World Settings

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Abstract

Acoustical building materials, with their ability to absorb and diffuse sound, can reshape the character of interior spaces in profound ways. Woven textiles often perform as acoustical materials, whether by coincidence or by design; strategic use of textile structure and dimensionality can yield specific experiential qualities in homes, offices and shared spaces. The way certain materials manipulate sound can feel otherworldly, as if they break the laws of physics or the familiar parameters of one's surroundings. The same properties can be found in emergent visual patterns and illusory lighting conditions, which provoke an investigative, deliberate way of looking.

In this thesis, I explore the history of architectural acoustics and the meaning of noise as a sonic, conceptual and technical term. Visual metaphors of windows and screens, digital and analog noise and perceptual phenomena shape this work, while the "aliveness" of self-organizing materials provides a rationale for new variations on weaving techniques. The result is a collection of interior fabrics that aim to modify room environments acoustically and visually, suggesting that the static "settings" of such places have shifted. I argue that this sense of unfamiliarity can be fruitful, prompting the viewer to spend time in a focused, exploratory state and become aware of the cognitive processes by which they make sense of the physical world.

Glossary of terms

2D weaving
A term describing conventional weaving techniques, in which a flat, usually rectangular piece of fabric is formed on a loom and retains its flat shape after finishing. Distinct from processes that produce three-dimensional fabrics.

2.5D weaving
A weaving technique in which flat fabric is woven at a loom and subsequently transformed off-loom into a three-dimensional shape, e.g. through cutting and unfolding woven layers or exposing the fabric to heat.

3D weaving
A weaving technique in which a two-dimensional array of warp yarns is fed into the loom (as opposed to a one-dimensional array in 2D and 2.5D weaving). The height distribution of warp yarns allows a three-dimensional fabric, such as a solid brick or hollow tube, to be formed on the loom.

Compound satin
A woven structure with multiple weft systems, or sets of weft yarns. Each weft system weaves a satin on the face of the cloth in select areas, producing a multi-color figured design. Often used in Jacquard weaving.

Compound twill
Similar to a compound satin, but with the replacement of twill for satin structures on the face of the cloth.

Compressibility
The ability of a material (e.g. upholstery foam) to withstand compression by deforming under a load and returning to its original shape when the load is removed.

Crimped (fiber)
Having a tightly folded or zig-zag shape. Crimped fibers may be natural (like wool) or synthetic (treated with heat and pressure to permanently set folds into the fiber). They are stretchy due to their structure, not their material composition.

Differential shrinkage
A phenomenon occurring in materials with non-homogenous structure or materials. When some areas of the material shrink more than others, the piece may buckle or deform.

Dithering (in digital image processing)
The addition of noise when compressing an image (often to a smaller palette of colors) to approximate the quality of the original. Different dithering algorithms preserve detail and add visual artifacts in different ways.

Elasticity
The ability of a material to elongate significantly under tension and spring back to its original size when tension is released.

Elastomeric (yarn or fiber)
Having a high degree of elasticity due to material composition, such as rubber or spandex. Elastomeric yarns can lead to differential shrinkage in woven fabrics if they are under tension while the fabric is constructed.

Finishing
Any treatment applied to a fabric after it is constructed. Steaming, washing and heat-pressing are finishing processes that can activate shape change.

Interlacing
The “over-under” intersection of perpendicular warp and weft yarns. Woven fabrics with a high density of interlacings are typically stiffer; fabrics with a low density of interlacings are typically softer, drape easily and allow yarns to move or shrink.

Loomstate
The condition of a woven fabric that has been removed from the loom but not yet finished.

Prestressed (yarn or fiber)
Subjected to tensile forces and then held in their elongated state. When allowed to relax (e.g. by exposure to heat or moisture), prestressed materials will contract.

Relaxation
A material’s process of settling into a new shape when activated by external conditions. The relaxed position is reached when the material is in a state of equilibrium.

Self-shaping
Having the capacity to transform autonomously in response to external conditions.

Taqueté
A weave structure with two warp systems and two or more weft systems. One set of warp yarns acts as a separating plane, pushing weft yarns to the face or the reverse of the fabric, while the other set of warp yarns binds all wefts in the same plainweave shed. Produces a multi-color figured design.

Thermoplastic (yarn or fiber)
Materials that soften and become moldable when heated. Many thermoplastic yarns are also prestressed, meaning that they shrink when heated.

Tiedown
An interlacing in a multi-layer woven fabric that mechanically joins two or more layers. Tiedowns can be used selectively to create pockets and voids within a multi-layer fabric, or to selectively stiffen and inhibit shrinkage in fabric regions.

Introduction

The term “world settings” refers to a set of parameters, across gaming and 3D modeling environments, that permit physically impossible changes. In these digital spaces, the strength of gravity, the behavior of light and the passage of time can be redefined at will. Adjusting these elements exposes the virtual world as unique in two ways: first, its conditions are explicitly defined by numerical inputs that are “user-facing,” making visible the mechanics by which they shape the world. Second, these inputs can be reconfigured arbitrarily to make the world more comfortable, more entertaining or simply different from the default. In the physical world, our control is more limited: we can’t cast rays of sunlight across the walls at night, or turn any room into an anechoic chamber. For most people, even choosing a living or working environment based on its experiential qualities isn’t possible: we settle into available spaces and adapt them, or ourselves. The promise of customizing one’s own physical world - not just by adding personal possessions, but by modifying the rules by which phenomena in that world occur - is appealing, perhaps empowering to those who feel at odds with their current settings.

Daniel Rybakken, *Surface Daylight*, 2010. The flat panel functions as a lamp, using LEDs beneath its surface to create the illusion of a ray of sunlight.

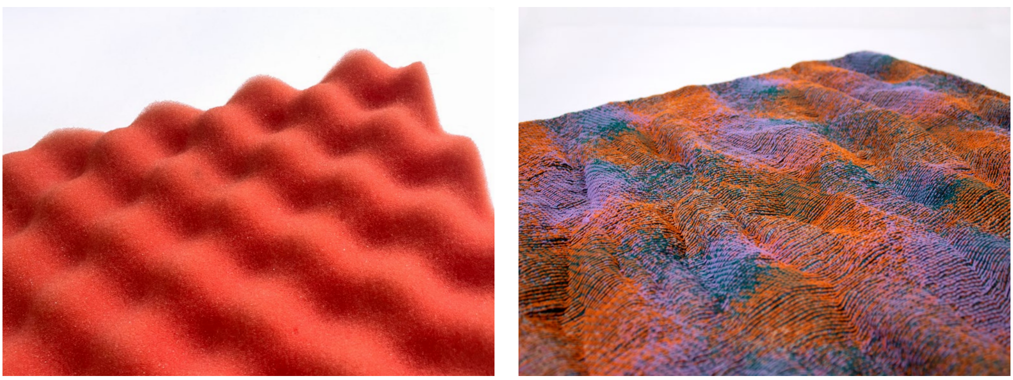
Some everyday objects already perform in this way, modulating sound, light, temperature and comfort. From velvet curtains to weighted blankets, textiles can affect the atmosphere of an architectural space at both far and close range.

The Gravity Blanket, a popular brand of weighted blanket. Photo by Betsey Goldwasser.

This body of work proposes a set of modifications for interior environments. Consisting of vertically hanging and freestanding textiles, the collection explores the sensory qualities of fabrics and their transformative powers. Fabrics with pronounced surface texture, pile, thickness and compressibility offer complex tactile stimulation; other constructions, such as foam-like materials and rippled surfaces, can shape the acoustic character of a space for an occupant some distance away, who may not even realize their presence. The visual patterns that emerge from these fabrics provoke a searching, "haptic" response from the viewer through suggestions of naturally-occuring light and shadow. Sight, hearing and spatial understanding are addressed simultaneously by the textiles presented here.

One thing many of these designs share is their refusal of the planar form: whether through dramatic curvature or small-scale texture, they demonstrate that weaving is inherently three-dimensional. Distinct from 3D weaving, a process in which precisely shaped parts are formed on a loom with an array of warp yarns, some of the methods used here might be called "2.5D," a term with tenuously related meanings in gaming and CNC machining. 2.5D weaving always starts with a flat, rectangular surface, as conventional looms dictate, that is subsequently distorted into a new shape. The catalyst for this shape change is typically an environmental condition, like the release of tension or the addition of heat: another group of "world settings" that modify the behavior of physical objects in logical, yet surprising ways. Other refusals, like disrupting the four-unit repeat of Jacquard wovens, exist within this body of work. In these 2D fabrics, exposure to certain dyes determines which of the many possible patterns embedded in the fabric will emerge.

The development of these fabrics was guided by two principles. First, it was important to me that the collection demonstrate the extremes that are possible when using weaving as a 3D fabrication method. I planned to examine the sound-absorbing and sound-diffusing capabilities of fabrics in relation to their overall thickness and local variations in thickness.



Dimensional weaving can produce fabrics that look and feel like thick foam panels. What manipulations might lead to fabrics that *behave* like acoustical foam?

My previous work creating acoustically resonant fabrics, which were typically thin, rigid and flat, suggested to me that fabrics intended to minimize reverberation should have the opposite of these qualities. Thickness and compressibility are relevant concerns in furniture design, where fabrics that behave like foams or springs, due to their internal corrugations, propose a potential alternative to traditional upholstery techniques. Still, even in vertical applications like wall panels, space dividers and window treatments, where textiles don't experience compression or physical touch, material depth can create a sense of constant flux.

Layers can interfere with incoming light, undulating surfaces cast shadows on themselves and both have the potential to control the propagation of sound. Highly dimensional surfaces also manipulate color and pattern in complex, illusory ways, often revealing a distinct image from each viewing position. Unlocking extreme thickness in woven fabrics yields these surreal and hyperreal visual objects.

Second, I intended these fabrics to arrive at their final form with little or no hand manipulation. This limitation follows an existing area of research - often called "self-folding" or "self-shaping" textiles - in which yarn behaviors are activated by heat, moisture or the release of tension. These methods have precedents in the broader fields of active matter and self-assembly, and propose an allocation of labor consistent with design for mass production. Time and expertise are redirected to the weave draft, a "program" that can be run infinite times, rather than the manual assembly of each iteration. Through knowledge of yarn behaviors like shrinkage and dye receptivity, the design of fabric topographies and patterns can be pushed backward, from post- to pre-production. The fabrics may be shipped flat or rolled and only activated on-site, shifting the finishing stage forward from the factory to the installation site. I often chose simple, allover finishing processes such as steaming: applying them does not require decision-making or skill, and they create a new, homogenous environment that provokes material change. These processes often create complex, emergent patterns and reveal the "aliveness" of seemingly inanimate objects. Elastomeric and thermoplastic yarns have abundant stored energy. In a sense, conventional yarns do too, whether they're petroleum-based or organic matter. Why not let them do the work?

1. Acoustical histories

The field of architectural acoustics often deals with concert halls and churches: complex, single-purpose spaces whose shape, ornamentation and materials alter the reverberation of sound. Their primary concerns are the elimination of external sounds (such as HVAC systems), the clarity of the performed sound and whether it can be heard well from each seat. Sound is directed towards listeners, its volume and tone preserved or even enhanced as it travels through space. This thesis is primarily concerned with a different category of spaces with distinct acoustical goals: offices, libraries, healthcare settings, apartments, and similar "semi-shared" venues where privacy is expected despite proximity to other people. Unwanted sounds, whether from the outside world, transmitted structural vibration, or other occupants of the space, must be blocked (reflected away) or absorbed (converted to heat) to maintain the sense of autonomy and privacy that these places offer. If these sounds can't be eliminated, they may also be diffused, or broken up into many disparate reflections rather than a single, clear reverberation. Diffusion and so-called "white noise" can make sounds such as nearby conversations less intelligible, creating the illusion of distance and privacy without actually reducing volume[1].

Minimizing the perception, if not the presence, of unwanted sound is a relatively modern concern that arose from industrialization and class stratification. As Marie Thompson describes in *Beyond Unwanted Sound: Noise, Affect and Aesthetic Moralism*, "[The] demand for control over one's own sonic environment corresponded with the nineteenth-century expansion of the bourgeoisie. Indeed, the contemporary notion of the domestic as a personal, intimate space that is closed off from the 'outside' world is largely indebted to a bourgeois conception of privacy and the subsequent separation of 'external' working life from 'internal' domestic life."[2] This expectation of domestic quiet emerged at the same time as what the architecture critic Kate Wagner describes as the new etiquette of the concert hall. Prior to this shift, "music rooms were designed for small numbers of people and were really social institutions more than they were

1. Christopher N. Brooks, *Architectural Acoustics* (Jefferson, NC: McFarland & Co., 2003), 91-93.

2. Marie Thompson, *Beyond Unwanted Sound: Noise, Affect and Aesthetic Moralism* (New York: Bloomsbury Academic, 2017), 22.

places that had to sound good," with aristocratic audiences often walking about and socializing during performances. "The idea of the silent, reverent concert hall is a bourgeois idea that came from listening practices in the nineteenth century, when the public concert became [widespread]." As Wagner tells it, concert halls and concertgoing culture were shaped by concerns, like stratified seating and an "obsession with silence," that upper-middle-class audiences had essentially invented to maintain their class position.[3]

Accompanying, or perhaps motivating, these newly formed desires were the realities of industrial production and the concept of noise itself as something disturbing and unnatural. "The normal sounds of rural life […] whether pleasant or not, were all recognizable. Here, however, the cacophony of sounds in the nineteenth-century street, factory shop and mine - seemingly random and meaningless - could not be easily isolated or identified. They became novel and potentially dangerous intrusions on the overworked human mind."[4] Mel Gordon's account of the industrial soundscape contains an "oft-repeated origin myth" that Thompson identifies: that noise, with all its negative connotations, emerges from that which is unnatural, foreign or "other." The implications of this myth reverberated into modern and contemporary acoustic ecologies.

3. Kate Wagner, "Avery Fisher Hall", with Liam Anderson, Alice Caldwell-Kelly and Justin Roczniak, October 21, 2021, in *Well There's Your Problem*, podcast, 19:11, https://wtyppod.podbean.com/e/episode-85-avery-fisher-hall/.

4. Marie Thompson, *Beyond Unwanted Sound*, 26.

Illustration from "City Noise", the Noise Abatement Commission's 1930 report.

The high-volume, rhythmic and inorganic sounds of machinery persisted, and continued to be characterized as new, disturbing phenomena, long after the height of the industrial era. Emily Thompson, in *The Soundscape of Modernity*, illustrates the pervasiveness of these sounds in early twentieth-century New York with firsthand accounts that recall "the steady burr of the motor, [...] the regular clank clank of the elevated [...] the recurrent explosions of the internal combustion engine, and the rhythmic jar of bodies in rapid motion."[5] In retelling the histories of an "anti-noise" society, citywide noise ordinances and legal disputes between neighbors, Thompson demonstrates that what, exactly, constituted noise was highly subjective. "Not only was it inconvenient and expensive to take a noisy neighbor to court, but there was no objective basis for determining the outcome of these cases [...] Clearly, the problem of defining what constituted a noise had to be resolved before the problem of noise itself could be solved."[6]

A noise-measuring van in New York City, 1930... (Property of AT&T Archives; reproduced from *The Soundscape of Modernity*, Emily Thompson (2002): 161.)

...and 1971. (Photo by Neal Boenzi for the New York Times.)

Popular opinion was split between those who believed noise, whether from a neighbor's amplified radio or a nearby factory, was a necessary byproduct of modern life, and those who resisted this designation and considered it a social ill and health hazard. Others still celebrated city noise for its similarities to jazz, its implications of social and technological change and its place as "the keynote of modern civilization."[7] A 1927 study showed that typists worked slowly and with more errors in noisy environments, positioning noise as incompatible with the Taylorist culture of efficiency that had migrated from economic into social and aesthetic realms. The root cause of the typists' inefficiency

5. Emily Thompson, *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933* (Cambridge: MIT Press, 2002), 117.

6. Ibid, 130.

7. Ibid, 115.

appeared to be energy expended toward involuntary stomach muscle movements, comparable to the "primal fear reaction."[8] While the study's author, the industrial psychologist Donald Laird, was primarily concerned with lost productivity, other perspectives in the "evolutionary argument" against noise suggest that physical and mental well-being are at risk when noise is inescapable. For early humans, loud sounds emanated from dangerous events, and those whose bodies released the stress hormones cortisol and adrenaline in response were more likely to survive. This "genetically encoded noise sensitivity" now appears in the form of sleep loss, increased blood pressure, impaired childhood development and overall stress[9].

Donald Laird, "Experiments on the Physiological Cost of Noise," *Journal of the National Institute of Industrial Psychology* 4 (January 1929): 253, fig. 1.

Chronic exposure to noise, like other forms of environmental pollution, can lead to chronic health conditions and should be taken seriously. The evolutionary perspective itself, however, is often used in support of ideological arguments that unilaterally position noise and its associated social causes as negative. Marie Thompson critiques R. Murray Schafer's model of acoustic ecology, which takes an aesthetic and moral stance against noise, for its romanticization of pre-modern, rural soundscapes and its condemnation of contemporary urban life. There is a regressive "beauty bias" in Schafer's arguments, which "[conflate] the natural with the beautiful and the beautiful with the good," closing off possibilities for understanding synthesized or messy acoustic phenomena as aesthetically valuable.[10] Alternative frameworks for evaluating sonic experiences acknowledge the subjectivity of sound, for example by showcasing the positive associations that culturally or technologically constructed sounds and urban noise hold for many people.

Thompson moves beyond this interrogation by unraveling the definition of noise itself: citing G.W.C Kaye's definition of "sound out of place [in space or time]," she argues that no sound can be considered inherently noise, only becoming noise in the presence of a listener that it affects negatively.[11] Affect theory can be applied to noise and sonic experience more generally: the way in which a body is affected is shaped by its capacity to affect and be affected. While the notion of an affecting or affected body

8. Ibid, 155-157.

9. Bart Kosko, *Noise* (New York: Penguin, 2006), 55-56.

10. Marie Thompson, *Beyond Unwanted Sound*, 90-95.

11. Ibid, 18.

is not limited to humans - a sound wave itself, as a system of air particles at rest and in motion, can be considered a "body" that both acts and is acted upon - the idea of this individual capacity is reminiscent of evolutionary sensitivity to noise and the subjectivity of sonic aesthetics. Thompson describes noise as "an a-signifying force-relation,"[12] meaning that while it has no semantic or symbolic content, it has the power to affect and leave traces of its entanglement with other entities, including people.

Some especially powerful instances of this relation are found in Paul C. Jasen's *Low End Theory*, an exploration of low-frequency sound and its embodied effects. In one anecdote, an engineer troubled by an apparitional presence and physical symptoms of dread traces them to a 19 Hz standing wave in the lab where he works.[13] These vibrations can be profoundly felt but not clearly heard, leading to "hauntings" - moments of sensory contradiction or uncertainty. The array of ancient instruments that produce low-frequency sound, or bass, includes bells, gongs and bullroarers, all of which Jasen suggests may have been used in ritual contexts to evoke the same unmoored reverence as thunder.[14] Before the physiological effects of these sound waves were fully understood, they played a role in what anthropologist Donald Tuzin calls the audiogenesis of religious culture. He posits that "...a certain type of naturally occurring sound has a perceptual effect on some, possibly many, animal species that is intrinsically mysterious and thus anxiety-arousing; that this sensation is humanly interpreted and its accompanying anxiety cognitively resolved by referring it to the mystery that is allegedly inherent in the supernatural realm."[15]

12. Ibid, 45-48.

13. Paul C. Jasen, *Low End Theory: Bass, Bodies and the Materiality of Sonic Experience* (New York: Bloomsbury Academic, 2016), 43-46.

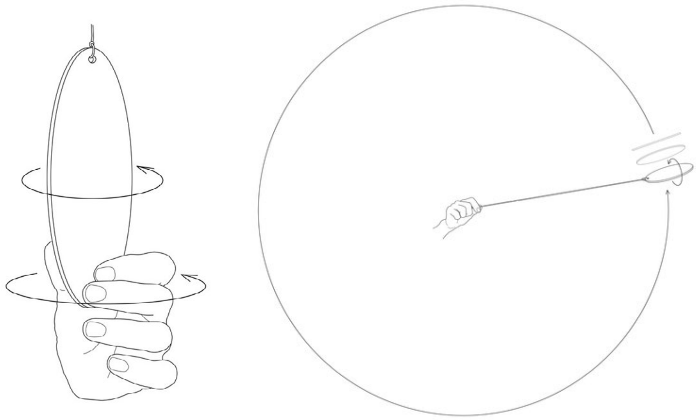
14. Ibid, 71-74.

15. Ibid, 79.




Clockwise from top left: Māori, Nandi, Masingara and Yoruba bullroarers. All photos property of the British Museum.

When there is not (yet) a logical explanation for sounds that emanate from nowhere, or rhythms that inaudibly resonate in the body, it seems as though the rules of the physical world have been altered. Whether this leads to a disturbing haunting or a profound spiritual experience - in other words, how it affects us - is shaped by our own explanations of the world by which these unseen forces make sense - our capacity to be affected.



A bullroarer produces low-frequency vibrations in air by twisting as it is whirled in a circle. Illustrations by Martina Lazzarini.

Modifying the acoustical character of a space, particularly a private or semi-private one, can be done strategically to induce specific emotive states or associations with natural or urban places. Silence may be the goal, though it's not the only desirable one nor is it especially specific. A room that feels "dry" (not reverberant), and that diffuses ambient sounds to a uniform hum, may resemble a dense forest, surrounding the listener with absorbent matter and instilling a sense of calm and protection. Beyond the practical goals of eliminating distracting and unpleasant sound, architectural acoustics can operate on imperceptible or indescribable levels, shaping the psychological and bodily experience of inhabiting a room. A more speculative application of known acoustical principles might aim to make rooms feel transportative or uncanny, rather than merely quiet and comfortable; while precise simulation of sound waves is still challenging, qualitative assessment of such spaces would be well-suited for the elusive qualities of embodied sonic experience. In situations where prolonged time in one space is common, whether for work, rest, study or rehabilitation, materials that affect the transmission of sound can have profound impacts.

Acoustically absorbent and diffusing materials are not necessarily technologically advanced. Nearly all textiles absorb sound to some degree, particularly dense, plush pile fabrics like the velvet curtains found in nearly every theater. By the early twentieth century, absorbent materials were on their way to becoming ubiquitous, spreading beyond performance spaces and into residential buildings. Demand increased in the 1920's, as did the overall scope of acoustical science in the era of telephone and radio.[16] By the 1930s, acoustical products made from "gypsum, mineral wool, volcanic silica, flax, wood pulp, sugarcane fibers, disinfected cattle hair, and asbestos" were put to use in everyday spaces, including offices, apartments and schools. Emily Thompson notes that the commercial success of these materials marked a new era of interior soundscapes, characterized not just by quiet but an "efficient nonreverberant quality" that signified the triumph of modern technology over natural phenomena. The aesthetics of these spaces complemented their clean, controlled sound, setting a new standard for how an invisible process - the propagation of sound waves - should be allowed to occur.[17] In preparation for this thesis, I visited two well-known examples of twentieth-century architecture whose acoustically absorbent materials, among other features, modify and control their sonic character.

16. Emily Thompson, *The Soundscape of Modernity*, 61.

17. Ibid, 169-172.

18. Ibid, 183-190.

The Gropius House in Lincoln, MA, a 1938 showcase of both Modernist architecture and modern family living, is almost entirely carpeted and uses acoustical plaster, a porous material that traps entering sound waves and converts them to heat, on its walls and ceilings. Porous ceramic tile had been patented in 1913 and utilized in monumental public spaces, but within a decade its use had expanded to everyday spaces like offices, alongside competing products like acoustical plaster and absorbent ceiling tiles.[18] This category of materials limited reverberation within and between rooms: in the close quarters of the Gropius House, parents, a teenage daughter and live-in maid could enjoy relative acoustical privacy when needed.

Porous acoustical plaster is visible behind the László Moholy-Nagy painting that hangs above the fireplace in the Gropius House's living room. Photo by Jill Erickson.

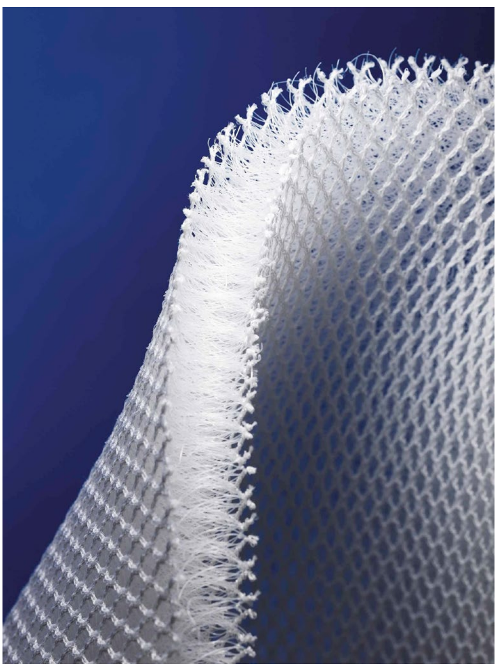
While the expanses of floor and ceiling were common destinations for absorbent materials, such as carpeting and ceiling tiles, the painting gallery at Phillip Johnson's Glass House in New Canaan, CT uses wool loop-pile carpet to surprising effect. Built in 1965, the subterranean space, wedged into the side of a hill, has concrete floors but almost entirely carpeted walls, including the entrance hall and the movable "pages" that hold the architect's painting collection. The acoustical properties of the wall-covering material may be incidental: it was chosen because art could be easily installed and deinstalled without leaving holes. Still, the experience of entering the gallery, perhaps aided by the knowledge that it is buried within a hillside, is one of profound stillness. Sounds like speech and footsteps are bright and clean, ringing out but hardly reverberating at all, and the room quickly reverts to silence when they stop. Ready-made carpet installed in this unusual way creates a sense of enveloping warmth and protection, raising possibilities for a similarly plush, tactile material designed with vertical surfaces in mind.

The carpet-lined entrance to the painting gallery.

A Frank Stella painting hangs on a carpeted wall.

Material properties at multiple scales can shape acoustical character: the raw material itself (wool, plaster), the process by which it's modified (creating a composite, or incorporating air) and the form it is cast or shaped into. Because the development of new fiber or yarn materials was outside the scope of this thesis, I focused on the latter two scales of material behavior. Each of these investigations led to a category of textiles in the final collection, with a common structure and fabrication process.

In the context of both acoustics and textile design, it makes sense to think of porous and aerated materials as a subset of composites. Air is a valuable building block, not just an absence of material: as a poor conductor of heat, it is essential in insulation for both buildings and people. Accumulations of material interspersed with air can also "trap" sound waves. The tile patented in 1913 by acoustician Wallace Sabine and architect Raphael Guastavino was unique due to its "peculiar porosity," in which interconnecting hollow channels (rather than isolated air bubbles) evidently allowed sound waves to enter the material and bounce within it until they subsided. Guastavino was motivated by the structure of piled sand, which performed better in acoustical testing than his previous designs, and sought to replicate its internal empty spaces.[19] Air pockets are also present at many stages of textile construction, including "low-tech" applications like a hand-knit sweater. Crimped wool fibers trap air when they pack together and can be spun into lofty low-twist yarns, then subsequently knitted into a loose structure that applies very little compression to the yarn. The end result is a thermoregulating, pliable material that uses fibers efficiently by distributing them over a large area rather than tightly packing them together.



Spacer fabrics are constructed with a uniform gap between two layers. Image property of SINDAT spol. s.r.o.

Air is present within and around loosely spun yarns, acting as a thermal insulator.

A less common incorporation of air is between layers of an otherwise tightly constructed fabric. Spacer fabrics, which can be woven, weft-knitted or warp-knitted, use stiff yarns in short vertical spans between two layers to create a soft, spongy

19. Ibid, 182-183.

texture. While these fabrics are usually less than a centimeter thick, recent work by Anastasia Onegina showed the potential to knit thick, robust spacer fabrics up to nine inches thick.[20] I recognized a similar opportunity to weave larger air gaps into a spacer fabric while controlling the density of each layer. Weaving naturally lends itself to air encapsulation, with the ability to separate two or more layers and selectively interlace them as channels or pockets. Setting these layers a significant distance apart can have sound-dampening properties, which can be further tuned by adjusting the absorbency and porosity of each layer.[21] My variations on woven spacer considered these possible benefits when a fabric is positioned between working areas or in the open space of a room, where it can function as an effective sound absorber.[22] The light-filtering and movement qualities of large-scale spacer fabrics also become relevant in interior applications, where they may provide a sense of animatedness and responsiveness in an otherwise static environment.

To zoom out as far as possible and assess a material's eventual form could be called a coarse view of materiality, or perhaps metamateriality. The effects of large-scale form and surface treatment in performance venues have been studied substantially, leading to knowledge that can be applied - as this thesis aims to do - in other architectural spaces with other acoustical needs. "The lack of sound-diffusing surfaces was not a problem before the twentieth century," Christopher N. Brooks writes in *Architectural Acoustics*, "because extensive ornamentation was integral to the architectural vocabulary. With the International Style of Van der Rohe and Le Corbusier came the radical elimination of architectural ornamentation."[23] Kate Wagner agrees that the sound-diffusing properties of Neoclassical concert halls were likely a happy coincidence: "the current taste for overdone, weepy ornament from all different periods of the classical era," combined with stratified seating and the ventilation practices of the era, tended to produce a pleasant acoustical experience. "The nineteenth-century shoebox-style concert halls are some of the best in the world," she states, "not because of the science of architectural acoustics, which didn't exist yet, but because of a combination of social factors, architectural factors and engineering factors."[24] By the same token, shifts in architectural tastes and technologies (such as modern HVAC systems) often had unexpected consequences for the sonic character of twentieth-century buildings.

20. Anastasia Onegina, "Deceptive Fragility: characteristics and fabrication methods of extra thick weft-knitted spacer fabrics" (master's thesis, RISD, 2017), https://digitalcommons.risd.edu/masterstheses/99.

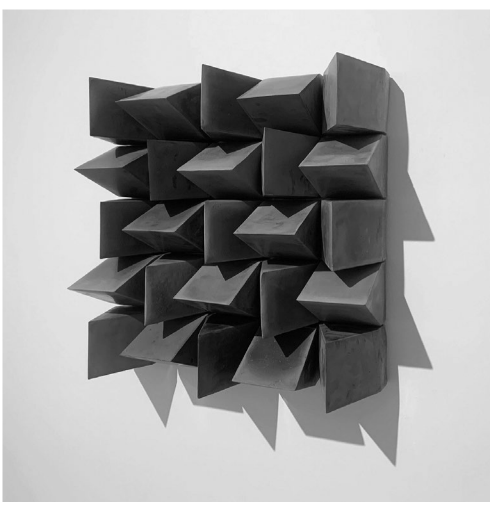
21. Kristina Fridh, Margareta Zetterblom, Paula Fermenías, *Textile Architecture: about sound absorbing facades and textiles in urban landscapes* (Malmö: Form/Design Center, 2019). Exhibition catalog. https://research.chalmers.se/en/publication/514210.

22. Petra Haikonen, "Woven Sounds: Design Exploration and Experimentation of Acoustic Curtain Fabrics" (master's thesis, Aalto University, 2016), 35-36, https://aaltodoc.aalto.fi/handle/123456789/23566.

23. Brooks, *Architectural Acoustics*, 129.

24. Wagner, "Avery Fisher Hall", 21:29.

Louis-Émile Durandelle, *Clef de la grande fenetre. Facade postérieure de la scène (Key for the great window at the back of the stage)*, albumen print, c.1875. Durandelle's *Le Nouvel Opéra de Paris: Sculpture ornementale* is a ten-year photographic documentation of the ornamentation of the Paris Opera.



Audra Wolowiec, *Concrete Sound*, cast concrete with pigment, 2020, and *Sound Mirror*, cast ceramic with metallic glaze, 2021. The sculptures demonstrate abstract diffusing geometry, inspired by the contours of acoustical foam.

If the flat expanses of modern concert halls resulted in unpleasant acoustical harshness, and if - as Brooks asserts - contemporary examples of ornament often "look tacked on because, well, they are,"[25] then integrating diffusing geometries into their architectural surroundings is crucial. This doesn't mean they must be permanent - movable acoustical panels are frequently used in multi-purpose rooms - or that their ornamentation must be figurative, like the "coffers, flowers and [...] caryatids" that produced the "pleasant, diffuse sound field" of well-known halls.[26] Nor are performance venues the only sites where diffusion is an important element in conjuring a pleasant or naturalistic affect. Instead, I hypothesized that rigid, wall-mounted surfaces with complex patterns of convolution, at varying scales, could serve as sound diffusers in spaces of work, rest and study.

This group of fabrics took inspiration from this history of ornamentation while staying firmly in abstract territory, using gentle bumps and curvature to produce dappled light and shadow on the fabric's surface. A guiding principle for the fabrics was that they should be onomatopoetic: the way they (are intended to) modify sound should complement the way they look and the way they feel. While some of my previous works dealt with more pronounced visual and haptic illusions, in which a fabric's texture was a disorienting surprise based on its appearance, it was important here that all sensory experiences were cohesive and had a logical relationship with each other. This served to promote the sense that one is in a natural environment, or at least one anchored by a certain consistent truth, rather than an arbitrarily constructed place. Without visually reproducing the elements of an outdoor setting, I hoped to allow the same positive affect, or sense of groundedness found in such settings, to emerge within the confines of a room.

25. Brooks, *Architectural Acoustics*, 59.

26. Ibid, 58.

2. The window

Exploring the history of acoustical materials provided not only a precedent for the three-dimensional form of these textiles, but also an array of visual metaphors that shaped their aesthetics and purpose beyond the practical. With the idea that these materials should make an interior space feel grounding, prompting focused inquiry or self-reflection, I found the recurring metaphor of the window to be a useful bridge between architectural acoustics, simulated environments and the study of perception itself.

The acoustician Wallace Sabine, in his experiments measuring room reverberation time, used seat cushions to systematically alter the behavior of sound. The gradual introduction of cushions to the lecture hall of the Fogg Museum, where he sought to correct "excessive residual sound", showed an inverse relationship between the amount of absorbent material and the room's reverberation time.[1] As identical, mass-produced objects, the cushions allowed Sabine to carefully increment the amount of sound-absorbing material present. Removed from their original location (a nearby theater) and stripped of their original function, the cushions served as variables in the then-unknown equations that described the room's acoustical character. Sabine initially proposed the "Sanders Theatre seat cushion" as a unit in which sound-absorbing power could be expressed, before replacing it with the more abstract "open-window unit." Sound that escapes a room through an open window never returns, thus the unit can be considered "one square meter of a perfectly absorbent material."[2] While a convenient mathematical constant, the open-window unit stands for a fantastical material that can never exist, one that transcends the limits of the physical world by immediately whisking sound away. In real-life experiments, Sabine's cushions acted as imperfect windows, or portals, into which some sound entered and slightly less sound returned.

1. Wallace Sabine, *Collected Papers on Acoustics* (Cambridge: Harvard University Press, 1922), 20.

2. Emily Thompson, *The Soundscape of Modernity*, 39-40.

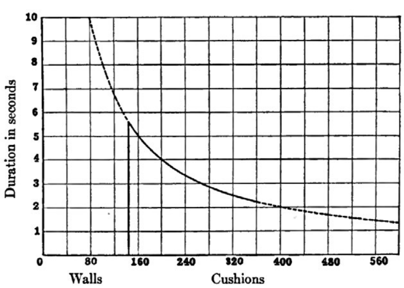
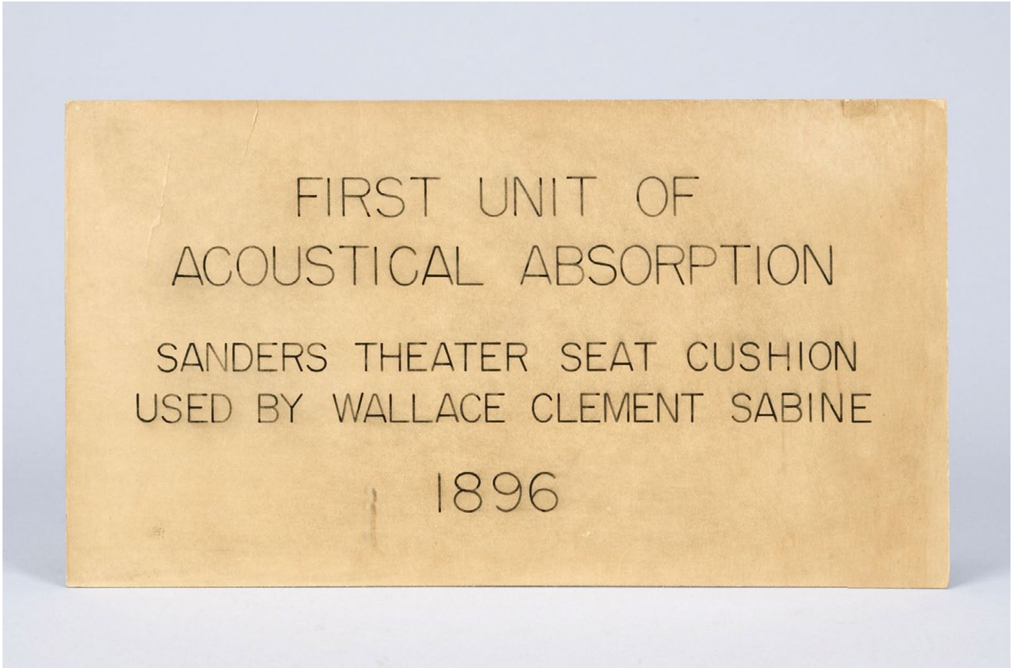


Fig. 6. Curve 5 plotted as part of its corresponding rectangular hyperbola. The solid part was determined experimentally; the displacement of this to the right measures the absorbing power of the walls of the room.

Graph showing a decrease in reverberation corresponding to an increase in exposed surface area of cushions. Reproduced from *Collected Papers on Acoustics*, Wallace Sabine (1922): 22.



A Sanders Theater seat cushion. Property of the Harvard Collection of Historical Scientific Instruments.

Portals in episodes of *Star Trek* (1967) and *Star Trek: The Next Generation* (1989) and the game *Bioshock Infinite* (2013).

The notion of a window as a discrete area that seems to defy physical laws is echoed in both computing interfaces and in science-fiction tropes such as portals and disturbances in space. Gazing into a screen, which displays something not physically present in the room, is transportative, a heightened version of looking through a window. Popular depictions of portals are vertical "surfaces" in midair, bounded to roughly a person's shape and meeting their gaze: it's understood that approaching one activates something anomalous. They often serve one of two functions: suddenly changing a person's location, or permitting them to peer into a distant space. Acoustical materials change locations in the sense of transforming their character, the experience of occupying that space, in a way that can feel otherworldly while nonetheless governed by physics. The textiles I designed merge the physical properties of these materials with the aesthetics of windows, screens and other interfaces through which we observe outside or distant worlds.

Windows and screens derive their power from closed spaces on whose boundaries they exist. "Always, the interior has pivoted on the opening: the view out," the writer Matthew Stadler notes in a 2013 lecture. "Early on, we supplemented the few real openings in a wall with artificial ones: first in tapestries; then paintings; and then the bulky consoles of the first television sets. Where windows could not be made, we made our own views out."[3] These false openings didn't need to act as optical illusions to be effective: we understand the floating, rectangular bounded image as a view of something spatially or temporally distant, not necessarily a cutaway view of the world just beyond the wall. Stadler embraces the contradictory confines and expanses of the interior, "a stage for the human activity of withdrawal and emergence [...] in which activities we become more fully human."[4] The agency to remain in the interior or depart it (physically, or through the digital interfaces that crop up in the latter part of the lecture) is essential to the human experience. So is the prolonged observation that actual windows enable: by enclosing an arbitrary scene in a frame or curtains, the window lends theatrical significance to the slow, plotless unfolding of everyday time.

3. Matthew Stadler, "Interior Decorating in War Time", lecture, Amsterdam, Netherlands, November 24, 2013, https://vimeo.com/80487823. A transcript of the lecture is available at https://issuu.com/hetnieuweinstituut/docs/benno_premsela_lecture_2013.

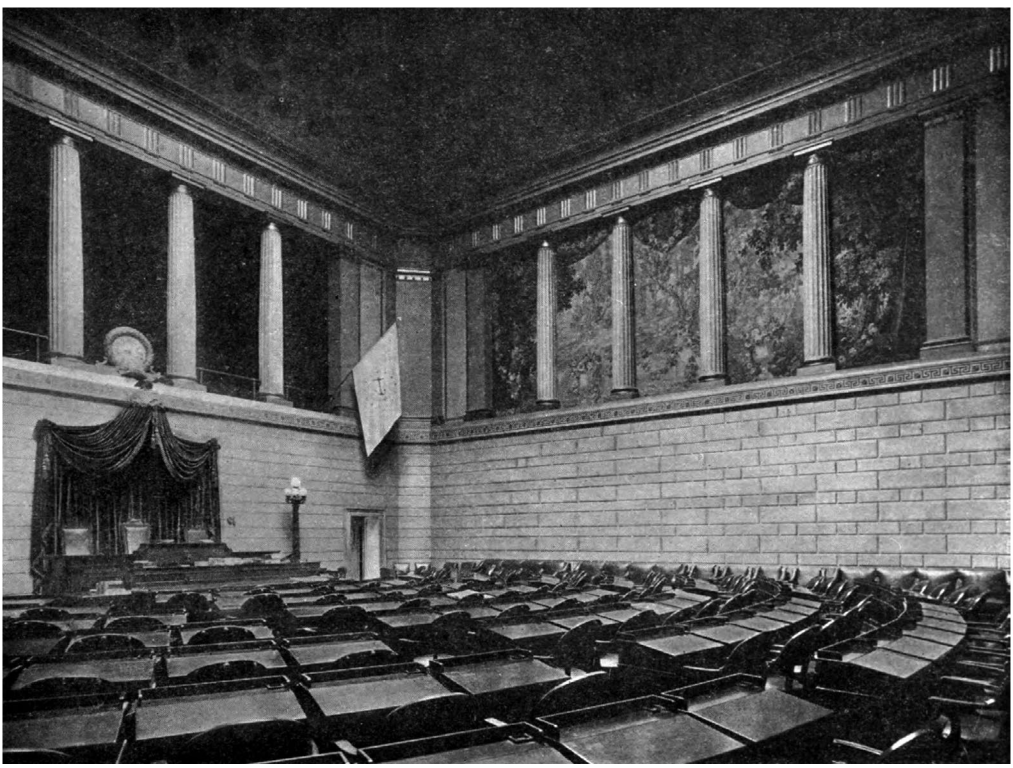
4. Ibid.

5. Barbara Brondi and Marco Raino, "Monument of Stillness", interview by Huan Hsu, *MacGuffin* no.2 (Winter 2015/2016): 44.

6. Erik Wong, "No Other Realities", interview by Huan Hsu, *MacGuffin* no.2 (Winter 2015/2016): 47.

In conversation on the views from their own windows, the architects Barbara Brondi and Marco Raino describe the warehouse that faces their studio as a "monument to stillness [but] if you look carefully and go through the details, there's always something going on. The cracks and leaks in the roof and wall, you can see these as activities, growing, like moss [...] It's like an installation piece in a way."[5] Raino also compares the studio's five windows to Bernd and Hilla Becher's photographs, as five slightly varying depictions of a standard, industrial scene. The designer Erik Wong often looks up from his screen to a window, to "witness that slow and spacious reality where nothing much happens [...] It all happens in front of you, it all happens in real time. There are no other realities in this village."[6] The smallest events become monumental when viewed through a constructed opening.

Looking through the screen onto a distant garden. Landa Conservatory started publishing ambient outdoor videos online during spring 2020, including "Orange Harmony Peace Break", pictured here.



In the Hall of the House of Representatives in the Rhode Island State Capitol, tapestries were hung in front of sound-absorbing felt panels to create a trompe-l'oeil garden. Reproduced from *Collected Papers on Acoustics*, Wallace Sabine (1922): 135.

Photographic curtains and wallpaper by the design duo BLESS. Photos by BLESS (top) and Frank Sperling (center, bottom).

Digital and physical windows were a primary source of information about the external world for the past two years, each offering a brief sensory vacation from indoor life. The window in my bedroom has blinds that act as a projection screen, flattening the shapes of outside objects into a semi-recognizable image. After a storm, the silhouette of a tree limb appeared on the screen, small branches shifting into and out of focus as the light changed. The meaning of the event was clear even if the fallen limb's size and location could not be determined. It felt cinematic, flickering throughout the day while the rest of the room stayed still, and offered forth a sort of puzzle. The blinds catch light and shadow in a distinct way, rendering the outside world's contours and depth of field as sharp and blurred features. At the same time, they stamp their own texture onto the scene and let important pieces of data, like color and texture, slip away. There is a truth embedded in the projection, but can it be untangled from these complicating factors? The way in which the window, as a visual transmission system, obscured details and added new ones can be considered noise, a term that possesses non-auditory meanings in the field of information theory.

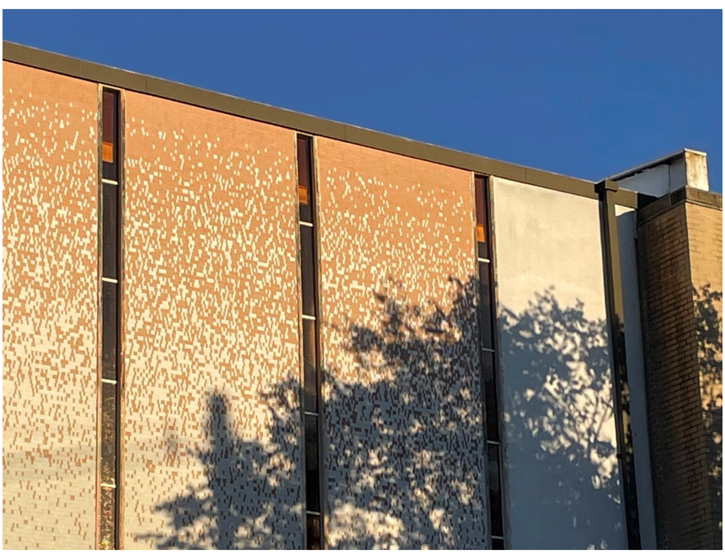
Noise can be visual, as in the staticky texture and JPG artifacts that occur when digital images are compressed or reproduced. Naturally-occurring patterns, like the scattering of small particles or flocks of birds, also possess a noisy character. From an information-theory perspective, noise is not one specific stimulus or pattern, but rather an affective relation that changes a message (of any data type) by introducing uncertainty.[7] Claude Shannon, the mathematician and pioneer of information theory, recognized noise as an integral part of any communication system, as much as the transmitter and receiver of the intended message. His generalized model of such systems, and strategies for making messages more resilient to noise, informed many file formats and transmission methods still in use today. Shannon and his colleague Warren Weaver also described signal and noise in ways that seem to invert colloquial understandings: more noise in a system generates more "information," or possibilities for what the intended signal could be, while the absence of noise reduces the space of possibilities to 1 (a space often described as having zero bits of entropy). Information, as a synonym for uncertainty, allows us to set aside questions of whether we are receiving a correct message and instead examine the total space of potential truths that noise generates.

7. Marie Thompson, *Beyond Unwanted Sound*, 50.

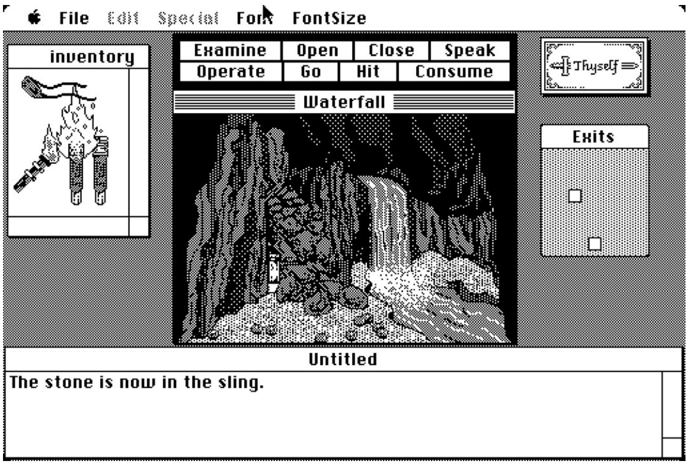
The window, photographed at various times during the winter and spring of 2022. Images in the bottom row are of another window in the same room.

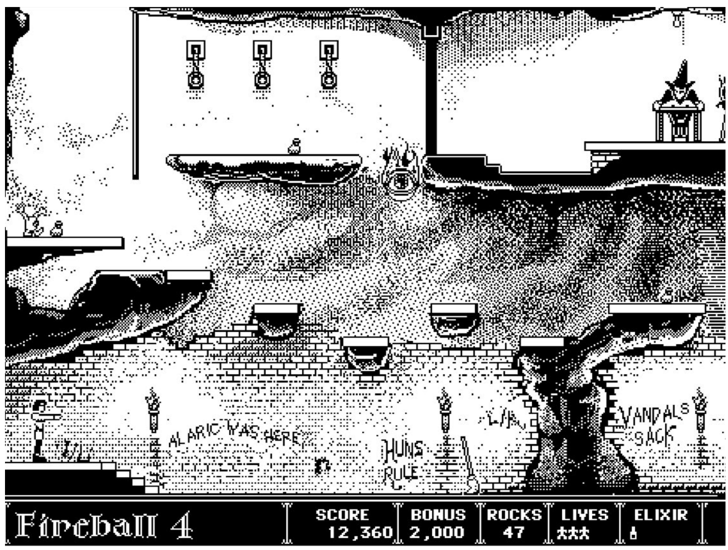
Media noise that prompts nostalgia, such as tape hiss or the warmth of vinyl, demonstrates that a transmitted message can be appreciated despite being an objectively degraded version of the original. The now-defunct blog "From Another Room" recognized the emotional qualities of audio noise, in its case derived from common listening scenarios rather than technologies. The blog's entries consisted solely of popular songs modified to sound as though they were heard from a distance, perhaps from outside a house party. The barely-intelligible lyrics and "underwater" quality were beside the point: for many listeners, the clips prompted memories and a sense of longing for a specific state - of standing just beyond a loud, thrilling event - that the audio distortions imitated.[8] Visual stimuli viewed through closed blinds or blurry windows also have a specific character imparted by noise, as do grainy film photos and compressed digital images. Perfect fidelity is not necessarily desirable; instead, noise can be applied strategically to evoke the sensation of looking through a familiar device. Textiles with scattered and dithered patterning implicitly reference the patina of digital images and emergent phenomena like murmuration, while their materiality creates blurred and dappled effects - literal fuzzy images. Together, these qualities can offer a series of sites through which to look beyond the physical room, windows onto visual stimuli that don't immediately resolve into a clear answer.

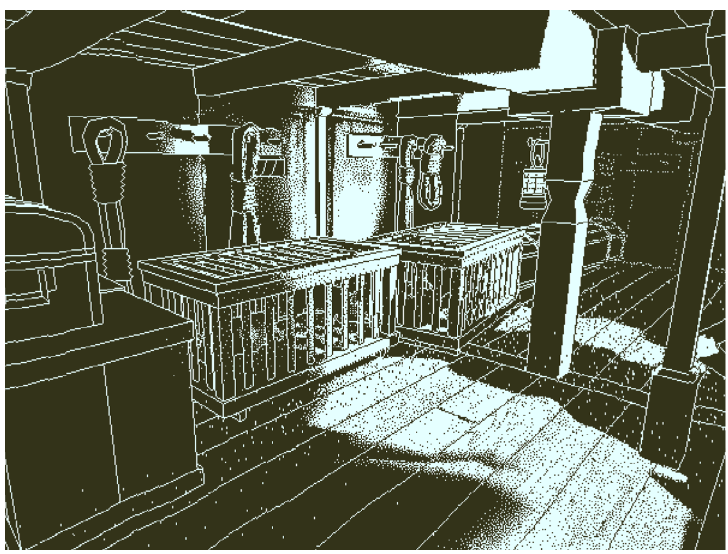
8. fromanotherroom (blog). https://fromanotherroom-revived.tumblr.com/. Note: this blog is a collection of posts gathered from the original fromanotherroom blog, which are no longer available at their original source as the blog was shut down in 2017 for copyright infringement.



Dappled shadows on a dithered tile facade: an emergent noisy pattern inferfering with a deliberately placed one. Aletheia Church, Providence, RI, photographed Spring 2022.







Dithered 1-bit graphics in the game *Return of the Obra Dinn* (2018, bottom) evoke nostalgia for early Macintosh games like *Shadowgate* (1987, top) and *Dark Castle* (1986, center).

The term “1-bit” is directly related to Shannon’s concepts of information and entropy: 1 bit of entropy means that there are 2^1 possible states. In these games, each pixel can be either dark or light. The pixel’s value is typically determined by a dithering algorithm that accounts for surrounding pixels’ values, filling shaded areas with scattered patterns to approximate the smooth gradients of the original image.

Why embrace visual noise and ambiguity in interior textiles? Moving beyond Shannon's definition of noise as a "necessary evil," Thompson suggests that while noise is unavoidable, it can be regarded simply as "a perturbing force-relation that, for better or worse, induces change."[9] Noise makes us aware that we're always taking in data through an imperfect interface, and self-aware of the cognitive work involved in piecing together the underlying message. The constant practice of observing and drawing conclusions about one's surroundings is such a basic human activity that it often goes unnoticed. The artist Uta Barth addresses this oversight by making perception itself her subject matter, stating "My primary project has always been in finding ways to make the viewer aware of their own activity of looking at something."[10] In photographs of empty rooms and blurred landscapes, she achieves this by "hindering or frustrating [the viewer's] ability to see and decipher an image" and straining their perception of "things that are barely visible, in some instances depicting pure light itself."[11] Deflecting a common criticism, she describes these images as perfectly in focus: "The camera just happens to be focused on an unoccupied point in space. So I am photographing the volume of a room instead of its walls, the atmosphere of a rainstorm instead of the landscape the rain falls on. The visual residue of making images this way is the unfocused walls and blurred street scenes. [...] I was interested in thinking about how this envelope of information would create the context and meaning for what we see."[12] This tactic references a long history of image-making, in which high fidelity was not always guaranteed yet the very act of photographing contextualized the scene as significant. Using photography as a framing device, Barth

9. Marie Thompson, *Beyond Unwanted Sound*, 42.

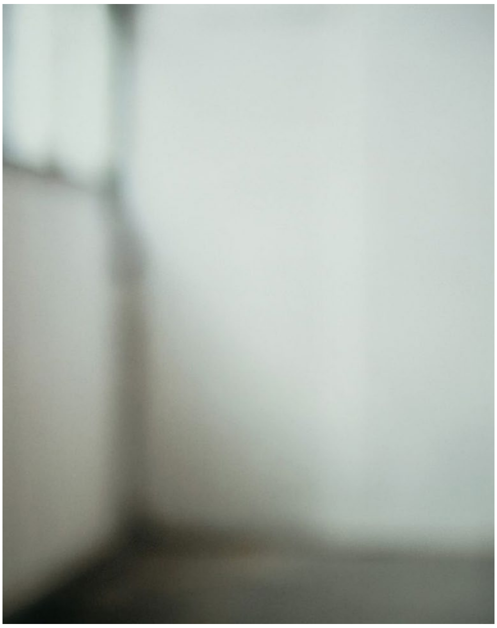
10. Uta Barth, interview by Sheryl Conkelton, *Journal of Contemporary Art* 8, no. 1 (Summer 1997), https://jca-online.com/barth.html.

11. Ibid.

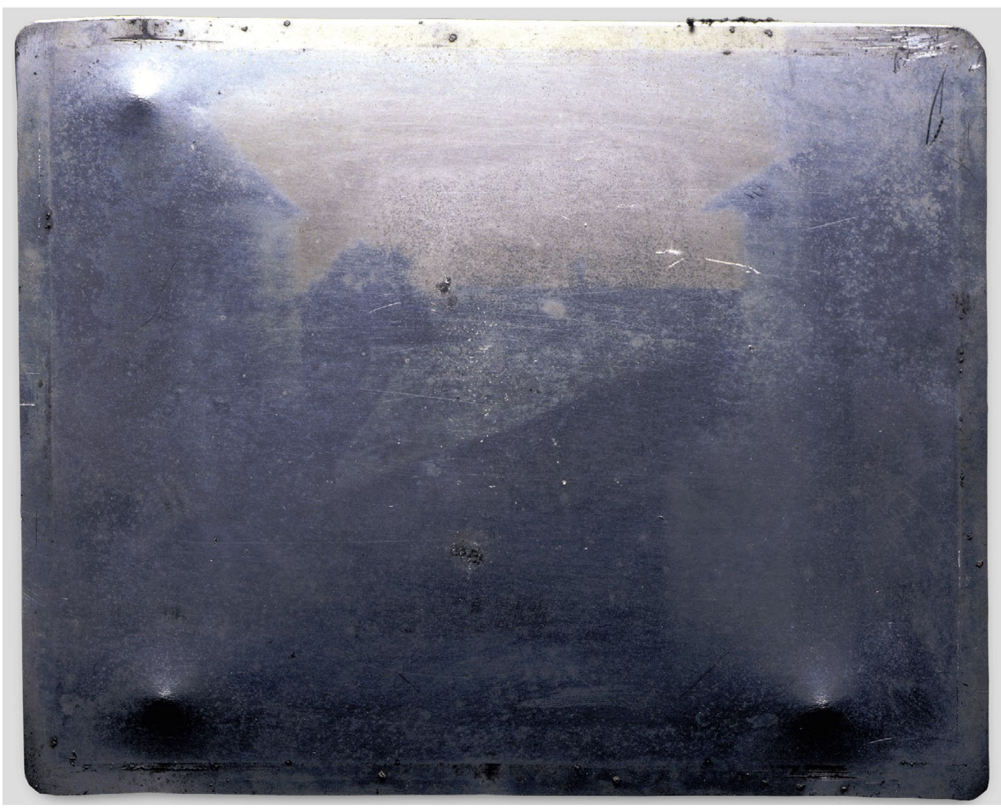
12. Uta Barth, "Light, Looking", interview by Sabine Mirlesse, *BOMB*, March 22, 2012. https://bombmagazine.org/articles/light-looking-uta-barth/.

Uta Barth, *Sundial*, chromogenic color prints, 2007.

anticipates viewers' expectations of a legible scene or figure and instead offers them a mirror of their own visual processing faculties. Like an ongoing practice of meditation or self-awareness, it can be grounding and affirming to recognize one's own process of understanding the physical world through partial and uncertain information. Barth's goals for her work resonate with my own approaches to image- and place-making through textiles. Subjecting observational photos to noisy processes results in fabrics that seem to shift, change and confound. My hope is that they encourage an inquisitive form of looking and self-reflection, one typically practiced in boundless natural settings, within the limits of interior space.

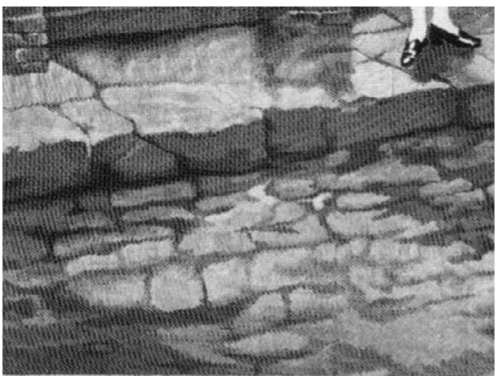


Uta Barth, *Ground #30*, color print on panel, 1994.

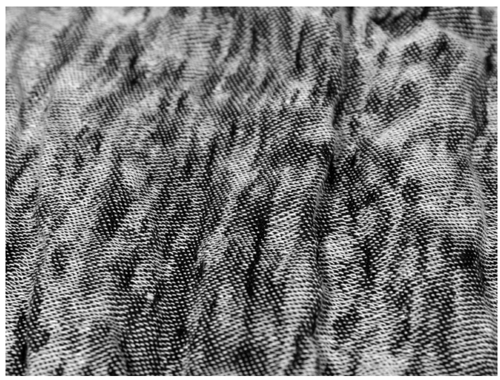


Nicéphore Niépce, *Point de vue du Gras (View from the Window at Le Gras)*, bitumen of Judea on pewter plate, 1827. Considered the oldest surviving camera photograph, the image was made by a days-long process known as heliography, in which the sunlight reflected by the scene outside the window hardened the plate's coating.

If the play of light and shadow against a window are the result of one layer of environmental noise - the translucent screen at a distance - photographing these patterns and rendering them in cloth add more instances of noise through lossy compression and imprecise translation. Jacquard weaving is well-suited to the noisy subject: yarns of different colors can be in close proximity, but will never truly blend together as in oil paintings or digital images. A degradation of information occurs when millions of colors are converted to a finite set of interlacings that produce a palette of fabric “colors” when viewed from a distance. These colors can then be even more coarsely mixed, by halftoning or dithering strategies that further corrupt the image by adding information not present in the original scene. Soft gradients can be rendered as vast fields of dots or speckles, steadily decreasing in density, but the texture of the field is then cemented into the resulting image.



Reproduction of a woven fabric containing 3600 warp ends (detail). Reproduced from *Jacquard Mechanism and Harness Mounting*, Fred Bradbury (1912): 16.



Experiments in shading with Jacquard-woven black and white yarns, October 2021.

While photorealistic Jacquard weaving is widespread, I chose to work at the edge of visual legibility. The rectangular shape of the woven panel ties it to the familiar aspect ratio of windows, imparting a framing effect while what, exactly, is being framed remains unclear. By selecting imagery that, while representational, was amorphous and abstract, and by applying dithering algorithms that introduce uncertainty at the edges of “objects” (spots of light and shadow) in the scene, I planned to weave fabrics with a sense of instability or elusiveness, suggesting to the viewer that what they depict, if they depict anything at all, can only be seen in quick flashes or out of the corner of one’s eye. “Contours, boundaries, and edges are very important to the process of visual perception," Richard Zakia writes in *Perception and Imaging*. "The eyes continuously search them out for information. Under certain conditions, a shimmering movement can occur at the boundary of an area." Paul C. Jasen describes this phenomenon as an "unhoming via the retina" that happens when we take in confounding visual and spatial information. [13]

Naturally-occuring "dappled things," from speckled trout to shimmering lake surfaces, embody this sense of ephemerality, prompting the eye to travel across patterned expanses while defying its attempts to focus on any singular spot. In these patterns, there is no underlying logic or resolution into a familiar figure, only an unfolding of matter governed by rules that we cannot fully describe. The sense of wonder associated with these phenomena may arise from a "haptic" way of looking, following the term's origins in media theory. Borrowing from the vocabulary of physiology, haptic vision described perceptual encounters in which "the eye, in caressing the visible surface of an artwork, assumed a tactile function - as if it were a fingertip moving across a textured material space."[14] This process of looking, provoked by certain images, is actively searching and exploratory, an attempt to make sense of complexity that emerges from an unidentifiable place. A textile that acts in this way can bring a sense of flickering aliveness to a room: if mounted on a wall or divider, it can suggest the illusion of a window to another place or a discontinuity in the parameters that govern the interior world.

13. Jasen, *Low End Theory*, 135.

14. David Parisi, *Archaeologies of Touch: Interfacing with Haptics from Electricity to Computing* (Minneapolis: University of Minnesota Press, 2018), 34.

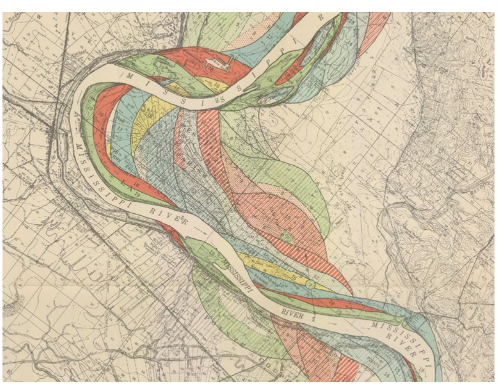
3. Material life

In her essay "Learning the Grammar of Animacy," Robin Wall Kimmerer recalls an epiphany while learning Potawatomi, her ancestral language: it contains far more verbs than English, many specific to natural objects or places. The word for "bay" exists as a noun, but so does a verb meaning "to be a bay." "A bay is a noun only if water is dead [...] To be a hill, to be a sandy beach, to be a Saturday, all are possible verbs in a world where everything is alive."[1] The syntactical emphasis on non-human action creates space to examine the behaviors of so-called inanimate objects, a culturally significant notion for many Indigenous people, including Kimmerer, for whom natural entities like mosses and ponds merit the same consideration as people. Traces of this sentiment exist in vernacular English, too; we often say a yarn "wants" to twist back on itself or an unstable structure is "trying" to reach equilibrium, in lieu of describing the physical forces acting on the object. Explaining why man-made structures collapse or natural processes occur is easier, if less scientifically precise, when we bypass compression and tension and simply say that their materials are acting according to their inherent, defiant desires.

Scientific understanding of material systems can coexist with this more intuitive, anthropomorphic view of their moody tendencies. The writer John McPhee traces the history of human intervention at the distributaries of the Mississippi river, which has "threatened" to jump its banks for over a century. Through historical records and interviews with present-day engineers, McPhee reveals a widespread reverence of the river and an uncertainty that any amount of human intervention can prevent it from assuming a new path. Speaking in 1928 on the possibility of diversion to the Atchafalaya branch, the president of the Mississippi River Commission told Congress that the river was "just itching to go that way"[2]; a manager at the flow-control structure, referencing the axiom

1. Robin Wall Kimmerer, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (Minneapolis: Milkweed Editions, 2020), 55.

2. John McPhee, *The Control of Nature* (New York: Farrar, Straus, Giroux, 1989), 46.



Detail of a 1944 map of the Mississippi's "meander belt", showing its oscillations over time. Map by Harold Fisk.

that anything that can happen will, remarks "This is where Murphy lives."[3] The river's behaviors include both self-perpetuating cycles and self-regulating tendencies: always in search of an optimal path, it has changed course roughly every millennium. Early human settlements moved in accordance with the water's preferential flows, but present-day cities must be defended by vast engineering projects that "convince" the Mississippi to stay in its lane indefinitely. Human knowledge of and interference in natural processes are a recurring theme in McPhee's writing: while fairly precise simulation of the river is possible, one engineer notes that "the data have lost their pristine character. It's a mix of hydrologic events and human events."[4] One set of data, colloquially described as the river's "wants," has collided with a set of manmade variables, opening a new space of potential behaviors.

A flock of starlings. Photo by Peggy Osterkamp.

A wooden handrail's grain pattern, visible after exposure to the elements.

The "aliveness" Kimmerer and McPhee describe in non-living systems may sound contradictory, but the self-organizing principles that shape these systems, emerging from the laws of physics, in many ways resemble flocking activities that have biological roots. Large groups of birds, ants or fish navigate space as a collective unit without a collective consciousness, and their movements can be well approximated by digital simulations with only a few rules.[5] The way we understand these large-scale systems can be extended to materials, whether living (like algae), dead (like wood) or inorganic (like glass). The term "active matter,"

3. Ibid, 15.

4. Ibid, 55.

5. Craig W. Reynolds, "Flocks, herds and schools: A distributed behavioral model", *ACM SIGGRAPH Computer Graphics* 21, no. 4 (August 1987), https://doi.org/10.1145/37402.37406.

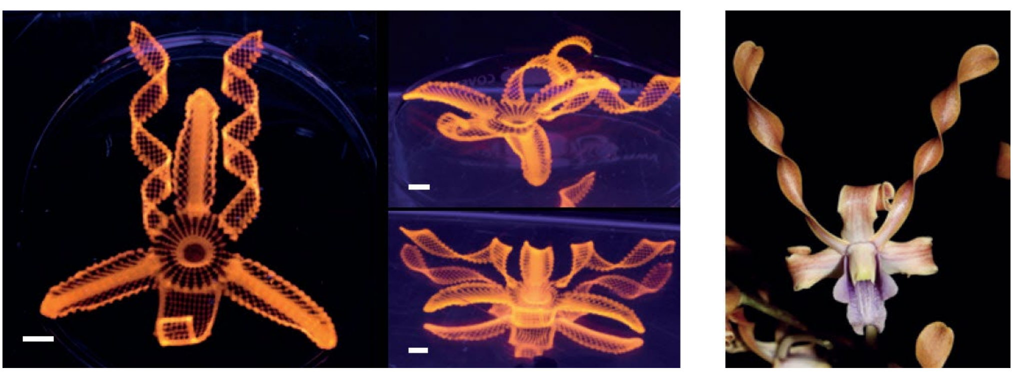
popularized by the 2015 summit and 2017 book of the same name, describes materials like these, whose capacities for change are both complex and predictable. "These multiagent systems do not need to consist of living creatures," Neil Leach asserts in the book's preface: "In the context of metallurgy, for example, populations of defects can cause a metal to be tough if they are allowed to be highly mobile, or rigid if they are constrained."[6]

Characterizing the particles or fibers of a material as part of a "population" is an important linguistic shift that allows us to imagine, through the lens of individual and collective "wants," how and why certain materials change shape. Some of these transformations are already familiar to us: we navigate the world with expectations, accumulated through experience, of how items in daily use will react when stretched, weighed down, heated or saturated with water. Material shape change, or deformation, can have negative connotations when it clashes with design intentions, like a piece of wooden furniture swelling with humidity. The researcher Skylar Tibbits laments that "a more surface-level understanding of the physical world tends to view matter as inert [...] Wood, a beautifully anisotropic and information-rich material, is turned into standardized lumber."[7] An alternate design approach, aligned with the principles of active matter, would allow space for or harness material behavior, rather than impose an absolute form onto the material.

6. Skylar Tibbits ed., *Active Matter* (Cambridge: MIT Press, 2017), 22.

7. Ibid, 16.

Uncontrolled and undesirable material behavior: wood veneer warps and buckles when exposed to moisture. Photo by Redbridge Marquetry Group.



A 3D-printed hydrogel containing cellulose, which swells when exposed to moisture. Controlling the alignment of the cellulose fibrils during printing enables the material to bend and twist into complex shapes, such as this example inspired by an orchid's shape-changing behavior.
A. Sydney Gladman, Elisabetta A. Matsumoto, Ralph G. Nuzzo, L. Mahadevan and Jennifer A. Lewis, "Biomimetic 4D printing", *Nature Materials* 15 (January 2016): 413-418. Part of fig. 4 is reproduced here.

A more poetic name for this field might be found in *Atlas of Novel Tectonics*, a survey of the architecture firm Reiser + Umemoto. Its introduction characterizes the firm's approach as "cold combustion": the "unfolding of geometry that [was] held in exquisite or frozen suspense."[8] By recognizing that the current state of their materials is temporary, architects and designers can anticipate this sudden "unfolding," or transformation of potential energy to kinetic energy. The event of deformation can be positive, even exciting and suspenseful, when it is the final chapter of a design process that yields a form from both controlled and uncontrolled actions. Here again, wood is referenced: as "an infinitely arrested but still smoldering fire," a "'flow' of information and time" that can be made visible through "modulation and control."[9]

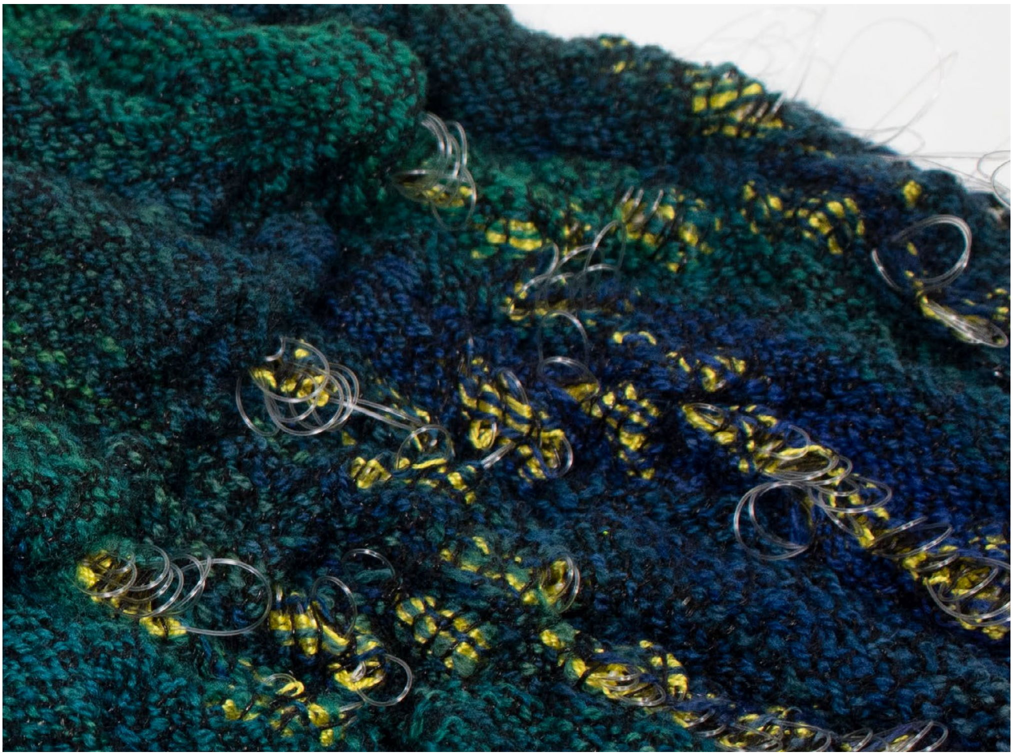
The architects also cite Aldo Rossi's retelling of Max Planck's account of a parable about a stonemason: moving from tacit knowledge to physics to a theory of architecture, the deeply layered tale addresses potential energy as a "fundamental precondition" for understanding the built environment. The mason who hoisted a heavy block of stone onto a roof "was struck by the fact that expended energy does not get lost: it remains stored for many years, never diminished, latent in the block of stone, until one day it happens that the block slides off the roof and falls on the head of a passerby, killing him…in architecture this search is also undoubtedly bound up with the material and with energy; and if one fails to take note of this, it is not possible to comprehend any building, either from a technical point of view or a compositional one. In the use of every material there must be an anticipation of the construction of a place and its transformation."[10] There are temporal and kinetic elements, Rossi argues, in all architecture whether or not they are deliberately considered. I would extend this argument to designed objects in general, whose lifecycles may include material growth or synthesis, initial fabrication, transformation catalyzed by sudden or gradual changes, usage and decay. This design philosophy is predicated on a deep knowledge of materials and a willingness to give them agency in determining the final outcome.

Where architects recognize certain materials' resiliency under tension or compression, such as the rods and fabric that make up an active-bending structure, textile designers understand the stubbornness of materials like coarse nylon monofilament and the corresponding force required to bend them into precise shapes.

8. Jesse Reiser and Nanako Umemoto, *Atlas of Novel Tectonics* (New York: Princeton Architectural Press, 2006), 14.

9. Ibid.

10. Ibid, 21.



Monofilament yarns escaping from a fabric that forced them to bend with a small radius. This behavior is a release of potential energy, as the tension exerted on elastic yarns is transferred to monofilament yarns, causing them to bend sharply until they pop out of the fabric like springs.

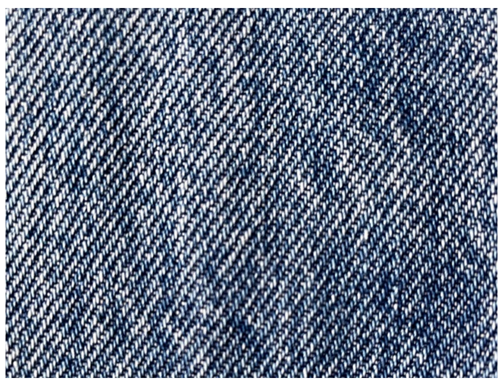
Monofilament yarns tightly woven into a fabric. The force of the elastic yarns is distributed along the entire length of each monofilament, contorting it into a smooth, rigid surface.

Stiff yarns like these have a propensity for escaping weave structures that they're not "happy" in, undermining the fabric's dimensional stability. Taking a moment to acknowledge the aliveness of these materials, we can choose to let this escaping behavior become a design detail, or build more deliberate weave structures that utilize the solidity of a stiff yarn tightly bound in place. Regarding textiles as active systems leads to realizations that some similarly strong materials, like tough monofilament and bungee-like elastic yarn, are well-matched and can hold each other in a state of equilibrium. Strategically pairing materials with each other, and with certain weave structures, creates modifications and novel expressions of fundamental material behaviors.

It can be challenging to draw a clear line between the behavior of specific materials, like wood and metal, and the behavior of specific shapes, like springs and lattices, whose material makeup is not prescribed. We intuitively understand that a spring, whether plastic, metal, or a coiled hair fiber, is elastic despite consisting of a relatively inelastic substance: in this context, the spring is the form and the fiber is the material. However, usage in a larger construction, like a net of springs or a knitted blanket, washes away this distinction as the springy yarn is now considered a material from which the end product is constructed. Is the division of materiality and metamateriality simply a question of scale? Do fabrics achieve three-dimensional shape because of their raw materials, their structure, or both? While fiber availability limited early "active textiles" to macro-level structural behaviors, contemporary examples operate on multiple scales to yield extreme and precise transformations, demonstrating the power and disposition that certain materials possess.

4. Textile precedents

A woven fabric that hasn't been washed or dyed is called "loomstate," retaining the qualities of yardage just cut off from the loom. The existence of this term implies an early knowledge of transformative finishing processes, often as simple as rinsing in water: loomstate fabrics are understood to be artificially held in tension, poised to spring into a new shape. With the language of textile manufacturing, we differentiate these fabrics from the default, perhaps as a caveat that they may change unexpectedly or to indicate their temporary nature. In most fabrics, finishing processes are irreversible and the initial state cannot be restored. It's also rare for contemporary fabrics or garments to be sold as loomstate, with expcetions for some products like specialty denim. Finishing is inevitable, though we may not appreciate its effects if we aren't familiar with how loomstate looks and feels, and thus can't readily make a before-and-after comparison.

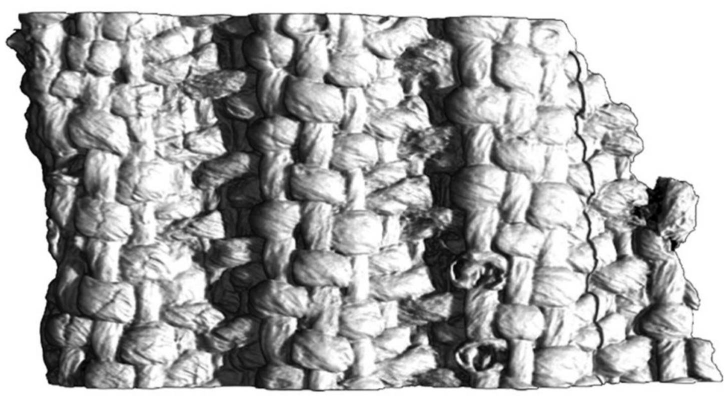



Crackled textures develop in muslin and denim fabrics after washing.

Historic textiles show the effects of finishing through shrinkage. Animal fibers like wool, and plant fibers like cotton and linen, relax from their prestressed state when exposed to heat, moisture and agitation. Uniform and smooth loomstate fabrics may crackle, pucker, curl at the edges or settle into place as a result of shrinkage. In denim design, these emergent textures, with names like "cantalouping" and "orange peel," arise from minute adjustments to yarn structure, weaving and finishing parameters, all applied to 100% cotton, 3x1 right-hand twills. Early twentieth-century denim fabrics are revered for these irregularities, and contemporary designers often recreate them by reenacting the production process as closely as possible. While the fading of indigo warp yarns makes small-scale distortions visible in denim, affording them a sort of cult status, these artifacts are present in many other industrially woven fabrics. Once regarded as defects, and later accepted as idiosyncrasies of the manufacturing process, the effects of shrinkage can now be considered desirable because they are controllable. With deep knowledge of yarn and fabric behavior during finishing, designers can imbue a fabric with specific character and handfeel to be activated later.

Shrinkage in fabrics with uniform weave structure and homogeneous materials results in allover texture on a flat fabric. Conversely, shrinkage in heterogeneous fabric can lift it out of its flat state. By interrupting the continuity of the weave structure or introducing a secondary material, early weavers created pleats, ridges and other dimensional features. Warp-faced weave structures, particularly twills, curl and become concave after finishing; weft-faced structures become convex. When used in alternating stripes, the two structures form a rippled surface that can in some cases expand and contract due to its mechanical stretch. This effect, called "ribbed twill" or "barred damask", can be achieved with natural fibers and has been known for millennia. Artifacts from Egypt (1st-2nd century CE) and Europe (6th-7th century CE) have been found to use this technique.[1]

1. Karina Grömer and Antoinette Rast-Eicher, "To pleat or not to pleat – an early history of creating three-dimensional linear textile structures," *Annalen des Naturhistorischen Museums in Wien, Serie A* 121 (January 2019): 95-96, 102, https://www.zobodat.at/pdf/ANNA_121A_0083-0112.pdf.



An example of barred damask, which appears to contain stripes of plain weave as well as twill. The weft floats in the twill, visible in the "valley" folds of the fabric, are responsible for its convolutions. Karina Grömer and Antoinette Rast-Eicher, "To pleat or not to pleat" (2019). Part of fig. 1 is reproduced here.

Strategic use of contrasting yarn types, such as stripes of thick and thin or S-twist and Z-twist yarns, is also present in early textiles. After wet finishing, the fabric may have a subtle dimensional effect, as each yarn type reflects light differently, or an extreme change in shape. Describing a garment excavated from Deshasheh, Egypt dating to the 24th-25th century BCE, Jana Jones writes that the fabric "was woven with alternating groups of thicker and thinner warp yarns […] After washing and drying, the fibres would shrink and cause the fabric to 'crimp' into fluted folds or corrugations, giving the impression of fine, irregular, vertical pleats."[2]

The pleated texture of the Deshasheh garment (above) is similar to contemporary woven textiles (opposite page) by Ann Richards that use natural-fiber yarns with high twist or varying fabric density. Image property of University College of London.

The weaver Ann Richards agrees that the "crimpled effect" of this and similar textiles could result from the liveliness of S-twist single yarns or from arrangements of dense and sparse warp yarns, indicating the possibility of deliberate self-pleating patterns.[3] Even without the use of elastomeric or thermoplastic fibers, these fabrics indicate designers' and makers' control over textile behavior and dimensionality. They serve as precedents for contemporary self-shaping and self-folding fabrics, in which highly specific final forms are possible. Likewise, extreme examples from these fields underscore the fact that textiles have always been dimensional, even those we regard as "flat": the character, texture, and patina of all fabrics are the result of yarns settling into their spatial relationships with each other.

2. Jana Jones, "The enigma of the pleated dress: New insights from Early Dynastic Helwan reliefs," *The Journal of Egyptian Archaeology* 100 (January 2014): 216, https://www.jstor.org/stable/24644971.

3. Ann Richards, "Could Ancient Egyptian Textiles Have Pleated Themselves?", lecture, Swansea University, Swansea, Wales, UK, May 11th, 2010, https://www.youtube.com/watch?v=0PgOWckOJyM. Presented as part of the conference "Experiment and Experience: Ancient Egypt in the Present".

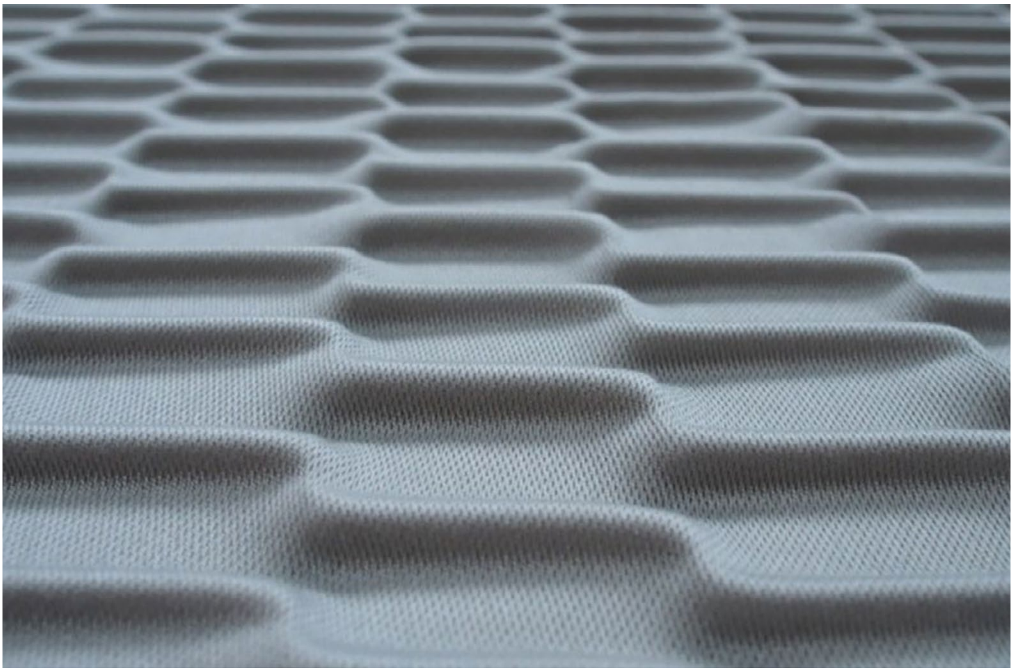
Self-pleating textile woven by Ann Richards. Photo by Nicky Barfoot.

Self-pleating textile woven by Ann Richards. Reproduced from *Weaving: Structure and Substance*, Ann Richards (2021).

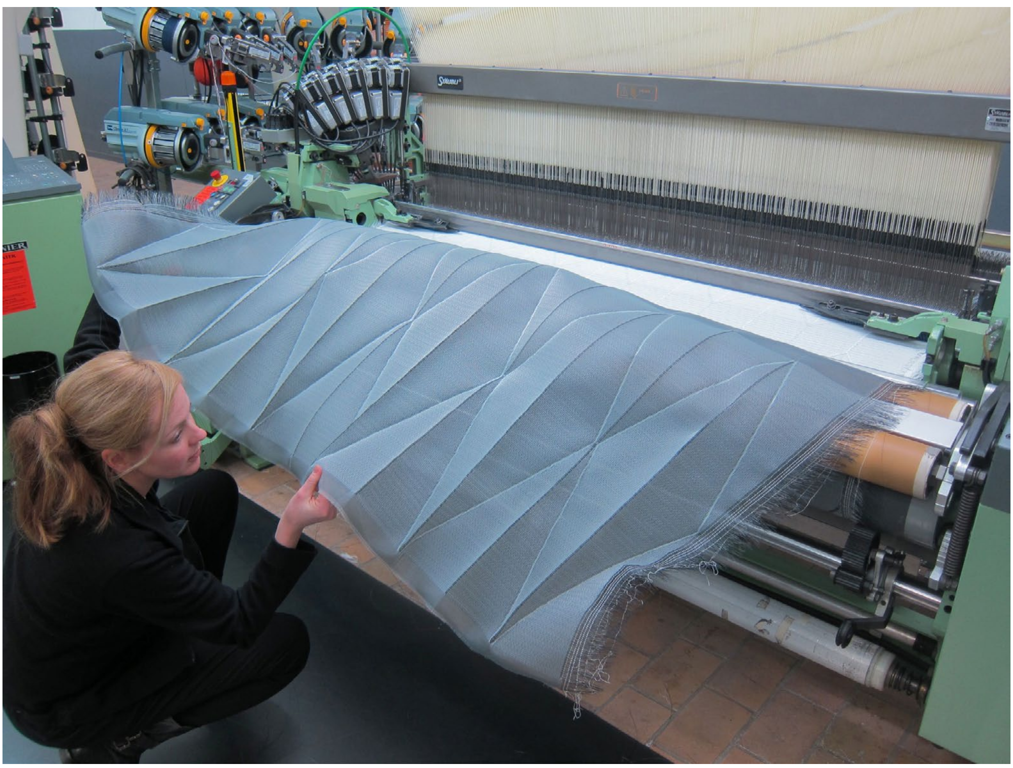
Contemporary textile designers including Aleksandra Gaca, Philippa Brock and Samira Boon use self-shaping techniques to create sculptural fabrics, often in the shape of paper-folding patterns, that include paper, monofilament, elastic and thermoplastic shrinking yarns. Boon's work includes canopy-type installations in concert halls, which suggest that the folds and convolutions of these fabric types can contribute to sound absorption and diffusion.[4] Gaca's designs are more often produced as yardage or panels, intended for use in office and residential spaces. Thick and dimensional with quilt-like sculptural surfaces, the jacquard-woven fabrics take on their shape - and resulting sound-absorbing qualities - when released from the loom.[5] The fabrics' ribbed and bubbled surface textures are likely the result of elastomeric or thermoplastic shrinking yarns on the reverse that pull against a stiff, densely woven upper layer. Issey Miyake's *Steam Stretch* collection is another variation of this method: unlike most of the designer's works, which are pleated explicitly by folding and pressing the fabric, the textiles for these garments were pleated implicitly: their structure (which likely uses short floats of a shrinking yarn) relaxes into a paper-fold pattern when heated. Yoshiyuki Miyamae, the head of womenswear at the brand,

4. "Concert hall Tilburg," *Samira Boon*, last modified January 8th, 2020, https://samiraboon.com/2018/09/12/concert-hall-tilburg/.

5. "Acoustics," *Aleksandra Gaca*, accessed January 29th, 2022, https://www.aleksandragaca.eu/acoustics-2.



Leevn acoustical fabric, Trevira CS polyester and elastane yarns. Designed by Aleksandra Gaca for Casalis.



Samira Boon's self-folding fabrics start to take shape as soon as they are released from the tension of the loom. Photo by Studio Samira Boon.

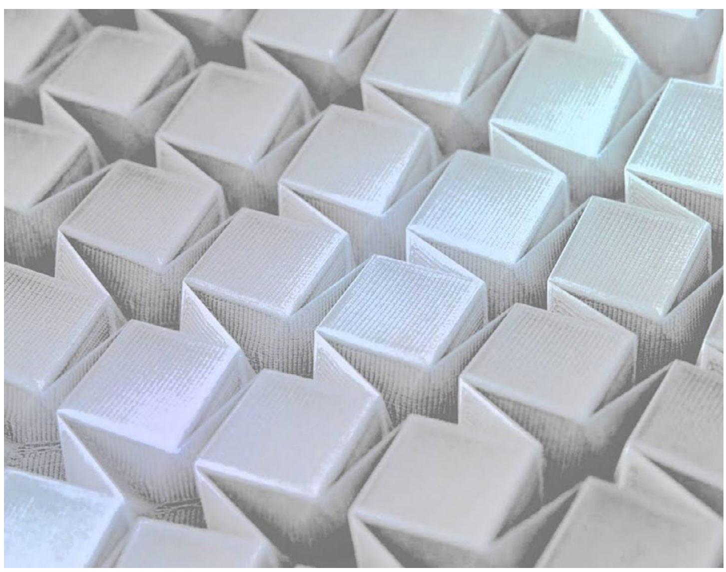
commented that the fabric "looks like origami but it's folded by steam, not by hand. It's not created by a mould or pre-formed."[6] This hands-off approach to shaping the fabric relies on the fold pattern embedded in its design. A crease formed by folding or pressing is sometimes described as "memory of shape"[7]; a crease that has not yet formed, but is bound to do so, represents a temporal inversion of memory that might be called predisposition or premonition - a memory of something that hasn't happened yet.

Philippa Brock, *Self Fold #1* (detail), jacquard-woven textile, 2010.

6. Yoshiyuki Miyamae, interview by Dan Howarth, *Dezeen*, November 12th, 2014, https://www.dezeen.com/2014/11/12/issey-miyake-yoshiyuki-miyamae-interview-3d-stretch-seam-fashion-technology/.

7. Tsai-Chung Huang, "In-Between Pleats: Pleats, pleating and 'pliable logic'" (doctoral thesis, Royal College of Art, 2020), 55, https://researchonline.rca.ac.uk/4351/.

Huang cites Sharon Baurley's analysis of the cultural significance of garment creases in Japan prior to the arrival of Western tailoring. Creased lines develop naturally when kimono are folded and stored away in a traditional manner: they were understood to be part of the fabric, as the concept of removing wrinkles with an iron is a Western invention.



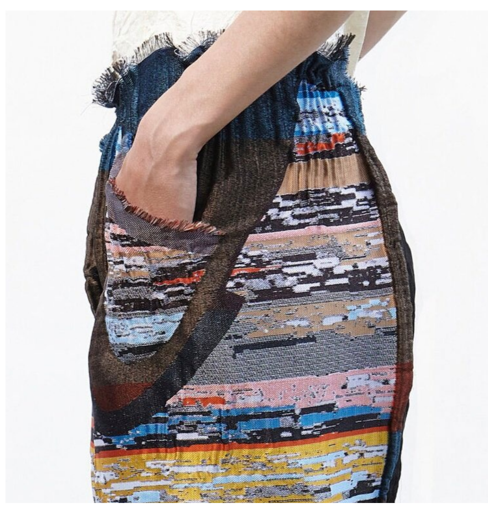
Still from Issey Miyake *Steam Stretch* promotional video, 2014.

Where Miyake's works typically harness active yarns to produce repeating geometric patterns, textile researchers including Kathryn Walters and Holly McQuillan have used similar material palettes in multi-layer, multi-structure wovens to yield organic texture and singular sculptural forms. Walters' explorations include self-supporting tube and tunnel shapes formed by mountain and valley folds in fabrics with elastic yarn floats.[8] More recently, she has created pop-up prismatic shapes from 2D woven fabric. Unlike the repeating cube pattern in *Steam Stretch*, which can be flattened back into a continuous sheet, this singular cube is excavated from several stacked layers. In some of McQuillan's self-shaping woven garments, which emerge from her prior work in zero-waste design, heat-sensitive yarns are woven in extremely loose structures, or "expandable bindings." The unconstrained yarns shrink as much as the design process allows them to: a garment heated in a dryer will become close-fitting, while the same garment fitted over a mold during heating will be halted in its shrinking process, retaining the mold's large and sculptural shape.[9] Here, the garment's eventual volume is dictated by its materials and structure, but multiple versions of it may be realized. Moreover, these works don't rely solely on shrinkage to arrive at the final form. Selective cutting, unfolding, lifting and sliding of woven layers are part of the set of actions that yield a 3D textile from a flat one. This movement potential is embedded in the fabric; the fabric is characterized by what it has the ability to be or become.

8. Kathryn Walters, "Form from flat: Exploring emergent behaviour in woven textiles" (master's thesis, Univesity of Borås, 2018), 106-109, https://www.diva-portal.org/smash/record.jsf?pid=diva2:1237227.

9. Holly McQuillan, "Zero Waste Systems Thinking: Multimorphic Textile-Forms" (doctoral thesis, University of Borås, 2020), 222-247, http://hb.diva-portal.org/smash/record.jsf?pid=diva2:1478307.

Kathryn Walters, woven cube from *Suture Structures* series, c.2021.



Detail of the Sediment Trouser from *Planet City*, a collaboration between Holly McQuillan, Karin Peterson and Kathryn Walters. Photo by Amanda Johansson.

My own work has strong ties to precedents in the fields of active matter and self-shaping textiles. I choose to work with these methods in part because they are challenging and result in novel forms, and because of the opportunities to address physical function and performance unique to three-dimensional fabrics. The poetic nature of active materials' movement and agency, and the implications of designing alongside rather than acting upon material, can also be considered in the context of technology and labor in the textile industry. Designs that make use of these material tendencies often assert that no other manufacturing process would have been suitable, for example deploying structures in remote or confined locations or working at a scale where the human hand can't intervene. The aesthetics of self-assembly, expressed as emergent or phenomenological pattern, are also celebrated by many practitioners. Less common are discussions of work, manual or otherwise, that the technique eliminates and creates. If we start with the assumption that the end product is good and necessary, is an automatic assembly method always more ethical than a manual one?

Weavers understand that some amount of tedious handwork will always be part of the process. The inherent set-up cost of our medium leads to a common logic: invest time in the beginning stages, and reap the rewards long after. Plan the optimal threading to weave as many variations as possible; fix mechanical problems as soon as they occur, because repetitive motion means they will occur again. Designing for production extends the logic of upfront investment even earlier in the process: the hard work of designing the file is done once, facilitating the creation of countless identical copies. Like the tooling for injection-molded plastic parts or a recipe for a polymer, the weave draft and yarn selections dictate the shape of every piece. This is not a novel idea, by at least a few centuries, nor should it suggest that mass production is easy work free of decision-making. It does, however, raise an opportunity to evaluate points in the production process where human intervention is needed, and push as many of them as possible to early stages where they need only be done once.

The mass production - and in turn, mass customization - of structurally complex products would not be possible without digital design tools. Where many industries, including apparel, convey assembly instructions to workers in the form of a spec sheet or tech pack, some specialized manufacturing methods permit the product to be wholly represented as a digital file. Human-readable and machine-readable instructions are in some ways parallel but have drastically different efficiencies and agilities. A machine can run a file from start to finish under minimal supervision; a queue of files can be run, with no expectation that any two are the same. This is an ethos found in whole-garment weaving and knitting, which propose an alternative to cut-and-sew steps in apparel manufacturing. Even subtle updates to existing techniques, like Miyake's steam-activated pleats, can re-allocate time to the design stage. Traditional pleating methods use a paper mold for each pattern, which is certainly faster than hand-arranging pleats but requires a new mold for each slight variation of the design. When the "mold" is digital, contained in the weave structure, it can be quickly or even procedurally updated, minimizing the work done by human hands and minds.

Some of the fabrics in this body of work are unambiguously self-shaping, with a clear "before" and "after" state. Others, like the woven spacer fabrics, are three-dimensional and can move freely between compressed and expanded states, powered by monofilament's stubborn material behaviors and resistance to bending. The Jacquard-woven pieces are much closer to conventional 2D textiles. All can be expressed as a set of instructions, in some cases accompanied by a digital file, but none were made in truly automatic or hands-free ways. If I use software to generate a composition of light and shadow and then spend hours painting it onto a fabric with dye, does that contradict my belief in the "upfront investment" of design for production? In another instance, digitally drafting a spacer fabric was simple, but configuring a Compu-Dobby loom to deal with the uneven stresses and extreme distance between the layers was not. While limited by time and equipment, what these works nonetheless propose is a reevaluation of the allocation of labor that reflects my own values. Physical making and handcraft have tremendous importance: they should be undertaken when they can achieve what machine craft cannot, or when the maker has a curiosity and enthusiasm for the task at hand. No one should be compelled to perform these tasks if less labor-intensive production methods exist. Encoding as much information as possible into a digital file - from weave structure to the specification of yarns - enables designed objects to arrive into the world, in some cases fully formed, propelled by their own material agency rather than the repetitive motions of laboring hands.

Threading, May 2022.

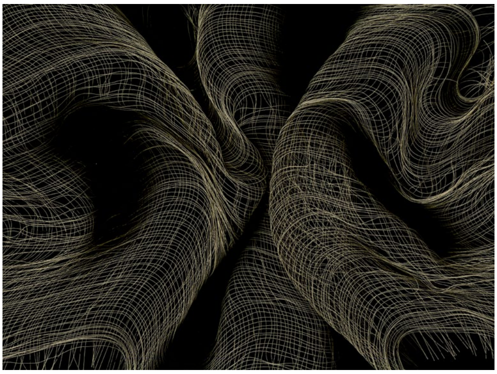
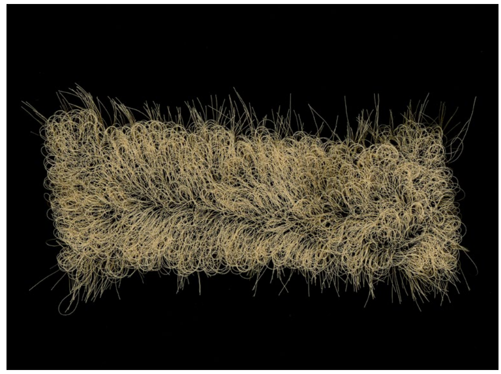
Jacquard-woven fabric coming off the loom, May 2022.

5. Methods of fabrication

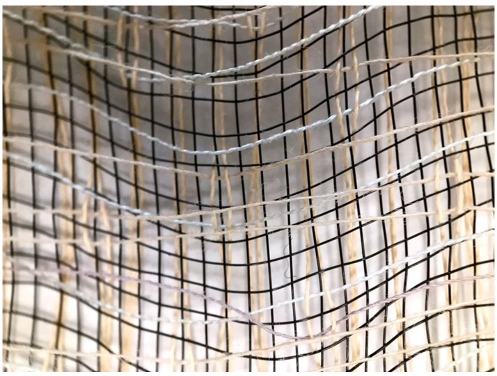
The self-shaping fabrics in this collection went through multiple transformations to arrive at their final form. From the start of the prototyping phase, I knew I wanted to create a malleable fabric that could take on a contoured, undulating form. Non-stretch fabrics can curve in one direction (as in a cylinder), but double curvature (as in a sphere) requires stretch or shrinkage for a smooth, wrinkle-free surface. The plastics PETG and styrene soften and droop during the heating stage of vacuum-forming, creating a doubly curved surface by stretching in the center under their own weight. I set out to imitate this effect by using a shrinking yarn as the structural base of the woven fabric. While my previous self-shaping works had used crimped nylon thread, which shrinks when steamed but retains some mechanical stretch, this new fabric type required a thermoplastic yarn that would hold its shape after shrinking. After testing a few types, including low-melt copolyamide and copolyester, I chose a polycaprolactone-based monofilament yarn.[1] Compared to other thermoplastic yarns I tested, this one had the highest shrinkage rate, had less tendency to pull apart under tension and became rigid when cooled. Because this yarn was already prestressed, my approach was to weave a fabric, heat it while lying flat to achieve maximum shrinkage, then heat again in a vacuum-forming or molding setup to allow the shrunken yarns to stretch out. This prevented tearing of the material, which could occur if the already-stressed yarns were stretched immediately after weaving, and promoted rigidity by concentrating the total amount of polycaprolactone into a smaller, denser surface. The method also presented an opportunity to build up surface textures like loop pile through differential shrinkage.

The prototypes and large-scale pieces in this category share the same basic structure. Thermoplastic warp and weft yarns form a plainweave base, and supplemental non-shrinking warp and weft yarns float on the face and reverse. When heated, the base yarns contract and the supplemental yarns arch upwards,

1. This yarn was generously provided by Orfit Industries, where it is used in the production of knitted thermoplastic tapes for orthoses.

This sample shrank from 46″ x 18″ to 20″ x 5″. Woven at 16 epi, 16 ppi with 2″ long floats.




Detail of a weave structure before and after shrinking. The beige and blue elastic yarns twist back on themselves, forming a dense low-profile pile. Woven at 32 epi, 32 ppi with 1″ long weft floats.

forming loops as their two endpoints are drawn closer together. The density of each set of yarns, and the tiedown pattern of the floats onto the base, determines how much the fabric will shrink and how pronounced the pile texture will be. This is distinct from conventional methods of producing pile fabrics, which are typically warp-pile. Terry fabrics are made with two sets of warp yarns, tensioned independently of each other so that slack warp yarns can be driven forward into the cloth to form loops. Velvet is also woven with two warp beams or a creel, but thin rods are inserted in the shed underneath pile warp yarns to create loops that may or may not be cut.[2] The effect of yarn shrinkage in my fabrics was comparable to the role of this differential warp tensioning, and resulted in weft loops on the face and warp loops on the reverse.

Early samples, which had a sparse plainweave base and floats as long as 2", shrank to as little as 20% of their on-loom width. While this produced a plush surface by gathering many tall loops into a small area, the dramatic shrinkage was not practical for producing large-scale finished works. Yarn type also had an impact

2. William Watson, *Advanced Textile Design* (London: Longmans, Green & Co., 1913) 382-3 and 395-7, https://www2.cs.arizona.edu/patterns/weaving/books/ww_atd_5.pdf.

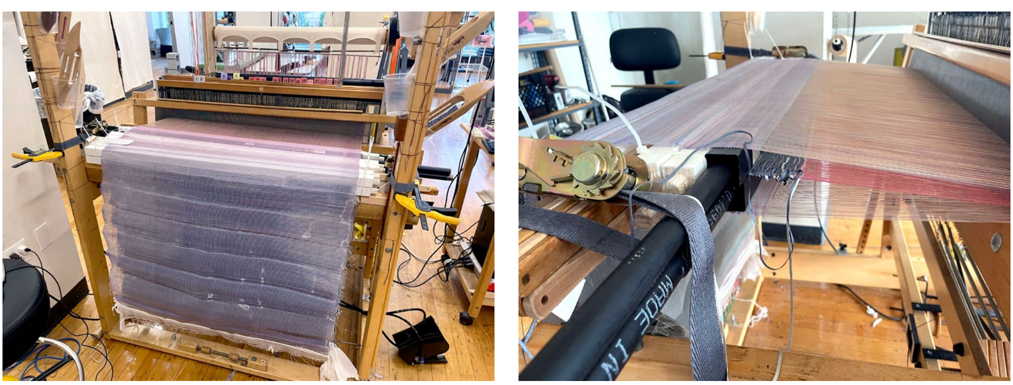
Final yardage, before and during the initial heating process that shrinks it to a 24" x 24" panel. This step is necessary to condense the pre-stressed yarns into a compact state, so that they can be stretched later.

on the loops' appearance: thin wool and cotton floats tended to flatten out, while high-twist and elastic yarns produced a tightly coiled surface texture with very little height. In the final version, I alternated floats of white viscose and hand-dyed elastic hemp yarns to create two coexisting pile systems: colorful, low-profile loops mostly hidden by smooth, tall ones. Viewing the finished fabric from different angles reveals a lenticular effect, as the camouflaging effect of the viscose loops dissipates and an internal color appears to glow through.

Heating the textile again in a vacuum former allows it to droop under its own weight. Instead of forming onto a solid mold with vacuum pressure, its shape is controlled by a thin stencil placed under the fabric.

Weaving spacer fabrics didn't involve any shape-changing techniques, instead building the textile's intended form on-loom. In industrial weaving, spacer fabrics are made by exchanging selected warp yarns between upper and lower layers while advancing only those warps, requiring at least two warp beams. Keeping the layers a fixed distance apart requires a specialized take-up system; in the small samples I wove on a floor loom, this was as simple as inserting square dowels between woven layers before exchanging and advancing the spacer warp, in this case a stiff nylon monofilament. (The fabric's thickness, and the "levitating" quality of the upper layer above the lower one, depend on the robustness of the spacer warp yarn). Because each layer is tightly woven, the dowel can eventually be used as a tensioning bar that pulls directly on all warp yarns without causing them to slip out of the fabric. This avoids the problem of wrapping the thick fabric around a take-up beam. At full width on a 24-harness dobby loom, highly rigid dowel inserts and a more robust tensioning system were needed.

Woven spacer prototype on a 16-harness floor loom.



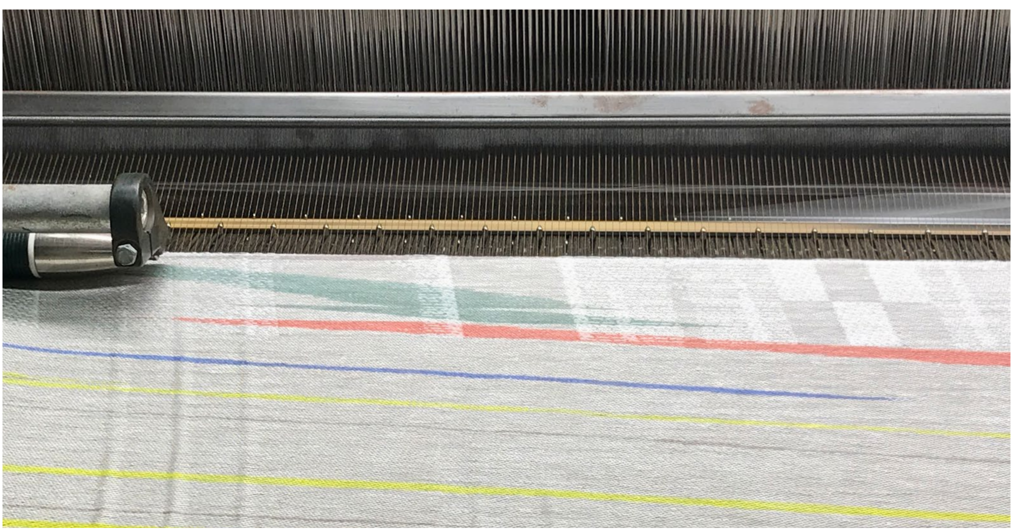
Large-scale woven spacer fabric on a 24-harness dobby loom.

Reference image and profile draft for the patterned inner layer of the large-scale spacer fabric.

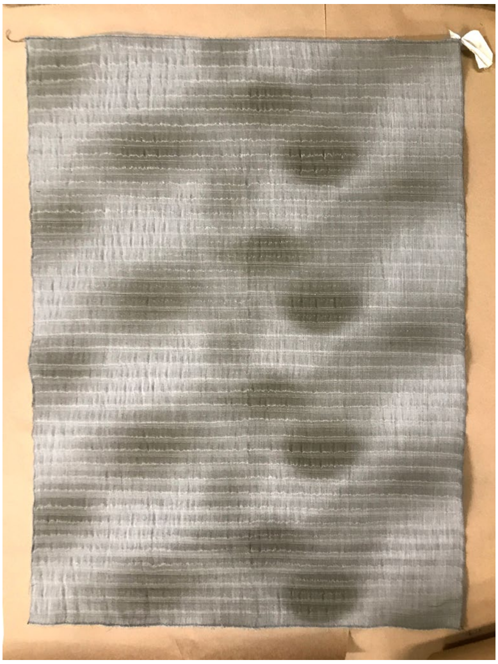
The design evolved from two plain layers, to one plain and one patterned layer, to a patterned layer suspended between two plain layers with monofilament yarns crossing through it. This decision doubled the spacer fabric's thickness while allowing it to serve as a vehicle for the type of visual and metaphorical noise that was essential to this work. Any imagery woven into the middle layer would be occluded or blurred by the translucent outer layers, whose semi-random weft striping would further complicate the underlying composition. With 14 of the 24 harnesses dedicated to design "blocks" of the middle-layer pattern, I drafted a non-repeating composition based on an image of dappled light in my window, at a size close to full scale. Interleaving the design blocks at their boundaries and using a range of fill patterns as grayscale values helped to soften edges within the design, imitating the soft, shifting light that I regularly watched and photographed. I used two weft colors in a structure similar to taqueté, resulting in an inverted-color image on the reverse side. The resulting fabric has faint light and dark shading, with a legibility that flickers as the viewer moves from the cross-section to the face.

The Jacquard-woven fabrics used similar imagery as a starting point for a repeating pattern. Although the Jacquard loom at RISD produces fabrics with four repeat units across the width, I wanted to weave a large-scale design that felt expansive and irregular, like a naturally occurring projection or reflection of light. Overlaying the repeating pattern with a non-repeating, asynchronous pattern would complicate the woven design and render each repeat unit slightly differently, breaking the rigidity of the repeat in favor of a more continuous, flowing appearance. In previous experiments, I used space-dyed weft yarns to create irregular bands of color in both Jacquard and handweaving, but the high weft density and automated nature of the Jacquard loom made it difficult to get dyed colors to cluster together. I instead opted to apply dye to the yarns after weaving.

One method of disrupting a repeat pattern with variegated yarn color: dyeing and then unraveling a knitten blank.

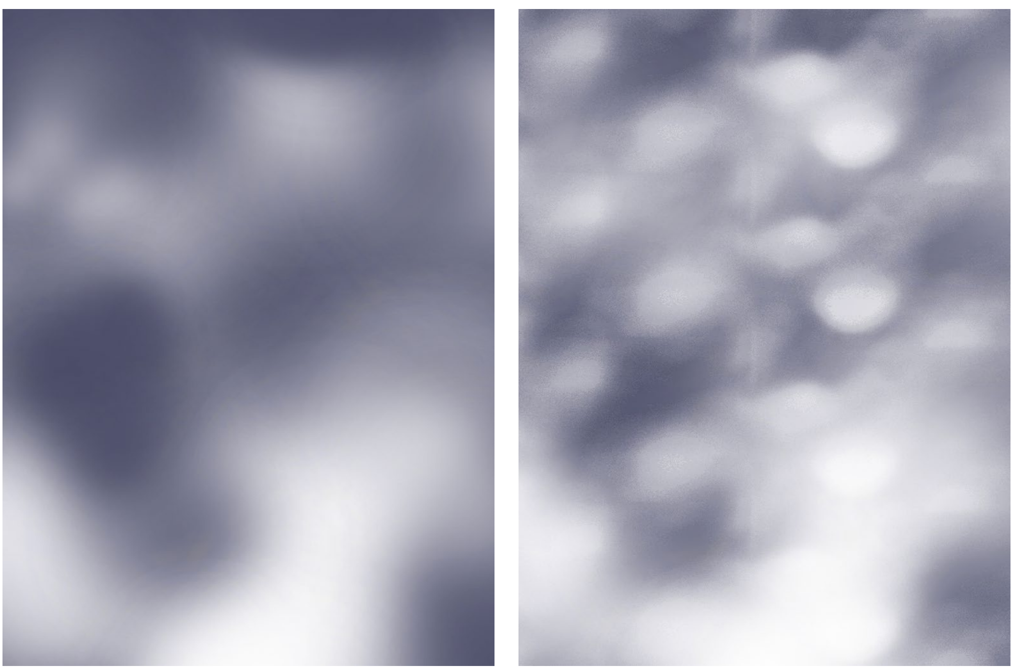


An alternative method: dyeing skeins at preciuse locations. This technique created irregular patches of color when woven on the Jacquard loom.

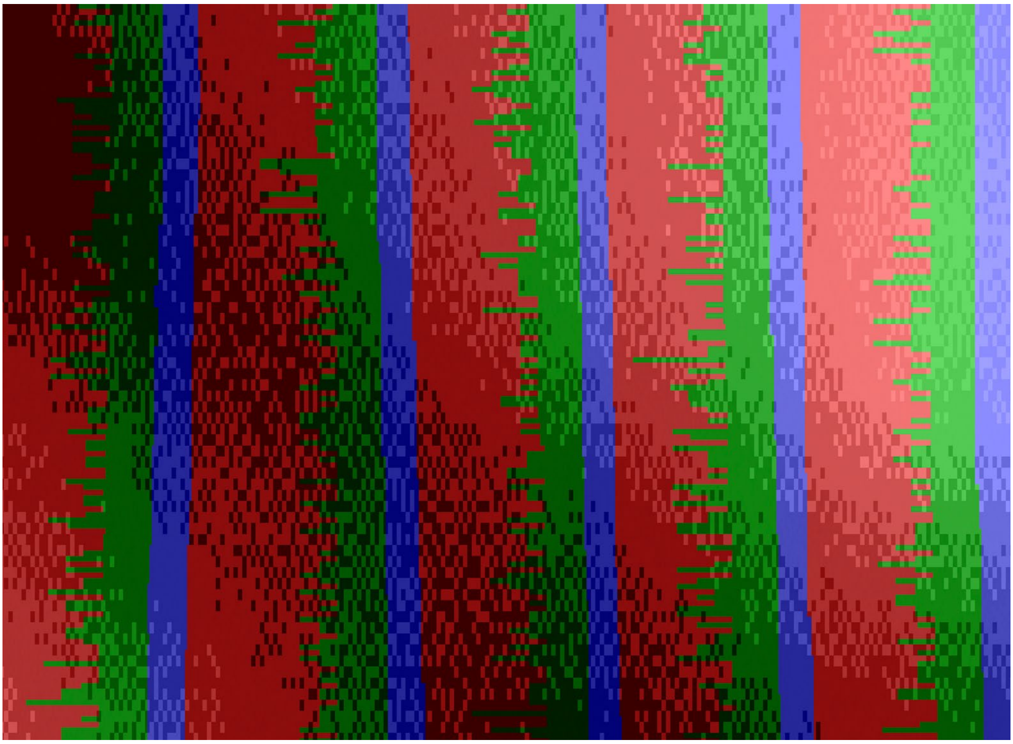


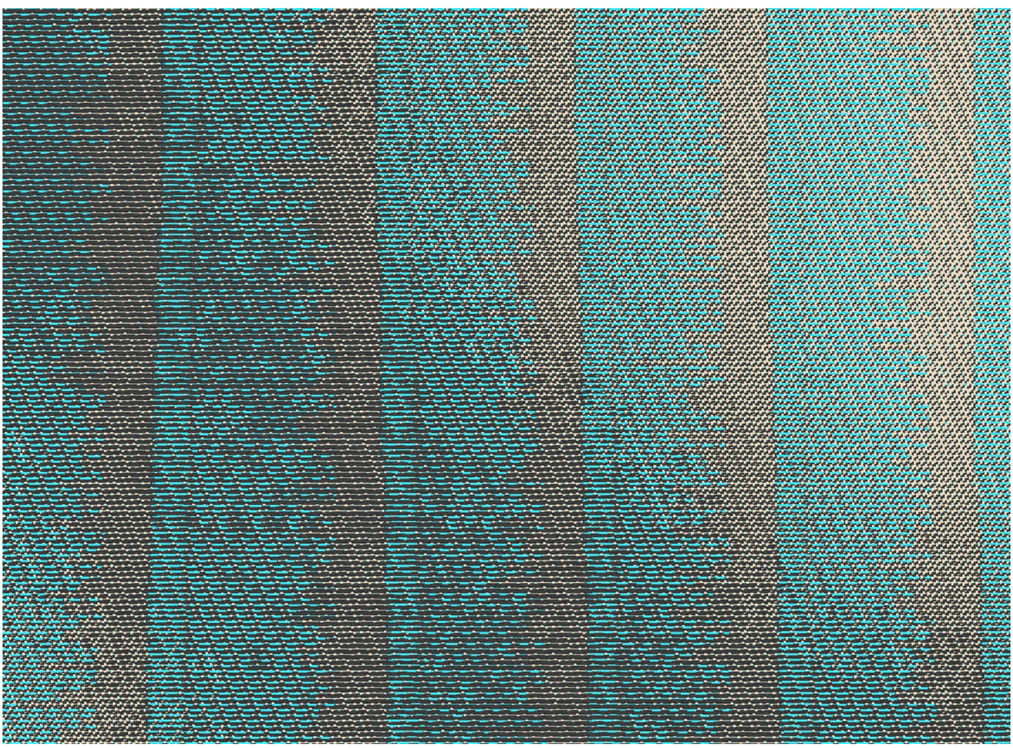
Jacquard-woven cotton, wool and nylon monofilament fabric, before discharging and painting with dyes. This fabric relied on contrast between warp-faced and weft-faced areas, using the Jacquard loom's taupe cotton warp and a light grey wool weft yarn.

I used wool, cotton and polyester yarns, each of which react in a distinct way to acid dyes. These yarns, woven into compound satin and twill structures, embed the grainy and ridged textures of the source images into a seemingly plain fabric. When dye is applied by hand, free of the four-unit repeat constraints, it heightens the contrast in some areas where wool meets cotton while the unpainted areas remain as uniform washes of light. Two of the final Jacquard-woven works were cut from the same upholstery-weight yardage, one utilizing the face and the other the reverse. A third variation used the same principles in a lighter-weight construction, using nylon monofilament to create a rounded profile in the channels between layers. The finer yarns in this piece lend themselves to a softer blurring of colors, in contrast to the scattered dithering of coarse yarns.



Dye-painting schematic (left) and mockup (right) of how acid dyes should react with absorptive and non-absorptive yarns. The mockup was not entirely accurate, since cotton can still pick up a small amount of acid dye; a fabric woven with polyester and wool yarns would have higher contrast between yarn types, allowing the underlying woven pattern to shine through.





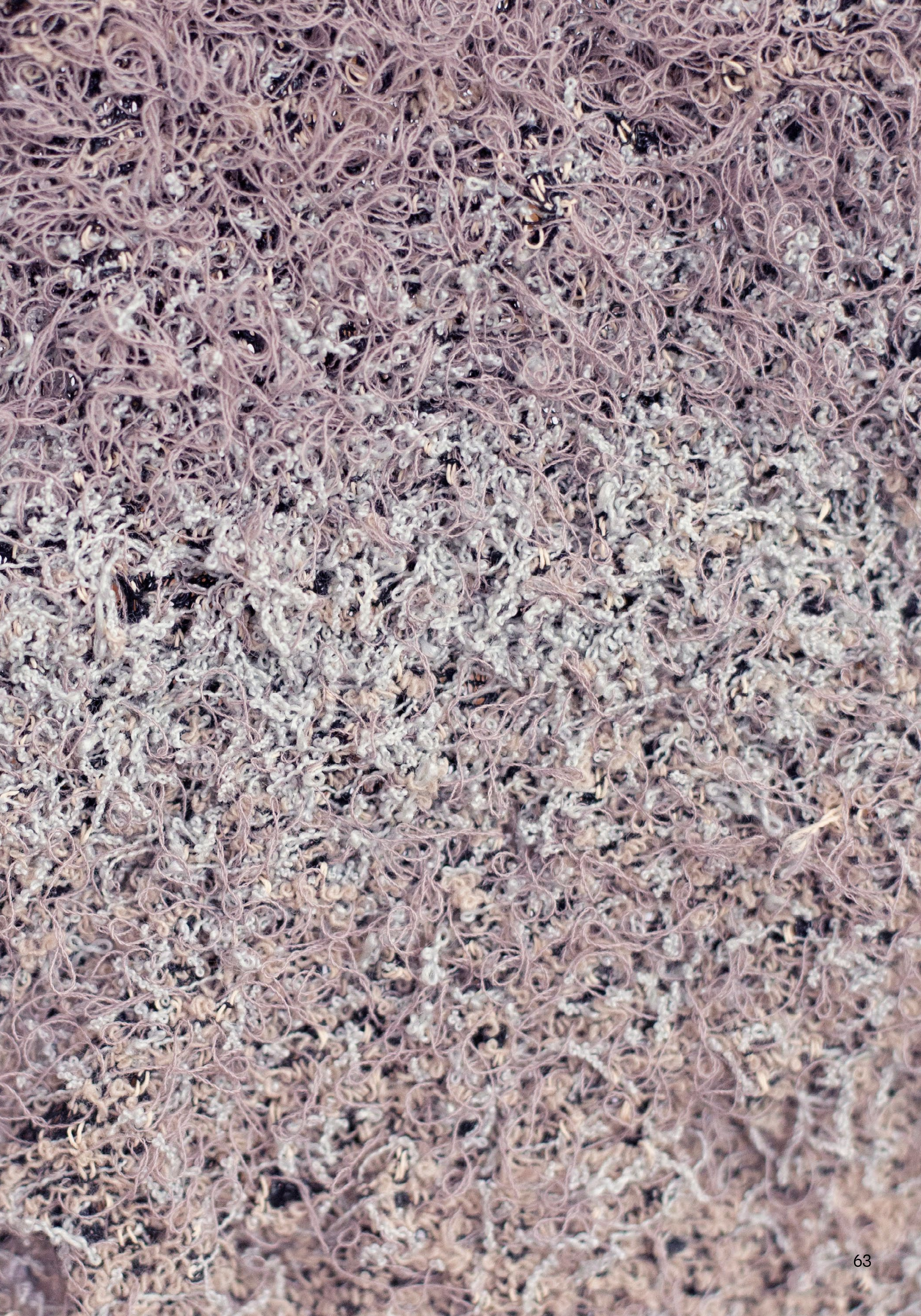
Detail of the weave graphic and Jacquard simulation, showing monofilament yarns (blue) intermittently weaving on the face of the compound satin fabric. Dark areas are weft-faced, where more dye will be absorbed.

6. Works

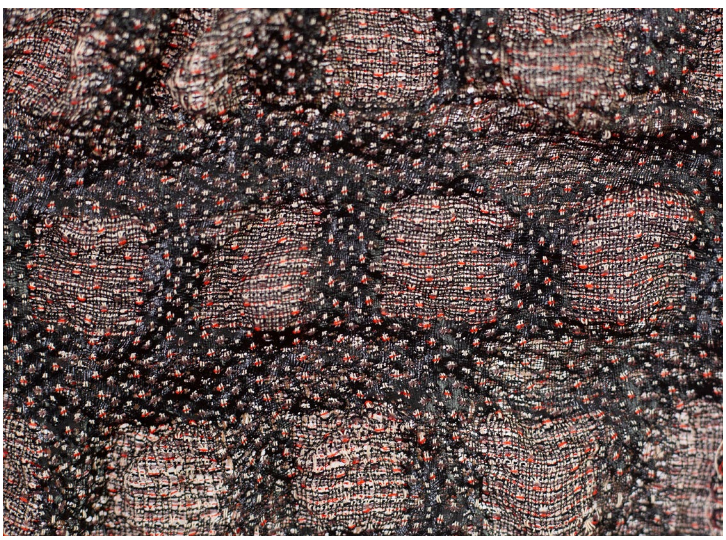
Loop-pile prototype 1, viscose and polycaprolactone yarns woven on 10-harness floor loom, 4” x 13”, 2022.

Loop-pile prototype 2, viscose, wool and polycaprolactone yarns woven on 10-harness floor loom, 5” x 20”, 2022.

Loop-pile prototype 3, cotton, elastic cotton, elastic hemp, viscose and polycaprolactone yarns woven on 10-harness floor loom, 4" x 11", 2022.



Loop-pile prototype 4, hand-painted paper, viscose and polycaprolactone yarns woven on 10-harness floor loom, 6” x 12”, 2022.



Loop-pile prototype 5, cotton, polyester, viscose and polycaprolactone yarns woven on 10-harness floor loom, 9” x 6”, 2022.

Loop-pile prototype 7, hand-dyed elastic hemp, wool, cotton, linen, viscose, nylon, polyester and polycaprolactone yarns woven on 10-harness floor loom, 8” x 10”, 2022.

Loop-pile prototype 6, hand-dyed elastic cotton, wool, cotton, linen, viscose, nylon, polyester and polycaprolactone yarns woven on 10-harness floor loom, 8” x 12”, 2022.

Loop-pile prototype 8, hand-dyed elastic hemp, wool, cotton, linen, viscose, nylon, polyester and polycaprolactone yarns woven on 10-harness floor loom, 4″ x 8″, 2022.

Loop-pile prototype 9, hand-dyed elastic hemp, viscose and polycaprolactone yarns woven on 10-harness floor loom, 3" x 24", 2022.

Double Portal, hand-dyed elastic hemp, viscose and polycaprolactone yarns woven on 10-harness loom, 24″ x 24″ x 4″ each, 2022.

Woven spacer prototype 1, cotton, polyester and nylon monofilament yarns woven on 16-harness floor loom, 12” x 16” x 1.5”, 2022.

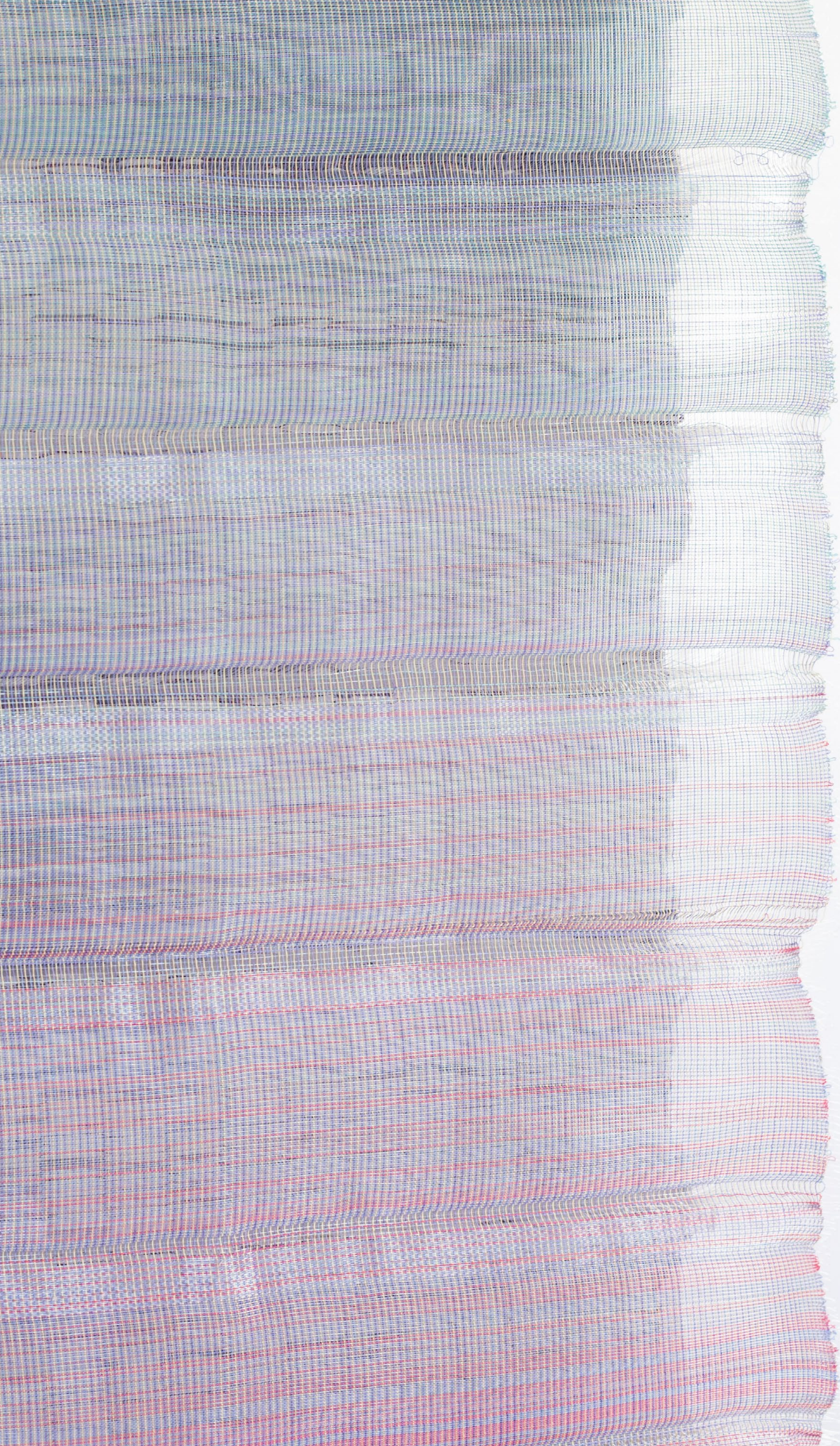
Woven spacer prototype 2, cotton, polyester, wool and nylon monofilament yarns woven on 16-harness floor loom, 12″ x 14″ x 1.5″, 2022.

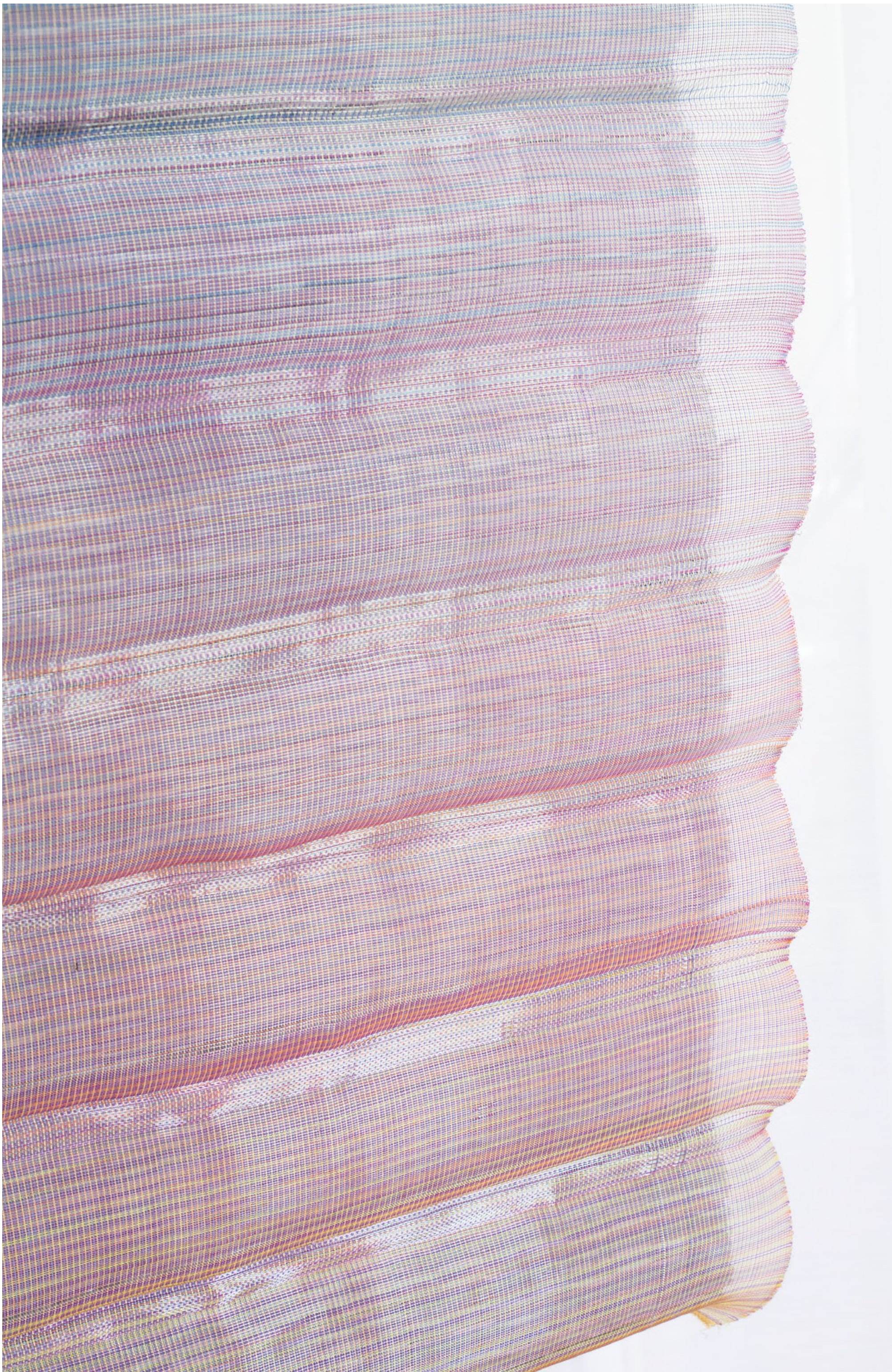
Woven spacer prototype 3, cotton, polyester, wool and nylon monofilament yarns woven on 16-harness floor loom, 12” x 14” x 2.5”, 2022.

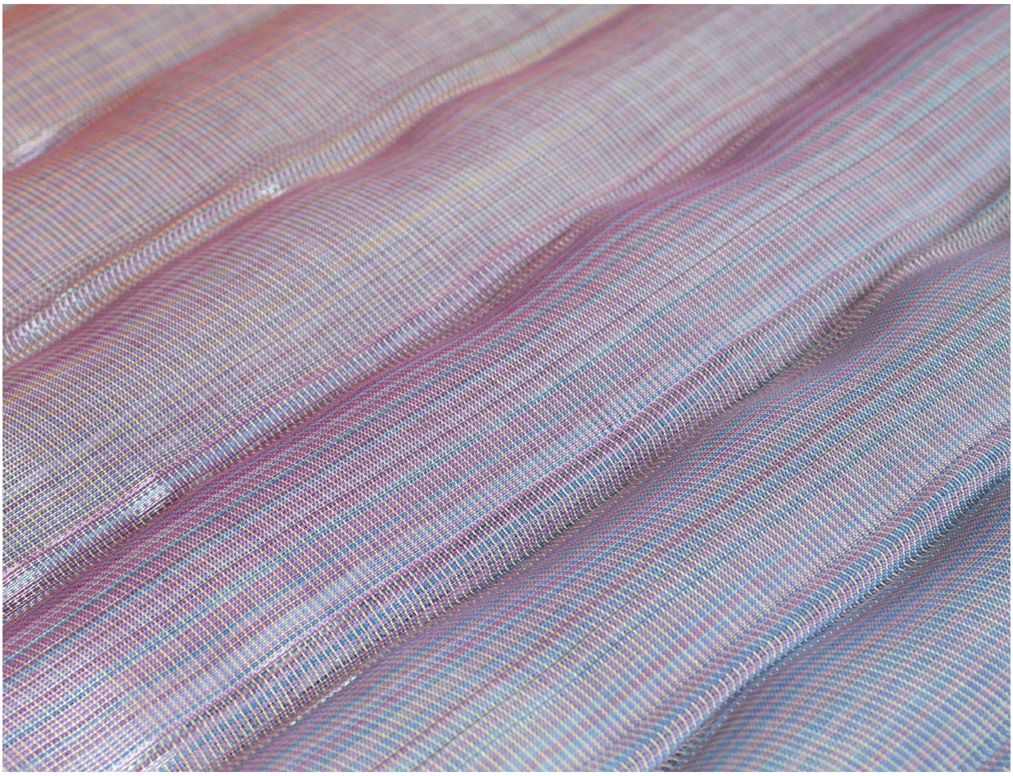
Translucency study for woven spacer, cotton, polyester and nylon monofilament yarns woven on 16-harness floor loom, 12” x 12”, 2022.

Testing the compressibility of woven spacer fabrics.

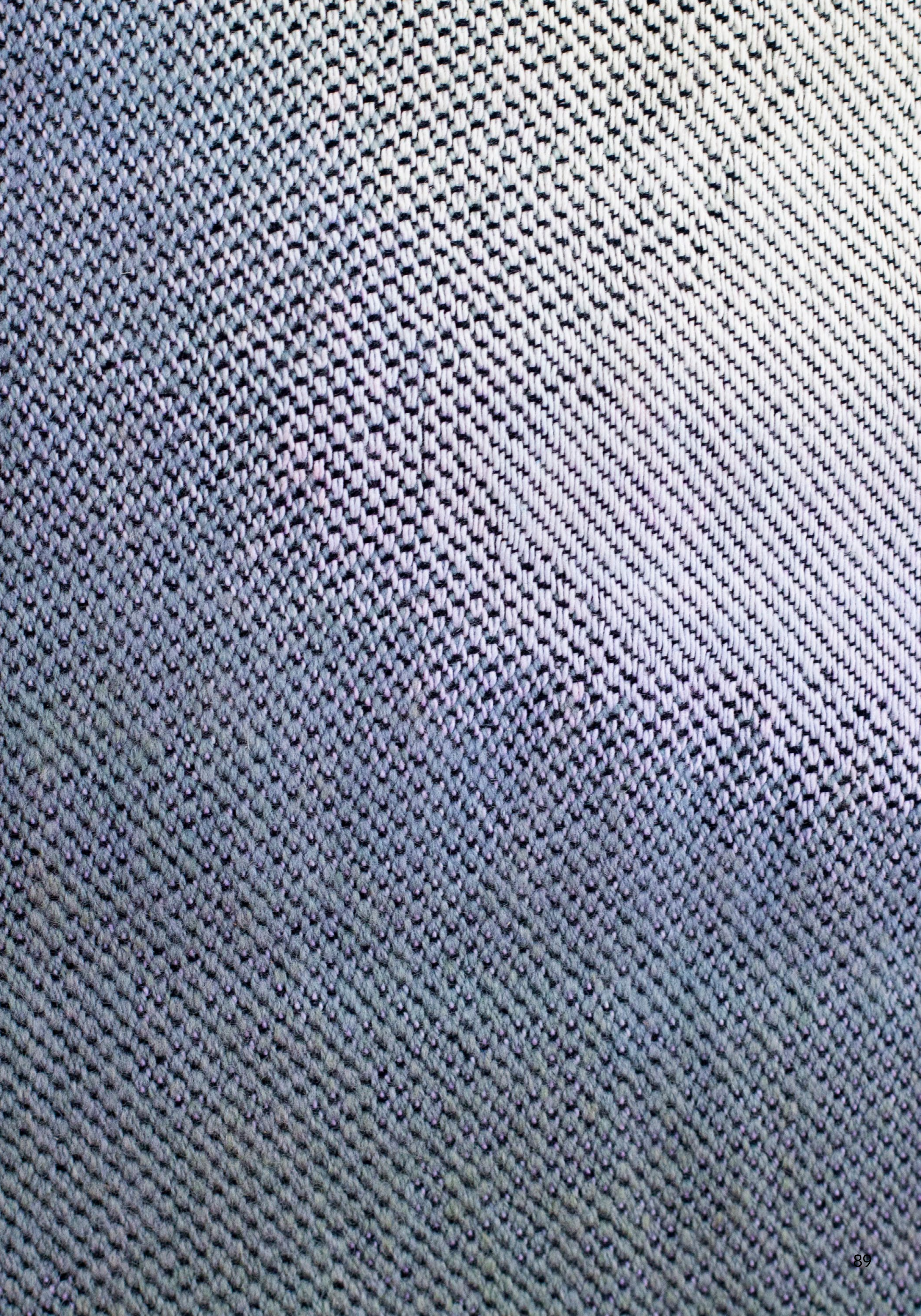
Sliding Threshold (reverse side shown here), hand-dyed cotton and nylon monofilament yarns woven on 24-harness dobby loom, 36″ x 48″ x 4″, 2022.





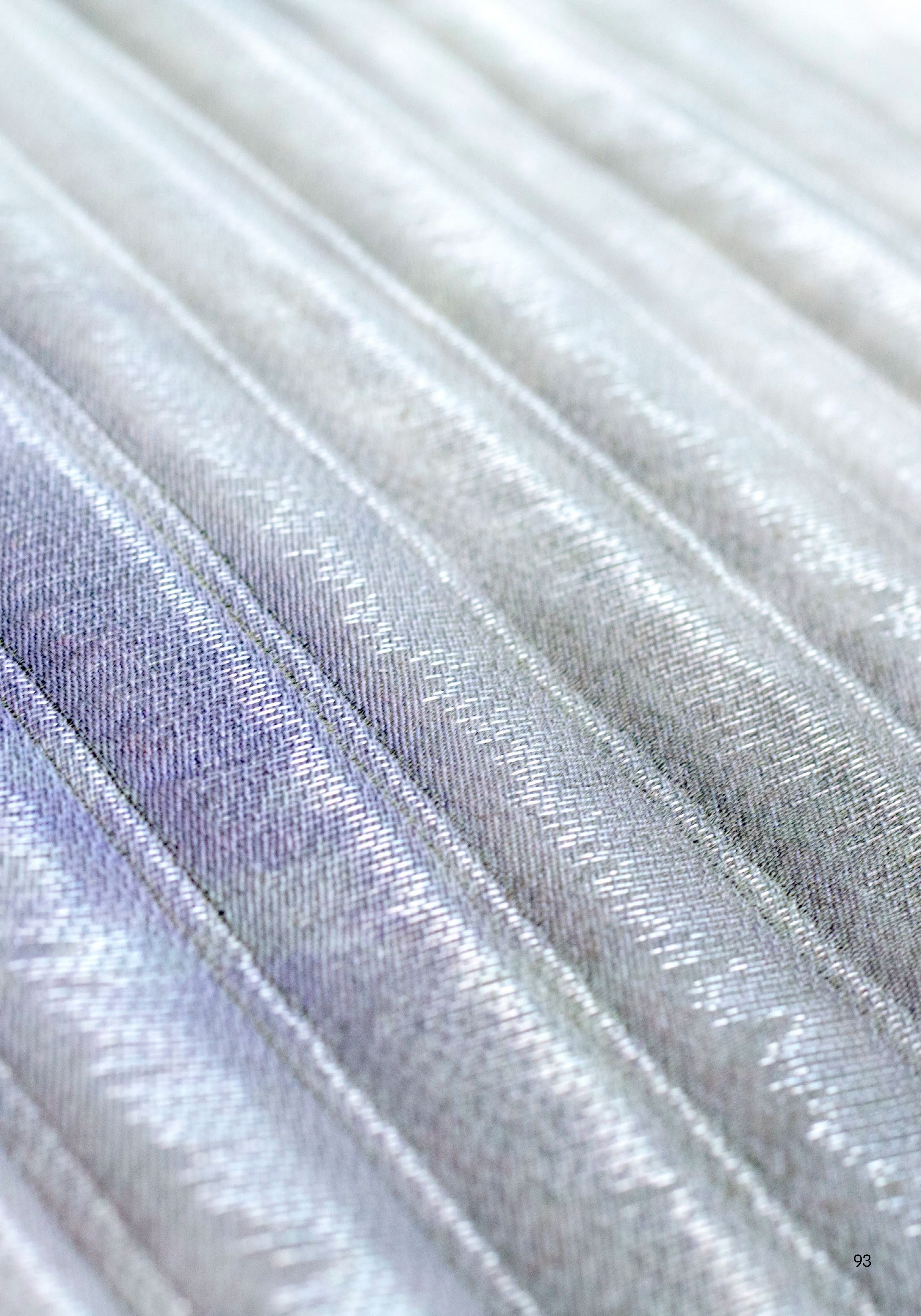


Depth of Field, hand-painted cotton and wool yarns woven on Jacquard loom, 36” x 54”, 2022.



Open-Window Unit, hand-painted cotton and wool yarns woven on Jacquard loom, 36” x 54”, 2022.

Lighting Condition, hand-painted cotton, wool and nylon monofilament yarns woven on Jacquard loom, 42″ x 54″, 2022.



Conclusion

Allowing active yarns and generative processes to influence the character of these fabrics was central to the methodology of this thesis. A sort of indirect shaping of matter, by setting the constraints of the landscape where spontaneous events unfold, is parallel to the stated goal of reshaping experiences in interior environments by changing the rules by which phenomena occur. Fabrics that trap sound in their dense interior layers, or allow hazy light to pass through, achieve this in a practical sense; colors and patterns that seem to shift, animating a static space, do so at the level of perception, blending universal cognition, cultural association and personal memory. Some samples made during this exploration also displayed potentially useful properties, like self-supporting structure and compressibility, that were not fully explored here.

While thorough acoustical testing was not within the scope of this thesis, the fabrics are intended to be prototypes worthy of future testing and speculation. They support the idea that functional fabrics can and should contribute to the aesthetic character and affective experience of the environment they are used in, rather than maintaining a neutral, technical appearance or being completely hidden. The form factors that enable a textile to perform at a high level can be incorporated into its ornamentation, but this illustrative mode is not the only option. As a textile designer, I balance a deep knowledge of structural properties with a directive to apply color, to let pattern unfold and let yarns twist and buckle within their bindings. These interventions on the surface of the fabric can coexist with, or even augment, its underlying function while constructing a new narrative about what the material is and what it is there for. A certain flexibility of language is useful when describing these works: a painted or woven image can be “active” while motionless, and beauty is one of many functions that a designed object can perform. What these fabrics can do, what they want to do, and what they may cause to happen is still unknown.

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