizers entered the residency narrowly considering technical knowledge as experience with traditionally "technological" or "digital" materials, they saw that these skills were much less important than the implicit knowledge that Sandra had built up through years of practice and training. In one sense, this inspired a shift away from seeking purely "technical" solutions to the problems and, instead, looking to solutions inherent in material practice and woven structures. Sandra's ability to intuit material behaviors, to predict and test the efficacy of structures and shapes, and "hacks" for working with the loom proved to be most effective in the exploration. This was aided by the engineering collaborators continual collaboration and testing of the electronic components and structures. Furthermore, Sandra knowledge of available materials, material properties, and how they might behave and perform in service of a given goal was incredibly similar to how the engineering/ design team might browse online shops for the right sensors to fit our design requirements. When approaching technological innovation as craft, there seemed to be a tradeoff between the inherent difficulty of the production process with the benefit of creating highly customizable performance structures and wearables. The collaboration allowed us to more rapidly locate a solution within this vast possibility space.

In reflecting on this finding, and with the idea of future residencies in mind, we think it would be useful to broaden our focus on traditionally "technical" materials in the applicant pool. This is informed by the finding that the textile innovation process, itself, could be the primary target for identifying a solution. In this sense, it shows how solutions are imagined within one's frame of expertise. If HCI includes technical collaborators, it is likely to find technical solutions. With craft collaborators, solutions can be found in the technical processes of craft.

Structuring Productive Collaborations

What proved to be more important than Sandra having a traditional "technical" knowledge turned out to be the "technical" collaborators appreciation and experience with "craft" knowledge. This inverts the traditional narrative of innovation: arguing that those working in central arenas of technical work need to learn skills that are not typically regarded as technical rather than the other way around. With this project as a case, we hope to provide strong evidence for why this knowledge matters and how it could fundamentally shape the future of innovation work.

Cultivating Craft Knowledge

While the organizers began the residency searching for a collaborator with knowledge of electronics and circuity, they found that the success of the residency was more aligned with their own knowledge of weaving. Laura and Katya have spent significant time learning to weave, and have found this experience deeply humbling. Specifically, they had looked around their environments and seen different weave structures on items like clothing, dish towels and upholstery and naively assumed that if they could just repeat the pattern (or run the code so to speak) that they could get those products out. This is not the case, as weaving is deceptively simple in appearance and complicated in construction.

Textile craftspeople have unique access and experience with these techniques, and struggling through the craft from a first-person perspective gave Laura and Katya a deeply embodied respect for their years of experience. Craft theorist Tim Ingold might refer to this as "knowing [weaving] from the inside" . This suggests that knowing about craft may not be enough to fully appreciate the value offered by a craftsperson. Knowing in a tacit and embodied sense, experiencing the time and labor of successful and failed weaves, cultivated the soil upon which a fertile collaboration could flourish.

It Takes Time and Support

This residency was not born on a whim. It took years to cultivate the relationships and partnerships that allowed the organizers to successfully recruit and support Sandra in our practice. The organizers had support from their institution, which was important in managing the Herculean bureaucratic hurdles of visa, pay, etc that we needed to make our program successful. Having a key organizer of our residency (Steven Frost) identified as an artist and craftsperson also proved to be very important. Their support not only provided us credibility, but gave us access to local arts organizations that they could call on to support our effort. Furthermore, they were central in supporting Sandra's own career ambitions during their visit, organizing trips and meetings with arts organizations in the area.

Pay Parity and Housing

We offered the selected resident the same rate that a PhD researcher would earn for the same duration of work ($3750 USD) in addition to providing free housing if they were willing to stay with the organizers, funds for the flight and a materials budget for the residency. This resulted in a stipend that was much higher than what many residencies compensate. Yet, the organizers felt like it was essential to create a dynamic in the lab that didn't privilege one viewpoint as more valuable than another (despite the economic differences in those fields).

We Encouraged Oversight from Other Artists

The organizers genuinely didn't know how this collaboration could be productive within the resident's practice a priori. Furthermore, there are tensions between those working in tech who have access to much larger streams of support and funding than those working in the arts. The organizers wanted to be especially mindful of these dynamics and create a structure that would not be considered exploitative. The advisory board was central in this capacity. In one sense, it helped demonstrate to our applicants that the organizers sought the advice and feedback of those outside of engineering. In another, it offered oversight to the organizers in each stage of development to make sure wording and program structures were fair. The advisory board also provided several points of contact through which the word to a much broader community of artists and weavers could be spread. Furthermore, the evaluation process which involved the board became a place where terms like "artist", "craftsperson" and "designer" became more clearly delineated and meaningful in terms of how they manifested in the organizers mind. Specifically, it highlighted that HCI's own treatment of the terms as starkly different is much more blurry in practice. Instead, the orientation towards art, craft, or design, simply emerged in addition to their care material practice.

Barriers to Collaboration

This project also helped us to see that the barriers to including craftspeople in collaboration are not just social, but deeply embedded into our tools and processes. Our residency made us realize exactly how much of our design process was focused on adapting electronics made under one context and set of assumptions to work with a completely different context and set of equipment and structures. Specifically, integrating a hard Arduino and wires into a soft fabric illustrates the challenges that come from adapting a new domain to one that has been the state of the art of years past. We believe that this history of technology as being hard, plastic, and rigid has legacy effects of making the craftperson's perspective seem less relevant. Since the materials have not been designed with textiles in mind from the beginning, it is easy to render a craftsperson's knowledge of these materials as less important than existing PCB design, say. Yet, we see by including them, we can envision a number of new kinds of systems, of integration and visions of yarn-based materials that we hadn't previously considered. These new visions come as much from a craftsperson's knowledge of materials and desired functionality as they do of the machine infrastructure (e.g. that some will have to be weaved while stretched, and then collapsed). Finding ways to work across the boundaries of material and structure, of existing solution and ideal solution, may necessitate different collaborative groups.

Future Residencies and Room for Improvement

While the organizers found the residency to be successful, we noted a number of ways in which the structure we developed was not as inclusive of artists and craftspeople as it could have been. Specifically, in the way we offer housing support. We, like many others, assumed the craftspeople we would recruit would be mobile and (likely) without families. Yet, many of the people who applied had families, partners, or performed work in collaborative teams. In the future we plan to fund raise and/or build more collaborations locally to provide artists with their own housing. A second approach might be to fund raise for "flex" funding, which can be used in the event of an artist with needs that cannot be satisfied with the accommodations we provide.

The next factor to consider is the duration of the residency. Six-weeks went by quickly, and Sandra expressed the potential of better solutions, particularly in exploring elastics specifically developed for textile machinery, opening Laura and Katya's eyes to the specificity of materials for particular tasks (e.g. not all elastics are created equally). Ultimately, the residency ended before we had completely worked out a solution. The collaboration, though, was so enjoyable and fruitful, the authors will continue to move forward in our work, and further deepen the interdisciplinary knowledge transfer. We will hold what we learned from Sandra and we were able to encode the structures, arrangements, and modifiable patterns for our design in a way that we intend to manipulate for future iterations. The knowledge we learned became "encoded" to some degree within a tool that we built to support future prototyping in this context.

Reflecting on the appropriate duration prompts reflection on the limitations of a residency structure itself. These opportunities are typically short term, aligned to provide focus and support for a limited time, and function as a kind of temporary or "gig" job for people trying to making a living as artists or craftspeople. The kinds of artists that can consider these opportunities are limited by their own demands or family commitments. As we work towards a future of productive collaboration, we should not consider the residency as an ending point, but a stepping stone that might help enable a broader appreciation of the technical knowledge of craft. In this sense, we might see other technical domains, engineering or otherwise, creating more stable and supportive opportunities for integrating those with craft degrees and training into their programs.

Organizers

Laura Devendorf is a design researcher who studies how technology shapes our relationships to the worlds in which we live. Much of this research has focused on the development of alternative digital fabrication technologies that make space for the creative agency of physical materials. Her recent work focuses on smart textiles—a project that interweaves the production of computational design and fabrication tools, reflection on gendered forms of labor, and visions for how wearable technology could shape relationships between humans and nonhuman "lives." She is an assistant professor at the ATLAS Institute as well as the Department of Information Science.

Steven Frost is an artist who tells the stories of hidden histories through objects and performances. He sources archival materials to help audiences engage with and remember forgotten narratives. He research focusses on queer narratives in pop culture and community development in DIY community spaces. Frost hosts the Colorado Sewing Rebellion. This free monthly performance and workshop is designed to encourage the public to mend and construct their own clothing. Frost is also an active studio artist with a record of national and international exhibitions. He holds a BFA from the New York State College of Ceramics and Design at Alfred University and received his MFA in Fiber and Material Studies from the School of the Art Institute of Chicago in 2011.

Allison Anderson investigates issues in aerospace biomedical engineering and human physiology in extreme environments. Her focus is to develop technologies to measure and mitigate the body's adaptations to extreme environments, which also has direct implications for patient populations here on Earth. She is currently developing wearable sensing systems to assess comfort and biomechanics in the spacesuit. Her interests in weaving and fiber arts include direct integration of electronics into custom built fabrics and advanced concepts spacesuits using woven elastics

Advisory Board

Arielle Hein is an artist, technologist, and educator whose work explores the imaginative use of emerging technologies and spans the fields of human-computer interaction, interaction design and art. Drawing on an interdisciplinary background and a research-based creative practice, Arielle explores the intricate relationships between technology and our human experience. As an educator, Arielle is passionate about empowering students through the exploration of interactive systems and the use of digital tools. Arielle earned her Master's degree from NYU's Interactive Telecommunications Program (ITP) in 2015 and is currently working as an Instructor in the ATLAS Institute and Technology, Arts and Media (TAM) program in the College of Engineering & Applied Sciences at the University of Colorado in Boulder. Arielle is also the Coordinator for ITP Camp at NYU.

Christy Matson is an artist based in Los Angeles, CA, whose hybrid woven/painted works engage hand-weaving as a lens by which to view history, abstraction and physicality. Challenging the tradition of hand-woven textiles as functionally objective objects, she creates artifacts that equally privilege the surface and the structure in the creation of her work. Recent exhibitions include the Long Beach Museum of Art, Craft and Folk Art Museum Los Angeles, Museum of Contemporary Arts Houston, The Milwaukee Art Museum, The Knoxville Museum of Art and the Asheville Museum of Art. Matson's work is in the collection of the Art Institute of Chicago and Smithsonian Museum of American Art's Renwick Gallery as well as numerous private collections. She received her BFA from the University of Washington and her MFA from the California College of the Arts. In 2012 she was appointed Associate Professor of Fiber and Material Studies at the School of the Art Institute of Chicago. Matson has been working with the Jacquard loom since 2002.

Erin Espelie is a filmmaker, writer, researcher, and editor, whose science-based experimental and poetic documentaries have shown at the New York Film Festival, the International Film Festival Rotterdam, the Natural History Museum in London, CPH:DOX, the Copernicus Science Center in Warsaw, the Full Frame Documentary Film Festival, the San Francisco Museum of Modern Art, and more. She has degrees in molecular biology from Cornell University and the experimental and documentary arts from Duke University. She currently serves as Editor in Chief of Natural History magazine, and works at the University of Colorado Boulder as an assistant professor in Film Studies & Critical Media Practices and co-director of NEST (Nature, Environment, Science & Technology) Studio for the Arts.

Janet Hollingsworth is a structural engineer, woodworker, and maker educator. She co-founded BLDG 61, the all-ages makerspace at the Boulder Public Library in 2016. As a creative technologist, she curates and facilitates maker programs at BLDG 61 including: woodworking, laser cutting, machining, sewing, 3D printing, electronics, digital fabrication, screen printing, book binding, and more. She has also developed special apprenticeship programs for underrepresented youth and individuals experiencing homelessness.

Joel Swanson is an artist and writer who explores the relationship between language and technology. His work playfully subverts the technologies, materials, and underlying structures of language to reveal its idiosyncrasies and inconsistencies. His work ranges from interactive installations to public sculptures that playfully and powerfully question words and their meanings. Swanson teaches courses on typography, creative coding, and media theory at the ATLAS Institute at the University of Colorado Boulder. He received his Masters of Fine Art at the University of California, San Diego with a focus in Computing and the Arts.

Rebecca Vaughan received her MFA from Carnegie Mellon University and BFA cum laude in Sculpture at the University of Colorado, Boulder. Ms. Vaughan has fifteen years of teaching at the college level and mentoring emerging artists, having served as the former Chair of Fine Arts and Head of Sculpture at the Rocky Mountain College of Art + Design. She also worked as the Program Director of the Art Students League of Denver and held a residency as a Resource Artist at Redline Denver from 2011-2013. Previously she worked as the project manager for Ann Hamilton's 2008 Circles of O performance, and assisted in other projects in Dialog: City, a city-wide arts event for the Democratic National Convention in Denver. She served as an Artist-Teacher for the Vermont College of Fine Art and was a visiting instructor at Bowling Green State University, OH.

Acknowledgements

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