RESEARCH-ARTICLE

Towards Yarnier Interactive Textiles: Mapping a Design Journey through Hand Spun Conductive Yarns

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Towards Yarnier Interactive Textiles: Mapping a Design Journey through Hand Spun Conductive Yarns

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Abstract

The ability to create a wide and varied set of interactive textiles depends on the materials that one has available. Currently, the range of yarns that can be used to bring interactivity to textiles is greatly limited, especially considering the diversity available in non-conductive yarns. This pictorial traces a design journey into hand spinning that seeks to address this limitation and contributes samples of techniques and materials that could be used to create conductive yarns along with reflection on design methods that enabled us to explore a wider range of aesthetic expressions. We advocate for an approach that reconnects with the textiles in e-textiles, embraces divergence, and prioritizes the material rather than function as the driver of a design concept. We offer pathways for readers and researchers to continue this exploration within varied domains and practices.

Authors Keywords

Interactive textiles; hand spinning; design journey.

CSS Concepts

• Human computer interaction (HCI)

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Introduction

Over the past decades, electronic or "smart" textiles have emerged as an exciting research area for exploring new interactive applications [4]. Textiles are flexible, multi-material, and dynamic assemblies. Many textile innovations in HCI are driven by the integration of so-called "smart" materials capable of conducting electricity or enabling programmable changes. However, these materials are typically sourced from a narrow set of suppliers in a limited range of colors, weights, and material characteristics. This constrains designers to working within the limits of what is readily available, rather than empowering them to craft materials tailored to their creative and functional needs.

Hand spinning—a technique for twisting fibers into yarns—is one of humanity's oldest technologies [3, 25] but has only recently been explored within HCI [15, 33]. Our project began with the goal of introducing this technique to DIS through the creation of conductive yarns. As our research evolved and new collaborators joined, our motivation shifted towards one of speculative play and material exploration: How could we make a more "yarny" conductive thread? What might emerge if we prioritize aesthetics (visual and affective characteristics) and materiality over application and performance? What kinds of yet unimagined textiles might this process inspire?

This inquiry unfolded through interdisciplinary collaboration among four core researchers working across design research, tangible interaction, textiles, and art, inspired by various influencers and collaborators. Our diverse perspectives enriched the process as we each contributed unique skill sets and contextual knowledge, combining skills in hand spinning, electronics, design application, and material inquiry. Over the course of our journey, we produced 45 different variations of conductive and nonconductive hand spun yarns and 30 swatches that explored those yarns in knit, woven, or braided samples. Along the way, we continually reflected on what applications these yarns inspired through their material, tactile, aesthetic, and functional qualities.

Much like a plied yarn, the contributions of this research are multi-stranded. First, the landscape of conductive and non-conductive hand spun yarns and swatches that we present illustrates a diverse palette that suggests the material and aesthetic range available to interactive textiles designers through hand spinning. Second, our reflections on the process highlight the value of continual divergence as a design approach—embracing sampling, play, speculative exploration, and "getting weird." Finally, by leaving loose ends [13] and departure points, we offer an open invitation for the design community to converge on and extend this work by imagining new applications and futures for interactive textiles.

Throughout our design journey we explored 16 materials and 5 techniques for spinning and integrating spun yarns into textiles. This pictorial traces paths through this process, revealing both pathways and possibilities for "yarny" conductive materials and interactive textiles.

Here we show all of our yarns and samples arranged chronologically by the semester in which they were produced.

Background

Yarn is created by twisting fibers together in a process called spinning. While there are many industrial methods for spinning, hand spinning is a tactile, craft-driven approach that offers more nuanced manipulation of fiber properties (flow, thickness, twist), giving rise to distinct textures, densities, and behaviors in the final yarn. The availability of drop spindles (in use since the 20th century BCE [18]), spinning wheels, and open-source spinning machines [8, 22] make hand spinning highly accessible. These processes are essential for creating traditional textiles and can enhance the exploration of interactive materials by allowing designers to create custom yarns using a wide range of materials.

The integration of conductive and non-conductive materials into functional interactive textiles is of growing interest in HCI. Conductive threads used in e-textiles are typically spun or coated with metals like copper or silver, which conduct electricity [31]. Integrating conductive elements with non-conductive fibers opens a rich design space where yarns serve as structural and textural components and interactive interfaces. Cords, filaments, and string-like structures have been used in HCI to enable dynamic, tactile interactions directly embedded in objects or garments [5, 23, 24,29,30].

While most textile research in HCI relies on pre-made materials [1, 10, 21], the customization and tunability provided by spinning techniques are being increasingly recognized for their potential to enable more personalized and responsive interactions [33]. For example, Jones et al. [15] worked directly with hand spinners to introduce spinning techniques and culture to HCI, highlighting how factors such as fiber type, blending, and dyeing can contribute to e-textile development. By experimenting with unique conductive and non-conductive hand-spun yarns, our research builds on these insights to expand the aesthetic and functional qualities of textiles. Prioritizing the yarn as a driver of innovation, this work embraces a divergent design process to contribute material samples that point to new directions for interactive textiles that integrate conductive materials.

Examples of commercially available conductive threads (L) and non-conductive yarns from a variety of materials and sources (R).

Methods

Design Journeys

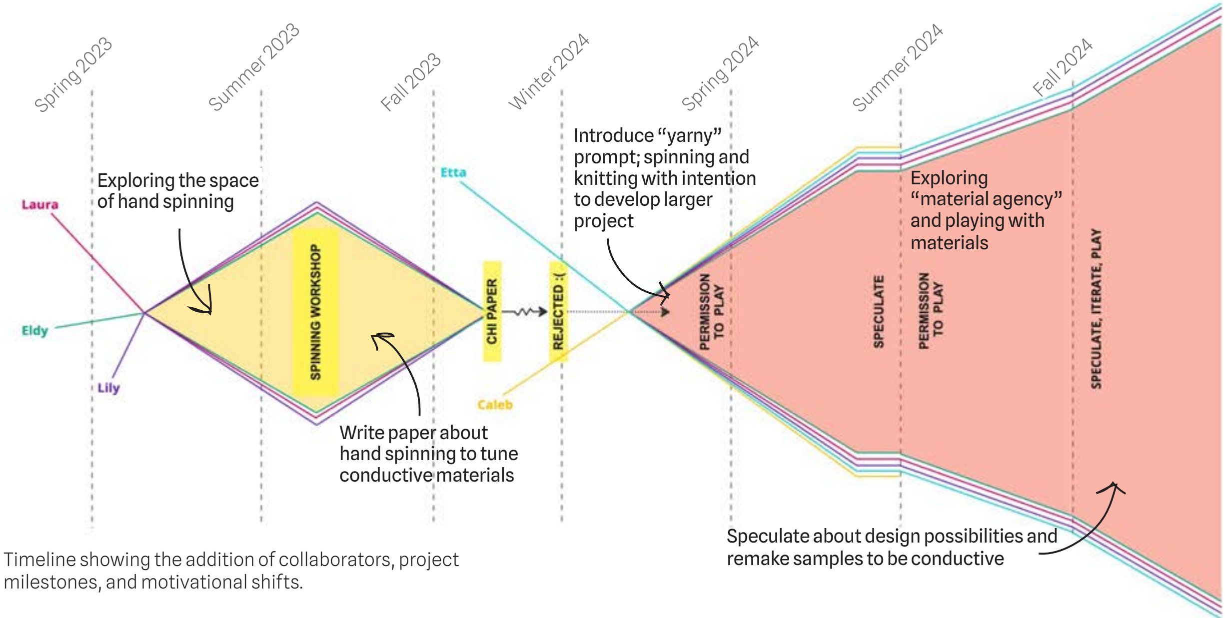
DIS researchers exploring material properties and working in craft contexts have increasingly embraced metaphors of travel [12] that can account for the wandering, itinerant [27], or "nomadic" [32] nature of material-responsive practices. These journeys are often non-linear and divergent, yet valuable in their ability to reach insights that may not have been possible through other outcome-driven or convergent research approaches [13, 14, 20]. In other words, divergent practices and design "drifts" [12] allow practitioners to explore the range and breadth possible in a design space. Many researchers have utilized the format of the pictorial to share these alternative practices of communicating embodied knowledge [6]. The pictorial allows designers to interpret their research within a wider range of contexts [9, 11, 20, 28] and describe both their inquiry and the paths not taken [13, 14, 20], noting paths not taken as opportunities for continued investigation. Here, we embrace these formats to communicate our inquiry, leaning into the metaphor of the journey and using mapping to help illustrate it. We do this to emphasize that our process is simply one of many possible approaches, to gesture to the vastness of possibilities in the realm of hand spinning, and to create "trails" of inquiry that other researchers might take up in their own contexts.

Timeline and Landmarks

This project first began with the goal of bringing attention to spinning and how it could be used for interactive applications by tuning for specific qualities in hand spun yarn. Through a workshop with local spinners and by learning more about spinning ourselves, the original group of authors (Lily, Eldy, and Laura) gained a better understanding of the materials and techniques for creating conductive yarns. This initial project phase took a systematic approach, seeking precise outcomes that could be used to guide how yarns are integrated into an application–like how blending conductive and non-conductive fibers could be tuned to give an exact sensing profile. When the publication from this early research was rejected, we were prompted to reflect on both our design approach and output. We found that we were more excited to "follow the fibers" and explore the space of material possibility that hand spinning offers than to present replicable outcomes or technical results. This marked a pivot point in our research trajectory that was further reinforced when Etta joined our team and by the later publication of Lee Jones et. al.'s CHI paper introducing spinning and its capabilities to HCI [15].

This series of events became an invitation to play as we tried to make more "yarny" conductive yarns–yarns with a wider range of textural and material qualities compared to standard conductive threads–and gave ourselves permission to follow material curiosities without a specific goal or application in mind. Our collaborative work involved hand-making and speculation together in our research lab and individually in home work spaces. Through weekly meetings, we followed phases of iterative and itinerant design by responding to the materials we had available and the samples we created. We reflected on the samples as we produced them, noting their color, texture, weight, material qualities and affect, and testing for connectivity using a multimeter. Since the electrical characteristics of conductive yarn vary depending on the techniques used to integrate them into cloth (e.g. knit structures stretch the yarn, lowering resistance), we considered them "conductive" if they produce a measurable resistance reading. The values ranged from 2 Ohms (for pure metal yarns) to 20K Ohms. The goal was not to find exact measurements for each sample, but to demonstrate their conductive potential as the metallic fibers spread apart or press together due to construction and interaction. Though not replicable at this stage, these tests suggested the possibility for these materials to become variable resistive sensors or conductive pathways in textile objects.

Each swatch became a prompt for further investigation and every meeting ended with a list of new samples to try. As we practiced spinning, we gained insight into ways that conductive elements could be exposed or hidden in the yarn and then integrated into a textile. Sometimes materials or techniques were set aside as others were explored, to be returned to later with increased skill and new material combinations. The insights of this pictorial focus on the outcomes of this research phase and advocate for divergence within textile explorations to produce more aesthetic richness in the design process.



Timeline showing the addition of collaborators, project milestones, and motivational shifts.

An Interdisciplinary Collaboration

This divergent design journey was shaped by the diverse perspectives and skill-sets of our interdisciplinary team of collaborators. Etta is a textile artist and experienced spinner whose research focuses on practices of inquiry in craft, art, and design. She brought a materials-driven, reflexive approach to the design process that encouraged sampling and speculation. Lily, skilled in a wide range of textile and computation techniques, did the spinning for the project. As their technical expertise grew throughout the process, their material curiosity influenced our interpretation of "yarny." Eldy became interested in spinning through her research developing biofibers. With her experience in HCI, she informed how we thought about the relevance of our exploration and shaped the framing of the research. Laura, a design researcher whose work integrates textile craft practices and computation in HCI, was a support and guide, giving further context for the design space of e-textiles and prompting play. Each of these backgrounds impacted the goals and methods of the project as it unfolded and our discursive reflection shaped how we are presenting the work in this publication.


Lily spinning in their home work space.

Mapping a Design Journey

As we reflected on our process, we organized every sample had we produced on a table. In one arrangement, we placed the samples chronologically as they were made (see pg 2) and in another, we organized them by their materials or techniques. Each of these groupings and juxtapositions provoked a different set of "next steps" or relationships to unpack. The flat plane of the table felt insufficient to hold the entanglement of our research pathways as material-technical combinations crossed categories. The process of arranging the samples reminded one collaborator of a description of multi-sited ethnography that describes the construction of a field site through various methods of tracing such as "follow the people" or "follow the metaphor" [19]. In this spirit, we decided to present our journey here as a series of pathways that emerged from following the different technical, material, and conceptual qualities of our samples.

The following pages index the materials and techniques we explored and then zoom in to tell more detailed stories. Specifically, we reveal what happens when we: follow a technique (core spinning, supercoil), follow a material (MerinoX, silicone caulk); and follow a concept ("yarny"). Each of these pages has a short introduction, a narrative description of our discovery process, and highlighted outcomes that communicate takeaways from their line of inquiry. These maps are not instructions to be followed but tracings of the steps we took in our material exploration and reflections on what we found along the way. There are numerous other groupings that we could present here, but we selected the ones that we found particularly intriguing and those that could be most applicable for use in interactive textile design.

Techniques and Materials

Hand spinning may not always be easy to replicate due to the difficulty of sourcing the same materials or equipment, and the challenge for two spinners to repeat the exact same process–especially for novices working from a textual or image description. Rather than offering a recipe of a particular set of yarns to recreate, the following pages provide a map into spinning intended to activate play and personal discovery. This index describes the materials and techniques we explored in our journey. We reference back to these materials and techniques throughout the pictorial by labeling each yarn with a code in the following convention:

(*)(Material Codes) / (Technique Codes)

We offer this labeling scheme to guide readers in making general connections between materials, techniques, and possible outcomes. Our list is not exhaustive, there is an infinite set of variations possible through spinning that we want to encourage this community to explore.

Examples:

Code: * **mx + pp / c**

This yarn was created by core spinning (c) a paper yarn (pp) around a MerinoX yarn (mx). **The * denotes that this yarn is conductive.**

Code: **wy + pp / p**

This yarn was created by plying (p) both wool yarn and paper (wy+pp). This yarn has no * because it is not conductive.

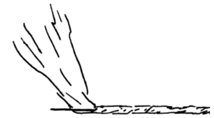
Techniques

Single (s)

An individual yarn strand spun directly from the staple fiber, the first step in making other types of yarn on this list [2].

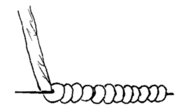
Ply (p)

Two or more yarns or strands that are spun together make a thicker, stronger, yarn [2].



Core Spin (c)

A yarn in which an unspun staple fiber is spun around a core strand, giving the seamless appearance of a spun single [2].



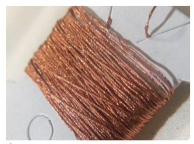
Supercoil (sc)

A yarn made by coiling a spun single or other strand tightly around a core, creating a yarn with the appearance of a metal spring [2].

Bouclé (b)

Bouclé is made by looping then binding: a textured single is spun around a core, then a second thread is plied to lock the loops in place [2].

Materials



*Karl Grimm Copper (co) source: [37]

*Shieldex Thread (st) source: [39]

*Silicone Coated Wire (wi) source: [38]

*MerinoX Fiber (mx) source: [36]

Acrylic Yarn (ac)

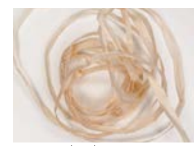
Alpaca Fiber (al)

Cotton Thread (ct)

Icelandic Wool Fiber (iw)

Merino-Possum Blend (mp)

Merino Wool Fiber (mw)



Paper (pp) source: [40]

Recycled Fiber Insulation (rf)

Silicone Caulk (sc)

Surrey Yarn (sr)

Thrifted Wool Fiber (tw)

Wool Yarn source: [41]

Considerations

Samples with the same code can still be very different

Both Merinox singles below use code: mx / s but they are twisted to different angles, yielding very different behaviors and textures.

Code: **mx / s**

Techniques can be combined

In this yarn, merino fiber is spun into a single before being supercoiled around a copper base.

Code: *** co + m / sc**

For complete descriptions of each yarn we produced, visit our online database at:

unstable.design/projects/yarny

Following the Technique

Core Spinning

Core spinning is a technique that involves wrapping an unspun fiber around a single spun or existing core (i.e. a thread or found yarn), covering it. This technique can be used to hide or insulate a core material with another, such as a conductive metallic thread with a wool fiber. To core spin, use a strong core yarn as base. While spinning the core yarn, draft from a hank of raw fiber at an 80° angle and feed it onto the yarn so that it spins around the core [2, 16].

1. Our first core spun samples (mw / c) did not include any conductive materials. Using fibers we had on hand, we spun a white single to use as the core, then wrapped it with a bright red merino wool. The resulting yarn had a soft, uneven texture that we incorporated into a lace knit swatch. The yarn was stiff and held its shape when knit and the slubs and bumps invited touch.

mw / c

Core spinning can add color and texture to an off-the-shelf material.

*mw + st / c

2. The following sample used a conductive Shieldex silver-plated thread as the core, spun with a natural merino wool (*mw + st / c). The yarn was fine and continuously conductive. When knit, it created a delicate, lacy swatch. In stockinette, the swatch demonstrates a bias in the direction of the core spun twist (Z).

A conductive thread can be fully insulated a texture cocoon.

pp + ac / c

3. We returned to the technique several months later when playing with a flat paper yarn that we found in our research lab. Amongst several explorations, we created a core spun sample with the paper yarn spun around a found acrylic yarn core (pp + ac / c). Excited by the stiff, cocoon-like texture that this created, we re-made the sample with a conductive hand spun MerinoX core yarn (*pp + mx / c).

*pp + mx / c

Demonstrating the conductivity of this MerinoX core spun with paper. The paper insulates the MerinoX and also keeps it from stretching.

*pp + mx / c

A sturdy outer material can prevent a volatile conductive core from stretching.

Following the Technique

Supercoiling

Supercoiling is a hand spinning technique that wraps a spun element–like a single, yarn, or filament–around a core thread, creating a tightly spun sheath around the core. Like core spinning, this technique can hide or insulate a conductive core with a non-conductive material and results in an intriguing, energized texture. To spin a supercoil yarn, use a strong core yarn and a pre-spun single. Ply the single around the core yarn at an 80°-90° angle so that it wraps around the core. Push the coiled yarn towards the spindle for more coverage [2, 16].

*wi + al / sc

1. We initially used this technique to create insulated wire-like yarns. Our first explorations (*wi + al / sc and *wi + mw / sc) coiled spun merino or alpaca singles around silicone wire. The combination of highly coiled singles and coated wire core resulted in stiff, heavily textured knit swatches. These yarns transformed the silicone wire by encasing it in a soft, springy texture.

*wi + mw / sc

Combining materials make conductive elements read as textile.

*st + mw / sc

Shifting tension and angle during spinning can swap the core and sheath materials, creating exposed leads.

2. In another early sample, we created exposed leads by alternating the spin angles of the metallic core thread and outer wool single with the idea that we could connect electronic components to the exposed conductive thread. This yarn (*st + mw / sc) resulted in an energetic and flexible knit swatch that acted as a variable resistance sensor and suggested multi-modality and playful unpredictability through its high twist and the obscurity and exposure of the conductive material.

3. As we practiced the technique, we were able to take our exploration in diverging directions and play with unexpected materials.

*co + mw / sc

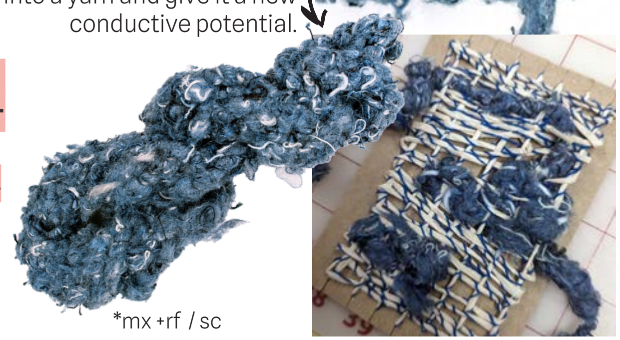
By working with conductive thread cores rather than coated wire and softer, thinner materials for the outer coil, the yarns became more flexible while retaining their coiled, cord-like appearance.

*co + mp / sc

Supercoiling led us to explore mutant varieties like possum-copper and recycled fiber insulation & Merinox combos.

ct + rf / sc

The materiality of recycled fiber insulation led us to create a chunky, yarn-like sample (ct + rf / sc) that we then re-made using a conductive MerinoX spun core (*mx + rf / sc). Using supercoiling, we were able to transform an evocative but challenging material into a yarn and give it a new conductive potential.



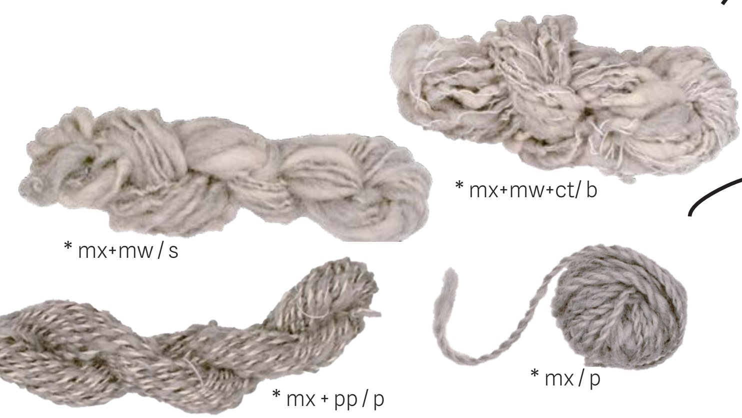
*mx +rf / sc

Following the Material

MerinoX

MerinoX is a commercially available conductive raw material blend of 80% wool and 20% fine micro steel. Ours was sourced from Bart and Francis [36]. Because of its high wool content and fine stainless steel fibers, it can be hand spun like other wool fibers and integrated into a wide range of custom yarns. MerinoX has been used in interactive textile design as a felted insert to create press sensors [6], and in early explorations of spinning in HCI [15]. We extended these previous uses by exploring a wider variety of yarn types, spinning techniques, and textile integrations.

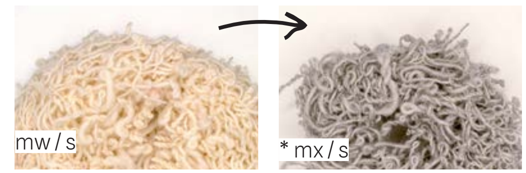
1. As we started to work more playfully, we were initially hesitant to use our supply of MerinoX because of its cost and sourcing limitations. In early samples, we blended the MerinoX with merino wool to extend the volume we had available (*mx+mw / s and *mx+mw+ct / b), however, this blended material was challenging to spin and resulted in an uneven yarn with inconsistent conductivity.



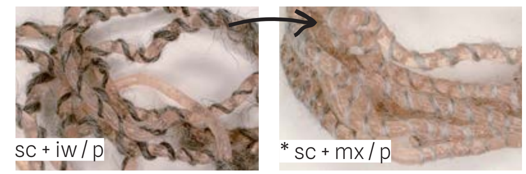
Spinning from Merinox fibers and blends can give rise to chunky and textured conductive materials.

2. To gain proficiency, we practiced spinning techniques using materials like merino wool that were more readily available (mw / s). After developing skills with these other materials, we were able to handle the MerinoX more easily. We became skilled enough to spin it like a merino fiber so we could easily incorporate it into spun samples. This skill development, with our permission to play, allowed us to experiment more with structures, such as bound bouclé (*mx + mw + ct / b) and plying MerinoX with other materials like paper thread (* mx + pp / p). We also found that we could prototype samples with merino and then remake them with MerinoX to add conductivity (* sc + mx / p).

Prototyping in other wool fibers before trying the same technique with MerinoX gave us practice and insight that led to successful samples.



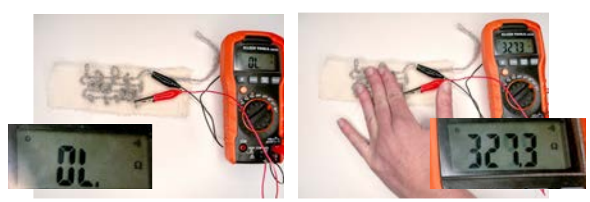
Samples of overspun merino and MerinoX. Overspinning adds elasticity, making the conductive yarn stretchy.



Samples of iclandic wool and MerinoX plied around silicone; this also created a stretchable conductive material.

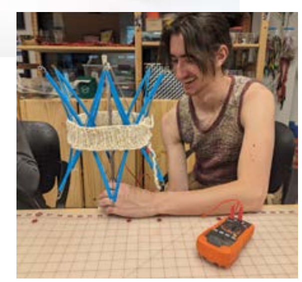
3. The Merinox samples looked and behaved more like yarns and are chunkier than off-the-shelf conductive options. We knit, wove, and braided them into different structures and blends to explore the material's potential as a sensor. We found that the swatches acted as resistive stretch and force sensors because of the way the fibers spread or compress when handled.

Yarns spun with MerinoX readily lend themselves to resistive sensing via press and stretch.



Woven inlay with loops created a force sensor due to shorting when the loops were compressed.

We knit a lambs tail pattern in MerinoX. When pressed, the fibers compress and the resistance lowers.



A band knit with MerinoX changes resistance when stretched on an umbrella swift.

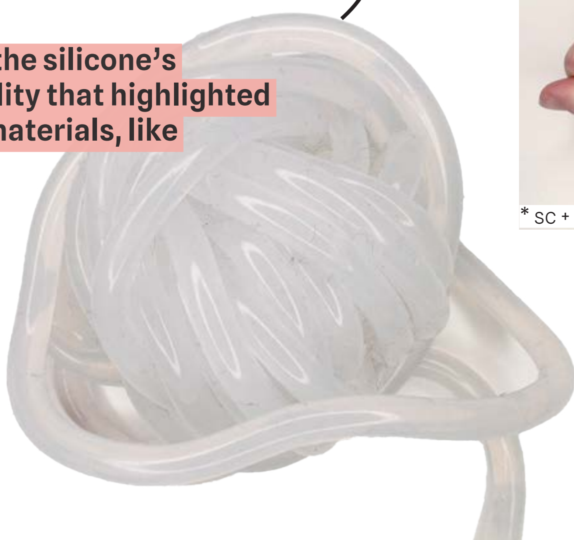
Following the Material

Silicone Caulk

Originally used as a sealant for home construction projects, this is 100% silicone that is room-temperature vulcanized. We created “yarns” or strands of the silicone using a caulking gun to extrude the silicone into a soapy water bath. After curing, the silicone is incredibly stretchy but will break after a certain point. The tendency of silicone to stick when it comes into contact with itself makes it a little hard to work with, but a light coating of cornstarch solves this problem and the material is even stronger when plied on itself.

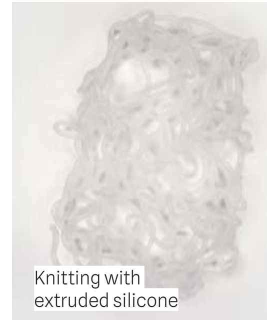
1. The use of silicone caulk as a material emerged when Lily was playing with hand spinning techniques and materials while visiting their parents during Summer 2024. It was a serendipitous discovery prompted by the tendency throughout our research to use materials we had on hand (in this case, their mom’s caulk gun) and by the “yarny” concept guiding our exploration. Extruding the silicone as a strand extended our concept of “yarny” as it pushed at the boundaries of what we might consider a yarn to be and revealed an unexpected material that could be used to create new yarns. We responded to the stretchiness of the silicone and its novelty as an unconventional spinning material by using it as a substitute for a spun single, plying it with itself and other materials.

We were intrigued by the silicone’s transparency as a quality that highlighted contrasts with other materials, like decorative copper.



sc / (none)

2. After using the silicone on its own, plying and knitting it into samples to see how it behaved as a yarn or textile, we prompted ourselves to play further. We combined the silicone strands with materials that had very different textures and aesthetics by plying them together. These included a wire-like copper thread (* sc + co / p) and a hairy icelandic wool (* sc + iw / p) that gave the resulting yarn a sense of artificial liveness that some found fascinating and most found slightly repulsive.



Knitting with extruded silicone

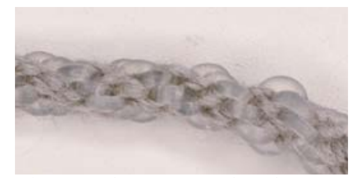
Extruded silicone dyed with colors

* sc + co / p

sc / p

sc / p

* sc + mx / p



Silicone and MerinoX combined via kumihimo brading

* sc + mx / p

Silicone allows conductive materials to stretch in ways they wouldn’t on their own.

3. When we connected our conductive silicone plies to the multimeter we found that the silicone provided a scaffold for the conductive material to stretch. When plied with MerinoX fiber (* sc + mx / p), the stretch lowered resistance (from the fibers compressing), with copper, it stayed nearly constant suggesting it could be a possible flexible connector.

Our curiosity guided this exploration, prompting us to try to see the material through to its possible ends: what if dye, what if bubbles, what if knit, what if woven? There was never an application-based reason for us to explored this.

Following the Concept

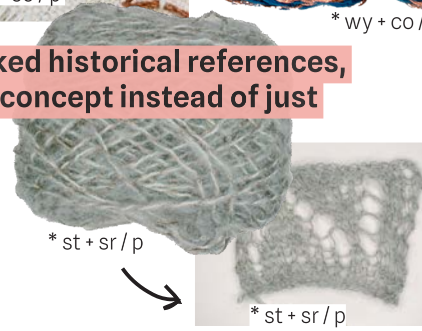
Yarny

A yarn is a long, flexible strand created from a spun fiber that can be used in textile construction processes like weaving, knitting, stitching, knotting, braiding, crochet, and lace making. The word yarn can also refer to a story or tale, sometimes one of imaginative quality [35]. Yarns can be made from a wide range of materials including natural fibers like wool, cotton, and linen, and synthetic materials like acrylic and polyester. Affective and aesthetic connotations associated with yarn emerge from daily engagement with textiles in our clothing and homes: squishy, soft, scratchy, warm, fuzzy, tangly. To us, "yarny" stood in for an ill-defined lack that we perceived in conductive materials: these materials made of metal tend to be thin, sleek, and ahistorical. In looking for "yarny" yarns, we sought to make them as textured–in a physical, visual, and cultural sense–as possible.

Yarny yarns spark visceral reactions and can delight or unsettle.

A historic example of metalwork in a cloth napkin from The Art of Dining exhibition [42]

Yarny yarns evoked historical references, giving voice to a concept instead of just adding function.



1. We used the concept of "yarny" as a guide, a nebulous notion that suggested conductive materials and aesthetic qualities that looked, felt, and resonated more as yarn than as functional components. In the creation of these custom yarns, we used only materials that we had available in our research lab or homes. Each unusual material – like recycled fiber insulation (* mx + rf / sc) or possum yarn (* mp + co / sc) brought home by a colleague from New Zealand – became an invitation for new technical explorations that could be remade using conductive materials. We asked ourselves: How were we defining yarn? What qualifies as "yarny"? If buying conductive yarns was like buying other yarns, what would we be making differently? We were seeking the joy of discovery, the textural variety, and the contextual stories found in the material diversity of non-conductive yarns.

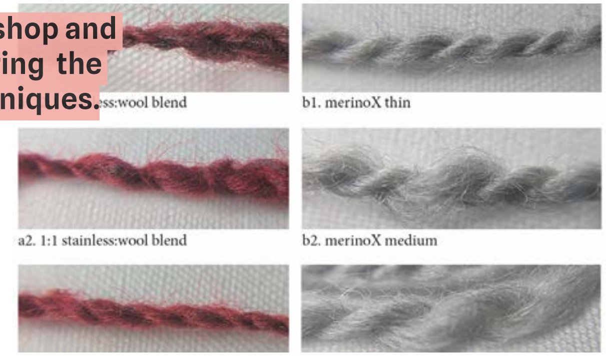
2. As we sampled, we came to assign "yarny" to the samples that produced the most visceral reactions–of both delight and discomfort. These reactions were a product of both the visual qualities of the yarn and their feel in the hand. Where we described silicone/ icelandic wool blends as feral (sc + iw / p), surrey plied with Shieldex was lacey and light (* st + sr / pl). Sometimes, just plying the conductive threads on themselves gave them stronger voices, like our multi-stranded metallic yarns (*co / p) that recall histories of metalwork embroidery on finery and ceremonial garments. Our reactions to the yarns' aesthetic character influenced ideas for what the materials could become, as though the conductive yarn was telling us what it wanted to be part of rather than waiting for us to "add function."

3. An important quality of yarn's yarny-ness is how it becomes a textile. As we developed spun samples, we knit and wove them into textile swatches to speculate about how these materials might be worked into larger designs. We used textile techniques like woven inlay and knit baubles to play with the textural qualities of the yarns and invite interaction like touch and press. In the process of becoming textile, they also populated "yarny" visions of the future that included hybrids between fisherman sweaters and spacesuits or baroque accessories for everyday sensing.

Yarny yarns suggested yarny futures as we reimagined the aesthetics of speculative design in fiber form.

Discussion

This pictorial showcases some of the material and technical range available through hand spinning that could be applied to interactive textile design by using conductive materials. As we present material findings, we reflect on our design journey, outlining how our process shifted from a systematic to a divergent approach. Through this reflection, we acknowledge the factors that impact a design project and show how our interdisciplinary collaboration and playful approach resulted in a wider material range than we expected. A belief that materiality and aesthetics should be considered with equal depth to function and application guided our design process and we note the landmarks and material discoveries that guided our way. We contextualize our findings in a series of maps through our design journey. These are intended to scaffold a pathway for understanding the numerous material threads that emerged for us through play. With this pictorial, we extend an invitation to other HCI textile practitioners to take up both hand spinning and more divergent design approaches, which we believe will lead to new discoveries and aesthetic possibilities in the field.



Images and outcomes of our Spring 2023 workshop and studies that focused on systematically comparing the electrical performance of yarn blends and techniques.

Images and outcomes after "getting weird" and letting our interests and curiosities guide us.

Embracing Non-Arrival in Divergent Design

Though we present an open-ended, divergent design journey in this pictorial, we admittedly tried to reconverge to reach a stopping point fitting for publication at various moments throughout our process. In Spring 2024, after a couple months of playing, we had produced twenty-two spun samples and sixteen knit swatches, each with unique aesthetic and technical qualities. Through close looking and discussion, we reflected on the different connotations that arose from each material and what design possibilities they elicited. We speculated about what these might become: a tank top that measures breath, an anti-bacterial hiking sweater, a data-gathering glove, a faraday cage that is also a snood or a purse. We tried to pick a target, to select one of these ideas to make material, but found we hadn't gone far enough in our exploration. We could see a landscape of material possibility emerging and we weren't ready to commit to a single direction. At each of these reflective junctures, we moved towards further material exploration. In other words, we tried to arrive, but we never did. Or perhaps, instead of arriving *some*where, by following the materials, we initiated numerous departures that have yet to land.

Our decision to let loose and give ourselves permission to play supported a great deal of divergence. Design projects are frequently characterized by arrival narratives that present a finished object or application within a linear process that describes how it came to be. This is often illustrated by the "double diamond" [43] that depicts phases of divergence (idea generation) and convergence (idea refinement and focus). As we reflected on our process, we realized that our decision to play led us to diverge, and then diverge more–convergence was something we trusted would come later. This orientation towards more divergence allowed each collaborator to responded to their curiosities and aesthetics. It led us to work serendipitously, finding materials that we had nearby or that had interesting stories. The textures were intriguing and unusual, things we had not previously seen in yarn, and certainly not conductive yarn. If we had tried to arrive for the sake of arrival after our twenty-two samples, half of the landscape that we present here would be obscured. As it is, we hardly touched on the infinite variety possible through hand spinning. By giving ourselves the permission to diverge, we were able to develop unique materials and combinations that we wouldn't have imagined otherwise, turning studio excess into wild, conductive yarns. We reflect on this here because we think this approach is one that can be embraced by designers across domains to create unexpected materials that might inspire wholly new textile designs.

Broadening Aesthetic Range for Interaction Design

Our research was undergirded throughout by a belief that aesthetics–a material's visual, tactile, and affective qualities–and function–a material's behavioral and performative qualities–are fundamentally linked. For instance, a wool sweater is cozy because it is warm, and it is warm because of the insulating properties of the wool fiber. This belief prompted us to respond to the aesthetic of a material as much as its function in our exploration. The aesthetic range of existing conductive materials available to e-textiles practitioners is currently limited to thin, sleek, metallic threads. This lack of material variety narrows the ability of designers to fully explore the design space of interactive textiles. The limited range of conductive materials creates a gap between a textile as substrate and the addition of interactive components which are applied supplementally in service to another function. Our samples allow us to imagine the possible designs that interactive textiles could take with the seamless integration of conductive yarns. For example, a conductive pathway could be woven or knit directly into a textile in a material that matches the overall design and reflects user preferences. By following material and prioritizing aesthetic as well as functional qualities, we reconnect with the textiles in e-textiles, designing from the material rather than from the desired output.

Throughout our process, we reflected on why the HCI community might be interested in these yarns and some authors felt a need to continually justify our commitment to open-ended play. We ended up with things that may be of questionable use in the immediate present, but are much more evocative than the conductive threads with which we typically work. They are yarns that could act as center pieces to design entire projects around, letting them lead the design with their strong material "voice." This is interesting because we tend to think of conduction as a means of moving electricity from here to there, added on after or in service to another idea or function. The act of doing divergence, and then more divergence, creates a palette of material possibilities that can be drawn on during later projects. Divergence, then, takes a kind of suspension of disbelief and a faith that at some point, this yarn will be perfect for the thing at hand, exactly what a designer was looking for but didn't know they needed. And sometimes, we need to play just to learn and gain technical proficiency in a new skill so that we can better understand how to apply it. This experience also builds confidence and complicity [17] with materials so that we might take further material and aesthetic leaps, like when Lily picked up their mom's caulking gun to experiment with extruded silicone as a "yarn."

Mapping the Design Journey

With the embrace of material drift through design journeys comes questions about where knowledge contributions from these practices reside and how we can effectively communicate those contributions. Unlike linear investigations, where contributions can be clearly scoped within an application context or by a predetermined set of goals, knowledge in materials-led design can be partial, embodied, and situated within an individual practice. To show this, designers have drawn on familiar organizational and communicative formats from their broader design processes like ledgers [20], portfolios [13], workbooks [11, 28], and instructional texts [6, 34]. We lean into the metaphor of the design journey by presenting our findings in this pictorial through a series of maps that guide readers through our material process. Like these other formats, mapping offers a familiar metaphor to describe non-linear processes and encompass the many small discovery points and shifts in trajectory along the way. The metaphor allows us to further articulate our process by using playful travel-related language like "pathways," "landmarks," and "arrival."

Notably, our maps are not directions that tell a reader what route to follow, but illustrations of some of our own travel through a design space. These maps reflect the knowledge, creativity, and inventiveness present within the many departure points and loose threads of the design journey that often get obscured in favor of completed works and arrival narratives. Like roadways in an atlas, each of these loose threads suggests one of many possible pathways that researchers could take in their own design explorations. The presentation of this research extends the prompt to diverge to the DIS community. The departure points that we present here in the tracings of our journey offer a new perspective on the material possibilities available in the domain of interactive textiles. We hope they inspire other designers towards arrivals that we have yet to imagine by embarking on their own journey into hand spinning, or simply by inviting more play into their design process.

Conclusion

This pictorial describes a collaborative design journey, unfolding over two years, focused on hand spinning custom yarns for interactive textile applications. Initially focused on the ability to "tune" conductive materials to specific applications, our research pivoted to a more divergent design approach in which we prioritized play and "following the materials," using "yarny" as a guiding concept. This exploratory research resulted in 45 spun samples and 30 textile swatches from various combinations of five hand spinning techniques and 16 materials. We present these through a landscape image, index, and five pages that follow the techniques supercoil and core spinning, the materials MerinoX and silicone, and the "yarny" concept. Drawing on the metaphor of mapping the design journey, we use this pictorial to trace the aesthetic variation and material possibilities that emerged when we gave ourselves permission to diverge and explore more freely. We suggest that both hand spinning and divergent design could be valuable approaches for interactive textile designers.

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