Feeling Fabrics: Prototyping Sensory Experiences with Textiles and Digital Materials

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Abstract

The experiential qualities of materials play an important role in how designed products are used, appreciated and understood. Materials with pronounced visual, auditory or haptic behaviors and temporal forms can lead to engaging, multisensory interactions. However, many designers, including textile designers, currently lack tools for directly shaping these end-user experiences at the sensory level, and for understanding material experience at an early prototyping stage. With a focus on the design of dimensional, shape-changing and otherwise structurally complex textiles, we present a set of design practices and a case study in building a collection of novel materials with highly specific sensory qualities that exist both digitally and physically. Two key additions to the typical textile design workflow presented in this paper are our use of the "generalized swatch", an initial prototype that prioritizes precise multisensory description; and our usage of procedural material design software to visualize these prototypes as digital materials that can convey sensory, tactile and temporal qualities. We used a program for creating physically-based rendering (PBR) materials, popular in visual effects and gaming, to design textiles directly from the generalized swatch, in many cases without a preexisting physical counterpart. The parametric nature of this software and our workflow supports a broader role for the textile swatch, as defining a space of possibilities rather than a single design. By operating in this uniquely constrained space, where sensoaesthetic properties are predefined but the material substance, structure, etc. that lead to those properties are not, textile designers can envision material interactions at an early prototype stage and generate novel ideas for sensorially rich materials.

Textile design; Materials experience; Procedural design; Sensory design; Textile sensation and haptics

Textile-design CAD programs provide a high-fidelity preview of the design, but cannot account for the sensory and experiential qualities of the resulting fabric. At the same time, these computational tools enable the design of intricate texture, multi-layer architecture, and dimensional surfaces that would otherwise be difficult to achieve. Such textile constructions -

whether knit, stitched, woven or composite - can result in unique experiential qualities, particularly the haptic effects of manipulating the material by hand. As a design team with deep expertise in designing and fabricating textiles with embedded movement and tactility, we focused our research on textiles that visually invite interaction, evoke multisensory experiences, change over time or occupy distinct states. We set out to create a framework for ideating and designing this class of textiles that privileges non-visual sensory qualities, retaining them throughout the prototyping process. Central to this work is understanding how such textiles can be formed in a digital space, where representation is typically audiovisual only. How can we transfer experiential knowledge of an existing fabric from one mode (eg. tactile) to another mode (eg. visual)? How can designers translate speculative concepts for sensory textiles into concrete prototypes?

Through this investigation, our team experimented with a range of ideation, sketching and sampling methods. The workflow we developed centers the textile swatch itself as the object of iteration and prototyping. While both material and form affect the sensorial properties of designed artifacts, we focus on the ability of materials to elicit "freestanding" sensory experiences in the absence of familiar forms or product usage activities. The way an individual interacts with a textile sample is significantly different than a garment or upholstered furniture: our explorations in unstructured material discovery revealed a wide range of interactions, and resulting embodied effects. With this approach, the design vision consists of a set of experiential qualities, and the prototype is an approximation evoking those qualities , which can be continuously refined. Our prototypes take one of three formats: a "generalized swatch", which directly describes the intended experience at the outset of the design process; a physically-constructed fabric, or a procedurally-generated digital material, which actualizes described traits into a physical or virtual form. These methods enable designers to declare an intended experience - of encountering the hypothetical material - and subsequently determine its formulation and fabrication. Reverse-engineering a textile from its intended sensory qualities can be a powerful technique for designers to create highly stimulating or finely tuned multisensory effects, especially those that engage with senses beyond the visual. The generative and procedural methods outlined here support the creative process by opening up the design space to exploration and improvisation, broadening possibilities for new material designs and experiences.

Background and Precedent Work

The body of research on materials experience (Giaccardi & Karana, 2015) informs our approach to characterizing existing multisensory materials and developing new ones. At the perceptual level, material properties are often described by rating on scales such as stiff/flexible, warm/cold, light/heavy, and rough/smooth. Resources such as Ashby diagrams (Ashby & Johnson, 2002) allow designers to select materials by comparing them along two axes, typically physical measurements. Mapping the sensoaesthetic properties of materials in this manner can identify ways of modifying materials to produce specific traits (Miodownik, 2007). Frameworks including the expressive-sensorial atlas (Rognoli, 2010), experience map (Camere et al, 2015) and experiential characterization toolkit (Camere & Karana, 2018) demonstrate relationships between material properties at several levels. Camere & Karana (ibid) note that combinations or contradictions at one level yield qualities at a different level: a material that is hard yet soft (sensorial) can be surprising (affective). Many current material mapping methods use unipolar or bipolar scales that position such properties as opposites, overlooking the interesting, uncanny results that can emerge when they coexist in a material (Veelaert et al, 2020). This insight is especially relevant to our work, which seeks out novel sensory experiences that both physical and digital textiles can evoke. Imbuing a material with affective qualities (eg. surprise) through sensory contradiction requires unique methods in digital space.

The growing prevalence of digital textiles in the design process and retail settings raises questions about how to effectively convey fabric handfeel. Atkinson et al (2013) showed that characteristics like roughness and stiffness could be inferred through touchscreen manipulation of interactive textile videos. Temporal form is key in communicating these physical properties, and can also provoke emotional and embodied reactions: participants who observed fabrics moving with distinct choreographed rhythms attributed to them a sense of aliveness and narrative (Vallgårda et al, 2015). In scenarios where touching a fabric is impossible visuals and movement heighten the sensory experience. Designers working in digital environments can utilize these dimensions, for example creating visualizations of physically implausible material behaviors to mockup interactions (Barati et al, 2017). Citing Edelkoort's (2012) notion of "super tactility", Petreca (2017) asserts that a virtual textile need not attempt to recreate physical fabric, instead balancing realistic qualities with the "imaginary and the emotional". We use procedural design software to prototype fabrics that convey experiential qualities through their appearance and range of possible states, leveraging the virtual textile as a vehicle for sensory experience rather than a representation of an existing fabric.

We engage with the textile swatch in the context of its typical use, critiques and proposed alternatives. In textile design, the swatch is a small sample that functions as a "promise and a possibility" of its counterpart, a large quantity of fabric yardage (Igoe, 2020). The swatch represents a finished design but leaves much to the imagination, convincing designers and consumers that the material it represents can appear as they envision it. Laughlin (2010) calls this underdetermined nature "the tyranny of the swatch", instead proposing the material-object, an intersection of material and form, as a type of sample that foregrounds sensorial qualities. While a typical use of materials libraries is comparison, a single material's range of expression can also be evaluated, eg. by molding it into a series of forms that yield different sensorial properties (Wilkes and Miodownik, 2018). Material samples that change over time, such as mycelium-based composites (Parisi et al, 2016) and textiles that respond to environmental conditions (Talman, 2019) similarly support the notion of the swatch as a space of possibilities. These expanded definitions of the swatch enable it to act as a prototype, a malleable idea of what a material could be.

Our research methods draw upon precedents such as experience prototyping (Buchenau & Suri, 2000), experimentation as improvisation (Douglas & Gulari, 2015) and material tinkering (Parisi & Rognoli, 2017; Rognoli & Parisi, 2020). We began this project with hands-on material exploration, inspired by recent research into ASMR as design inspiration (Klefeker et al, 2020) and the idea that unstructured play can yield valuable insights. A broad palette of interactions and gestures promotes discovery of sensorial and affective qualities, especially when the individual cedes control to the material (Cary, 2013; Aktaş & Groth, 2020). The influential textile designer Anni Albers advocated for a similar type of "active play" to spark creative impulses and restore understimulated tactile sensibilities (Albers, 1965), a sentiment echoed in present-day material tinkering and material activism (Rognoli & Ayala Garcia, 2018). Our team used these principles in the information-gathering stage and while developing new material concepts that embody gesture, movement and multisensory effects.

Methodology

Capturing textile behavior

Identifying and describing textile behavior was an important precursor to developing a workflow for multisensory textile prototyping. Our prior work designing and fabricating dimensional textiles with textured surfaces served as a starting point for identifying the sensory qualities of fabrics. Using these samples, we experimented with a range of interactions between body and textile (eg. twisting, squeezing, resting, stroking, enveloping) and documented the results with video and written annotations. Video was particularly important in identifying haptic qualities: while a fabric's surface texture cannot be fully represented visually, the audio cues that result from interacting with the surface, and the motion of a hand moving across or pushing against it, provide implicit clues about its physical properties. At this stage, it was important that we subject these fabrics to a wide set of actions not limited to typical uses of textiles. While some, like sitting on or wrapping oneself in a textile, are reminiscent of furnishings or clothing, others, like folding a thick, compressible sample upon itself or swaying a fabric suspended in midair, position the textile as an object of investigative play.

Figure 1: Stills from video documentation of textile interactions that captured a range of gestures.

Moving from these specific samples towards a generalized method of capturing and communicating textile behavior, we gathered descriptive words from our written annotations, industry-specific and vernacular terms that reference the auditory, olfactory and tactile properties of materials. Many common textile-industry terms act as similes or borrowed language, describing a fabric as "peachy", "sandy" or "soapy"; while it might be surprising to encounter a fabric that feels like rough sand, the experience of touching its surface is effectively communicated through comparison. Likewise, everyday words like "silky" and "fluffy" use fibers and textiles as a reference point from which non-textile materials can be understood. Another subcategory that we identified as useful in prototyping sensorially rich materials is onomatopoetic terms, such as "buzz", "hum", "crinkle" and "thump". These words, whose phonetic pronunciation closely aligns with their meaning, suggested a way of translating sensory experiences synesthetically. If reading a word evokes the sense of touching a familiar material and hearing the sound it makes, a deliberate grouping of multiple terms may suggest an idea for an entirely new type of material, for which a frame of reference and prior experience do not exist. We proposed that materials can also be onomatopoetic if the way they look is consistent with how they sound and feel. Such "cohesive" materials, like smooth, lustrous silk, are distinct from "contradictory" materials, like a quilted fabric that is bulky yet ultralightweight. When physical properties are surprising or concealed by material appearances, uncanny or impossible-seeming sensations can arise. Collecting words and phrases from disparate sources enabled our next phase of experimentation, in which we combined several general terms to narrow their broad meanings into a specific material idea.

Sounds & actions	Olfactory terms	Tactile terms	Tactile terms with textile origins
flutter shuffle	antiseptic sweet	corrugated dense	gossamer bristly
crunch hiss thump	floral dusty briny	springy frothy coarse	furry downy wiry
rustle scratch	savory powdery	abrasive rubbery	cushioned leathery
purr creak rattle	clean musty acrid	filmy spiny pliable	taut wrinkled sheer
warble chatter	synthetic vegetal	encrusted jagged	starched pleated
thud squeak swish	fruity musky gamy	fragile warm grainy	velvety silky lacy
whoosh murmur	lemony chemical	soapy polished	tweedy shaggy
waft smack clink	putrid minty earthy	prickly gooey bulky	ribbed hairy fluffy
crinkle whisper	piquant woodsy	tough embossed	quilted frayed

Figure 2: Selected sensory terms.

Text-based ideation

Working with language as a building block for material ideation can provide unique insights. Textile designers often begin the creative process by compiling visual reference material, including fabric swatches, colors and images, that inform the conceptual, aesthetic and material qualities of their work. We adapted this strategy by using textual descriptors as movable units that add connotation and specificity, forming an as-yet imagined material. Each time a word is added to a group, it narrows the space of possibilities of how that material might be realized. A term like "fluid" is broad and could describe many diverse materials, but a grouping like "fluid, sleek, abrasive, pliable" conjures images of a particular material that may vary depending on the designer's experiential knowledge of material behavior. "Fluid" and "pliable" seem to contradict each other, as the latter implies a higher level of hardness in a substance that can be molded with some effort. Does the material look fluid (like polished metal or plastic) but feel like soft clay, is it made of movable folds of a silky fabric like charmeuse, or is its handfeel dependent on factors like thickness and temperature? Each potential resolution of the apparent contradiction is a specific material design, in which known or hypothetical fabrication strategies and ingredients are combined to produce a result aligned with the text-based prompt. In developing material ideas from language, we acknowledge that the structure of this workflow bears some resemblance to currently available text-to-image AI applications, in which the user enters several words and an image is synthesized from their meanings and contexts. In these cases, the image is the final product, neither a prototype nor a tangible design for a material. Our process utilizes language to provoke design ideation: crucially, the designer must determine how each term is embodied by the material, making unique choices based on prior knowledge or subjective opinion. This results in a sensorially specific prototype, representing a space of possibilities not yet reduced to a single idea, from which refined material designs can be developed.

Figure 3: Examples of text-based groupings created to define new material designs.

Semantic ambiguity allows sensory terms to build increasing specificity when layered in this way. Words relating to human-material interactions, like "squish" and "thwack", can describe sound, handfeel or appearance, depending on context. They may indicate a material's tendency to react (produce a certain sound or haptic feedback) when manipulated, or describe the *expectation* of sensory feedback that a material elicits based on its appearance, ie. the type of interaction that it invites. In the context of a group of descriptors, the ambiguity of such terms is resolved, describing a singular material experience. This approach to building specificity through grouping is distinct from typical textile design processes, in which images and existing materials are combined into reference-objects for creative outputs: these can unintentionally constrain design choices to the space of colors, finishes and constructions found within the references themselves. Our method also differs significantly from technical textile creation workflows, in which the physical properties of the fabric are specified at the outset. In these scenarios, fabrication methods are determined early on, and iterations in structure or raw-material type are assessed quantitatively rather than sensorially. By using words as references, accompanied by abstract or ambiguous imagery, we preserved two goals central to our methodology. First, the sensory experience inherent to a material is at the forefront, described by words that engage with multiple modes of sensing. Second, we avoid focusing on textile fabrication strategies or raw materials at this stage, allowing previously unimagined or underexplored material creation methods to emerge as the designer considers the qualifiers and constraints. The logical/associative process of determining a material's makeup in this way may lead to novel or hybrid swatches, reverse-engineered from their own descriptions. Our process shifted between specificity (documenting existing fabrics) to generality (accumulating sensory descriptors) back to specificity (creating complex/contradictory groupings). This way of prototyping allows concrete ideas to emerge that are not directly derivative of their precedents.

Building a collection of multisensory materials

Figure 4: A collection of materials developed using this methodology. The title of each material is derived from its generalized swatch, a prototype format that leads to subsequent digital and physical iterations.

To design a collection of novel materials with highly specified sensory properties that exist in both digital and physical space, we looked to procedural material creation for its capacity to preserve and amplify features relevant to materiality and sensory experience. We utilized Adobe Substance 3D Designer, a program for creating physically-based rendering (PBR) materials popular in visual effects and gaming, to realize material concepts that emerged from initial text-based and generative exercises in the framework of a "generalized swatch". In design practices, the swatch is a small, rectangular material sample that serves as a reference. It is useful to designers in the prototyping phase but is not itself a prototype: the material has already been designed, refined and possibly even manufactured, and is not open to further changes. Related concepts in textile design, such as the sampler or sample blanket, include many copies of the same material subjected to different processes (eg. washing, bleaching, dyeing) or constructed with different parameters (eg. different threading sequences on a loom, which produce pattern variations). These examples demonstrate a greater degree of flexibility regarding the fabric's final form by permitting multiples of the same basic unit, the swatch, to exist side by side. It's implied that one variation will be selected as the final design, locating the sampler at an earlier stage of the design process than the swatch and allowing it to function as a prototype of what the material might become in many parallel instances. We took inspiration from this format for representing fabrics as potential outcomes, and coined the "generalized swatch": a cluster of text and images that form the boundary of what the material could be. The generalized swatch is distinct from a design brief or request for development in that it intentionally underspecifies details that designers use as starting points. It does not contain explicit directives about colors, raw materials or fabrication processes; instead, it describes the visual, auditory, tactile and olfactory qualities that the eventual material will possess, or the sensations and resemblances it may evoke, asking the designer to reverse-engineer it from these outcomes. For example, a generalized swatch may assert qualities like "dense", "rubbery", "ooze", "thwack", raising the question: what sort of material might behave and be perceived in such terms? In this way, it acts as a prototype, preserving the openness that exists at the beginning of the design process by prompting the designer to think abstractly and associatively. This first draft of the material, which lacks concrete representation but is nonetheless precise, leads to subsequent prototypes rendered in physical and digital form.

Figure 5: A generalized swatch includes text and images that describe experiential qualities.

When moving from the generalized swatch towards tangible prototypes, we identified two potential workflows for material creation. Because a core goal of this project was to demonstrate the sensory potential of newly designed materials in physical and digital space, it was important to establish methods by which both versions of the material could be created, coexisting and informing one another. The order in which these parallel prototypes were created was particularly important, as designers of physical fabrics often use immaterial references as guidelines and vice versa. We recognized that the first material sample would inevitably influence later samples, visually clarifying details to emulate or diverge from. This led to two complementary workflows: (1) a physical-first workflow, in which the generalized swatch guides selection of raw materials (eg. yarn and fiber) and fabrication techniques (eg. loop-pile knitting) in the creation of a physical sample, and (2) a digital-first workflow that bypasses fabrication constraints and distills the text- and image-based prompt into a procedural material (eg. a biomimetic cellular pattern) with flexible parameters.

Physical-first workflow

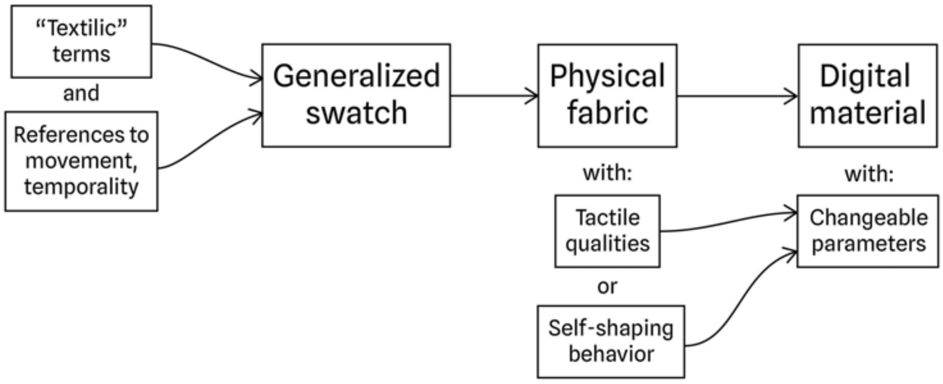

Figure 6: Diagram of three kinds of prototypes generated from the physical-first workflow: generalized swatch, physical fabric and digital material.

Before initiating this phase of work, we established criteria for deciding which approach would be appropriate for each generalized swatch in the collection. The first approach, which is related to typical textile prototyping, is suitable for materials whose experiential qualities can be directly connected to a specific textile technique. Generalized swatches that included descriptors like "prickly", "stiff" or "scrub" were more immediately evocative to the textile designers on our team. Such terms suggested fiber-based constructions, like short, coarse yarns protruding from a fabric's surface that feel scratchy when brushed. An early test of this workflow was done with the generalized swatch "sandy staticky buzz", which included references to small-scale, high-stimulus phenomena: glitchy, grainy, irregular patterns and textures with many points of contact. We identified loop-pile knitting as a technique that distributes small segments of yarn across the surface of the fabric, closely matching the white-noise qualities of the generalized swatch. Overtwisted linen yarn was selected for its tendency to twist back onto itself and form small, dense bumps in the fabric, ideal for a highly textured "sandy" handfeel. We characterized this design as onomatopoetic, as its scattered visual pattern evoked how it felt to touch its fine-grained bumpy surface.

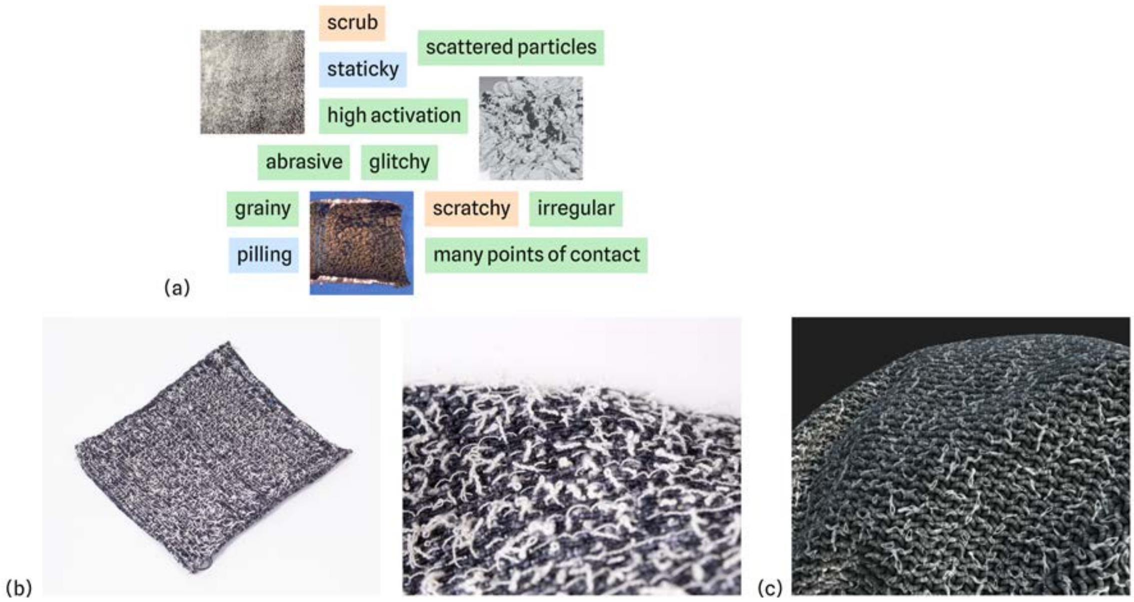

Figure 7: The generalized swatch (a) informs the knitted prototype of "sandy staticky buzz" (b), which is then used as a reference material to develop a digital material in Adobe Substance 3D Designer (c).

This process of translation from sensory terms to relevant textile techniques is a movement from generality to specificity, filling in many of the blanks (what is this made of? What equipment is used to make it?) so that a singular material can be created. In this method, the physical swatch is assessed for its adherence to the sensory qualities expressed in the generalized swatch. It is then used as a visual/tactile reference object when creating a procedural material, which may be an improvement upon it or simply an alternate manifestation of the same material qualities. Characteristics like the shape of knit stitches, the twisting of yarn loops, and the colors of variegated yarn would be highly challenging to model from imagination, and doing so would miss the point of this workflow altogether. As textile designers, we know that these small details of the fabric's construction are integral to how it looks, sounds, feels and moves. Using the physical swatch as a source of information for the digital swatch not only enables a higher level of realism in the digital material ("this looks convincingly like a fabric"), but also embeds specific haptic qualities ("this material looks like it would feel sandy, and make a scratchy noise when manipulated by hand"). The fabric's visual and physical features can be rendered by the digital material's base color, heightmap, roughness and other channels, suggesting a complex sensory profile.

Digital-first workflow

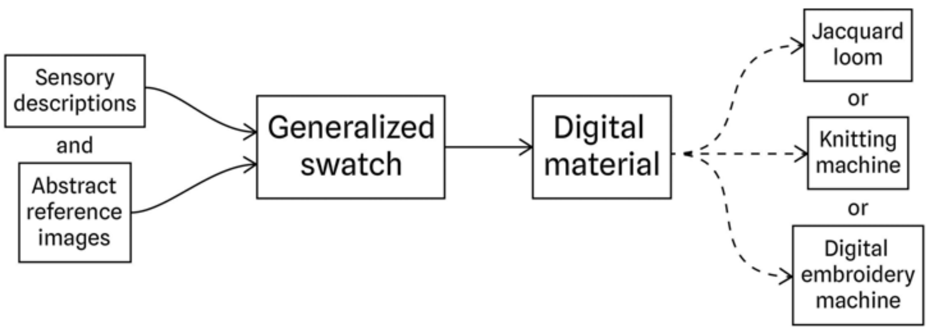

Figure 8: A digital material is generated first in this workflow, which then informs a physical fabric that may be made in a variety of ways.

In the second workflow, the terms of the generalized swatch feed directly into procedural, rather than physical, material-making. This approach is suitable for materials whose "haptic interest" is derived not from textile structure but from broader qualities like reflectivity and smoothness; those with contradictory pairings of terms, such as "stable / gooey" or "fluid / fractured"; and those whose descriptors suggest a biological or immaterial phenomenon, like the refraction of light, rather than a deliberately constructed textilic artifact. We characterized these materials as "at home" in digital space, not belonging to a specific textile technique, in part because of their uncanny qualities. Working in a digital-first way, without fabrication constraints, allowed us to visualize the physical improbabilities built into certain generalized swatches. The PBR materials that we created are somewhat illusory and fictionalized, since they depict the outer surface of a material in great detail but don't comply with the rules for how knits or wovens are actually constructed beneath the surface. A greater level of improvisation and freedom is thus possible, with procedural methods enabling instances of tinkering or "bending" the material past the point of realism. The ability to quickly visualize a speculative material, in higher fidelity than a sketch or mockup, is a key strength of procedural material design software. The digital material lends a level of concreteness to the first prototype, an abstract definition of a sensory experience, and serves as a visual and strategic reference for creating the next prototype, a physical sample.

A material in our collection named "tensile gelatinous membrane" demonstrated many of the qualities outlined above, leading us to select it as a candidate for this digital-first workflow. To design a material that felt biological yet otherworldly, filmy and effervescent yet robust, we started by setting parameters for roughness and color, creating a slick translucent effect. Air bubbles on the surface and (seemingly) embedded in the material were used to suggest its viscosity and thickness, and a webbed pattern with raised edges was added to the heightmap, suggesting that the base material might be tensioned or spanning across edges like a soap film. With this approach, solutions to open-ended or contradictory prompts are found in an intuitive, free-associative way, with the designer borrowing visual features from familiar materials to imbue the prototype with the same connotations and implied tactile qualities. We then used the digital material to inform the physical material: the design choices during the procedural design process, which could not have been made in a textile fabrication setting, empowered us to select unconventional raw materials and methods. The webbed scaffolding was digitally embroidered, with several layers of thread built up to create a piece of dimensional lace. Casting a liquid silicone into the spaces between lace segments created a thin, stretchy yet constrained film with the desired "tensile membrane" effect. There were practical advantages to this workflow, including the ability to generate fabrication inputs (eg. a digital embroidery file) directly from the digital material's node graph. More significantly, deferring decisions about materials and methods until after developing the material in an unconstrained, speculative and highly visual space can lead to "hybrid" (eg. embroidery-casting) or entirely new ways of making textiles.

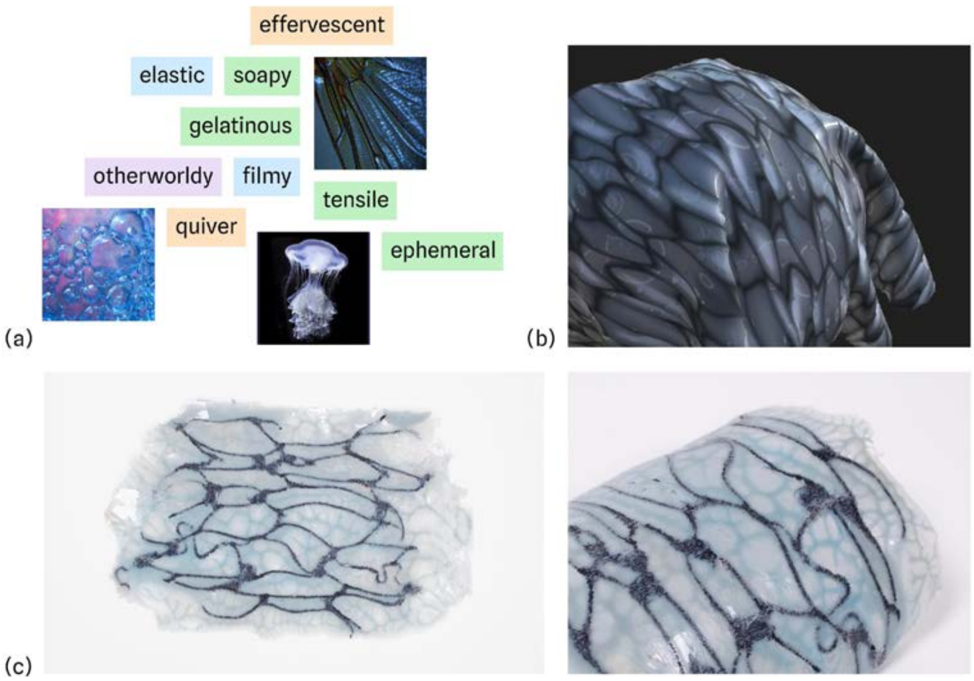

Figure 9: In this workflow, the generalized swatch (a) informs the digital prototype for "tensile gelatinous membrane" (b), followed by a physical interpretation (c).

Temporal qualities of material prototypes

The parametric nature of the swatch in our workflow aligns with the idea of the textile sampler, illustrating many potential states in which a material concept can be realized. With procedurally designed textiles, one way to visualize this solution space is to animate the material. We differentiated between two uses of movement in digital materials: simulating physical motion, as in a pleated textile that expands and contracts, and traversing a space of possibilities. While behaviors appear in the latter case that aren't physically plausible - the material transforms from one instance to another, seemingly flickering, pulsing or breathing - this mode of representation is valuable for understanding the boundaries of the generalized swatch and identifying convergences within it. For a digital textile with a complex surface pattern and pleated structure, based on qualities including "drifting", "whoosh" and "caress", we built a node graph that closely resembled the actual steps of designing a Jacquard-woven fabric. The textile's noise level (the degree to which yarn colors are randomly scattered), and the height and irregularity of its soft pleats, were exposed as parameters in the procedural design software so they could be quickly changed to update the material's appearance. Arranging the resulting variations into a temporal form allowed us to assess the many states that fit the "generalized swatch" definition, something a physical fabric doesn't permit. The underlying structure of this digital prototype also allowed us to extract parameters to fabricate any instance of the design that met the initial sensory criteria.

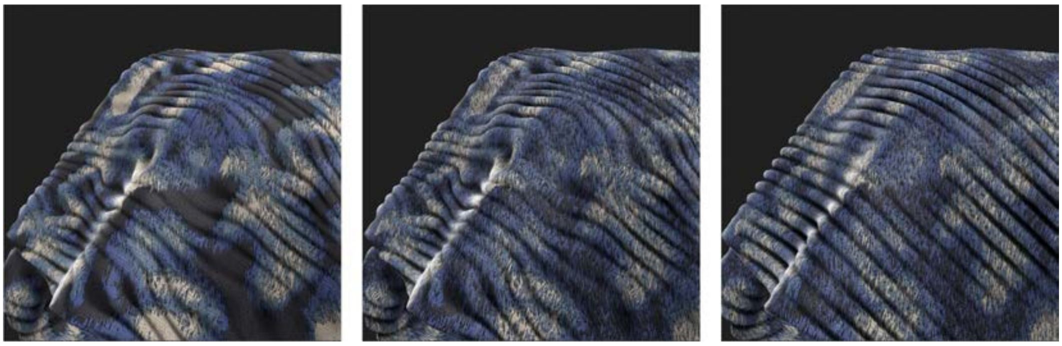

Figure 10: Stills from the animated material sample illustrate distinct intersections of noise, pleat height and irregularity.

Conclusion

By acknowledging the multiple representations inherent to a single material, we propose a unique form of prototyping that privileges experiential qualities. Our method replaces the traditional swatch in textile design with the "generalized swatch", which encloses a constellation of material representations and sensory qualities. This form of prototyping specifies experiential qualities at the beginning and derives a material design from them, an inversion of typical material-selection processes that enables designers to develop sensorially complex materials. Textile designers currently lack tools to envision the sensory or temporal aspects of materials in the design stage, despite the rich potential of textiles to operate in these dimensions. With rapid improvement of appearance-based modeling software, we see an opportunity to apply strategic design methods that consider the multisensory properties that appearance and movement can imply. We aim to demonstrate the value of these tools, and potential ways of reconfiguring them, in support of the ideation of novel textile materials.

Figure 11: Additional knit, woven and non-textile materials developed from generalized swatches.

Future steps for this work include organizing digital and physical textile samples into a library, in which users can compare and assess materials. Studying the range of responses allows us to measure, and subsequently tune, the variability in our design methods. Prior knowledge and cultural context play a large role in how we perceive materials, and are certainly present when we generate new materials from expected perceptual behaviors. Asking outside participants to describe their experiences of encountering our materials, which originated from sensory descriptions, closes the loop on our design process and indicates how it might be modified to produce more precise, powerful or favorable conditions of material interaction. We acknowledge that our current methods are limited by various factors: the examples in this paper were developed by English-speaking designers, so some language-specific details, like onomatopoeia and semantic ambiguity, will differ across linguistic contexts. Working primarily with text, as in the generalized swatch, may be challenging for designers accustomed to compiling visual and material references to inform their work. Moreover, our methods are not completely automatic or generative like text-to-image tools: they require the designer to both provide and synthesize inputs to create a novel material idea. While these steps necessitate a certain amount of creative effort, we find that they lead to highly unique and sensorially rich material outcomes.

We also see an opportunity to expand the format of our material prototypes by including audio or interactive movement behavior, further heightening the sense of materiality in settings where the tactile aspect is missing. There are well-established software pipelines for bringing digital materials into 3D modeling, gaming and VR environments, where they can change dynamically based on user inputs. In these systems, the underlying design of the procedural material (ie. the node graph itself) closely controls the types of responsive behaviors that can occur, so designers may choose to structure the digital material in a way that mimics the physical logic of an existing one. Properties like thickness, bending stiffness and elasticity can be directly applied, rather than visually implied, through the use of software plugins that enable PBR materials in CLO, a popular digital fashion-design program. A thorough investigation of these methods could give designers the ability to more fully prototype material experiences early in the design process.

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Elizabeth Meiklejohn

Elizabeth Meiklejohn is a textile designer and researcher with a focus on the three-dimensional qualities and movement behaviors of fabrics. Her work blends procedural design, digital simulation and hands-on craft methods to achieve these complex forms and capabilities, all while investigating material origins and lifecycles. She recently completed her MFA in textile design at the Rhode Island School of Design, where she specialized in woven fabrics and was a member of the Virtual Textiles Research Group. Through ongoing research, Elizabeth explores techniques that enable fabrics to move, transform and respond to external forces. This practice is motivated by curiosity about these static objects' potential to interfere with sensory perception, through haptic and visual illusory effects. Simultaneously, she develops software tools, notation systems and methodologies that allow creative practitioners to design and fabricate materials with intricate or unconventional structures, seeking to create new visual languages for understanding textile forms.

Felicita Devlin

They are an interdisciplinary artist/designer from Fort Lauderdale, FL, currently residing in Providence, RI. Their research investigates and reflects upon their personal consumption of digital culture and technology. As technology further intermeshes the internet into the physical realm, it has produced its own materiality into our culture. They are primarily focused on how technology has been a portal/paradise for queer expression, as an extension of survival. As a way to celebrate the fluidity & formlessness of gender and identity through themes of sci-fi, horror, and the unknown.

Caroline Silverman

Caroline Silverman is an interdisciplinary artist who focuses on the intersection of object, narrative, and context. Working predominantly with textiles, her work explores how the soft things that people live with reflect the realities and records of their experiences. In the process of exploring what draws people to their objects, she has made quilts, writing, embroideries, tools, poetry, garments, books, and paintings to help her better understand this relationship. In her work she contemplates how these objects are often made with the intention to provide comfort and protection, and strives to extend these gestures to her collaborative work and teaching. Caroline's recent research has delved into the tactile and intimate relationship between textiles and the body, specifically looking at quilts and embroidery as an extension of memory and embodied experiences. She thinks this relationship is particularly important to consider in analog and digitalized ways. Caroline lives and works in New York City, and travels often to Providence where she teaches at the Rhode Island School of Design.

Joy Ko

Joy Ko is an artist and educator. Her teaching, research and writing explore the use of computation and digital technologies to augment and extend the creative process. In her studio, she renders walks in the woods, mixes memory with imagination, and keeps things moving forward by staying (more or less) still. Trained as a mathematician, she has found her way towards the intersection of mathematics, computation, art and design. She believes art and design has a unique role in guiding society: to anticipate changes, to explore these critically and to show many possible futures. Since 2010 she has taught at the Rhode Island School of Design (RISD) and contributed to multiple departments including Architecture, Textiles and Industrial Design. She helps lead the Virtual Textiles Research Group (VTRG).