Feeling Air: Exploring Aesthetic and Material Qualities of Architectural Inflatables

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ABSTRACT

This work explores aesthetic, material, and experiential qualities of inflatable architecture. We created large-scale inflatable structures—from several stories high, to 15m long, to filling a plaza with an inflatables assemblage—in public space. Working from a first-person approach, we offer somaesthetic, material, and practical reflections and design considerations for architectural inflatables. Our findings detail how such large scale inflatables can alter sensory perception in compelling ways. Our discussion suggests future directions for sensory engagements with architectural inflatables.

CCS CONCEPTS

• **Human-centered computing → Interaction design**.

KEYWORDS

inflatable, architecture, somaesthetics, human-building interaction

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1 INTRODUCTION

We draw from related work in Human-Building Interaction, inflatables in HCI, and inflatables in architecture to explore public, outdoor, large scale inflatables. By leveraging first-person soma design methods, we attend to experiential, aesthetic, and material qualities of these architectural inflatables. From there, this late-breaking work points to future opportunities to incorporate interactions with digital technology and architectural inflatables.

2 BACKGROUND

2.1 Human-Building Interaction

As HCI expands to not only develop artefacts but also architecture, new design considerations are needed for human-building interaction [4]. Alavi et al. call for investigating considerations needed for designing environments rather than artefacts, how to combine interaction design and architecture, experimenting with novel interactive architecture designs, bringing architecture theory into HCI, and examining how methods and approaches from HCI can be applied to architecture [5]. Responding to this, our work surfaces particular considerations for designing inflatable environments rather than inflatable artefacts and offers one instance of combining approaches from interaction design and architecture. Nabil et al. outline opportunities for interactive architecture to leverage

[*]The first author led the digital media project studio and the writing of this paper. The second author led the architecture project studio and the making of the inflatables.

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Figure 1: Iterations: Our iterative prototypes increased in scale and technical difficulty over time. (top row) One of the first inflatables we made, a 3m cube wrapped with cords shown inflating. When inflating up to size, inflatables tumble, writhe, and transform before settling into their equilibrium shape, gently swaying but stable. (middle) Several 3m square 'pillows' cascade down a building, glowing in the light and swaying in the breeze. (bottom) The assemblage of rounded foil forms felt like alien meteors that had recently fallen to earth, or monstrous dew drop pearls.

Figure 2: Final Exhibition: The site-specific forms for the Black Mountain College Museum and Arts Center annual conference invited conference attendees to mingle in the courtyard and explore the interior of a 4m cube (left) and go in a 15m tunnel (right).

explore nonplanar, morphing 3D shapes [29]. Engaging their key considerations for this, our work investigates the expressiveness and aesthetic experience of inflatable architecture.

2.2 Soma Design Approaches

Höök's *Designing with the Body: Somaesthetic Interaction Design* outlines kinaesthetic properties of large shape-changing interfaces, such as walls and furniture, as being of particular interest for soma design (p. 166) [22]. Drawing on first-person experiences can be used for soma design to help foreground the experience of dynamic materials; designers use their own body, senses, and somatic sensitivity to more fully understand the experience of what they are designing [23]. For example, Tsaknaki used soma design for the wearable inflatable the Breathing Wings [41]. Considering how Human-Building Interaction and the shift from artefacts to environments demands attention to the inherently immersive and multisensory qualities of environments, we sought to use first-person soma design approaches to shape our inflatable environments. Through estrangement, a suggested tactic for first-person soma design [23], the lead author in our work spent time slowly attending to unique somaesthetic qualities of being inside inflatable environments.

2.3 Inflatables in HCI

Related work explores somaesthetic, material, and performative aspects of inflatables. For example, Bewley and Vallgårda outline ways that the provocative and performative qualities of inflatables

Figure 3: Fabrication: After 3D modeling shapes and 'unwrapping' 2D surfaces as patterns, shapes were cut out of sheet material using frames or other stencils (right) and required many hands to hold the pieces in place and tape along the seams (left, middle).

can help expand the design space for soft robotics [10]. Bewley shows the throbbing [7, 8] of a small, pale, rounded inflatable Blo-nut. Tsaknaki's Breathing Wings offer an autobiographical soma design inquiry into breathing [41] qualities of inflatables on the body. The softness and embodied tangibility of inflatables can have an 'aliveness' and material vibrancy [6, 42]. In their liveliness and gentle responsiveness with human bodies, inflatables have their own expressiveness that lends a feeling of otherness, as Boer and Bewley describe with Blo-nut [9, 11]. Oktay analyzes a small, curling inflatable as a liminal interface between animate and inanimate [31, 32]. At the scale of artefacts, wearables, and social robots, inflatables have a sense of liveliness and otherness. In our work, we explore this lively otherness at architectural scale.

HCI explores a variety of interactions and fabrication techniques with inflatables. Interaction possibilities with inflatables include punching [27], theatrical data display [40], squeezing a mouse [25], exploring affective qualities of simple movements [37], petting inflatable rabbits [14], bodily compression [15], simulating objects in VR [38], force feedback on the arms in VR [19], or a shoulder "tap" to indicate left or right when giving directions [36]. Fabrication techniques include embroidery with silicone bladders [34], silicone bladders [28], stitching on stretchy fabric to control shape change [39], replay direct manipulation [30], firm 3D printed inflatables [20], rapid prototyping [18], and other shape-changing interfaces [24]. These works are often airtight and at relatively smaller scale. In our work, we explore fabrication approaches for large scale inflatables that are not airtight (see 4.1).

2.4 Inflatables in Architecture

Ant Farm, a collective of architecture dropouts from California, self-published *Inflatocookbook* [1] in 1971, which they circulated widely while also conducting workshops across the US. Their document and work promoted techniques for making large-scale inflatables from polyethylene sheeting, encouraging an alternative form of spatial production counter to the rigidity of traditional architecture [1]. In our work, we draw from Ant Farm's fabrication techniques for using polyethylene sheets to make architectural inflatables.

Ant Farm's work demonstrated how inflatables can activate public space. Their 1972 "Air Emergency", a 12x12m inflatable dome, protested declining air quality [16]. Decades later in 2014, Inflatable General Assembly offered a gathering space for Occupy protests in New York City [21]. Inflatables can also invite playful interactions in public space, such as rainbow arches [3] or a chamber with beams of light [33]. In a similar vein, Christo and Jeanne-Claude used very large textiles to make bold, joyful forms across landscapes [13]. Lightweight, quick to un/install, and sometimes capable of eliding city permit constraints, inflatables have potential to resist imposed order and privatization of public space through protest and play [12]. We designed our inflatables to activate the outdoor public space at an arts conference.

3 PROCESS

We collaborated across distance and disciplines. The first and second author taught two simultaneous graduate level project studio courses at two different universities 650km apart in the United States. One project studio, in an architecture department, focused on inflatable architecture. The other project studio, in an interaction design department, designed digital interactions with architectural inflatables, for critical reflection on facial recognition surveillance in public space. This paper focuses on architectural inflatables, yet all students of both project studios are credited as authors to acknowledge the collaborative nature of the process. The two project studios brainstormed together on Miro, an online whiteboard platform, resulting in over 40 sketches of different forms. The architecture project studio iteratively prototyped inflatables of increasing technical difficulty and scale (Fig. 1). The two project studios collaborated in producing an exhibition for the Black Mountain College Museum and Arts Center annual conference [2], about equidistant from the coauthors' two universities. The site-specific forms for the exhibition (Fig. 2) were designed to activate to the outdoor space of the arts conference.

We draw from a first-person soma design approach. From these experiences designing, building, and exhibiting inflatables, we gained firsthand knowledge the multisensory experience of these immersive environments. The lead author specializes in tangible, embodied design and works with large inflatables as part of her ongoing arts research practice. In this project, she engaged estrangement [23] for soma design as a way of slowing down and noticing unique qualities of inflatables. She documented her reflections with notes, photos, and video snippets of particular interactions.

Figure 4: Textures: (left) Rain drops and wrinkles add textural memories of recent rainfalls and un/foldings. We used translucent polyethylene sheets (6mil thickness) because it is recyclable and durable. It diffuses light and blurs what is on the other side. (middle) The foil crinkles noisily. It both reflects light like a broken mirror and is slightly translucent. (right) Dichroic film splits light into multiple colors, shown here reflecting off of polyethylene around sunset.

4 FINDINGS

4.1 Designing and Making Inflatables

Inflatables were first sketched, then 3D modeled, then 'unwrapped' into patterns to cut out from flat sheets (Fig. 3). We found that cutting with scissors and joining seams with packaging tape was both faster and more easily precise than other methods such as heat sealing. We found that, whatever we modeled, all shapes bulged outward toward spheres, cylinders, or pillows, so we gravitated toward these forms. We taped in vertical zippers for people to enter and exit.

We had to collaborate with air's material agency. Air pushes outward in all directions against the shell, constantly flowing in via fans and out via seams, reaching equilibrium. If the seams do not have enough holes, they break open at places to achieve equilibrium. This is advantageous because an prick during outdoor deployment makes no difference. In windy conditions, a large inflatable can blow away. We placed sandbags in it for stability while allowing it to still move in the breeze. In one case, we had to rotate the tube inflatable (Fig. 2) 90 degrees to avoid catching the wind.

We experimented with a variety of computational interactions, such as inflating/deflating, bubbles, lighting, capacitive sensing, amplifying the crinkling sounds of the inflatables, and projecting dynamic visuals onto the surface of the inflatables from the inside. We used Arduino, Raspberry Pi, Processing, Python, power relay, pneumatics, LED strip, piezos, speakers, amplifiers, and projectors. For example, turning the fans on and off automatically with a power relay can create a 'breathing' effect. The foil sheet material is conductive and can work as a capacitive sensor. We found that the inflatables can support taping or hanging small items from the side walls.

4.2 Exploring Textural and Material Qualities

Polyethylene diffuses light and blurs shapes and colors passing through it. A sunbeam onto the cascading pillows got 'caught', diffused, and created a glow (Fig. 1). This material can be recycled at some locations. Scraps can easily be re-sealed with heat sealing or clear packing tape, and holes patched over with clear packing tape. Polyethylene in 6mil thickness is widely available at big box hardware stores in our region because it is used to cover the floor and other surfaces when painting. It is also more sturdy and does not propagate tears when nicked. For all these reasons, we used this translucent white polyethylene sheets as the base material for many of the inflatables as the base material, adding foil and dichroic film as accent patches. When an inflatable of polyethylene shifts in the breeze, it rustles. As with the foil and dichroic film, polyethylene can be cut with scissors and sealed with clear packing tape.

Surplus agricultural foil was donated for this project. The foil quickly crinkles and holds its wrinkles. It reflects light like a broken mirror; its 3D crinkled surface reflects light in different directions and with the curved distortion. Colors are relatively unaltered but shapes are shattered. The foil is also slightly translucent.

The dichroic film filters light. It allows some colors of light to pass through and reflects other colors of light. In natural sunlight, swaying in the breeze, this created a mesmerizing effect. Its appearance changes depending on the surrounding objects, a cloud passing by the sun, or the quality of light changing over the course of the day. The reflected light came through in complex spider web and angular patterns from the wrinkles in the material, and reflected off the white polyethylene and surrounding pavement, people, or whatever else was around. For example, at sunset, it created stunning lace-like wisps of flame (Fig. 4), whereas on a sunny afternoon with clear skies it looked completely different (Fig. 2). This material was more expensive and fragile, so we used it primarily for accent patches or stripes.

4.3 Being Inside: Altered Sounds, Movements, and Spatial Perception

Being inside offers a unique soundscape. It is windy inside; the fans produce a drone hum. The inflated membrane is constantly swaying and stirring in ambient breezes, rustling and crinkling. The interior environment both muffles and strangely amplifies sounds of speaking or footsteps. Outside sounds are dimmed by the fan hum. As the inflatable sways in the breeze, it rustles. The foil crinkles noisily, sometimes too intense, almost overwhelming, overriding conversation and obliterating thought, sometimes more like the satisfying crunch of walking on dry leaves.

Regarding movement, even the slightest breeze can make the inflatables shift and sway. As people enter and exit through zippers, the opening causes the inflatable to sag. Once the zipper is closed, the inflatable gradually expands again. From inside, sagging can feel a bit claustrophobic if the zipper is left open too long. People often tap, poke, punch, or stroke the inflatables' surfaces. Depending on

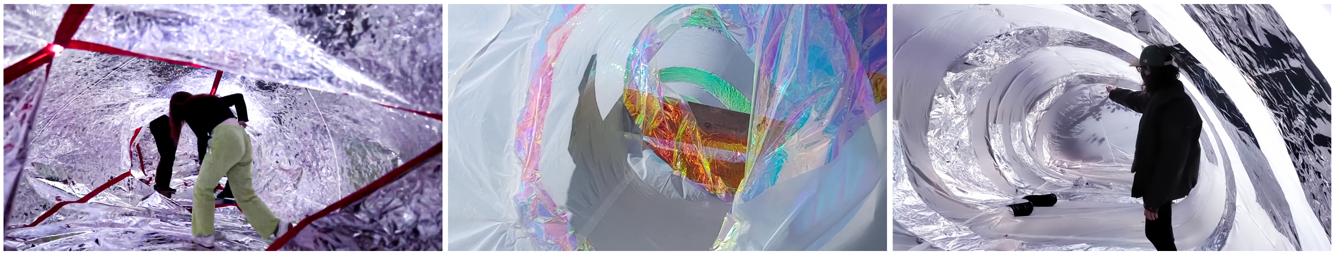

Figure 5: Inside (left) foil, (middle) polyethylene and dichroic sheets, and (right) a tube of polyethylene with foil stripes.

the shape, passerby may also hug or attempt to climb them. These are relatively low pressure inflatables and do not support climbing, though people could lean against them.

Being inside alters spatial perception. They filter natural sunlight in unexpected patterns. Seen from inside, objects outside such as tree branches or trellis beams cast shadows that lie in unexpected curves along the curved surface of the inflatable. From inside, everyday familiar objects that provide reference points for ground or vertical are hidden. Instead, one is surrounded by swaying sheets of soft material (Fig. 5). With no clear horizon line or vertical reference point to orient one's sense of balance, it could be immersive, a bit disorienting, or even nauseating as the walls swayed unceasingly in the breeze. At their best, however, the spatial effect is immersive and enchanting, a world apart from the exterior everyday environment. People inside the inflatable often interacted with people outside the inflatable, playing with the effect on distance on how blurred their appearance was to one another, or pressing hands together across the material. For an inflatable with relatively vertical polyethylene sides such as the cube (Fig. 1), a person inside can stand near a person outside; they can see one another, slightly blurred. For a shape such as the large tunnel (Fig. 2), people outside can stand close to the surface and be seen by people inside. People inside cannot stand so close to the surface due to the tube shape, so they appear as blurry, shadowy figures to those outside.

5 DISCUSSION

Our findings detail how being inside these inflatables offers a multisensory immersive environment. The sounds, light, and swaying surfaces respond to the outside environment, yet inside feels like a different world. This defamiliarization offers a kind of estrangement, a break away from the familiar and taken-for-granted auditory, visual, and spatial perceptions, that invites attending to these senses anew. Soma design approaches helped us attend to the unique qualities of inflatables. We argue that the complex sensory effects achieved with relatively simple materials merits further exploration for somaesthetic design. Reflecting on the highly collaborative engagement with materials we engaged in, we also see opportunities to analyze practices of making inflatables through the lens of *sympoietic* craft in HCI as put forth by Frankjaer and Dalsgaard [17].

Engaging the shift described in Human-Building interaction from artefacts to architecture [4], our findings detail ways in which inflatables are like and unlike typical buildings. Seen from afar, these inflatables may seem less like buildings and more like alien shapes or sculptures due to their unusually curved and smooth surfaces. From inside, the inflatables create an immersive space (similar to a building), but they still constantly respond to the ambient light, breeze, and sounds from outside. These inflatables are more sensorially exposed than a typical camping tent with opaque sides and tension wire framing. These inflatables play with notions of public and private space with translucent, porous boundaries. In their design, too, they are lightweight and can be designed and built relatively quickly, at the time scale of computational artefacts. We posit that inflatables may offer a bridge or unique blending of qualities of artefacts and architecture that merits further exploration.

In future work, we aim to continue exploring digital interactions, both for critical design and algorithmic experience [26] as well as tangible possibilities. For example, mechanical systems or air chambers of different shapes could offer kinetic actuation possibilities. Building on the potential of shape-changing data displays [35], large inflatables could be a performative, provocative [10] collective data display.

6 CONCLUSIONS

We offer detailed aesthetic, material, and experiential qualities of architectural inflatables we created. We describe specific techniques for making these inflatables, as well as particular textural qualities of the materials used. We describe the multisensory experience of being inside these inflatables—how filter sound and light and alter spatial perception. We also begin to point to exciting possibilities for human-building interaction to explore architectural inflatables with future directions by integrating digital interactions with architectural inflatables.

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REFERENCES

[1] 1971. *Ant Farm Inflatocookbook.* Technical Report. http://inflatocookbook.kadist.org/
[2] 2021. ReVIEWING 12 Conference Schedule. https://www.blackmountaincollege.org/reviewing-12-conference-schedule/
[3] 2021. SKY CASTLE – Interactive public art installation. https://www.eness.com/projects/skycastle
[4] Hamed S. Alavi, Elizabeth Churchill, David Kirk, Henriette Bier, Himanshu Verma, Denis Lalanne, and Holger Schnädelbach. 2018. From Artifacts to Architecture. In *Proceedings of the 2018 ACM Conference Companion Publication on Designing*

Interactive Systems (DIS '18 Companion). Association for Computing Machinery, New York, NY, USA, 387–390. https://doi.org/10.1145/3197391.3197393

[5] Hamed S. Alavi, Elizabeth F. Churchill, Mikael Wiberg, Denis Lalanne, Peter Dalsgaard, Ava Fatah gen Schieck, and Yvonne Rogers. 2019. Introduction to Human-Building Interaction (HBI): Interfacing HCI with Architecture and Urban Design. *ACM Transactions on Computer-Human Interaction* 26, 2 (March 2019), 6:1–6:10. https://doi.org/10.1145/3309714

[6] Jane Bennett. 2010. *Vibrant matter: a political ecology of things.* Duke University Press, Durham.

[7] Harvey Bewley. 2016. @performing_objects - A warm heartbeat in the hand. #konstfack #design #weird #touch #glow #arduino #expression #playful. https://www.instagram.com/performing_objects/

[8] Harvey Bewley. 2017. @performing_objects - Throb. Throb. Throb (#throb). https://www.instagram.com/p/BaUm4kzFaKn/

[9] Harvey Bewley and Laurens Boer. 2018. *Designing Blo-nut*: Design Principles, Choreography and Otherness in an Expressive Social Robot. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18).* Association for Computing Machinery, New York, NY, USA, 1069–1080. https://doi.org/10.1145/3196709.3196817

[10] Harvey Bewley and Anna Vallgårda. 2017. Provoking Performing Objects: Expanding the Design Space for Soft Robotics. In *Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems (DIS '17 Companion).* Association for Computing Machinery, New York, NY, USA, 243–248. https://doi.org/10.1145/3064857.3079154

[11] Laurens Boer and Harvey Bewley. 2018. Reconfiguring the Appearance and Expression of Social Robots by Acknowledging their Otherness. In *Proceedings of the 2018 Designing Interactive Systems Conference.* ACM, Hong Kong China, 667–677. https://doi.org/10.1145/3196709.3196743

[12] Gavin Browning (Ed.). 2015. *Group efforts: changing public space.* GSAPP Books, New York, NY.

[13] Christo Christo and Jeanne-Claude Jeanne-Claude. 1972. Valley Curtain. https://christojeanneclaude.net/artworks/valley-curtain/

[14] Ben Dalton. 2004. Rabbit field. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques (DIS '04).* Association for Computing Machinery, New York, NY, USA, 316. https://doi.org/10.1145/1013115.1013166

[15] Shreyosi Endow, Hedieh Moradi, Anvay Srivastava, Esau G Noya, and Cesar Torres. 2021. Compressables: A Haptic Prototyping Toolkit for Wearable Compression-based Interfaces. In *Designing Interactive Systems Conference 2021.* Association for Computing Machinery, New York, NY, USA, 1101–1114. https://doi.org/10.1145/3461778.3462057

[16] Ant Farm. 1972. Air Emergency.

[17] Raune Frankjaer and Peter Dalsgaard. 2020. Knowledge-creation Processes in Crafts-based HCI Research: Introducing a Sympoietic Framework. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society.* Number 49. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3419249.3420114

[18] Radhika Ghosal, Bhavika Rana, Ishan Kapur, and Aman Parnami. 2019. Rapid Prototyping of Pneumatically Actuated Inflatable Structures. In *The Adjunct Publication of the 32nd Annual ACM Symposium on User Interface Software and Technology (UIST '19).* Association for Computing Machinery, New York, NY, USA, 78–80. https://doi.org/10.1145/3332167.3357121

[19] Sebastian Günther, Mohit Makhija, Florian Müller, Dominik Schön, Max Mühlhäuser, and Markus Funk. 2019. PneumAct: Pneumatic Kinesthetic Actuation of Body Joints in Virtual Reality Environments. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19).* Association for Computing Machinery, New York, NY, USA, 227–240. https://doi.org/10.1145/3322276.3322302

[20] Changyo Han, Ryo Takahashi, Yuchi Yahagi, and Takeshi Naemura. 2021. 3D Printing Firm Inflatables with Internal Tethers. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems.* Association for Computing Machinery, New York, NY, USA, 1–7. https://doi.org/10.1145/3411763.3451613

[21] Greta Hansen, Kyung Jae Kim, and Adam Koogler. 2015. Inflatable General Assembly. In *Group efforts: changing public space*, Gavin Browning (Ed.). GSAPP Books, New York, NY.

[22] Kristina Höök. 2018. *Designing with the body: somaesthetic interaction design.* The MIT Press, Cambridge, Massachusetts.

[23] Kristina Höök, Baptiste Caramiaux, Cumhur Erkut, Jodi Forlizzi, Nassrin Hajinejad, Michael Haller, Caroline Hummels, Katherine Isbister, Martin Jonsson, George Khut, Lian Loke, Danielle Lottridge, Patrizia Marti, Edward Melcer, Florian Müller, Marianne Petersen, Thecla Schiphorst, Elena Segura, Anna Ståhl, Dag Svanæs, Jakob Tholander, and Helena Tobiasson. 2018. Embracing First-Person Perspectives in Soma-Based Design. *Informatics* 5, 1 (Feb. 2018), 8. https://doi.org/10.3390/informatics5010008

[24] Hyunyoung Kim, Aluna Everitt, Carlos Tejada, Mengyu Zhong, and Daniel Ashbrook. 2021. MorpheesPlug: A Toolkit for Prototyping Shape-Changing Interfaces. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems (CHI '21).* Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3411764.3445786

[25] Seoktae Kim, Hyunjung Kim, Boram Lee, Tek-Jin Nam, and Woohun Lee. 2008. Inflatable mouse: volume-adjustable mouse with air-pressure-sensitive input and haptic feedback. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08).* Association for Computing Machinery, New York, NY, USA, 211–224. https://doi.org/10.1145/1357054.1357090

[26] Goda Klumbyte, Phillip Lücking, and Claude Draude. 2020. Reframing AX with Critical Design: The Potentials and Limits of Algorithmic Experience as a Critical Design Concept. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society.* Number 67. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3419249.3420120

[27] Hyosun Kwon, Seok-Hyung Bae, Hwan Kim, and Woohun Lee. 2012. Inflated roly-poly. In *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction (TEI '12).* Association for Computing Machinery, New York, NY, USA, 189–192. https://doi.org/10.1145/2148131.2148172

[28] Hedieh Moradi and César Torres. 2020. Siloseam: A Morphogenetic Workflow for the Design and Fabrication of Inflatable Silicone Bladders. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference.* Association for Computing Machinery, New York, NY, USA, 1995–2006. https://doi.org/10.1145/3357236.3395473

[29] Sara Nabil, Thomas Plötz, and David S. Kirk. 2017. Interactive Architecture: Exploring and Unwrapping the Potentials of Organic User Interfaces. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction (TEI '17).* Association for Computing Machinery, New York, NY, USA, 89–100. https://doi.org/10.1145/3024969.3024981

[30] Ryosuke Nakayama, Ryo Suzuki, Satoshi Nakamaru, Ryuma Niiyama, Yoshihiro Kawahara, and Yasuaki Kakehi. 2019. MorphIO: Entirely Soft Sensing and Actuation Modules for Programming Shape Changes through Tangible Interaction. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19).* Association for Computing Machinery, New York, NY, USA, 975–986. https://doi.org/10.1145/3322276.3322337

[31] Gizem Oktay. 2020. In the Process of a Relational Becoming. https://mcharg.upenn.edu/blog/process-relational-becoming

[32] Gizem Oktay. 2020. Liminal Beings. https://www.gizemoktay.com/liminal-beings

[33] Pneuhaus. 2021. Atmosphere. https://www.pneu.haus/atmosphere

[34] Bruna Goveia da Rocha, Oscar Tomico, Daniel Tetteroo, Kristina Andersen, and Panos Markopoulos. 2021. Embroidered Inflatables: Exploring Sample Making in Research through Design. *Journal of Textile Design Research and Practice* 9, 1 (Jan. 2021), 62–86. https://doi.org/10.1080/20511787.2021.1885586

[35] Kim Sauvé, Saskia Bakker, Nicolai Marquardt, and Steven Houben. 2020. LOOP: Exploring Physicalization of Activity Tracking Data. In *Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society.* Number 52. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3419249.3420109

[36] Tim Claudius Stratmann, Shadan Sadeghian Borojeni, Wilko Heuten, and Susanne C.J. Boll. 2018. ShoulderTap - Pneumatic On-body Cues to Encode Directions. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (CHI EA '18).* Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3170427.3188624

[37] Haodan Tan, John Tiab, Selma Šabanović, and Kasper Hornbæk. 2016. Happy Moves, Sad Grooves: Using Theories of Biological Motion and Affect to Design Shape-Changing Interfaces. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16).* Association for Computing Machinery, New York, NY, USA, 1282–1293. https://doi.org/10.1145/2901790.2901845

[38] Shan-Yuan Teng, Tzu-Sheng Kuo, Chi Wang, Chi-huan Chiang, Da-Yuan Huang, Liwei Chan, and Bing-Yu Chen. 2018. PuPoP: Pop-up Prop on Palm for Virtual Reality. In *Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology (UIST '18).* Association for Computing Machinery, New York, NY, USA, 5–17. https://doi.org/10.1145/3242587.3242628

[39] Rundong Tian and Jonathan Bachrach. 2015. Multiplanar. https://rutian.github.io/multiPlanar

[40] Cesar Torres, Jasper O'Leary, and Eric Paulos. 2016. LiveObjects: Leveraging Theatricality for an Expressive Internet of Things. In *Proceedings of the 2016 ACM Conference Companion Publication on Designing Interactive Systems (DIS '16 Companion).* Association for Computing Machinery, New York, NY, USA, 5–8. https://doi.org/10.1145/2908805.2908807

[41] Vasiliki Tsaknaki. 2021. The Breathing Wings: An Autobiographical Soma Design Exploration of Touch Qualities through Shape-Change Materials. In *Designing Interactive Systems Conference 2021.* Association for Computing Machinery, New York, NY, USA, 1266–1279. https://doi.org/10.1145/3461778.3462054

[42] Vasiliki Tsaknaki, Karey Helms, Marie Louise Juul Søndergaard, and Marianela Ciolfi Felice. 2021. "Vibrant Wearables": Material Encounters with the Body as a Soft System. *Journal of Textile Design Research and Practice* 9, 2 (May 2021), 142–163. https://doi.org/10.1080/20511787.2021.1923202 Publisher: Routledge _eprint: https://doi.org/10.1080/20511787.2021.1923202.