Digital Fabrication in Interior Design

Body, Object, Enclosure

Edited by
Jonathon Anderson
and **Lois Weinthal**

ROUTLEDGE

Digital Fabrication in Interior Design

Digital Fabrication in Interior Design: Body, Object, Enclosure draws together emerging topics of making that span primary forms of craftsmanship to digital fabrication in order to theoretically and practically analyze the innovative and interdisciplinary relationship between digital fabrication technology and interior design. The history of making in interior design is aligned with traditional crafts, but a parallel discourse with digital fabrication has yet to be made evident.

This book repositions the praxis of experimental prototyping and integrated technology to show how the use of digital fabrication is inherent to the interior scales of body, objects and enclosure. These three scales act as a central theme to frame contributions that reinforce the interdisciplinary nature of interior design and reinterpret traditional crafts by integrating new methods of making into conventional workflows. Featuring significant international practitioners and researchers, the selected contributions represent the ever-increasing interdisciplinary nature of design, demonstrating a breadth of disciplines.

A foundational text for interiors students and practitioners, *Digital Fabrication in Interior Design* expands the necessary dialogue about digital fabrication at the scale of interiors to inform design theory and practice.

Jonathon Anderson is the Associate Chair and an Associate Professor of Interior Design at Ryerson University in Toronto, Canada. Additionally, Jonathon serves as the Director of The Creative School Design + Technology Lab. He holds a Master of Fine Arts in Furniture Design from Savannah College of Art & Design and a Bachelor of Science in Architecture from Southern Illinois University. His work explores how industrial manufacturing, robotics and CNC technologies influence the design and making processes. As a result, the work is characterized by innovative and explorative methods that result in interconnected design, fine art and technology solutions. From this non-traditional process emerges a provocative, complex design language that visually communicates at varied scales and emphasizes corporeal and phenomenological experiences. To Jonathon, making is not only a practice but a form of critical thinking.

Lois Weinthal is Chair of Interior Design at The Creative School and Professor at Ryerson University in Toronto, Canada. Her research and practice investigate the relationship between architecture, interiors, clothing and objects resulting in works that take on an experimental nature. Her teaching explores these topics where

theoretical discussions in seminars are put into practice in the design studio. She is the editor of *Toward a New Interior: An Anthology of Interior Design Theory*, co-editor of *After Taste: Expanded Practice in Interior Design*, and co-editor of *The Handbook of Interior Architecture and Design*. Lois has received grants from the Graham Foundation, Fulbright, SSHRC and DAAD, and has exhibited and lectured nationally and internationally. Previously, she was Director of the Interior Design Program at Parsons The New School for Design and Graduate Advisor for the Master of Interior Design Program at The University of Texas at Austin. Lois studied architecture at Cranbrook Academy of Art and the Rhode Island School of Design. She currently holds the position of Honorary Professor at the Glasgow School of Art.

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List of Contributors

Viola Ago (b. Lushnjë, Albania) is an architectural designer, educator and practitioner. She directs MIRACLES Architecture and is the current Wortham Fellow at the Rice University School of Architecture. Recently, Viola was awarded the Yessios Visiting Professorship at the Ohio State University Knowlton School of Architecture and the Muschenheim Fellowship at the University of Michigan Taubman College of Architecture. Viola earned her M.Arch degree from SCI-Arc, and a B.ArchSc from Ryerson University. Her written work has been published by Routledge and Park Books, as well as in *Log*, *AD Magazine*, *Offramp*, *Acadia Conference Proceedings*, *JAE*, *TxA*, *Architect's Newspaper* and Archinect.

More recently, Viola's work has been focusing on the role of architecture in a world defined by environments of formal and aesthetics duress. Her personal experiences with the affective conditions of remnants of war has fueled her ambitions towards a design research project that looks at the aesthetic and formal agency of destruction through methods of perceptual mechanisms outlined by political theory and the phenomenology of empathy; and digital technological advancements such as real-time physics engines and fabrication methodologies.

Assa Studio Limited, founded in London in 2003, is closely working with companies' R&D and business innovation units as well as public institutions. Clients include Samsung, Nike and Panasonic as well as the UK government Technology & Strategy Board, the Science Museum, the Design Museum and the Victoria & Albert Museum. The studio focuses on design technology for social and cultural progress.

Assa Studio practice and research is very much about innovation and the development of new industrial design methodologies within digital design and manufacturing. In the center of the Studio's developments is the virtual 'life' of an object, before it is physically produced. Opened to users' input, the digital object can be produced using a wide range of additive layer manufacturing technologies (widely known as 3D printing), mixed with mass production solutions. This is the key difference and maybe the most novel aspect of the Studio's practice. Aesthetics, adaptation and reconfiguration of forms are elements in flux within this new product design workflow.

The Studio today includes a network of highly skilled specialists from the design, science and manufacturing sectors who participate in the development of

dedicated 3D software of sophisticated engineering solutions as an integral part of our design methodology.

Ashley Bigham is an Assistant Professor of Architecture at the Knowlton School of Architecture and co-director of Outpost Office. She was the 2015–2016 Walter B. Sanders Fellow at the University of Michigan's Taubman College of Architecture and Urban Planning. In 2014 Ashley was a Fulbright Research Fellow at the Center for Urban History of East Central Europe in Lviv, Ukraine.

Ashley holds a Master of Architecture from Yale University and a Bachelor of Architecture from the University of Tennessee, where she was awarded the Tau Sigma Delta Bronze Medal for best graduating project. Ashley's design work has been exhibited at the Milwaukee Art Museum, A+D Museum, the University of Michigan, Harvard University GSD, Yale School of Architecture, the Cooper Union and Princeton School of Architecture. Her work has been featured in architectural publications including *Metropolis*, *Mark Magazine*, *ARCHITECT*, *SURFACE*, *PLAT*, *STUDIO*, *POOL* and *CLOG*. Prior to co-founding Outpost Office, Ashley practiced at MOS and Gray Organschi Architecture in New Haven, CT.

Brennan Buck is a principal at FreelandBuck in New York City and a senior critic at the Yale School of Architecture. FreelandBuck has been recognized as a member of the Architectural League of New York's 2019 Emerging Voices, the 2017 Architectural Record Design Vanguard and as a 2018 MOMA PS1 Young Architects Program Finalist. Brennan's writing on technology and representation within the discipline of architecture has been published in numerous academic and professional journals. Prior to teaching at Yale, he was assistant professor in Studio Greg Lynn at the University of Applied Arts, Vienna. He has worked in the offices of Neil M. Denari Architects and Johnston Marklee & Associates in Los Angeles and Walker Macy in Portland, Oregon. Brennan is a graduate of Cornell University and the UCLA Department of Architecture and Urban Design.

Sean Canty is the founder of Studio Sean Canty, an architecture practice based in Cambridge, MA. The studio is interested in choreographing unconventional relationships between spaces of contemplation and collective gathering. The work of the studio engages formal combination and juxtaposition at a variety of scales—from objects to interiors—and explores a range of programmatic types—from domestic environments to cultural spaces. Canty is an Assistant Professor of Architecture at the Harvard Graduate School of Design and founder of Office III (OIII), an experimental architectural collective. Canty's work and writing has been published in domus, Harvard Design Magazine, MAS Context, and the forthcoming publications *BLANK: Speculations on CLT* and *Inscriptions: Architecture Before Speech*. Canty is the recipient of the 2020 Richard Rogers Fellowship.

Brandon Clifford develops creative approaches to the world's most pressing problems. He identifies contemporary blind-spots by mining ancient knowledge that holds resonance with topics of today. He is best known for bringing megalithic sculptures to life to perform tasks. Brandon is the director and co-founder of

Matter Design. He is also an associate professor at the Massachusetts Institute of Technology. Brandon received his Master of Architecture from Princeton University and his Bachelor of Science in Architecture from Georgia Tech. Brandon is a designer and researcher who has received recognition with prizes such as the American Academy in Rome Prize, a TED Fellowship, the SOM Prize, the Design Biennial Boston Award and the Architectural League Prize for Young Architects & Designers. His work at Matter Design is focused on re-directing architectural research through spectacle and mysticism by re-posing a series of ancient, but hauntingly relevant questions. For instance, could walking massive statues help us design for transportation and assembly? Is the key to recycling our building materials locked inside the cryptic walls suspected of being built by primordial giants? These ancient ways of thinking compound cultural significance, ceremony and mythology with technical and methodological procedures that have the potential to resolve our contemporary problems. Brandon is dedicated to challenging default solutions by making things that disrupt common practices.

Dana Cupkova holds Associate Professorship at the Carnegie Mellon School of Architecture and is a Co-founder and Director of EPIPHYTE Lab, an architectural design and research collaborative. From 2005 to 2012 she was a Visiting Assistant Professor in the Cornell University Department of Architecture. From 2014 to 2018 she served on the ACADIA Board of Directors and currently she is on the Editorial Board for the IJAC. Professor Cupkova is Track Chair of SoA's Masters of Science in Sustainable Design (MDDS) program.

Cupkova's design work engages the built environment at the intersection of ecology, computationally driven processes and systems analysis. In her research, she interrogates the relationship between design-space and ecology as it engages computational methods, thermodynamic processes and experimentation with geometrically driven performance logic.

Karl Daubmann is the dean and professor at the College of Architecture and Design at LTU. He has taught design and seminars in digital media, robotic fabrication, construction and multidisciplinary design. Daubmann has taught at the University of Michigan where he was the Associate Dean for Post Professional Degrees and Technology Engagement. He has also held visiting appointments at Roger Williams University, the University of Cincinnati and at the Boston Architectural College as the Sasaki Distinguished Visiting Professor.

Daubmann received his Bachelor of Architecture from Roger Williams University and a Master of Science in architectural studies from Massachusetts Institute of Technology where his concentration was in design computing. Daubmann is a fellow of the American Academy in Rome and won the Founder's Prize in 2015. His research while in residence in Rome was focused on construction geometry related to the Baroque.

Phillip Denny is an architectural historian and curator based in New York City. Phillip holds Master's degrees in architecture and architectural history from Princeton and Harvard. At Princeton he received the certificate in Media + Modernity, as well

as the School of Architecture History and Theory Prize. He is currently a PhD candidate at Harvard, writing a dissertation on histories of architectural prefabrication, colonialism, and urbanization in the twentieth century. During his doctoral studies, he has been supported by the Bauhaus Dessau Fellowship for Global Modernism Studies, the Graham Foundation, and a Sheldon Traveling Fellowship. He is also a recipient of the Henry Adams AIA Medal and a Louis F. Valentour Fellowship.

Phillip frequently writes about architecture, art, and design. His writing has recently appeared in Harvard Design Magazine, Volume, Metropolis, The New York Times, CLOG, PLAT, Urban Planning, Footprint, See/Saw, and Pidgin. He is a member of the editorial advisory board of Architect's Newspaper and an editor of New York Review of Architecture.

Karola Dierichs is a Professor of 'Material and Code' at weißensee school of art and design berlin and the Excellence Cluster 'Matters of Activity' (MoA) at Humboldt-Universität zu Berlin. Previously she has been a research associate at the Institute for Computational Design and Construction (ICD) within the Cluster of Excellence 'Integrative Computational Design and Construction for Architecture'. At the Institute for Computational Design and Construction (ICD) Karola Dierichs has conducted research on 'Granular Architectures', where she has developed designed granular materials in architecture. She has been engaged in transdisciplinary research collaborating nationally and internationally, among others, with the Institute for Multiscale Simulation (MSS), Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany and the Behringer Lab, Duke University, USA. She has published numerous articles in her field and lectured both within Europe and the USA. Her research on designed granular materials has been recognized with the 'Holcim Acknowledgement Award Europe 2014' and the 'materialPREIS Acknowledgement Study and Vision 2019'. Selected works have been included in the traveling exhibition 'Hello, Robot.' starting in 2017 at the Vitra Design Museum, Germany and the opening exhibition 'Minding the Digital' of the Design Society in Shenzhen, China.

David Freeland is a principal at FreelandBuck in Los Angeles and design faculty at Southern California. FreelandBuck has been recognized as a member of the Architectural League of New York's 2019 Emerging Voices, the 2017 Architectural Record Design Vanguard and as a 2018 MOMA PS1 Young Architects Program Finalist. Prior to SCI-Arc he taught at Woodbury University where he was instrumental in developing the FabLab and teaching fabrication and computation. Freeland has worked with architecture offices in Los Angeles and New York including Michael Maltzan Architecture and Peter Eisenman Architects. He holds a B.S.Arch from the University of Virginia and an M.Arch from the UCLA Department of Architecture and Urban Design.

Ying Gao, a Montreal-based fashion designer and professor at University of Quebec in Montreal, former head of the Fashion, Jewelry and Accessories Design Programme at HEAD-Genève, has achieved personal distinction through her numerous creative projects: six solo exhibitions in France, Switzerland and Canada, and

more than one hundred group exhibitions around the world. Her varied creative work has enjoyed international media coverage.

Ying Gao questions our assumptions about clothing by combining fashion design, product design and media design. She explores the construction of the garment, taking her inspiration from the transformations of the social and urban environment. Ying Gao explores both the status of the individual, whose physical contours are transformed by external interferences, and the garment's function as a fragile transitional space. Her work testifies to the profound mutation of the world in which we live and carries with it a radical critical dimension that transcends technological experimentation.

Erik Herrmann is an Assistant Professor of Architecture at the Knowlton School and co-director of Outpost Office. He was the 2016–2017 Walter B. Sanders Fellow in Architecture at the University of Michigan, Taubman College of Architecture and Urban Planning. In 2015, Herrmann was a German Chancellor's Fellow of the Alexander von Humboldt Foundation at the Institute for Computational Design (ICD) at the University of Stuttgart.

Herrmann holds a Master of Architecture from Yale University where he was awarded the Carroll L.V. Meeks Memorial Scholarship in recognition of outstanding performance in History and a Bachelor of Architecture from the University of Tennessee where he received the Faculty Prize. His design work has been exhibited at the A+D Museum, the University of Michigan, Harvard University GSD, Yale School of Architecture and Princeton School of Architecture. His work and writings have been featured in architectural publications including *Perspecta*, *CLOG*, *Dimensions* and *PLAT*. Prior to co-founding Outpost Office, Herrmann practiced at Trahan Architects in Louisiana and Gray Organschi Architecture in New Haven, CT.

Elena Manferdini, principal of Atelier Manferdini, has twenty years of professional experience in architecture, public art, design and education. Manferdini has received a Professional Engineering Degree from the University of Civil Engineering (Bologna, Italy) and a Master of Architecture and Urban Design from the University of California in Los Angeles (UCLA). She currently teaches at the Southern California Institute of Architecture (SCI-Arc) where she serves as the Graduate Programs Chair. In 2019, Manferdini was honored with the ICON Award as part of the LA Design Festival, which is a prize that recognizes iconic women who have made an indelible mark on Los Angeles, culture and society in general through their work, character and creative leadership. With a body of work that spans various scales and disciplines of design, her eponymous atelier has completed projects over three continents. Manferdini loves art, technology and inventions, and she deeply believes in the positive power of education, community outreach and creative collaboration.

Geoffrey Mann has exhibited nationally and internationally since graduating from the Royal College of Art in 2005, and in 2012 was named a 'Designer of the Future' by *Newsweek* magazine. Mann's work embraces the symbiotic relationship between digital media, physical form and traditional process. His fascination

with transposing the ephemeral nature of time and motion has created a studio practice that challenges the existing divides between art, craft and design. In 2008, Mann was awarded the World Craft Council Prize for Glass and in 2009 won the Jerwood Contemporary Makers Prize. His work is in the permanent collections of the Museum of Modern Art, New York, the Cincinnati Art Museum, the Museum of Art and Design, New York, and the New Orleans Museum of Art. Mann is currently a Senior Lecturer of Product Design & Craft at Manchester School of Art, Manchester Metropolitan University, UK.

Achim Menges is a registered architect in Frankfurt and full professor at the University of Stuttgart, where he is the founding director of the Institute for Computational Design and Construction (ICD) and the director of the Cluster of Excellence Integrative Computational Design and Construction for Architecture (IntCDC). In addition, he has been Visiting Professor in Architecture at Harvard University's Graduate School of Design and held multiple other visiting professorships in Europe and the United States. He graduated with honours from the Architectural Association, AA School of Architecture in London, where he subsequently taught as Studio Master and Unit Master in the AA Graduate School and the AA Diploma School. The focus of Achim Menges' practice and research is on the development of integrative design at the intersection of computational design methods, robotic manufacturing and construction processes, as well as advanced material and building systems.

Evan Pavka is a writer, editor and Assistant Professor at Wayne State University. He has presented work at the Art Gallery of Ontario, the former Museum of Contemporary Canadian Art in Toronto and the KTH Royal Institute of Technology in Stockholm. In addition, his writing has appeared in *Azure*, *ArchDaily*, *ANInterior*, *Canadian Art*, *Lunch*, *Pidgin*, *-SITE*, *The Architect's Newspaper*, and the special issue of *Field Journal*, "Becoming a Feminist Architect," among others. He holds a Master of Architecture in Architectural History and Theory from McGill University, where his thesis won the Maureen Anderson Prize.

Art Group **Random International** run a collaborative studio for experimental practice within contemporary art. Founded in 2005 by Hannes Koch and Florian Ortkrass, today they work with larger teams of diverse and complementary talent out of studios in London and Berlin.

Questioning aspects of identity and autonomy in the postdigital age, the group's work invites active participation. Random International explores the human condition in an increasingly mechanized world through emotional yet physically intense experiences. The artists aim to prototype possible behavioral environments by experimenting with different notions of consciousness, perception, and instinct.

Noa Raviv is an Israeli artist based in New York. She has a background as a fashion designer, a soldier, and a math teacher, and is interested in the way the body and social systems are intertwined. Searching for patterns and logic, she makes

collages, installations, textile-based pieces, and paintings. Her work has been exhibited internationally in museums and galleries, including the Metropolitan Museum of Art in New York, the Boston Museum of Fine Arts, and the Israel Museum. Raviv has lectured at the Anchorage Museum, the Glasgow School of Art, RSID in Toronto, University of Wisconsin-Madison, Parsons School of Design and the School of Visual Arts in New York, Holon Design Museum in Israel, and MODA Design Museum in Atlanta, and her work has been featured in *Vogue*, *The Cut*, *BBC*, *Wired*, *Nylon*, *Dezeen*, *Fast Company*, *Timeout*, and *The Met Museum's Manus X Machina* catalog, among other publications. She is an MFA candidate at Hunter College in New York, and is currently working on a novel about a female soldier in the Israeli army.

Virginia San Fratello is an architect, designer and educator. She is a partner at Rael San Fratello and in Emerging Objects, which is a pioneering design and research company that specializes in 3D-printed materials and objects for the built environment based in Oakland, California. San Fratello is the chair of the Department of Design at San Jose State University. She holds a Master of Architecture degree from Columbia University in the City of New York. In her practice, Virginia focuses on the convergence of digital, ecological and creative material explorations. Her research is applied through the design and fabrication of innovative buildings and their components, furniture elements and site-specific installations that often look at inherent material resources and have embedded political consequences.

Igor Siddiqui is an architect, design educator and writer. He is best known as an academic whose work simultaneously engages design practice, scholarship and pedagogy. Siddiqui currently holds the appointment of Associate Professor of Architecture and Interior Design at The University of Texas at Austin and is the Gene Edward Mikeska Endowed Chair of Interior Design. Over the last decade, his work has explored a broad range of issues, including craft, materiality, mass-customization, participatory processes and social programs such as housing, with the overarching aim of linking design innovation to public engagement. Siddiqui is also known for promoting interiors as a body of interdisciplinary knowledge central to the understanding of contemporary life. He studied architecture at Yale and Tulane and has taught, lectured and exhibited his work internationally.

Nader Tehrani is the recipient of the American Academy of Arts and Letters' 2020 Arnold W. Brunner Memorial Prize for his contributions to architecture as an art. Nader Tehrani is founding principal of NADAAA and Dean of the Cooper Union's Irwin S. Chanin School of Architecture. His research focuses on the transformation of the building industry, innovative material applications, and the development of new means and methods of construction, especially through digital fabrication. Tehrani's work has received many prestigious awards, including the Cooper-Hewitt National Design Award in Architecture, and eighteen Progressive Architecture Awards. Prior to becoming Dean at the Cooper Union, he taught at RISD, Harvard GSD, Georgia Institute of Technology and MIT. His office, NADAAA, for the past

seven years in a row, has ranked in the Top eleven design firms in Architect Magazine's Top 50 Firms in the United States, ranking as First three years in a row.

Sue-an van der Zijpp is curator of applied art and design at Museum Boijmans van Beuningen, Rotterdam, Netherlands. She graduated in Art History (Rijksuniversiteit Groningen, Netherlands), studied Fashion and Design at the Royal College of Art (London) and Philosophy of Technology (University of Twente, Netherlands). With a strong focus on design at the interface of art and technology, she's been responsible for numerous publications, museum acquisitions, lectures and exhibitions at the Groninger Museum where she was curator of contemporary art, fashion and design until 2021. She curated exhibitions of, among others, Marc Newson, Hussein Chalayan, Mariko Mori and Joris Laarman. Iris van Herpen's major solo which debuted at the Groninger Museum in 2012, toured internationally to both Europe and North America.

Iris van Herpen perceives Haute Couture as a transformative language, an interdisciplinary entity that emerges from the space in which innovation and craftsmanship interlace. The symbiotic relationships found in nature's intricate web, the invisible forces that structure architectural patterns, and the mercurial dance in which the body and mind intersect are influences that shape the visionary creative process. The Iris van Herpen maison was founded in 2007 and showcases its collections bi-annually at Paris Haute Couture Week as a member of the Fédération de la Haute Couture. The brand stands for slow fashion with a multidisciplinary approach towards collaborations with artists, architects and scientists. Each collection is a quest to venture beyond today's definition of a garment, exploring new forms of femininity for a more meaningful, diverse and conscious fashion for the future.

Jean Wainwright is a Professor of Contemporary Art and Photography and an art historian critic and curator living in London. Her areas of expertise are in contemporary art and photography, with particular reference to Andy Warhol on whose life and works she is an internationally recognized expert. Jean Wainwright's areas of expertise are in contemporary art and photography. Her practice as an art critic and art historian most prominently feature interviews with international artists, photographers, filmmakers and curators. Wainwright's interviews (she has more than 2,000 in her archive) can be found both in the numerous catalogues and books she has written and contributed to and at the Tate Gallery in the archives and online (177 interviews). Wainwright has a PhD on Andy Warhol's voice.

Foreword

Igor Siddiqui

Modes of material production have always had a profound influence on the social status of interior design. Indeed, the very definition of the field of interior design as we know it today is in large part a result of the emergence of mass production as a dominant paradigm for manufacturing and construction. Standardization and mechanization of industrial processes in the 19th century enabled goods like furnishings, textiles and art objects to be produced in large quantities, making them more abundant and affordable. The mass-produced marketplace, emblematic of the 20th-century commerce and still alive today, rendered interiors and their users as key participants of mass consumption and the interior designer as the figure skilled at mediating the relationship between the market and the user.[1]

Mass production certainly did not obliterate bespoke, custom-crafted, unique or one-off goods; on the contrary, it only further elevated their status and value. The relationship between the mass-produced and the custom-crafted also fueled the technological development of what, since the 1980s, has been known as mass customization; that is, a paradigm whereby automated processes are capable of delivering customized goods and services with the efficiency of mass production.[2] Today's users come into contact with mass customization each time they encounter a customized advertisement online or a morsel of news algorithmically targeted at them. Enabled by digital processes, the mainstream market also offers users a panoply of mass-customized shirts, sneakers and cars made viable by the seamless flow of data linking the user's initial input with the final output of the product.[3]

Since the 1990s, digital fabrication explorations by designers have uncovered a range of creative possibilities for producing customized constructions – from discrete parts to whole objects, surfaces and structures – with the aspiration of overcoming the limitations inherent to standardized mass production while achieving its levels of efficiency through computation. The direct link between digital input and output – that is between design and product – has also enabled the development of uniquely contemporary manifestations of intricacy, complexity and extravagance found in fabricated patterns, surfaces, forms and assemblies whose physical realization would have not been likely through any other means.[4] It is through such explorations that a new kind of interior has emerged.

The present moment – two-plus decades into the 21st century – frames digital fabrication not only in terms of its potential, but also as a matter of results, outcomes, effects and consequences. It makes an assessment of the role of digital fabrication in interior design, such as the one proposed by this volume, timely if not

overdue. Indeed, in addition to suggesting future trajectories for exploration, the selection of contributors in this book demonstrates how much work has already been done in this area of professional practice, design research and creative scholarship. Besides the scalar and typological differences implied by the volume's subtitle, what is remarkable to note from the sum of the contributions is the diversity of approaches to digital fabrication. A rapid scan through the book's provocative chapters reveals that digitally fabricated interiors are granular, edible, anthropomorphic, graphic, self-organizing, responsive, interactive, wearable, enveloping, automated, readymade and even postdigital. While the acknowledgment of digital fabrication tools abounds – this includes engagement with advanced applications of 3D printing technologies, scripting, scanning, robotics, augmented reality, artificial intelligence, as well as innovative uses of hybrid processes, novel materials and crowdsourced data – they enable the overarching conversation without having to lead it. Beyond automated making, a number of authors also treat digital fabrication as the means of generating interior experiences using interactive media; in other instances, the notion of fabrication alludes to the kind of fictional invention – a digitally fabricated tale perhaps – that questions the appearance of reality itself in the age of data.

I would be remiss not to note that Anderson and Weinthal's edited book functions as an interior space, an impression not entirely out of place given that it was a live symposium, which initially brought a number of its contributors together, that prompted its development as a publication. Its discursive space – the space of interior design as a field of knowledge – is defined by a soft boundary: pliable, porous and absorbent. This boundary is designed to encourage productive exchanges between its exterior and interior; it makes a space that is welcoming, receptive and generous. As the book's title elucidates, digital fabrication is nested within this space of interior design. In some ways, it has just arrived; in others, it has always already been there. Each included author has followed their own individual journey to this space, some perhaps more direct than others; a mix of intentional itineraries, chance and serendipity. Not unlike many of them, my own journey to this space started with architecture. My earliest recollection (revealed at the risk of dating myself) of grasping the convergence of digital fabrication and interior design was my initial encounter with Bernard Cache's 1995 book *Earth Moves: The Furnishing of Territories* soon after its publication. This encounter remains seared in my memory as it seems to have had created an aperture in my own sense of possibility as a designer and, later, as design educator and scholar. By being able to see through it, this new intellectual opening framed a number of issues at the intersection of theory, technology and design that would, unbeknown to me at the time, preoccupy me for years to come.

A student of the late philosopher Gilles Deleuze[5], Cache emerged on the scene as a proponent of computationally enabled non-standard architecture and is, as a designer, best known for his digitally fabricated furnishings. In *Earth Moves* Cache presents a theory of architecture founded on Deleuzian philosophy in which concepts of image, frame and territory work to 'rethink the relationship between body and soul, past and present, and between furniture, architecture, and geography'.[6] The density of the text aside[7], what I remember as

particularly striking about it was the way in which it engages design, specifically that of interior objects. Of the book's 12 chapters, most begin with the description of furnishings designed by Cache: a wall-mounted light fixture, a writing desk, a bookcase, an armchair, a tubular chair, two different tables, as well as a series of digitally fabricated surfaces and freestanding sculptural objects. Within each chapter, an object's role is both introductory and conclusive; it serves as a prompt for theoretical exploration, but is also a tangible proof of concept. I vividly remember discussing Cache's work with a classmate. 'How can a theory of the whole planet result in a bookshelf?' we wondered with both bewilderment and excitement. In the conclusion to the book, Cache writes, 'Our times are such that we seek the outside on the inside, geography in furniture, but also images in things themselves.'[8] My interest in these ideas too may have been a sign of the times, but it also reflected an earnest attempt to discover an architecture that is more than *just* building. It was thorough this unanticipated philosophical journey that I encountered that which buildings typically contain – interiors – as something that seemed to be more, rather than less, than buildings themselves.

Today, what I find remarkable about Cache's book is its effectiveness in modelling a form of critical design practice – the kind of practice that is in the academic art and design disciplines referred to as creative scholarship or design research – particularly in relation to digital fabrication in interior design. In his editor's introduction to the *Earth Moves*, Michael Speaks refers to Cache's practice as exemplary of Deleuze's concept of the fold and thus describes it as pliant, complex, heterogeneous and supple, yet resilient.[9] These are indeed the adjectives that one could also use to point to the designers and thinkers included in this edited volume and whose work, not unlike Cache's, elucidates new potential for reframing both practice and discourse. To convey the philosophical context for what he refers to as folded practice, Speaks reminds the reader of Deleuze's critical distinction between the realization of the possible and the actualization of the virtual as two kinds of multiplicity: one reductive and redundant, the other – the latter – creative and generative of what has yet to be. One can effectively appropriate this distinction to serve as a framework for evaluating the production of new knowledge generally and of innovation in the realm of digital fabrication in interior design specifically. How, in other words, are digital fabrication and interior design leveraged not in service of reproducing that which is already known or has been done, but rather in order to enable the actualization of a range of alternative possibilities?

The tug of war between convention and innovation is a preoccupation for many of us who teach design, especially in professionalized fields like interior design and architecture. For interior design scholars, such as Anderson, Weinthal and myself, as we teach our ambition is not only to professionally train our students but also to continue to build our fields through the production of new theoretical and applied knowledge. In this way our students have the opportunity to learn not only how to be effective practitioners, but are also prepared to serve as future leaders and stewards of the body of knowledge that is interior design. Technological advancements have always been linked to social change, so it is prudent to interrogate next-generation technologies in order to better forecast what the role of the new generation of interior designers may look like. Strategic alliances, such as the one

with digital fabrication forged by this book, serve as powerful precedents for articulating the field's role in gathering intelligence from both within and without. Like the discursive space defined by this book, interior design has over the last two decades proven exceedingly capable of making room for and hosting robust intellectual exchanges across a range of fields. I would like to suggest, however, that along with showing our students how to be impeccable hosts, this edited volume also prompts future interior designers to imagine how they might also wish to prepare for the role of the guest of honor.

NOTES

1 Penny Sparke, *The Modern Interior* (London: Reaktion Rooks, 2008), especially Chapter 3 ('The Mass-consumed Interior') and Chapter 8 ('The Mass-produced Interior'); also see Penny Sparke, 'Taste and the Interior Designer' in *After Taste: Expanded Practice in Interior Design,* edited by Kent Kleinman, Joanna Merwood-Salisbury and Lois Weinthal, 14–27. New York: Princeton Architectural Press, 2012.

2 Joseph Pine, *Mass Customization: The New Frontier in Business Competition* (Cambridge: Harvard Business School Press, 1993), 48.

3 Branko Kolarevic and Jose Pinto Duarte, 'From Massive to Mass Customization and Design Democratization' in *Mass Customization and Design Democratization*, edited by Branko Kolarevic and Jose Pinto Duarte, 1–12. Abingdon: Routledge, 2019.

4 Lisa Iwamoto, *Digital Fabrications: Architectural and Material Techniques* (New York: Princeton Architectural Press, 2009), 4–15.

5 It is Gilles Deleuze's mention of Cache's *Earth Moves* manuscript, originally written in French and completed in 1983, in notes to two of his own books, that is credited with bringing attention to it and eventually resulting in its publication in English. See Anne Boyman, 'Translator's Preface' in Bernard Cache, *Earth Moves: The Furnishing of Territories* (Cambridge: MIT Press, 1995), viii.

6 Michael Speaks, 'Folding toward a New Architecture' in Cache, *Earth Moves*, xviii.

7 The book's translator acknowledges that *Earth Moves* 'offers an unfamiliar picture of architecture itself, speaking something of a strange new tongue in architectural discourse' and that the book 'takes us off in a strange uncharted conceptual territory in which old words come to be used in new ways and new words are invented in an effort to open out new domains of thought, or to introduce variations in old ones' Boyman, 'Translator's Preface', viii.

8 Cache, *Earth Moves*, 152.

9 Speaks, 'Folding toward a New Architecture', xvi.

Acknowledgements

We would like to thank the contributors in this book whose works make visible the connection between digital fabrication and interior design when it is not always apparent on the surface. This book would not have been possible without the support of Ryerson University, The Creative School, and the students, staff and faculty in Interior Design. Additional thanks goes to the Social Sciences and Humanities Research Council for their support of a Connections Grant that launched this book topic with a symposium at Interior Design at The Creative School.

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Introduction

Jonathon Anderson and Lois Weinthal

Interior design is an ambiguous field to define because it is both a container of objects and contained by architecture. The architectural envelope is the formal boundary where the interior designer orchestrates the placement of objects while anticipating movement and unpredictable actions that change space. To further articulate the interior, designers need to synthesize knowledge from allied disciplines that complement body, object and enclosure scales and be versed at moving fluidly between them. The results materialize in designs that adapt to the needs of occupants and support functional spatial configurations. At the same time, works of allied disciplines, such as artists, product designers and architects, are populating the interior with outcomes that span traditional crafts to digital fabrication. Although sited in the interior, these outcomes remain in the discourse of their respective fields. If the lens shifts and the discourse is placed in the field of interiors, then a new practice begins to emerge in the discipline, one that reflects the integration of design strategies informed by digital fabrication tools and processes while still addressing interior design professional practice. Until now, digital fabrication has been showcased in the context of allied disciplines, yet the underlying concepts and outcomes produced are symbiotic with the scale of the interior.

Allied disciplines have normalized the use of computational design using tools and processes that synthesize concepts and material. Themes such as ornament, pattern, senses and materials are a sampling of topics that fall under the traditional vocabulary of interior design, yet these themes are being reshaped by allied disciplines bridging computational design to material fabrication and subsequently altering the interior. The results offer a new facet to the interior with alternative approaches to representation, conceptual thinking, prototyping and material agency enhanced by computational workflows. These workflows prompt a change to interior design through a symbiotic relationship where elements inherent to the interior meet computational methods in an effort to optimize, rationalize and improve efficiency. This new alignment reveals the missing discourse of interior design to digital fabrication, which has yet to be made explicit or theorized in the discipline. This is important because the theoretical positioning means that a body of work has already been produced and situated in the world. However, these outcomes still respect the spatial definition and practices of the interior but enhance attributes that have been latent and allow them to emerge.

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The result is a new paradigm for the interior where conventional boundaries are ignored and instead celebrated.

This book grew out of the missing body of knowledge that bridges interior design to digital fabrication. The collection of essays and projects presented in these chapters are not a manual of techniques or tools for how interior designers can use computational processes and digital fabrication. Instead, the content addresses everyday design problems that the interior designer must resolve but seen through new strategies. Reinforced throughout the chapters is the use of computational processes and theoretical ideas to discover new approaches and workflows that allow designers to linger in the space of process rather than viewing digital fabrication merely as a set of tools to realize final outcomes. In this process, digital fabrication techniques are used as a medium for experimentation, decision-making and problem-solving to formulate and realize complex artifacts that were once considered unbuildable due to limitations in prototyping and construction. This computational control advances traditional construction processes and expands the boundaries of making and spatial design through additive or subtractive materialization. This can be largely contributed to the democratization and leveraging of digital fabrication technology. The forthcoming chapters facilitate discussions about experimental prototyping, autonomous production, creating new tools, celebrating failures, material agency and developing interdisciplinary workflows that seamlessly integrate technology and reimagine the possibilities of interiors through bespoke, made-to-order, on-site and mass-produced digitally fabricated components at multiple scales found on the interior.

Integral to this discussion is the role of scripting to reveal how traditional topics of interior design, such as ornamentation, materials, surface, thermal comfort and light, can be tailored to the interior when informed by computational processes and data. This marriage of interior design and digital fabrication does not seek to diminish the role of the interior designer under a paternal umbrella of digital fabrication. Instead, interior design acts as the foundation upon which strategies that use computational tools and theories slip in and adjust so that the realm of the interior is always in the foreground. Examples include the ability to materialize sound waves, track the movement of body, or reimagine the role of decoration and ornament, all repositioned through the lens of technology and revealing alternative forms of patterns and visual understanding. Even without the emphasis on digital fabrication, the works make visible the complexity of capturing form and materializing them to enrich our experience of the interior. These topics are often unstructured and intangible, yet computational design and fabrication help visualize what is often invisible in the interior.

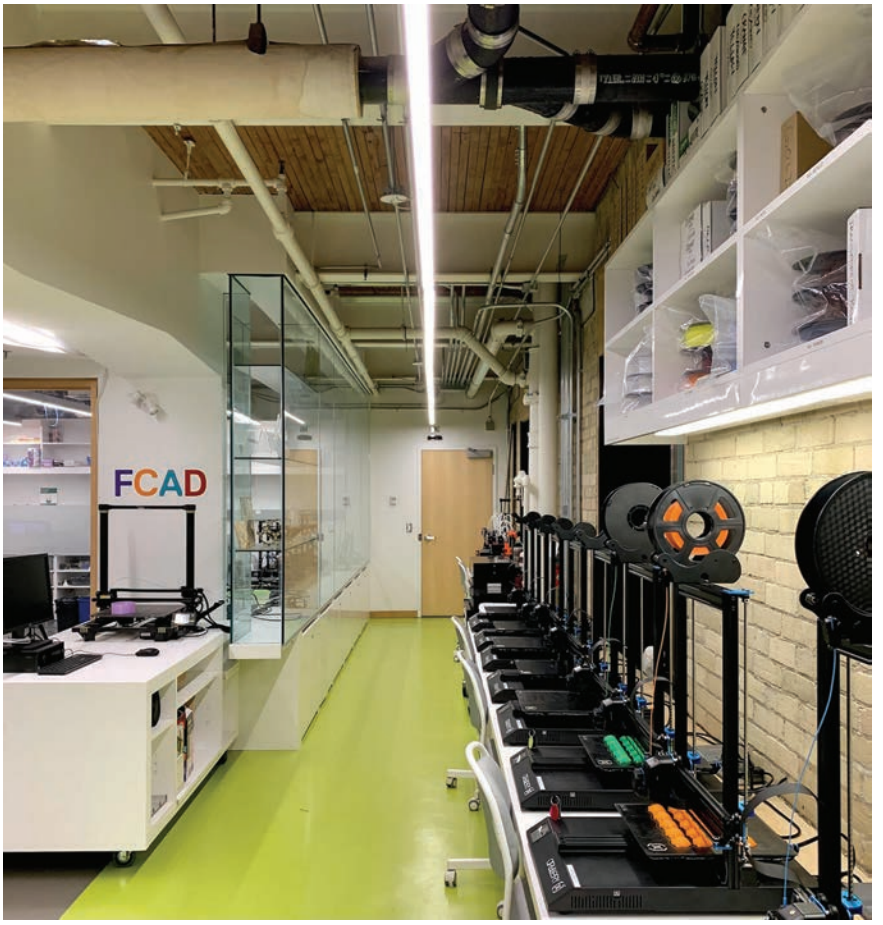
Digital fabrication inherently draws into question its relationship to traditional forms of craftsmanship and authorship, especially in the context and scale of interior design. Interior design has a long history of hands-on pedagogy owing to its immediate scalar relationship to the body where products such as textiles and furniture span craft and scale. Yet, a parallel pedagogical discourse in digital fabrication framed in the context of craft and the interior has yet to be made evident. This relationship does not disregard traditional crafts; instead, it opens up new paths by taking traditional knowledge and viewing it through a computational lens.

The outcomes reveal new ways of thinking that still address traditional materials and techniques and positions these works in the discipline of interiors as a natural repository. The results are numerous, and it is the set of software and tools such as laser cutters, 3D printers, 3D scanners, CNC routers and robots that tailor ideas at the scale of the interior. The production scale of the tools and processes limits much of the work created using digital fabrication. Additionally, the interior is a place where materiality meets the scale of the body, and the articulation of these spaces are traditionally built from standard building materials that directly correlate with the size limitations of the tools and processes. An additional underlying commonality between this pairing of interiors and digital fabrication is their alignment at the scale of non-loadbearing structures. These scale limitations are an asset for the interior since they allow for an unlimited number of outcomes not bound by an architectural shell and structure.

CONTEXT

Our interest in bringing digital fabrication to interior design grew from curricular opportunities in Interior Design at The Creative School. The program's long history and dedication to making pedagogy was the foundation for us to expand upon and advance not only the tools and skill set of the student, but the mindset of how to approach interior design and digital fabrication. Interior Design students are introduced to analog forms of making in the first week of their first year, in a Workshop with traditional machine and bench rooms integrated in Interior Design's stand-alone building.

0.1
Interior Design Workshop Bench Room. Photo courtesy of Carol Kaifosh



0.2
The Creative School Design + Technology Lab Service Bureau. Photo courtesy of Jonathon Anderson

0.3
The Creative School Design + Technology Lab – Kuka robot with custom 3d printing tooling. Courtesy of The Creative School Design + Technology Lab

By the start of the second year they are introduced to various forms of digital fabrication with the support of two labs. A year before this book started taking shape, The Creative School Design + Technology Lab Service Bureau was integrated into a space adjacent to the Workshop, making the first floor of the building dedicated entirely to making spaces. At the same time, The Creative School was investing in expanding the Design + Technology Lab to provide access to state-of-the-art equipment, hands-on training and experiential learning opportunities for the nine Schools within The Creative School. The lab is 8,300 square feet and considered to be more than a fabrication space. It is a space that engages many forms of technology through a diverse and forward-thinking community that strives to push the limits of what is possible.

The introduction of digital fabrication reveals how this knowledge not only impacts education but the future of interior design praxis. As evidenced in the forthcoming chapters, the profession of interior design will continue to expand the way in which facilities are utilized in an effort to bridge digital fabrication to the interior.

CENTRAL AND SECONDARY THEMES

This book repositions the praxis of experimental prototyping and integrated technology to show how the use of digital fabrication is inherent to the interior scales of body, object and enclosure. These three scales act as a central theme to frame contributions that reinforce interior design's interdisciplinary nature and reinterpret traditional crafts by integrating new methods of making into conventional workflows. Content and structure are developed to meaningfully identify opportunities for innovation between design education, professional practice and the emergence of digital fabrication. The essays seek to pull apart the current models and propose innovative ideas that will radically transform how we operate and ultimately construct the design process and end solutions while establishing digital fabrication as a common language within interiors.

The accompanying diagram identifies themes that run throughout the book and provide a critical framework that defines the work and language of interior design and digital fabrication. Interior design provides the overarching umbrella under which digital fabrication is placed and identified as a set of tools, processes and theories to generate and initiate design strategies that reshape the interior. A list of design strategies is connected directly to the realm of digital fabrication but inherently falls under the larger umbrella of interior design since these themes seamlessly span both areas. These themes are carefully curated to reveal to the reader the inside workings and thought processes of the designers at the forefront of integrating digital fabrication into the field of interior design.

As new forms come into being, a new strand of history is being initiated for interiors that have yet to be articulated in the discipline. We now identify this emerging area of interior design history as a result of this new paradigm. Essays are arranged in a way that allows for a scalar reading of body, object, enclosure from start to finish. Many of the invited authors move seamlessly between scales and highlight how interconnected these three scales are. Alternatively, the index

provides guidance by highlighting the shared themes across different works. The selected contributors represent the ever-increasing interdisciplinary nature of the interior design profession, demonstrating a breadth of disciplines where dialogues about digital fabrication and the scale of interiors permeate aspects of design theory and practice.

0.4
Diagramming the book's critical framework.
Diagram drawn by Nicolas Burbano Diaz (RSID student)

BODY

1 Iris van Herpen

The Art of Fashioning the Future

Sue-an van der Zijpp

Translated by Sarah Fopma

Can a dress change our worldview? Can a garment enhance our senses and buttress our consciousness? Can a piece of clothing shift the way we perceive ourselves and other species?

These might not be the first questions that spring to mind when seeing Iris van Herpen's designs on the red carpets of A-list events, worn by celebrities such as Lady Gaga, Beyoncé or Naomi Campbell. On such occasions the beauty and charm of her outfits catch the eye, how they move enchantingly around the bodies and give the wearers an almost otherworldly presence. Although her work is firmly rooted in the world of fashion, with its mesmerizing pieces that convey the joy of transformation, escapism and extravagance, the cultural meaning of Van Herpen's interdisciplinary oeuvre reaches far beyond fashion's conventional repertoire. Her work ventures into the worlds of art, architecture, biology, technology and science, in the most imaginative and perplexing ways.

The Dutch Iris van Herpen (Wamel, 1984) grew up in a small town without televisions or computers and developed a passion for classical ballet in her youth, an influence that still is of major importance for her ideas about movement and transformation of the space around the body. She trained at the Fashion Department of the ArtEZ University of Arts in Arnhem (the Netherlands). Following internships at Alexander McQueen and Claudy Jongstra, the designer founded her own label in 2007. With her striking silhouettes and unusual materials, such as magnets, iron fillings, steel and umbrella tines, she was noticed almost instantly, both nationally and internationally. The Chambre Syndicale de la Haute Couture welcomed Van Herpen as a guest member in 2011, an act with which the Parisian institute with its strict admittance policy secured her a place on the official couture calendar. However, whereas Haute Couture is characterized by unique, handmade pieces, Van Herpen has expressed the ambition to reinvent the métier as the engine of innovation, pushing forward materiality and sustainability and enriching its scope with unexpected cross-disciplinary collaborations.[1]

In 2012 the Groninger Museum (the Netherlands) curated Van Herpen's first solo exhibition and it has since acquired more than 30 key works for its collection. The exhibition then travelled Europe and subsequently toured six US locations in revamped form as *Iris van Herpen, Transforming Fashion* before its finale in

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Toronto.[2] Van Herpen also participated in numerous international exhibitions, for example *What is Luxury?* (2015) at the Victoria and Albert Museum in London, and *Manus x Machina: Fashion in an Age of Technology* (2016) at the Metropolitan Museum in New York.

BEAUTY AND COMPLEXITY

At the heart of her groundbreaking work lies researching and experimenting with new materials and applications, in the course of which she combines diligent handiwork with digital production technologies. All of her collections are creative

1.1
Capriole, Snake Dress. Courtesy of Iris van Herpen

investigations displaying a plethora of themes and topics, such as the ambiguous beauty of smoke, the effects of synesthesia and the world of microorganisms. Becoming increasingly more complex, her later work even incorporates notions such as the delineation between the physical and the digital, synthetic biology, and the mutable nature of identity. Featuring many collaborations with artists, designers and architects, the desire to transform and control materials is a leitmotiv that runs through her work. An overarching theme is becoming increasingly clear, with nature, physics and biology as its central pillars, subsequently provoking philosophical questions about nature and culture; living and

1.2
Sensory Seas.
Courtesy of Iris van Herpen

1.3
Sensory Seas.
Courtesy of Iris van Herpen

dead matter; and humans, animals and machines. Blurring the boundaries with her cross-disciplinary body of work, she seems to epitomize the current convergence of science and technology.

It is not easy to pinpoint how these themes intertwine and come together in an outfit or a collection. The majority of the designs are neither direct

1.4
Sensory Seas, Morphogenesis.
Courtesy of Iris van Herpen

representations nor literal renderings of her ideas. It might be more accurate to describe them as amalgamations of representation, mimetic elements, fantasy and embodiment. These elements collide, conflate, layer and finally take shape during a technical hybrid manufacturing process that is equally important for her work's narrative. Altogether this makes her pieces also a primarily dynamic and tactile affaire.

The 'Snake Dress' (*Capriole*, 2011), an example of her early work, consists of a sort of tangle of handmade high-gloss tubes of acrylic sheets that writhe like snakes around the body. It can be considered a symbolic representation of a state of mind, portrayed as a metonymic image. Over time, Van Herpen's collections have become increasingly layered and intricate. A recent example is *Sensory Seas* (2020). Its works are almost hyperbolic in terms of the richness and complexity of concepts, associations and a manufacturing process involving heat bonding, oil painting, printing, digital technology and a great deal of painstaking handcraft. She took the early 20th-century anatomical drawings of brain structures by neuroscientist Santiago Ramón y Cajal as starting points, mirrored these with the world of Hydrozoa, small sea animals some of which echo dendrites and synapses. Adding a special color palette materialized in glass organza, silk, and screen-print mesh, this collection contains outfits that fluently fan out in psychedelic clouds with each movement and dresses with striking semi-transparent leaf-like shapes that slowly flow with each step. Another example of a *Sensory Seas* piece is the 'Morphogenesis Dress'. Van Herpen: 'This piece drew on geostrophic turbulence patterns and came into being by 3D twisted vortex models created in Rhino with Grasshopper algorithms, thousands of fine white screen-printing mesh layers were numbered and sliced into 3 mm distance, which then by a KERN laser cutter were provided by a triangulated grid of chevron-holes. Then each layer was embellished by hand with a grid of minuscule transparent chevrons.'[3]

1.5
Sensory Seas, Morphogenesis. Courtesy of Iris van Herpen

MAN AND MACHINE

As has often been emphasized by Van Herpen and shown in videos about her manufacturing process, manual work and traditional craftsmanship still take up the biggest part of her practice and this (creative) process is as essential to her as the final result.[4] Instead of drawing, she drapes the material directly onto the dummy with her hands, literally feeling and exploring the material's possibilities.

This synergy between hand and material seems mind over matter, yet perhaps can more accurately be compared to the reciprocal process of potter and clay, in which a synergy between the hands and the material determines the 'material agency' during the making process. Like many fellow craftspeople, Van Herpen's creative abilities seem tacit knowledge: knowledge that appears to originate from her hands and consequently is not easily passed on verbally. It flows from a physical

1.6
Capriole, Skeleton Dress. Courtesy of Iris van Herpen

1.7
Capriole, Cathedral Dress. Courtesy of Iris van Herpen

1.8
Voltage Dress.
Courtesy of Iris van Herpen

manufacturing process of weeks or even months in which thinking about and feeling the materials is a form of creative knowledge production in itself.[5]

Van Herpen started employing digital production technologies, such as 3D printing, laser sintering, stereolithography and laser cutting, in an early stage of her career. Often working together with architects and specialized companies, she actually is the first fashion designer to 3D print entire outfits. One of the first examples is the shell-like top from the 2010 *Crystallisation* collection. Pushing the limits of this technology, other examples include the 'Skeleton Dress' (*Capriole*, 2011) and the 'Cathedral Dress' (*Micro*, 2012). With these stiff, inflexible pieces, that certainly would not pass the 'sit-down ability' test, as Van Herpen calls it, she explored the boundaries between fashion, architecture and sculpture. These outfits can therefore also be understood as wearable sculpture or miniature architecture.[6] During the subsequent year, she worked with designer Neri Oxman and architect Julia Koerner to develop revolutionary semi-flexible outfits using 3D printing and laser sintering that do indeed, to a certain extent, sway along with their wearers' movements.[7]

Over the years, Van Herpen's work practice has become hybrid. Parts are created using digital technology and subsequently reworked, draped or assembled manually: a reciprocal process blurring the boundaries between handmade and machine-made. These designs not only compel us to rethink value judgments associated with machine-made objects, such as quick, cheap and ugly, but also the production process's underlying presupposition that the machine is antithetical and hostile to humankind.[8] Taking an instrumentalist position that deems technology useful and neutral, Van Herpen considers both high-tech machinery and her hands as tools, in accordance with the world-renowned Canadian philosopher Marshall McLuhan's notion that all media technologies are extensions of human bodies.[9] From Van Herpen's practice, however, an even more radical image arises, in which

the traditional contradiction between human and machine not only manifests itself as a false dichotomy, but as inextricably intertwined. It is this hybrid practice in particular that enables the production of pieces that could not have been accomplished otherwise, and that reveal the world in a different way by opening up new prospects.

HYBRID MATTER

Meeting the Canadian architect/artist Philip Beesley in 2012 was a pivotal moment in Van Herpen's career. It started a dialogue that visibly influences her subsequent

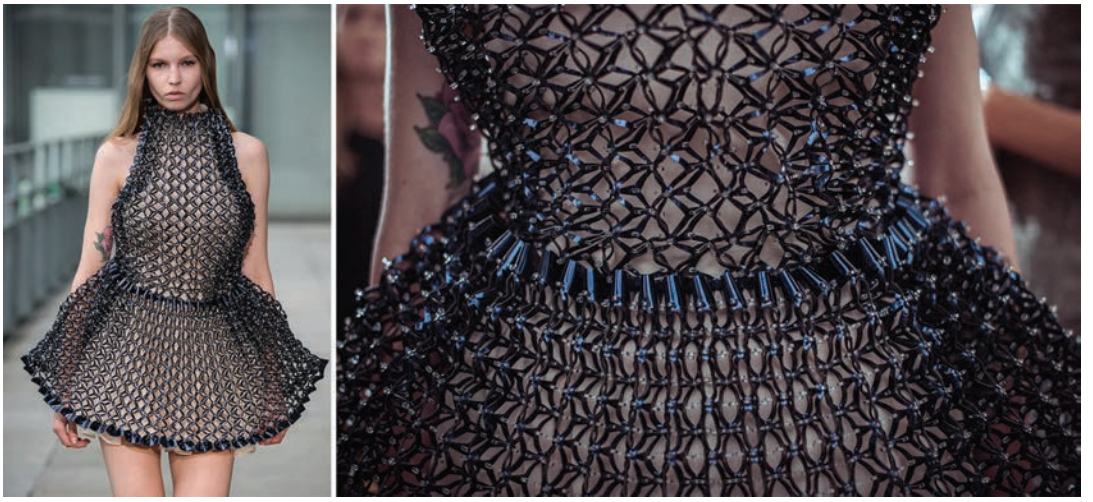
1.9
Hybrid Holism.
Courtesy of Iris van Herpen

1.10
Hybrid Holism. Courtesy of Iris van Herpen

1.11
Voltage. Courtesy of Iris van Herpen

work. She has found herself fascinated by his immersive, responsive architectonic environments such as *Hylozoic Ground* (2012), an architectonic installation with microprocessors and touch sensors that respond to visitors with light and movement.[10] Inspired by Hylozoism, the ancient belief that all matter has life, Beesley collaborates with synthetic biologists and chemists to develop systems that simulate life, that at some point will start to act like living creatures, and that someday perhaps may even behave intelligently. Van Herpen incorporated this idea in *Hybrid Holism* (2012), a collection proposing a future in which fashion is somehow alive and evolving, resulting in a more durable relationship with its wearers, countering the current reality of fast fashion.

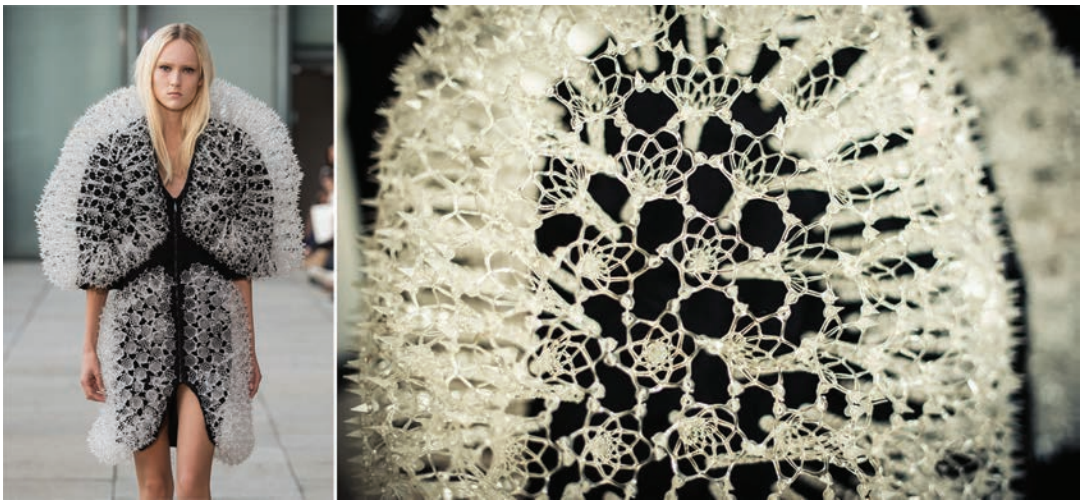
The most manifest elements of their collaboration are the developments of new materials and structures with which the artists keep challenging each other. Van Herpen and Beesley have developed a shared visual language that first materialized in *Voltage* (2013). Energy and electricity featured heavily in this collection

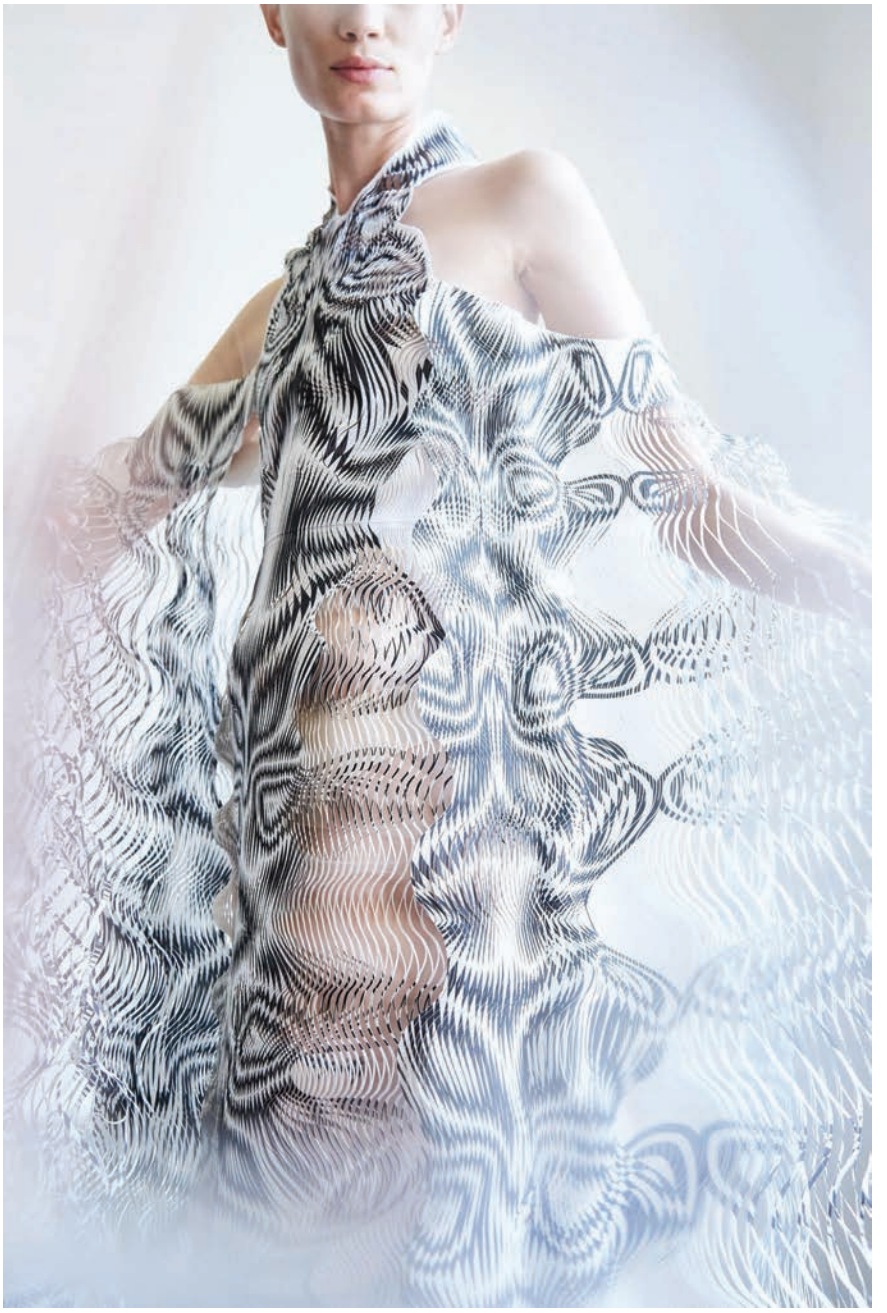


1.12
Magnetic Motion.
Courtesy of Iris van Herpen

which showed 3D textiles that seemed to vibrate the bodies' energies like antennas and surrounded the models like halos. *Magnetic Motion* (2014) was inspired by a visit to CERN, the European Organization for Nuclear Research, and the Large Hadron Collider. The unfathomability and invisibility of those immense natural powers, such as magnetic fields, inspired captivating 3D textiles that seem to arise from the replicating geometric structures around the body of transparent thermoformed acrylic.[11] A recent result of their collaboration is *Hypnosis* (2019), utilizing a technique involving thousands of plotter cut mini ripples that continuously dissect the dress through each movement of the body, flashing skin in-between the whimsical spheroid patterns.[12] Humans' incapability of registering these delicate, quick movements causes optical illusions: The artists knowingly deceive the eye by playing with the limits of human perception.

1.13
Magnetic Motion.
Courtesy of Iris van Herpen





1.14
Hypnosis. Courtesy of Iris van Herpen

The collaboration between Van Herpen and Beesley also is a continuous exploration of the nature and role of fashion and architecture, and the way they both relate to the body and its surroundings. From the early stages of her career, Van Herpen has regularly worked with architects, including Benthem/Crouwel Architects, to create *Crystallisation* (2010), and Neutelings Riedijk Architects in 2019, that resulted in a kilometer-long frieze of seemingly smooth, wavy fabric, conjuring up an image

1.15
Hypnosis. Courtesy of Iris van Herpen

of earth layers compressed by tectonic forces, that is draped around the Naturalis Biodiversity Center in Leiden (the Netherlands).[13] As discussed in various publications and exhibitions, fashion and architecture are increasingly being linked and parallels are found with regard to shapes and structures.[14] Furthermore, the disciplines share a preoccupation with protecting and shielding our bodies from their surroundings. As McLuhan pointed out, there is no fundamental distinction between

1.16
Hypnosis. Courtesy of Iris van Herpen

fashion and architecture: 'If clothing is an extension of our private skin . . . housing is a collective skin or garment.'[15] From outfits made of paper-thin materials wrapping the body like a second skin and voluminous open-structured pieces to installations and entire environments: The designers each work at opposite sides of the same spectrum. According to Van Herpen, 'both fashion and architecture can create thought-provoking spaces, unfamiliar places that inspire new ideas'.[16]

Semi-living systems such as architecture also mark a transition, marrying the digital with the biological. Constituting interactive responsive interfaces between humans and the external world, they make the traditional boundaries between fashion and architecture less distinct, less absolute. An interactive material could, for example, respond to temperature changes or even make people aware of phenomena their own senses cannot perceive. Beesley alludes to a future matter that can learn, sense and even care.[17] These new hybrid materials do not shut out the external world. On the contrary, they create a bond between that world and the user, blurring the boundaries between notions that were previously considered rock-solid, such as inside and outside, natural and synthetic, and people and things.

FASHIONING THE FUTURE

Imagining a world of hybrid life forms offers endless new possibilities and novel relations.[18] Additionally, it forces us, humans, to rethink our self-attributed exceptionalism and to reinvent ourselves. Van Herpen's work has always steered clear of prevalent ideas about innovation and technology as functional and efficient. Rather than dressing a new superhuman, she envisions the future of fashion as an open lab where experiments and concepts materialize in stunningly beautiful pieces with improbable tactile qualities that transport the viewer to unknown territory. Van Herpen's own practice is constantly evolving too, as she is eyeing the latest developments in fields such as synthetic biology, nanoengineering, 4D printing that programs shape-changing behavior into matter, and the advent of real-life 'invisibility cloaks'. These vistas will most likely take center stage in her material world someday. Bringing body, object and enclosure into focus in her particular way, Van Herpen rewrites the narrative of fashion through a radical and much-needed change of perspective. Can a dress change our worldview? Yes, she can!

NOTES

1. Laird Borrelli-Persson, '10 Questions for Iris van Herpen as She Prepares to Celebrate 10 Years of Fashion Innovation at Couture', *Vogue*, 30 June 2017, https://www.vogue.com/article/iris-van-herpen-haute-couture-anniversary-interview.
2. Her first solo exhibition at the Groninger Museum, Netherlands, in 2012, was curated by Mark Wilson and Sue-an van der Zijpp. The touring exhibition, *Iris van Herpen, Transforming Fashion*, was in collaboration with design curator Sarah Schleuning of the High Museum, Atlanta.
3. Accessed 1 September 2020. https://www.irisvanherpen.com/haute-couture/sensory-seas.
4. Accessed 1 September 2020. https://www.irisvanherpen.com/video, see process films.
5. L Malafouris, 'Creative Thinging, the *feeling of* and *for clay*', *Pragmatics & Cognition*, 22, no. 1 (2014): 140–158
6. Van Herpen mentions the term 'sit-down ability' in an interview with Sarah Schleuning, see *New Bodies, New Worlds: The Collaborative Work of Iris van Herpen and Philip Beesley*, accessed 3 September 2020, https://www.youtube.com/watch?v=Diu00NhYFHU
7. Iris van Herpen, Mark Wilson, Sue-an van der Zijpp, Jerry Stafford, Sarah Schleuning, Heather Medlock, Andrea Gollin, et al., *Iris van Herpen Transforming Fashion* (Atlanta:

High Museum and Netherlands: Groninger Museum, 2005) on the Voltage collection, and M Thys, ed., *Iris van Herpen* (Wommelgem, Belgium: Groninger Museum and BAI Publishers, 2012).

8. See, for example, Mary Shelly, *Frankenstein*, Fritz Lang, *Metropolis*, Chaplin, *Modern Times*. A Bolton, *Manus x Machina: Fashion in an Age of Technology* (New York: Metropolitan Museum of Art, 2016).
9. Bolton, *Manus x Machina*, interview section, p. xvii and M. McLuhan, *Understanding Media: The Extensions of Man* (London: Routledge, 2008).
10. Beesley represented Canada at the Architecture Biennale of 2012; see also, accessed 1 September 2020, http://www.philipbeesleyarchitect.com/sculptures/0929_Hylozoic_Ground_Venice/.
11. CERN is the European Organization for Nuclear Research. Its business is fundamental physics.

    Its Large Hadron Collider is the world's largest and highest-energy particle collider consisting of a 27-kilometer ring of superconducting magnets, that's more than 100,000 times more powerful than the earth's magnetic field, see, accessed 25 August 2020, https://home.cern/science/engineering/pulling-together-superconducting-electromagnets, and *Iris van Herpen, Transforming Fashion*, on Magnetic Motion.
12. Accessed 5 September 2020, https://www.irisvanherpen.com/haute-couture/hypnosis
13. Accessed 3 September 2020, http://www.neutelings-riedijk.com/naturalis-biodiversity-center
14. See also B Hodge, *Skin+Bones: Parallel Practices in Fashion and Architecture* (Los Angeles: The Museum of Contemporary Art (MOCA), 2006), and B Quinn, *The Fashion of Architecture* (Oxford: Berg Publishers, 2003).
15. McLuhan, *Understanding Media*, 129, 133
16. Accessed 24 August 2020, https://www.dezeen.com/2019/08/28/iris-van-herpen-naturalis-biodiversity-center-leiden-neutelings-riedijk-architects
17. *New Bodies, New Worlds*.

2 Great Mistakes

Noa Raviv

During the winter 2012–2013, I interned at the fashion design department of Escada in Munich, Germany. Twice a week, after work hours, I went to study German at Klartext, not knowing many people in town, most other evenings were spent on a red couch in a small studio apartment, reading design magazines. 3D printing was at its most promising peak, with exciting futuristic subject lines about 3D-printed organs and full-scale 3D-printed rooms, a 3D-printed prosthetic foot that saved a duck's life[1], or *Wired*'s cover that featured Bre Pettis cradling a MakerBot home 3D printer and the words, 'This machine will change the world'.

After six months, I returned to Tel Aviv, where I was studying fashion design at Shenkar College of Engineering Design and Art. I cross-registered for a Rhino 3D class with the Jewelry Design department. Command after command – the teacher demonstrated how to draw a straight line, then a curve. Then circles and squares and hexagons, and later on spheres and cubes. Learning this software was like learning German: At first it was just single disjointed words, then, with practice, the vocabulary was expanded and the virtual shapes became more complex, like sentences. An extruded asymmetrical daisy. A sphere connected to a tube. A hollow Windex bottle. As I rendered them, I learned how to speak. They appeared in grayscale tones, flattened on the monitor that was divided into four viewports: Top, Front, Right and Perspective. And when clicking and holding the spacebar to turn around an object in the Perspective view, magic happened – *the object was alive.*

Simultaneously, all 45 students in the Fashion department, including me, were working on their graduate collections. My research started around Hellenistic Greek sculptures.

As a child in Israel, we had occasional school trips to the Israel Museum in Jerusalem. Looking at the Greek and Roman-style archaeological findings that were discovered in Beth Shaan or Tel Shalem, an hour and a half from that elementary school, was an experience of indifference and boredom. Moving as a class through the galleries, the broken stone sculptures all seemed the same to me: background props in a film. Only years later, at the age of 19, while visiting The Metropolitan Museum of Art in New York to see an exhibition at the Costume Institute (*Poiret: King of Fashion*), and passing through the expansive Greek and Roman galleries, did the beauty of those sculptures hit me. Fascinated by the draped lightweight fabric,

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rendered precisely in hard, cold marble, I could suddenly appreciate the treasures found in my own homeland.

What metaphors did those Greek statues carry? What was so striking about them?

The Greeks were obsessed with the image of the perfect body. And like our current preoccupation with our bodies, the gym was a fundamental part of it. Across ancient Athens, men, naked, were working to build a lean and well-muscled body. The perfect body.[2]

And there was also the realistic representation of one material, translated into another. The precise rendering of draped textile in stone. The ideal figure wrapped in a perfectly rendered marble tunic.

As much as the Greeks strove to have a flawless body, artists over the years have also sought those immaculate depictions of textile and flesh.

The large A3 papers of my sketchbook were filled with cheap laser prints of Greek statues and modern works by artists who referenced them: *Nike of Samothrace* from the Louvre archives[3]; Adrian Paci's video work, *The Column*[4] – where Paci hired a group of Chinese craftsmen to complete a full-scale classical Greek-style marble column on the passage from China to France; two plaster casts of classical sculptures placed one opposite the other, from Giulio Paolini's Mimesis series[5]; The Met collection's *Marble statue of a wounded Amazon*[6]; and Rachel de Joode's photograph[7] depicting a woman in a grey background studio setting, mimicking the posture of a broken statue.

How did this widespread artistic obsession get started?

Soon after Greece reached its cultural peak in the Classical period (5th–4th century BCE), educated and wealthy Romans desired works of art that evoked Greek culture. To meet this demand, artists created marble and bronze copies of the famous Greek statues. Molds taken from the original sculptures were used to make plaster casts that could be shipped anywhere in the Roman empire, where they were then replicated in marble or bronze.

By the 2nd century CE, the demand for copies of Greek statues was enormous – besides their domestic popularity, the numerous public monuments, theaters and public baths throughout the Roman empire were decorated with niches filled with marble and bronze statuary.[8]

Fast forward to the 18th century when there were significant efforts to retrieve the lost glories of the Classical period – Young American and European aristocrats embarked on the Grand Tour, where they visited Paris, Venice, Florence and, above all, Rome. There, they were guided by a *cicerone*, a docent who led them through the mazes of museums, churches and marmoreal monuments. Neoclassicism arose from such firsthand observations and reproductions of antique works and came to dominate European architecture, painting, sculpture and decorative arts.[9]

In the 20th century, small plastic replicas of those sculptures, their Roman copies, or their neoclassical versions, started to be sold in the street markets of Firenze – a summer trip souvenir on a bookshelf gathering dust and dirt and eventually thrown away.

Today made-in-China resin copies are sold on Amazon for as little as 2.50 USD, indexed according to size, material, price, and the mythological hero they depict.

From the ideal symbol of beauty, the original Greek sculptures devolved into a manifestation of ubiquitous kitsch.

So, when everything is copied and reproduced – Chinese factories copy Italian souvenirs which were based on the works of Italian masters, which based their paintings on treasures from the Roman Empire, where reproducing works from Ancient Greece was widely practiced – what's the point in striving for creative innovation? And what can make an object truly original?

3D printing makes those questions even more pressing, especially since 3D-printed objects have started being sold via online marketplaces and their files are available for instant download. Now an endless variety of objects can be rapidly prototyped anywhere in the world, in any size, any color, any material. A plastic Venus de Milo for everyone.

3D printing and digital versions of the simulacrum, a representation of someone or something – and also the Latin term for statue or idol[10] – seem to have consumed any chance to create a one-of-a-kind object.

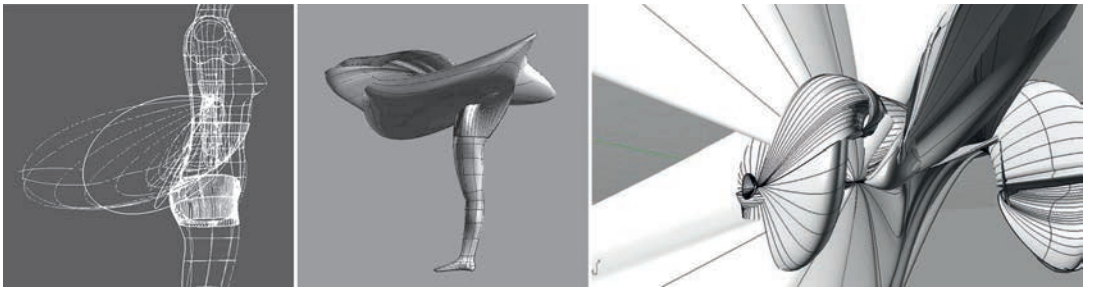
An image has long been able to be reproduced and copied. But was this now true for any other object as well? Would files replace kitchenware and clothes? Could anything eventually be 3D scanned and 3D printed, countless times, in myriad materials? At first, the bombastic headlines of 2013 stimulated my imagination. Then they made me panic: If 3D printing could indeed take over, wouldn't we then live in a world of lifeless polymer copies?

In one of my Rhino 3D classes, I made a wrong command in the software and instead of a smoothly connected cube and sphere, the result was a messy explosion of grey surfaces and repetitive black lines. A twisted mop tangled up in a magnetite crystal. I examined it for a long moment before calling over my teacher, Tal. A tall, blond, reasonable man, he stepped up to my computer station to see this wireframed explosion. 'Noa, it's a mistake. It's worthless. You can't even print it.'

Why couldn't it be printed? And if so, is there only value to what is tangible and working? What about the beauty in the damaged and the accidental?

In the weeks following that lecture, I went back to the computer lab to recreate more of those glitches, trying to come up with strategies and methods for making digital tasks that would result in tangled up surfaces. Simple commands made wrong: I created holes in two spheres, then turned the holes to face away from one another and connected them with the 'Blend Surface' command. Since there was no path for them to be connected through, it resulted in a virtual glitch of a surprising volume. I then played with the sliders in the pop-up window to enhance the aesthetics of that glitch and shape it in accordance to my taste. At other times I worked with a 3D model of a woman, hands and legs stretched to the side, like DaVinci's Vitruvian Man, dissecting or extending the computerized figure, corrupting its ideal proportions.

The work with those glitches gradually turned my obsession with perfection into a growing interest in flaws and errors.



2.1
Rhino Drawings, 2013. Courtesy of Noa Raviv

The Statue of Tyche from the 3rd century CE at the Israel Museum in Jerusalem depicts Tyche holding her symbol, the cornucopia. A pleated tunic hugs her body, tied with a delicately crafted rope, emphasizing her curves. Holes in her neck, lower body and right arm contain the remains of metal pins, indicating that the statue was broken and repaired in ancient times.[11] This perfectly crafted sculpture, of the 'ideal' body, was damaged and repaired with the technological tools of its era, then impaired again. Those marks reveal its history, making it unlike any other.

When Walter Benjamin talked about the destruction of the object's aura, he referred to technical reproductions and their lack of 'one-timeness'. Their unique existence at the place where they happen to be was no longer relevant. The need to reproduce objects and images is largely based, according to Benjamin, on the desire to 'get closer' to things.[12] But maybe nowadays, when a computer, with its immaculate capabilities, fails to perform a task it is given – resulting in a distorted

2.2
Noa Raviv's Sketchbook, 2013–2014. Courtesy of Noa Raviv

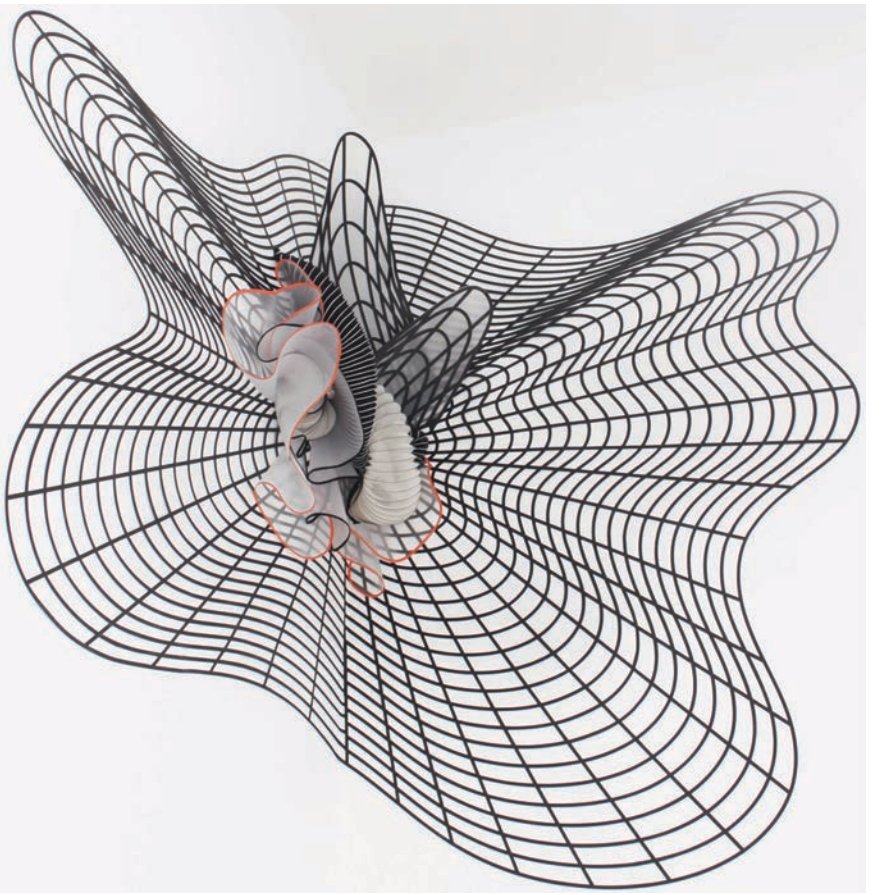
image – the aura is there too. Such digital mistakes create an unprecedented image and bring us closer not only to the object but also to its facilitator and to that otherwise lost uniqueness.

Flaws, for the most part, are not desirable. Therefore, they are less likely to be copied. And it is harder to recreate the exact same mistake twice.

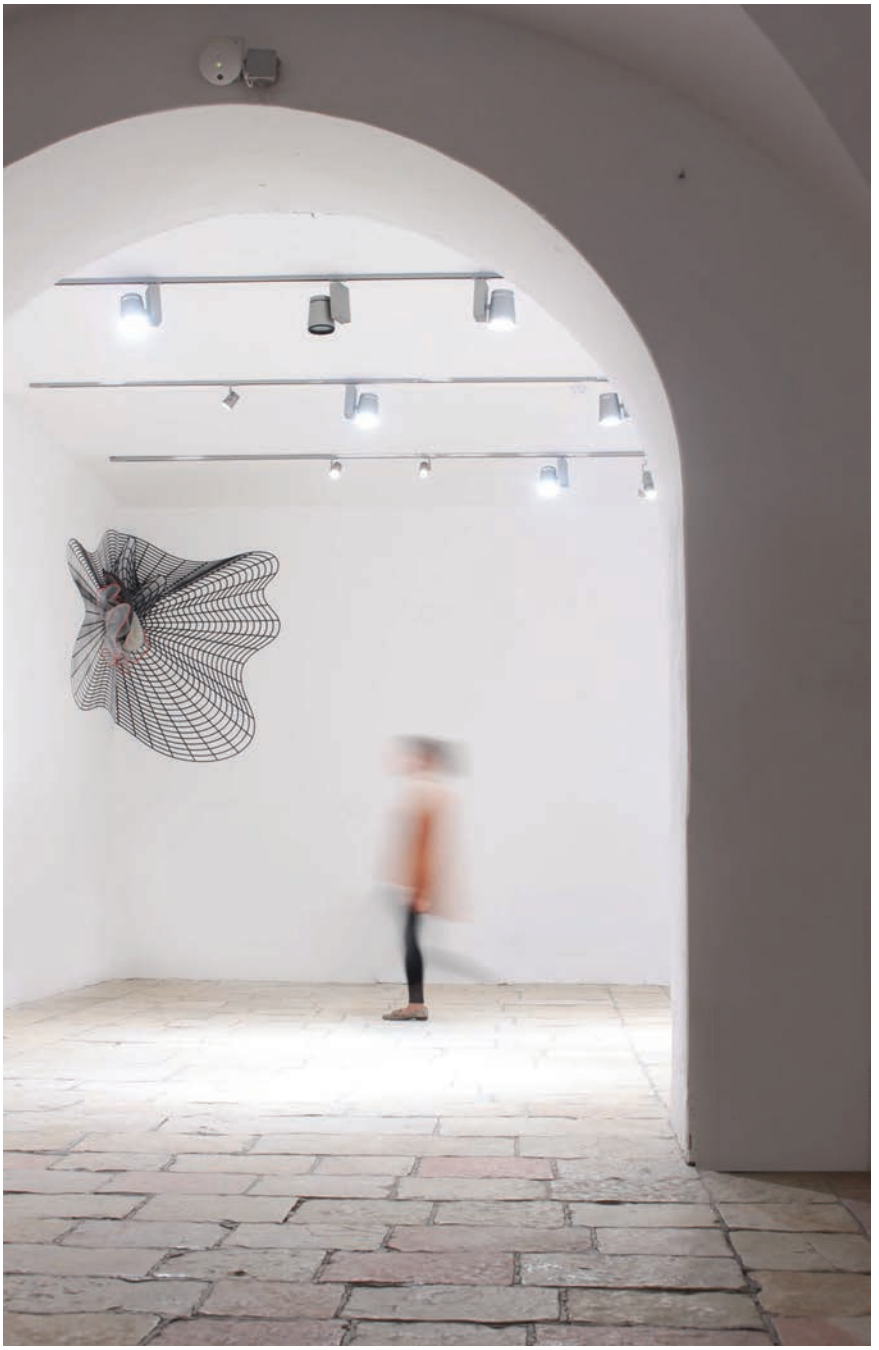
Imperfections, marks of a human hand, of time, of history, have the power to create an irreproducible object.

I used those failed computer commands as the main idea for the creation of my first collection (presented in 2014). It informed both the concept and the visual principles of the garments. Being a fashion designer used to working with my hands and real three-dimensional materials, I looked for ways to mimic those mistakes with fabric in real life, and create handmade versions of those digital glitches.

In my home studio, I started draping fabrics to imitate those wireframed messy forms and develop different textiles that could hold up many of the ideas and visual identity that the computer glitches had. After much trial and error, I came up with a pleated textile, its edges dyed manually in contrasting colors of black and white, purple and orange. Bugle beads were hand-embroidered between the pleats, adding structure and volume to the light, flowy fabric.



2.3
Installation view of Hard Copy, a wall sculpture created in 2015 and exhibited at Hansen House, Jerusalem, as part of OOPS, an exhibition curated by Yuval Saar. Courtesy of Noa Raviv



2.4
Installation view of Hard Copy, a wall sculpture created in 2015 and exhibited at Hansen House, Jerusalem, as part of OOPS, an exhibition curated by Yuval Saar. Courtesy of Noa Raviv

In order to speak about the tension between 2D and 3D, I wanted to find a flat material to combine with the pleated textile. After trying plaid fabrics and tulles, lace and different patterns for sublimation prints, I developed another textile – one that borrows its aesthetics from the grid wireframes of the 3D software. A black net-like structure was created with laser cutting and then glued onto a fine transparent tulle.

Despite the sleek digital look, both textiles required dozens of hours of manual labor. Up until that point the 3D software and its glitches were only a source of inspiration and a design tool. But because the project's ideas and processes were deeply rooted in the world of digital fabrication, I wanted to incorporate the work of actual 3D printers.

The little experience I had with 3D printing back then included making a few small rings. It was expensive and slow. In order to print at the scale of the body and the complexity of the designs I needed a partner that could provide access to the technology and resources for such a printing process. I partnered with Stratasys, which supported me with the creation of two out of the seven outfits in the collection.

2.5
Ensemble, 2014. Black and white 3D-printed polymer (fabricated by Stratasys), black polyester with adhesive applique of laser-cut white polyester twill weave. Courtesy of Noa Raviv. Photograph by Ron Kedmi.

I didn't know how to approach the design of a large 3D-printed object and the start of this process was baffling. I met architects and engineers and was confused by their advice as much as I learned from it. One of the experts I consulted with suggested to approach it like a fashion design project and start with draping. Digital draping. Once again, I was working around a virtual model of a woman's body, this time not for the creation of glitches. I started by building volume around the

2.6
Ensemble, 2014. Black and white 3D-printed polymer (fabricated by Stratasys), black polyester with adhesive applique of laser-cut white polyester twill weave (Detail). Courtesy of Noa Raviv. Photograph by Ron Kedmi.

wireframed figure, sketching grids and curves, as if I was placing textiles on top of a mannequin. Around the waist, on the back, on top of the right shoulder, influenced by the real-life draping I used to do, searching for compositions that resonated, looking for the right proportions and textures, gradually seeing them appear on the screen.

The base structure was made with Rhino. Then the surface was built with Grasshopper: a parametric code created a wavy shell-like texture with contrasting edges. After several tests and revisions, the objects were sent for production.

Stratasys's Objet500 Connex3 Multi-Material 3D printing technology, provided the means to print high-resolution combinations of black and white polymers. The sophisticated method of support material enabled the objects' geometry to include hundreds of little spaces and gaps without any need for after-printing assembly, and for the thickness of the material to be extremely fine. Due to their geometric intricacy, those parts could not be fabricated by any other technique. Later on, and in order to break the traditional hierarchy between the handmade and the machine-made, the two 3D-printed objects were hand-sewn into the garments.

2.7
Ensemble, 2014. Black and white 3D-printed polymer (fabricated by Stratasys), hand-sewn synthetic tulle with adhesive applique of laser-cut black polyester twill weave. Courtesy of Noa Raviv. Photograph by Ron Kedmi.

The final collection, which was titled Hard Copy, presented in 2014, included seven pieces made from both handmade materials and digitally manufactured elements. In the finished result, 3D-printed pieces imitated handmade pleated textiles. And those pleated fabrics emulated the computer glitches. The glitches inspired the design of the grid textiles. It wasn't clear anymore what was handmade and what was done by a machine.

One day, almost a year after first presenting this collection, I was walking back to my Tel Aviv apartment, carrying a loaf of bread from the bakery, when an email with an intriguing subject line popped up on my phone: 'Exhibition: future [im]perfect: fashion, science, and technology'. The sender was Andrew Bolton, the head curator of The Metropolitan Museum's Costume Institute. He said that there is a

2.8
Ensemble, 2014. Black and white 3D-printed polymer (fabricated by Stratasys), hand-sewn synthetic tulle with adhesive applique of laser-cut black polyester twill weave. Courtesy of Noa Raviv. Photograph by Ron Kedmi.

2.9
Ensemble, 2014. Pleated polyester, beads, ribbons and hand-sewn synthetic tulle with adhesive applique of laser-cut black polyester twill weave (Detail). Courtesy Noa of Raviv. Photograph by Ron Kedmi.

possibility of including my work in the next spring exhibition. We had an interesting phone call the following week about copies and originals, handwork and digital craft.

In 2016, two pieces from this collection were presented in the exhibition titled, *Manus X Machina: Fashion in an Age of Technology* at The Metropolitan Museum of Art. The exhibition revolved around the relationship between the hand and the machine, and the role it plays in the artistic production of fashion. One idea of the exhibition, as it was presented in the catalogue, is that traditional hierarchies between manual labor and machinery work might not be relevant anymore: Hand and machine work best in combination, sometimes unconventionally, to assist and enhance the design process and enable imaginative inventions that could not be possible without such a synthesis.[13]

One magnificent example that Bolton chose to present in the main hall of the exhibition was a Chanel gown with a long train that required 450 hours of workmanship. It was both hand painted and machine printed; the design was hand sketched then manipulated on the computer. And unlike most haute couture creations, it was entirely machine sewn. The exhibition included other works by prominent designers and fashion houses such as Yves Saint Laurent, Dior, Martin Margiela, McQueen, Iris van Herpen, Louis Vuitton, Issey Miyake, among others.

In his interview with Sarah Burton (McQueen's creative director), which appeared as part of the catalogue, Bolton opens one of his questions with the

2.10
Ensemble, 2014. White silk organza, black ribbons and synthetic tulle with adhesive applique of laser-cut black polyester twill weave. Courtesy of Noa Raviv. Photograph by Ron Kedmi.

following statement: 'In terms of aesthetics, the hand has come to signify imperfection while the machine has come to signify perfection. Advances in fashion, as in any design discipline, are often the result of mistakes.'

On the lower level of the exhibition next to an ensemble by Thierry Mugler and facing a Balenciaga dress, were two of my pieces. What started out as a computer mistake in a college lab in Israel was now on exhibition at The Metropolitan Museum, across from the Greek and Roman galleries that I visited as a teenager.

2.11
Noa Raviv, Ensemble, 2014 (left); Marble statue of a wounded Amazon, 1st–2nd century AD (right). Courtesy of Noa Raviv. Photograph by Ron Kedmi (left); gift of John D. Rockefeller Jr., 1932, The Metropolitan Museum of Art (right)

2.12
Noa Raviv, Ensemble, 2014 (left); Marble statue of Eirene (the personification of peace), Roman copy of Greek original by Kephisodotos, ca. AD 14–68, (right). Courtesy of Noa Raviv. Photograph by Ron Kedmi (left); Rogers Fund, 1906, The Metropolitan Museum of Art (right)

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3 Fashion and Technology

The Intangible as a Working Material

Ying Gao

INTRODUCTION

Through the interactive garment projects developed in my lab, in which my two main interests – fashion and media arts – converge, I am attempting to free the garment's structure, but also to explore the possibility of working with the intangible elements surrounding us in the physical world. Components such as air, sound, and gaze harbor great ambiguity. Fashion is made up of shapes and formats, but also of materials which have, over the last few years, progressively evolved due to the advent of technical-grade materials. Today, textile and garment design can add a new dimension to Man's relationship with his environment: sensory perception. Interactive garments introduce a new substrate on which to rebuild the relationship between the human body and its surroundings. These garments act as mediators between the human body, its surroundings and the notion of 'transitional spaces'.

THE CREATIVE CONTEXT AT '*EXERCICES DE STYLE*' DESIGN STUDIO

From Haute Couture to Smart Clothing

From the 19th century to today, fashion's schematic can be summarized to haute couture, the clothing industry and ready-to-wear. According to Gilles Lipovetsky (1987), from the mid-19th century to the 1960s, *la mode de cent ans (*hundred-year fashion*)* could be described as the creation of bespoke luxury items, called *haute couture*, which was in direct opposition to large-scale production, or the 'clothing industry'; the latter would reproduce copies of exclusive, haute couture creations. The creation of original designs and industrial-scale reproduction have been coexisting ever since. However, this marriage of reason is particular in the way both parties utilize radically different materials and applied technologies, mirroring society's divisive class hierarchy, which enshrines vastly different lifestyles and aspirations. Today, the relevance of intelligent garment projects addressing Man's relationship with his surroundings is expanding as information technology lays an increasing pressure on our capacity to absorb new information feeds and interaction schematics. New technologies occupy a growing space in our day-to-day lives, much like textile, which is found everywhere. The basis of all research on intelligent (smart) garments is as mundane as it is obvious: As the body and its

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surroundings are simultaneously transmitter and receptor, smart garments could therefore become their interface media.

'Where garments appear, there begins socialisation; they can even be seen as cultural objects' (Deschamps, 1979, 31). New social structures, new schools of thought and new materials affect the substance, surface and structure of contemporary garments. However, should technological advancements lead to dematerialization, virtualization and multisensory perception, what will then become of clothing in the third millennium? In spite of its purely decorative connotation in modern societies, clothing has long lived at the core of our existence as a social object. Flügel (Flügel, 1985, 220) maintains that clothing would only survive as episode in the history of Humanity, and that

> man will one day live (and perhaps, woman before him) comfortably in the mastery of his own body and of his physical environment, rejecting the clothing crutches which he was dangerously dependent on over the course of taking his first steps toward a superior culture. Meanwhile, the crutches remain. We can however take care that our burgeoning sciences allow us to mould them in a realistic way, use them wisely and thus, facilitate our progression.

Flügel's clothing (1985) has three main purposes which have constant agency in the civilized world: adornment, decency and protection. Even though decency and protection have taken on considerable importance since the appropriation of clothing, adornment seems to be clothing's main goal at its root. It is undoubtedly troubling to observe the coexistence, paradoxical and simultaneous, of adornment and decency within the same group: The main function of adornment is to magnify physical appearance and visually engage others, when decency lies directly opposite, as it tends to camouflage physical imperfections and deter external gaze.

This fundamental contradiction constitutes an infinitely rich introduction to the development of fashion in modern societies: Fashion is all about ambivalence, controversy and compromise.

Fashion and technology are among the most ephemeral domains. Today's novelty is doomed to be swiftly forgotten. Fashion designers have long known that their life's toil is ephemeral in nature, and that their creations begin to fade as soon as completed. The integration of digital technology deeply transforms clothing's creative process, in terms of substance, surface and structure. This integration could also contribute to the return of a slower creation/consumption cycle, which is to say, to more sustainable and thought-out fashion.

So, what is a smart garment? In the absence of an official terminology and according to what has been created up to this day, smart garments are defined as cyber-clothing, incorporating textile and new biological, chemical and nanotechnologies, as well as digital and electronic components. Technological materials were first brought about through the work and research of chemical engineers. From the start of the 20th century, scientists have invented a vast array of textile protection treatments using simple priming processes. The initial results of chemical fiber research were put to use during the Second World War. Even today, the majority

of innovative textile research aimed at creating smart or technically advanced garments is carried out by telecommunication companies, ministries of defense or medical labs rather than the textile and fashion industries. For the most part, such garments are created to facilitate the integration of computers or similar gadgets to the human body using pockets, inserts, cut-outs, clip-ons, etc. Stylistic innovations are often limited, and many unknowns come into play, such as how to link a power source. Fortunately, collaborations between industrial and fashion designers have become increasingly common over the last few years, which allows us to expect a more positive future in this domain.

Exercices de style *Studio's Singular Approach*

Artists working in media arts and fashion designers are already anticipating a more complex yet subtle integration of technological devices to garments, by exploring the themes of playfulness, the extension of self and the notion of second skin. The idea of the garment being a finished object with a preestablished purpose is being questioned by the arrival of communicating and modular materials, which can be adapted to our physiological needs, or to specific external conditions. It is now entirely plausible to envision the evolution of contemporary fashion through the lens of such materials, as it will prompt us to first imagine the creation process as taking place in the designer's lab, rather than in his couture workshop. Two major experimentation fields must therefore be addressed: the new material's substance, and the construction phase of the actual garment.

I founded the *Exercices de style* studio in 2004, where I have been working with my fashion design and interactive media assistants, as well as with professional consultants in industrial design and robotics. Along with my team, I formulate new ideas and attempt to push back the boundaries of clothing design. Usually, my assistants – who are for the most part studying fashion design – create clothing collections aimed at a specific market and source their inspiration from images or objects. Their integration in the studio allows them to reflect further on the outcomes, purposes and new functionalities of contemporary garments, to see clothing as an element of media ecology and to theorize their work process. Technically speaking, the development of pattern pieces for modular garments presents great complexities. Through the years, we have explored in depth new clothing design techniques.

The originality of the projects conceived at the studio mostly resides in the complexity of the process, as much on the conceptual level as on the aesthetic and technological levels, as well as in the way they distinguish themselves from the 'smart garment' trend. The 'smart garments' created to this day do not include proper structural research as such, or very little, as all interactions tend to happen on the textile's surface; to my mind, when applied to the specific realm of fashion design, this process should rather be about the creation of original clothing. I thought it relevant to consider the evolution of contemporary clothing through the lens of new and changing modular structures, combined with interactive technology: this way, the fashion industry will have to firstly imagine the creative process as taking place in the designer's lab, where information technology devices are found, rather than in his workshop, and using tools like scissors and pins.

Historically, mutations in the realm of textile first began with the creation of nylon in the late 1930s. Artificial and synthetic textiles have multiplied in the decades that followed. Progressively, but rapidly, fashion has appropriated a large portion of all chemical, physical or electronic innovations. Textile ennobling has greatly modified garments in general but has mostly simplified women's lives since the 1960s; 'with time, clothing has become a true functional barrier, and is no longer a merely aesthetic shield' (Guillaume, 2000, 63). Indeed, clothing can today be edible, climate-controlled or antibacterial. The term 'textile' is often replaced with 'material', which has a wider and rather indeterminate meaning. These brand new materials allow the imagination to roam further, as they aren't associated with the usual references; their uses have quickly overturned their original design's purpose, such as defense, aeronautics or medicine. Today, evolution seems to favor softer and lighter textiles, with simplified care instructions. Great progress has been achieved in textiles created for the military and sport, later invading the world of fashion having been recycled by designers and diverted from their original function.

In Japan, research in the field of what is now called 'smart' textiles superseded the creation of more traditional materials as early as 1987. The very first international conference on 'Smart, Intelligent Materials and Systems' was held in Tsukuba in 1989. The term 'intelligent materials' is an abbreviated version of the more detailed designation 'intelligently elaborated materials or systems'.

Among the researchers spearheading this sector is

> Toshinori Tagaki, who proposes that this concept is modulated through a hierarchical ladder of intelligence, points to three distinct categories of intelligent materials. Firstly, there are materials endowed with a primitive intelligence offering three main functions: sensation, action, and processing. These are maintained by appropriate structures, accompanied by transfers of energy and information in the form of chemical processes. At the second level are actual intelligent functions: self-diagnostic, homeostasis . . . Finally, there are functions which can be defined as a type of superior intelligence, capable of adaptation to human or social values, like harmony. (Guillaume, 2000, 38)

Nowadays, fashion designers no longer need to foster direct relationships with their clientele, and a designer's success no longer depends on his capacity to express his identity and share his universe. We are all confronted with a 'conceptual' problem. It would also seem that haute couture, which used to soak up the spotlight, has reached its limits. The evolution of contemporary fashion could put an emphasis on materials and their relationship with the environment. As a designer and a teacher, I think that this may influence future fashion designers to leave their 'couture workshop' in order to create in a 'design lab'.

STUDIO CREATION PROJECTS

At my studio-laboratory, research questions surrounding the intangible are addressed through a practice which is both experimental and systematic. On one

hand, there is the material construction of clothing objects, and on the other, a sort of 'speculative screenwriting' about the viewer's participation. The ambivalences that underpin our projects are reflected by the variable nature of these interactive garments, which rarely are entirely stable or final, forever on the cusp of metamorphosis. The unpredictable yet scripted reaction of the viewer to these microprocessor and sensor-incrusted garments is, for instance, a representation of indecision about word choices when the sound of a human voice can alter the clothing's shape, making it expand or contract. The intangible participates in the unpredictability of the relation itself, as evoked by the reciprocity between figures: Here is a 'clothing-based situation' encompassing the viewer whose gaze, voice, breath and facial expression activates the garment's movements, in a sort of crest-and-trough ballet creating an undulatory dialog. Our projects study this singular problematic hinged on the intangible, so that it can be modelled as a non-stipulation through which an object or perception ends up being transformed in various ways, becoming 'other'; the result, although not scripted, does not follow an entirely arbitrary path.

During the creation of a workshop on the impact of digital technology on fashion held at the Haute École d'art et de design in Geneva, I noted two main axes of application. Firstly, the 'gadgetization' of design – à la Star Trek – in other words, the explicit addition of gadgets to garments. Secondly, technical applications like design software, rapid 3D prototyping, etc. used during the creative process. Intuitively, however, I wished to integrate digital technology in a more subtle way through the creation process, as a source of inspiration.

Among some 20 collections created since 2004, I deem relevant to highlight six interactive garment projects that were exhibited in over 100 museums and related institutions worldwide, as these conceptual projects illustrate particularly well the themes explored in these pages.

Walking City

The very first project created at the lab in 2004, entitled Walking City, calls for a new paradigm. It sits at a crossroads between clothing design and media arts. Walking City is about the creation of three pneumatic interactive garments. This project is also an homage to the British architectural collective, *Archigram.* Conceived in the 1960s, their successive projects, Instant City, Suitaloon and Cushicle, along with the notions they put forward, pushed urban planners and architects to interpret urban spaces in a new way. These concepts were reflected in the building of temporary and inflatable living structures, both mobile and modular, designed for the individual experiencing a deep intimacy with the urban environment. *Archigram* were among the first to bring about more fluid habitable structures, comprised of tactile and reactive spaces, and have paved the way for the wearable items we see on the market today. Following *Archigram*'s lead, the smart garment could also be defined by the contemporary urban environment; moreover, it could be designed to respond to physiological or psychological needs associated with transitory spaces, such as highways, airports, terminals and thoroughfares, as well as their respective auditory environments. The Walking City garments were similar objects to the inflatable structures presented by *Archigram,* although on a smaller

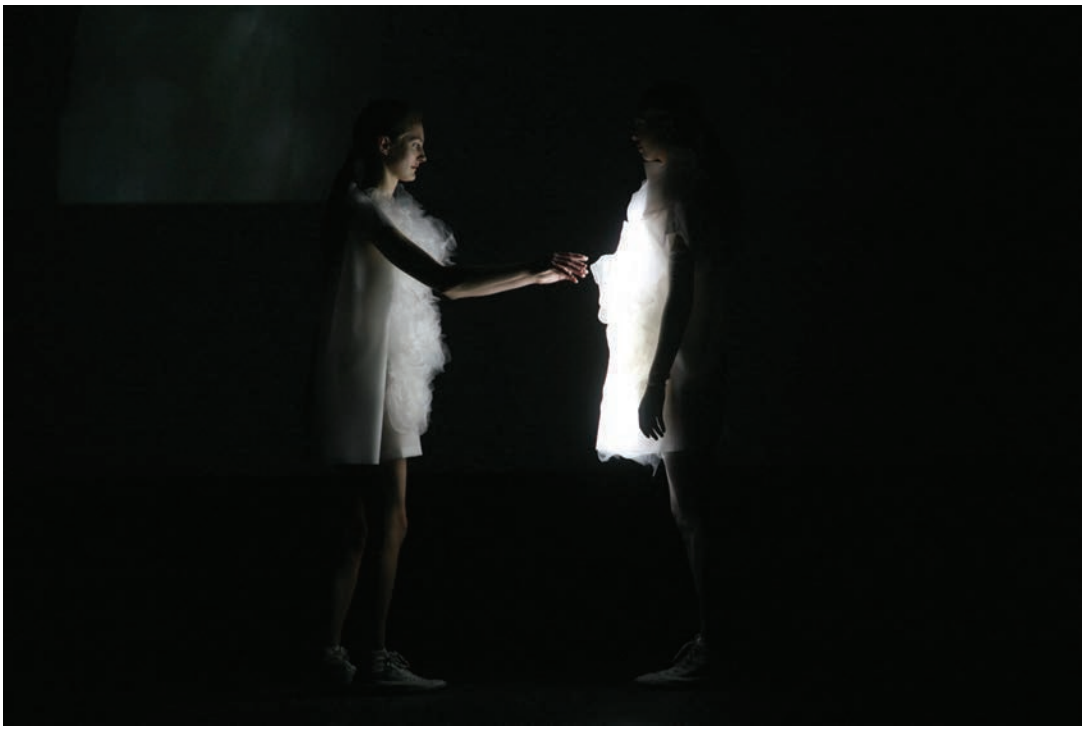
scale. In fashion design, the project's challenge is to build clothing in a way that allows for fluidity in terms of structure and volume, thus offering the possibility of multiple shapes, in contrast with the unequivocal and preestablished shape of 'traditional' clothing. This project presents an in-depth study of the modular structure of clothing and the integration of pneumatic technologies within it. I have always believed that inflatable clothing was amongst the most difficult to achieve. When

3.1
Walking city.
Courtesy of
Ying Gao

air is pumped into a 'lifeless' jacket sleeve, it is instantaneously transformed, giving the impression of being filled by an invisible body. Air is the element where color, light and vibrations converge. Lightweight, intangible, everchanging and poetic, air escapes all boundaries. Inspired by this fascinating media, my intention was to give shape to the intangible by creating clothing light years away from the idea of a protective barrier, and closer to the dimension of playfulness and the concept of ambiguity.

Playtime

A few years and many projects later, in 2009, project Playtime was born. This entire creative project, including its title, is an homage to the feature film *Playtime* by French director Jacques Tati. Filmed between 1964 and 1967, Tati's *Playtime* mirrors the work of a *couturier* who would have created each one of his garments with the utmost precision. This visionary film is built around the homogenization of overmodern architecture, and of urban surveillance. A full 25 years before the notion of overmodernity existed, Tati depicts non-places through installations allowing the accelerated circulation of people: airways, highways and vast distribution centers. Tati films the dissolution of the body in space by the use of stylistic devices like *trompe l'œil* and mirrors, which will be translated in the aesthetic aspect of my clothes; the long corridor crossed by a character shows how space renders the body non-existent, and how Man can be confused with his own reflection, as the urban environment in which he dwells doesn't allow him any agency. It is also the material itself, glass, that creates an illusion maze



3.2
Playtime. Courtesy of Ying Gao

3.3
Playtime. Courtesy of Ying Gao

rendering location identification nearly impossible. The body is lost, is multiplied, and lost again through the reflections.

The creative project I presented to the lab consisted of designing a collection of interactive and photosensitive clothing. The conceptual and aesthetic references of these garments were sourced from the film's five key sequences: arrival at the airport, the labyrinthine office building, the lounge, the showcase houses and the restaurant's opening. These garments can physically metamorphose and fragment,

according to their own perception of their physical environment. The echoes, resonances and audio superpositions in Tati's film inspired me to create photosensitive and visually blurred clothing. This project offers an exploration of clothing, of the user and the space encompassing them: When the viewer attempts to capture an image of the garments using a camera, in the context of a fashion show for example, the clothing transforms by physical fragmentation, effectively blurring their visual aspect as if the camera itself was out of focus.

(no)where (now)here

For the 2013 (no)where (now)here project, I found inspiration in Paul Virilio's (2004) essay *Esthétique de la disparition* (Aesthetics of Disapearance). The author's definitions of time and of the visible spoke to me at a visceral level. He describes time as the cycle of light, and the visible as the direct effect of light's output. In this project, my own experience of the visible and of the invisible is made concrete, expressed through the duality of the absence and presence of the garment and its viewer. When work began on this project, my lab students/assistants and I reflected mostly on the best way of merging the conceptual and technical aspects. More and more applications and software now contain oculometric technology; Samsung, among other smartphone manufacturers, is developing programs designed to harness a laptop's frontal camera and allow the user to direct text scrolling and video streaming. Facial recognition software is also commonly used by numerous artists in the field of new media; I was aware of these options and, so, along with my team, we opted to adapt existing software to our project's needs and problematics. Displayed

3.4
(no)where (now) here. Courtesy of Ying Gao

3.5
(no)where (now) here. Courtesy of Ying Gao

in a darkened room, the dresses revealed an internal vein-like network that would light up when the inner photoluminescent wire was triggered – or 'excited', in technical terms – by the viewer's gaze. The phosphorescent reaction was not triggered so much by a deliberate stare, but rather by a sort of intermediate attention, a sideways glance. Paradoxically, the experience created an effect of *chiaroscuro*, a shadow play in which the garment's luminosity was unveiled by a detached, nonchalant gaze.

Neutralité: Can't and Won't

The project entitled *Neutralité* (Neutrality) is made up of two dresses, Can't and Won't, whose aesthetic treatment resemble microbial life. By reacting to a facial expression recognition system, they stop moving when the face of whoever is viewing them becomes mobile again, thus contradicting the widely received notion that interactivity is necessarily a reactive effect of movement. Inversely, *Neutralité*'s pieces will remain still and indifferent to the viewer's efforts for as long as he or she will attempt to interact with them in a proactive manner.

Can't and Won't – once having captured the viewer's calm attention – present subtle transformations resembling *trompe l'œil* work, where robotized movements intertwined with lighting effects create the illusion of a shallow, delicate breathing. Being rather covering garments, when compared to some of my earlier projects, the dresses envelop the body and head with much volume and expansion. Analogies to a perceptive or psychological dimension easily come to mind. Integrating head

coverings into one-piece garments seems to inject an ethos, a personality, even a unique will into the clothes – in direct opposition to the concept of neutrality.

My objective when creating the Can't and Won't dresses was to explore the idea of false neutrality. A real and effective neutrality, signifying a total absence of implication. We can easily conclude that, in this case, the level of neutrality needed is in fact interested, that is to say, it is neutral in appearance only. The viewer feigns neutrality by remaining still, but, in reality, he is hoping and expecting to trigger a reaction, a movement of the garments. The body remains stoic, but the interior reality is most assuredly not. Neutrality thus becomes the ideal, an idea that cannot be sustained in the given context.

The title itself also functions as a reader's key: The idea of neutrality is placed at the forefront, only to be immediately muddled by the words Can't – being unable – and Won't – being unwilling. By expressing various states of hindrance and lack of willpower, we remain in a causal relationship that is in no way impartial.

By generating a paradox in the project's title, my aim was to put emphasis on this contradiction and highlight our false perception of neutrality and the way in which we are continuously duped by appearances – echoed by the microbial life surrounding us, but invisible to the naked eye. Being a default stakeholder in a living system, the viewer thus becomes the component of a self-generating ecosystem, as suggested by French philosopher Edgar Morin in *La Méthode, La Vie de la Vie* (The Method, or Life of Life): 'self-eco-organisation signals the multiplicity of possible relations within a living organism; it is at once closed onto itself and infinitely open to its surroundings and to diversity' (1980). In the same way, a sort of ecology is at work here: The interaction between the viewer and the

3.6
Neutralité: Can't and Won't. Courtesy of Ying Gao

dresses hinges on a certain register, contained within a perimeter of possibilities, while remaining receptive to the spectrum of variables between immobility and hyperactivity.

Can't and Won't function on the level of contradiction, demanding that the viewer, usually over-solicited, reactive and expressive, adopts an absolutely restrained demeanor. It's on this condition that the garment prolongs its 'life', its movement having already started before the viewer's presence in the room; it is a call for humility, in sharp ideological contrast with the hyper-expressive society in which we live, and by which are conditioned on a daily basis.

Possible tomorrows

I conceived the Possible tomorrows project following a prolonged reflection on the multiplicity of possible futures, and the feeling of insecurity that often accompanies this state of mind. A definite future is sure to come, both unique and shared, that will remain in memory as the pathway of universal history; but up until the emergence of this global portrait, each second of our lives is in itself a myriad of possible junctions. Our individual histories contain endless 'possible tomorrows'

3.7
Possible tomorrows.
Courtesy of
Ying Gao.
Photography by
Dominique Lafond

3.8
Possible tomorrows.
Courtesy of
Ying Gao.
Photography by
Dominique Lafond

that we can anticipate, sense, dread or hope for. This feeling of insecurity, real or latent, requires a counterbalance – and this is precisely what our technologies are incessantly striving to achieve.

Both Possible tomorrows robotized garments are connected to a fingerprint recognition system. However, the notion of security having been diverted, they

3.9
Possible tomorrows.
Courtesy of
Ying Gao.
Photography by
Dominique Lafond
and Alexandre de
Bellefeuille

only become animated when in the presence of unknown individuals, whose fingerprints are rejected by the scanner. The very tool that is meant to protect and to guarantee access via the uniqueness of our fingerprints reacts in the opposite way: not only does it not provide exclusivity of access, it also remains open to all others, to all unknown identities. This atypical reaction from the garment brings the viewer to question the very concept of security and its meaning. Is this a truly exclusive form of security, meant for me alone? Or is this inclusive access an open door to a cluster of equally possible outcomes, mirroring our daily experience?

The motion animating the garments presents an aesthetic reminiscent of the hypotrochoids, borrowed from the vintage Spirograph game commercialized during the 1960s. Composed of multiple perfectly parallel lines, these curves are generated by the trajectory of a flat disc turning inside the circumference of a slightly larger disc. The design underpinned by these nylon thread patterns was developed from a series of algorithms used in the field of pattern recognition and point cloud systems, resonating with fingerprint recognition technology. The overlapping effects are created and multiplied by the choreographed motion of robotized thread links, evocative of an uncertain, hesitant life form.

The prosthetic-like aspect of the molded shape integrated at the neckline accentuates the garments' feeling of safety and protection. Mimicking sculpted blocks, these shapes act as neck-covering elements – one of the body's most vulnerable areas – and frame the lower part of the face, thus elongating the upper body as a single, solid mass. Suggesting a totally novel protective breastplate shape, these volumes seem to emerge from a prophesized, unidentified future. By sourcing my inspiration from notions of protection, access and identity, as well as from concepts of individual vs. collective and uniqueness vs. multiplicity, I aimed to give shape to the idea of possible tomorrows, and eventual futures.

Flowing Water, Standing Time

Flowing Water, Standing Time consists of two robotized garments, reacting to the chromatic spectrum. As expressed in its title, this double-layered clothing object can be perceived as a shape given to the paradigm of constant motion – like water – that finds its equilibrium, calm and, on some level, stillness, through constant motion. This motion, however, depends upon the clothing's chromatic environment. We are therefore witnessing an adaptative behavior for which the garments have been programmed; their reactivity is their balance – their changing 'moods' their stability. This project was inspired by neurologist Oliver Sacks's novel, *The Man who Mistook his Wife for a Hat*, in which he relates the story of Jimmie G., a 49-year-old former sailor convinced of being aged 19 since having left the Navy. Shocked by his own reflection when Sacks hands him a mirror, Jimmie reverts to his 19-year-old self as soon as his gaze leaves the reflective surface. Having lost any sense of temporal continuity, Jimmie lives as a prisoner to this single, perpetual moment, oscillating between a presence to the world and a presence to self.

Much like Jimmie G., the garments evolve between two states and display perpetual metamorphosis as they react to the chromatic spectrum. This travelling between opposite states – from immobility to movement – does not operate as a dichotomy. Upon the field of time, which injects energy into the very core of inertia, fluctuates the intensity animating each garment in its unique way. These two states are mere dropping-off points among an infinite array of possibilities. In order to echo this varying mobility, the garments are also capable of chromatic movement. Capable of recognizing the colors in their immediate surroundings, they are at once liquid and chameleon-like, adapting to the slow rhythm of their ever-changing environment. A mirror effect is at play: The garments are reacting to what they see. In the manner of Oliver Sacks's patient, they alternate between what they are and what they can potentially become – all the while embodying the inherent complexity of all things.

3.10
Flowing Water, Standing Time. Courtesy of Ying Gao. Photography by Malina Corpadean

3.11
Flowing Water, Standing Time.
Courtesy of Ying Gao.
Photography by Malina Corpadean

Made from silicone, glass, ultra-light organza, PVDF and electronic components, the interactive dresses of Flowing Water, Standing Time are activated electronically by sensors and gear motors. Solid containers filled with microcontrollers, microswitches and tiny gear motors required to move the clothing are hidden within the lining. A delicate system of pulleys activated with nylon threads tied to the motor gears, visible to the naked eye, makes moving alternate sections of the clothing possible.

CONCLUSION

The intangible as mutable matter gives value to the ambivalence through which uncertainty gains structure; it prefers flux to steadiness and favors a continuous back and forth between polarities. Appreciation of the intangible is also an aesthetic position statement, an alternative to the importance given to visibility and ornamentation in the Western tradition of clothing design. The intangible is a key element of my lab's creative concepts, and of each project's realization. Elements that cannot be touched or sensed are an integral part of the garments. In some cases, this immateriality is expressed using a fabric so light that it seems to barely exist. Other imperceptible elements are also inherent to my practice: A garment may be activated by the stimuli of a gaze or a flash of light, giving life to the concept as much as to the garment itself. The intangible also manifests through the idea of transition: Change, flux and transience are typical attributes of these interactive garments.

Charles Baudelaire once said that beauty was a two-faced god: one representing the present, and the other, infinity. It is impossible to create beauty without linking together those aspects – an ephemeral, mortal element, and an eternal, immortal one. If fashion makes an impact, be it positive or negative, if it pleases some and offends others, ultimately it is down to the same reason: Fashion reminds us of humanity's dual nature, that we are all inescapably mortal beings dreaming of immortality. Let us not confine tomorrow's designers to sowing sensors and microprocessors into clothing in order to alert emergency services before the heart attack even happens. Fashion design must first and foremost echo our daily expectations and uncertainties.

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4 Random Bodies

PRAXIS: Random International

Jean Wainwright

The sound reaches you first, propelled through the moist air, suddenly you are confronted with a hyperreal torrential downpour, each drop shimmering with bright reflected light, a curtain of rain that stretches into the surrounding darkness. You make the decision to step into the wet, amplified and sparkling arena, perhaps with your mobile phone in your hand to capture it, and as you do the rain ceases above you, controlled by a sophisticated program of motion sensors, containing you in your own dry micro bubble. You view others through the continuous rain, standing still, waving their arms, running, trying to outsmart the technology, perhaps you also glimpse Wayne McGregor's dancers moving to a different choreographed rhythm. This is Random International's *Rain Room* (2012 – ongoing) a multisensory feat of engineering and programming, art meets technology and nature. First exhibited in the Barbican's Curve gallery in 2012 and since then in different museums and art spaces around the world,[1] the effects are intensified by the precision lighting, creating a supernatural theatrical space. Our behaviour in *Rain Room* is to a great extent controlled by computers, yet we *sense* the opposite, as we appear to develop a playful empathy with the constructed and magical environment: As Emma Ridgeley has argued 'This shift in how we conceive of nature sets new possibilities for environmental aesthetics and how art may represent our relationship to "nature", beyond our inherited Romanticism to something new and counterintuitive' (Ridgeley, 2012, 59).

The conception of *Rain Room* was arrived at through the experimental freedom and liberating open discussion that underpins Random's studio ethic. Established in 2005 by Hannes Koch and Florian Ortkrass, the studio is staffed by scientists, civil engineers, software programmers and a dramaturge. Their studio philosophy is to question how our consciousness, perception and instincts can be provoked by interaction with neutral machines, resulting in unexpected synergies and intense experiences. Both Koch and Ortkrass love playing with 'what if' scenarios, testing technologies and algorithms, pitting digital programming against human behavioral pattens, sometimes with unpredictable results. *Rain Room*, for example, metamorphosed from innovative image creation, using light on light-reactive canvases. Koch and Ortkrass were 'dropping an image, [and] paint and water, from a great height onto a surface and seeing how [it] would distort when printed on water-reactive substance' and they discussed '"what if you're actually in it, totally immersed" and it went from there to being *Rain Room*' (Koch, 2012). For Random physical

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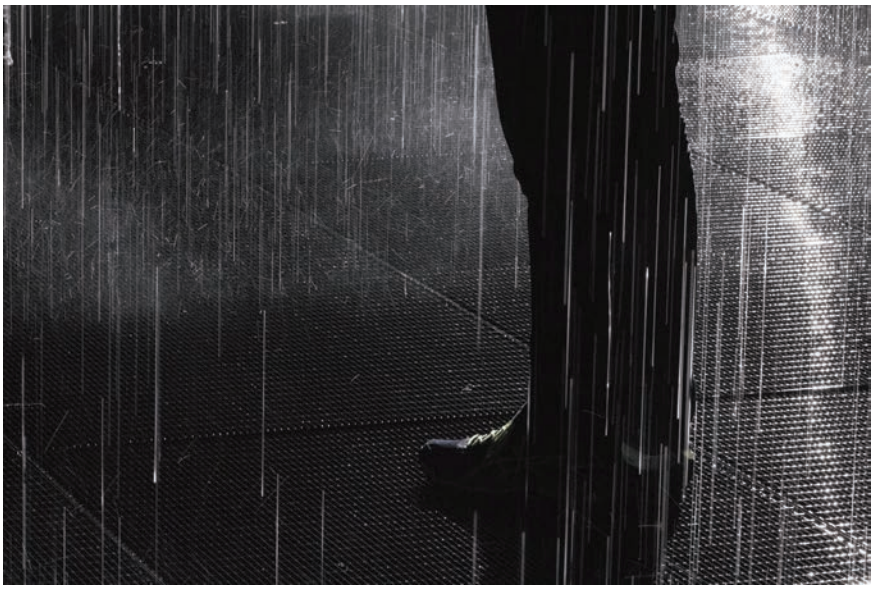
4.1
Random International, Rain Room, 2012. Exhibited at The Curve, Barbican, London. Courtesy of The Maxine and Stuart Frankel Foundation for Art. Photography by Random International

engagement can't be preempted, their work needs to be built and experienced, the complex environments, sculptures, algorithms, robotics and cogitative science behind each work are designed to encourage embodied behavior. Random's creatively designed spaces entice us to navigate around or within their artworks creating our own pathways and interactions, from *Audience* (2008) where mirrors



4.2
Random International, Rain Room, 2015. In the collection of LACMA, LA. Exhibited courtesy of LACMA, RH, Restoration Hardware and The Hyundai Project: Art + Technology, a joint initiative exploring the convergence of art and technology. Photography by Random International

4.3
Random International, Rain Room, 2015. In the collection of LACMA, LA. Exhibited courtesy of LACMA, RH, Restoration Hardware and The Hyundai Project: Art + Technology, a joint initiative exploring the convergence of art and technology. Photography by Random International

appeared to be following and tracking you to *Zoological* (2018) where people instinctively ascribed human behavior to the orbs floating above their heads as they related to them. Koch explained that Random wants to intensify awareness of our physicality 'because we are nothing without our bodies. We are not very present through a screen. I think humans need the feeling of presence to survive, we can't just live with a one zero zero one brain' (Koch, 2012). Or as Ortkrass expands in 2014, people often think that Random's work is about 'rational or planned and rational decisions, when it's at the very core of our work's experimental nature that we permanently

4.4
Random International, Rain Room, 2013. Exhibited at MoMA, New York. Courtesy of RH Contemporary Art. Photography by Random International

4.5
Random International, Rain Room, 2013. Exhibited at MoMA, New York. Courtesy of RH Contemporary Art. Photography by Random International

juggle [ideas]'. *Rain Room* is, as Koch surmises, 'a reflection on how we engage with art now; everything has become more multi-sensual, and so the experiential becomes more and more relevant. We're isolating certain experiences and emphasising certain processes; that's a huge part of what we do.'[2]

Whereas *Rain Room* was immersive and a response to our increasing anxiety about the natural world and its balance, *Zoological* (2017) works with our need to assign 'sentience and meaning' to objects in spaces: As Koch elaborated, 'It started with swarming and murmuration, there is an efficiency and elegance of movement that is built into each member of a [Starling] flock – we thought, "this

4.6
Random International, Zoological, 2017. Exhibited at Roundhouse, London. Artwork commissioned for +/- Human by Wayne McGregor at the Roundhouse, 2017. Photography by Random International

is so beautiful" . . . "let's try to recreate it".[3] Koch felt that the work needed to be majestic and 'pretty quickly' the idea emerged of spheres that would float. The entire space of the Roundhouse became a performance arena for *Zoological,* their most complex work to date, a 'flock' of seven autonomous algorithmically driven flying spheres, their skin made from super light space foil and fitted with special navigation propellors floating in a dramatically lit space. Partly informed by Fritz Heider and Marianne Simmel's 1944 animation *An experimental study of apparent behaviour*, the experience becomes magical as people encouraged the spheres to 'see' them by jumping, walking and gesturing, interacting, or in the case of McGregor's performances *+/- Human* dancing with them, accompanied by a musical score. As Koch confirmed the spectators believed they were being followed or singled out, 'It's a little zoo of sentient beings and sometimes one of them comes out and it is curious, it looks at people and it goes back into the flock, they feel, "Oh it talking to me!".[4] Just as Andy Warhol, when seeing the first iteration of his floating *Silver Pillows* in 1965 on the roof of his Factory space, became overwhelmed, exclaiming 'it's beautiful Billy [Klüver] oh! Oh! Oooh!' and the many different installations that followed including his set for Merce Cunningham's dancers in 1968,[5] *Zoological* was also emotionally inspiring for its viewers tapping into responsive encounters: As Jonathan Jones remarked when experiencing it, 'They [the spheres] are the most convincing embodiment of artificial intelligence I have ever seen. For these responsive, even sensitive machines truly create a sense of encounter with a digital life form that mirrors, or mocks, human free will' (Jones, 2017).

Whilst *Zoological* focuses on our increasing anxiety about the natural world and its balance, our intrinsic relation to technology and our humanness, *Future Self* (2012) and *Our Future Selves* (2019) concentrate on our body appearing in two spaces at once and our recognition of it as 'other' in a gallery situation or museum installation. At the inception of the *Future Self*, Random investigated behavioral

studies from the 1960s and 1970s; their artwork appears to be inventively re-animating the dialogues that emerged from some of the adventurous 1970s investigations into the marriage of technology and the body, including Experiments in Art and Technology (EAT)[6] or the work of Peter Campus and Bruce Nauman. Historically, new technologies have excited avant-garde artists and Campus, speaking in 1975, describes the thrill of seeing his body and its 'reflection' simultaneously in his work, commenting how 'alive' the image appeared to him, in an equation between energy and light matter:

> Photons of light penetrate the wall. I feel the emptiness around me. I let myself go into this extension of self. For a brief moment I am at the same time this image and this self. In a closed-circuit video situation, one is no longer dealing with images of a temporarily finite nature. The duration of the image becomes a property of the room. (Campus, 2020)

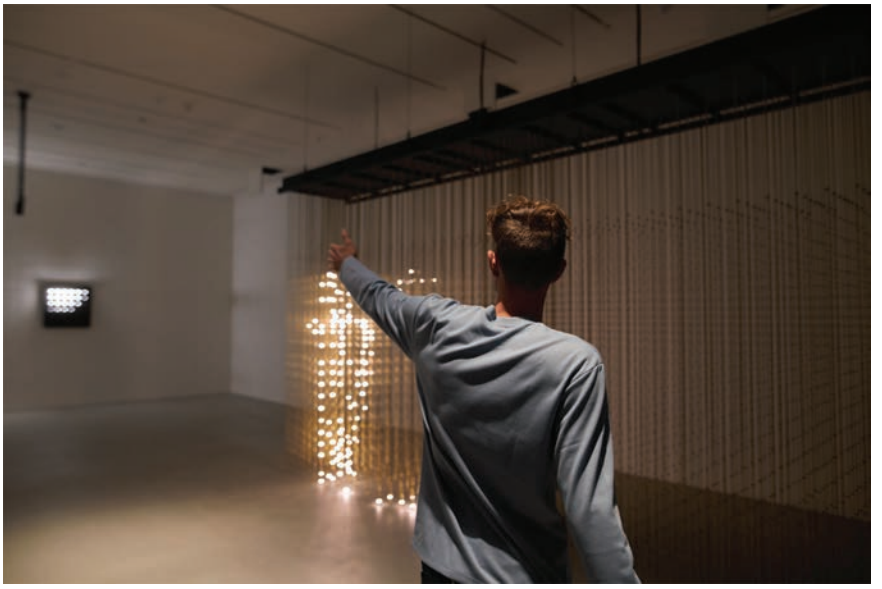
If Campus's work *Stasis* (1973) or *Anamnesis* and Bruce Nauman's *Live-Taped Video Corridor* and *Going around the Corner Piece*, both from 1970, are precursors in terms of space, video, electronics and audience involvement in the 20th century, Random's 21st-century *Future Self* deploys the latest technology, yet avoids virtual reality headsets, you are not removed from the actual environment. Rather than make something that can 'do everything', they decide early on what it actually 'needs to do' and then we [only] do that – 'we focus on that possibility' (Faust, 2014, 108). Koch and Ortkrass had been reflecting for a while on capturing or

4.7 *Random International, Future Self, 2012. Performance by Studio Wayne McGregor.* Photography by Ravi Deepres

enclosing a simulated being in a three-dimensional box. 'We'd worked with the two-dimensional self-image before with the *Printing Machines*, we'd experimented with full body recognition in space with *Audience*. So, it was on the plate to then put that together, but to not display simulated natural movement, rather to reflect actual, real human movement in a three-dimensional way, using light.'[7] *Future Self* was also designed to be 'performed' with dancers choreographed by McGregor and a responsive music composition by Max Richter. The trained dancers' bodies negotiate space in a continuous oscillation in solos or pas de deux; as McGregor explained 'The choreography lived in the light object [of *Future Self*] it set the rules.' His job was to work out how the dancers could behave in this context . . . 'To the dancers, the light object became another body. We always aim to extend our mental architecture so that bodies stop being bodies' (Shanken, 2012, 40). Random also observed that there was a constant desire to touch, that people would go right up to *Future Self* expecting a reaction when actually the point of engagement was further back 'in the non-space'. The work was a 'virtual 3-D mirror, performing a luminous image, joined in a composite identity' (Shanken, 2012, 24) The relation of past and future self was as Random observed only in the past the first time, once you understood it, it could heighten your sense of the present.

Our Future Selves further develops the experimental environment. The steel rods, custom electronics ToF sensors and LEDs are more developed, the installation now forms a passageway which onlookers are invited to enter, meeting their own reflection at the end, before walking on past it. The three dimensionality is further emphasized by the fact that our transitory appearance of ourselves appears as thousands of points of light, our action captured and relayed with a time lapse, fleeting, yet highly seductive. The brain has the capacity to stitch images together 'the challenge is picking out where one actually is: Is it in the space around [us] or contained within the piece . . . you have to observe and train your thoughts a little.

4.8
Future Self by Random International, 2012, exhibited at Lunds Konsthall, 2014. Choreography by Wayne McGregor. Photography by Random International



4.9
Random International, Our Future Selves, 2019. Exhibited as part of the solo show Physical Algorithm at Paradise City Art Space, Seoul, South Korea, 2019. Photography by Random International

4.10
Random International, Study for Fifteen Points / I, 2016. Photography by Random International

That's why the performative element is so important, to show how you can push past our observed spatial limits.'[8]

Fifteen Points / II (2019) continues Random's experimental conversation with embodiment and how our brains register figures in space. Art history has always engaged with representing figures in motion, from Leonardo da Vinci to the Cubists and Futurists, from Julian Opie with his walking figures to experiments with virtual reality. Random though have their own innovative approach. Their research partly emerged from Fritz Heider and Marianne Simmel who observed that when we see

abstract animated shapes in 2D space we find it hard *not* to see them as animate individuals with particular kinds of intentions. Working with scientists in a biomotion lab and with Harvard University, Random began an intensive study to analyze what was the minimum amount of information needed to recognize a human figure in motion. Then, by deploying sophisticated engineering and collaborating with a robotics company in Germany, they built their artwork, obsessing over every detail, the material of the robotic arms, the servo motors, driver electronics and LED lights, as every part of the engineering had to be on display, the finish and fabrication had to be perfect, there is no wizard hidden behind the curtain. The custom software development was incredibly precise as 'Even the most minuscule manipulation of the points' position can cause the form to return back into an inorganic, geometric arrangement.'[9] 'What is extraordinary is our willingness and ability to ascribe human characteristics to a machine, we see in just fifteen points of light, a figure walking towards us, sometimes fatter or thinner, male or female, even though what is actually there is robotic arms placed on track that moves' – the increasing factory scenario – here transformed to mesmerizing art. Random questions how our instincts take us from the natural to the artificial world by appropriating and manipulating the familiar.

Macgregor, reflecting on his experience with Random's practice suggests that 'People don't tend think about their own kinesphere, which isn't limited to an arm's reach but extends to the space all around, in front and behind. Interacting with Random's work caresses this space.' He echoes Random's ethos by suggesting that in the future life will be inextricably linked to technology, a fact that is already happening and that, 'taking the body as an interface. (Their) work doesn't remove you from daily life practices, it enhances them.' At the core of Random's work is always the focus on the possibilities inherent in the marriage between digital fabrication, robotics, programming algorithms and our bodily responses in a specific

4.11
Random International, Fifteen Points / II, 2019. Exhibited as part of the solo show Physical Algorithm at Paradise City Art Space, Seoul, South Korea, 2019. Photography by Random International

space. Both Koch and Ortkrass emphasise that Random's practice is about physical material and people – nothing that they have done is really predetermined, it's not projection – it's living. 'Experience shows that human beings are not passive components in adaptive systems. Their responses commonly manifest themselves as acts of personal creation.'[10]

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NOTES

1. *Rain Room* is in the collection of Los Angeles County Museum of Art and has been exhibited under the museum's historic Art and Technology initiative. It has also been shown at The Museum of Modern Art, New York (2013); Yuz Museum, Shanghai (2015/2018). Jackalope Art Pavilion in Melbourne (2020). An edition of *Rain Room* has become the first permanently installed artwork at the Sharjah Art Foundation, UAE (2018), and is housed in its own building.
2. Hannes Koch in conversation with Jean Wainwright. Random International Studio, London, 13 September 12 + 26 June 2014.
3. Hannes Koch in conversation with Jean Wainwright via Zoom 29 January 2021.
4. Hannes Koch in conversation with Jean Wainwright via Zoom 29 January 2021.
5. Andy Warhol On the Roof with Billy Klüver audio recording tape 1199 Archives Andy Warhol Museum. Merce Cunningham. State University Buffalo NY 9 March 1968, performance with Silver Balloons by Andy Warhol.
6. E.A.T was launched in 1967 by the engineers Billy Klüver and Fred Waldhauer together with the artists Robert Rauschenberg and Robert Whitman.
7. Koch and Ortkrass in conversation with Jean Wainwright London, 2014.
8. Hannes Koch in conversation with Jean Wainwright, 2014.
9. Koch conversation with Jean Wainwright in their London studio 14 September 2018.
10. René Jules Dubos was an experimental pathologist, environmentalist and humanist. *Man Adapting* 1966.

OBJECT

5 An Architectural Romance between Subject and Object

Brandon Clifford

Architecture suffers from a clear brand. Because of this clarity, it is commonly understood that architects design buildings. So, a dependent definition emerges. It cannot be architecture, without a building. This definition bounds a discipline by the product it produces, but in doing so, it reveals two deep wrinkles. First, the majority of buildings are not realized by architects (Rudofsky, 1964). Second, 'architects do not make buildings; they make drawings of buildings' (Evans, 1989, 369). While the former does little to shore up architect's claims to buildings, the latter offers a bit of clarity in understanding that architects are a subset of design, dedicated to producing drawings that serve as instructions for others to make buildings. Unfortunately, it discounts architects that orchestrate buildings without drawings. There are those master makers such as Antoni Gaudí, Sigurd Lewerentz and Félix Candela, or the master masons of the gothic era that prioritize materials and construction over scale representations of architectural intent. Despite its clear branding, the elusive disciplinary definition is becoming more and more complex! To make matters worse, it's not clear what is and is not a 'building'.

Whether it be Laugier's (Laugier, 1755) retrojection that architecture was founded on a need for shelter, or modernist efforts to hermetically seal architecture at the 'enclosure'[1], these prevailing positions on architecture classify it within a utility. These positions, when taken dogmatically, do more to exclude than they do to define. In the process, a number of casualties emerge. The Pantheon for example, suffers from a massive hole in its roof – not architecture? These utilitarian definitions dominate the default positions on architecture, but there are alternative models that enrich the discussion.

Sigfried Giedion (Giedion, 1971) offers a way of thinking about architecture that isn't tied to a finite definition, but a flux between three space conceptions – objects that radiate space around them, enclosed rooms, and a hybrid. Giedion falls into his own version of a retrojection by attempting to categorize these three types to explain an architectural evolution.

He relies on prevailing theories of the time proposed by Alois Riegl (Riegl, 1985/1901, 27) and Wilhelm Worringer (Worringer, 1953) that suggest early civilizations, such as the Egyptians, constructed dense objects like pyramids and obelisks due to a 'fear of open space' (Worringer, 1953, 15). Aside from that problematic assumption, what is most compelling about this proposal is that these three modes are less categories to distinguish between, but moments that constitute phase

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changes and transitions between them. Architects invest tremendous amounts of energy trying to define what is and what is not architecture. While no one else is asking this question, these efforts to classify, rarify and define the discipline of architecture are often projected onto others instead of reflecting the architect's own position within a foggy field. The following chapter chronicles one researcher's quest for a more fundamental understanding of an architecture. Spoiler alert, there is none.

> Let me temporarily shift to the first person because these experiments should also be understood as an attempt to reconcile my own interest in sculpture and product design with having stumbled into the profession of architecture. The reference to 'I' represents my own thoughts, reflections and point of view; however 'we' refers to the team, the partners and the collaborators that make these projects real. I myself have been interrogating the discipline of architecture by testing its foundations; which, in turn, happily share endless properties with adjacent disciplines. I'm abandoning utilitarian definitions in favor of procedural relationships. I'm rejecting the premise that architecture encloses space for specified functions. I'm denying any definition that claims architecture does anything exclusively. What I'm embracing is a range of approaches; that, in their totality, might offer a definition of my own contribution to architecture. With the slate cleared, we can start to exercise three distinctly different approaches to the ultimate destination, which is to craft a relationship between inorganic matter and the human body.

The following dissects a series of speculative built projects that test alternative perspectives on what defines architecture – object, enclosure and body. By circulating through these various mindsets, some unconventional allies emerge – deceit and deception.

OBJECT

The object mindset abandons the idea that architecture encloses space and situates architecture as an object that radiates space around it. It adopts the Egyptian obelisk as a place maker, the hearth as a gravitational force, and the nebulous relationship between humans and objects as the primary question at stake.

Periscope Foam Tower (Figure 5.1]) is designed to signify an event in Atlanta Georgia. At 60 feet tall, it is positioned on a ridge that runs parallel to the primary growth ridge in Atlanta – Peachtree Street. Periscope reaches above the urban context, shored up by this geological formation, making it visible from across the city. It serves as a beacon, first experienced from a vast distance, where the tower appears as if it is fabric being stretched vertically in an apparently impossible manner. Upon closer approach, the tower maintains a memory of classical orders – with a base, bundled shaft and a capital. The proportions of which hold a curious relationship to the proportions of the human body. Upon closer inspection, the tower is not stretched fabric. It is composed of solid volumetric foam that is tethered down to its own base. In this mindset, the architecture takes advantage of the temporal approach that the human takes towards an inanimate

5.1
Periscope Foam Tower. Courtesy of Matter Design

object. While the object remains unchanged, the perception of this object inverts, thus revealing a discovery for the participant.

Helix (Figure 5.2) operates in a similar manner, but isn't able to capitalize on distance in the same way as Periscope. Helix presents itself as a concrete spiral staircase in a gallery space. This undeniably recognizable form immediately situates the object as a utilitarian element and yet the reality couldn't be further from the truth. The surrounding context gradually offers hints that reveal Helix's naughty posturing. First, Helix is adjacent to an actual stair, raising a question about necessity. Its adjacency also reveals that Helix is half-scale, unable to allow humans to occupy it, rendering it useless. As the visitor approaches the stair, they touch the assembly and it sways away from them. Helix appears as a compression-only concrete stair resting on the ground, but it is suspended from the ceiling, floating in the space as a pendulum. The choreography of these revelations constitutes the generation of this project.

> To be clear, no one asked for an inadequately redundant stair to be set adjacent to a perfectly functioning stair, but this adjacency serves as the backstop for this revelation. In this mindset, the revelation is the architecture, not the concrete stair. In exercising this utilitarian costume, an interesting result emerged. Helix, more than

any other project, is continually confused for an architectural product instead of the rhetorical experiment it is intended as. We are regularly approached by potential clients, often building out loft spaces in SOHO, asking how to purchase Helix. This understandable confusion is the result of experiencing Helix through photography instead of in person.

A unique phenomenon occurs when entering incredibly dark spaces, forms and figures emerge slowly from the darkness. The darkness constructs a lag in reception as the human eye adjusts to its new conditions. That lag could be seen as unproductive, or it could be seen as experience. That experience could not be recreated by pulling back a curtain to reveal an object. The magic of tenebrosity is in slowly becoming aware of something that was always present. The question being raised in the object mindset is how to reveal a transformation, without transforming the object itself. These objects transform exclusively through a temporal shift in perception. These indignant experiments in architectural thought appear to resist conventional notions of what constitutes architecture, but, in their mischievous performances, they are dedicated to producing an experience of inverting

5.2
Helix. Courtesy of Matter Design

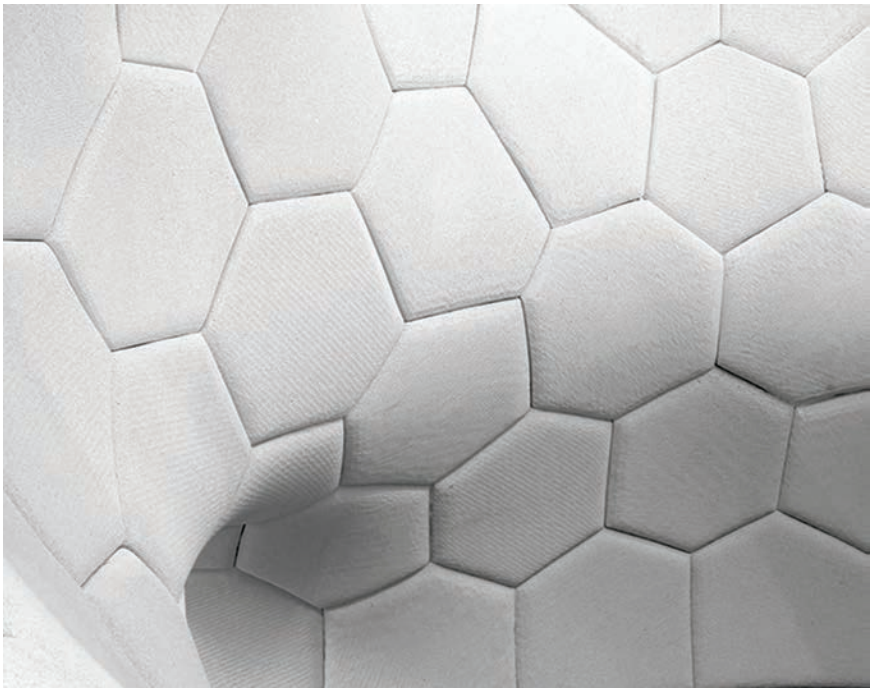
perception for the people that engage them. They obfuscate reality by posturing in opposition to their primary reading. In this model, architecture resides in a continual rediscovery of an object through time. The opposing approach will be explored in the 'body' section.

> While I find this shift away from the object and to the experiential byproduct of the object to be productive, it brings into focus the finite conclusion of the revelation. Once you realize the stair is redundant and rhetorical, that revelation will not be continually powerful. It is a one-time experience, and therefore crafted around an introduction, experience and conclusion. This raised a question in this research trajectory about the benefits of bracketing experiences versus crafting cyclical, looping or recursive revelations. These various approaches are also explored in the 'body' section.

ENCLOSURE

While the object mindset positions architecture as a node that radiates space around it, enclosure adapts the more prevalent mindset that architecture envelops

5.3
Round Room. Courtesy of Matter Design

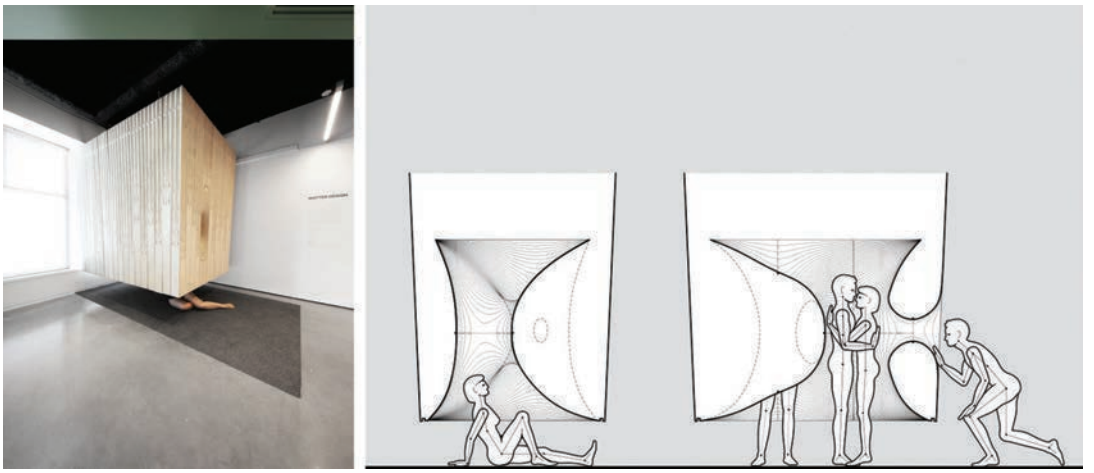


5.4
Round Room.
Courtesy of Matter Design

the body. The experiments in this phase invert the subject–object relationship, but they maintain lessons learned regarding perception and reveal. While the idea that architecture as enclosure is quite conventional, these experiments find their friction through testing the limits of size and dimension by tailoring material to the body. This approach to architecture is not interested in offering generous space. Instead, it is in pursuit of the irreducible limitations of the body. What potentials emerge through the restriction of dimension? What are the limits of distilling architecture?

Round Room begins as a blue rectilinear object in a small gallery space (Figure 5.3). Visitors walk around the volume, but the box is justified to one corner. This forces the visitor to shuffle sideways through the tightest side, then barely squeeze their shoulders through the next, and ultimately into an apparently spacious gap where a custom creeper is inviting the visitor to lay down on their back. In this position, the visitor is looking up towards the ceiling, gliding backwards into the blue volume through a mouse-like hole at the base (Figure 5.4). **Microtherme** offers a similar approach, though this time presented as a hovering wooden box, suspended from a flat-black ceiling (Figure 5.5). A carpeted rug extends beyond one side, where a small aperture is large enough to peek in at navel height, or to reach in with a single arm to feel the interior, but not both. The volume is hovering 17 inches above the rug, which is just enough space to lay down and roll under the volume to enter into the interior (Figure 5.6). These constrained dimensions are pulled from Henry Dreyfuss Associates' studies on the human figure (Diffrient and Tilley, 2000, 7). The studies view architecture as minimal constraints and therefore have a series of caveats associated with them. If you expect someone to fit through a manhole and rotate, there is a dimension for that, but if you can get away with

simply passing the body without rotation, there is an even tighter dimension. The potentials of this mode of thought often elude us in architecture as we are regularly designing for flexibility over singular actions.



5.5
Microtherme exterior and sections. Courtesy of Matter Design

5.6
Microtherme. Courtesy of Matter Design

In the first section, object is dealing primarily with perception of form through vision, neglecting the other senses, but enclosure gradually starts to layer in the other contingencies that concern architecture. As the visitor positions themselves on the creeper and starts to roll into Round Room, an entirely different form is revealed inside. Soft, pillow-like masonry elements carved from autoclave aerated concrete round out the boxy enclosure. Simultaneous to the action of sliding backwards into the space, the visitor experiences the volume of ambient music increasing, as if it is tailored to their entry into the space. In fact, the volume is not increasing, but the geometry of the interior space is formed to entrap the acoustics. While visitors circulate around the box, they hear very little, but inside it is as if they placed noise-cancelling headphones on. This ceremonial experience is achieved precisely because of the tight constraints of the entrance and the deviance between the rigid exterior form and the highly figured interior.

A similar game is played in Microtherme, where the visitor rolls under the wooden volume to discover a soft concrete interior with two vertical apertures. One is large enough for a human to stand and rotate, while the other only allows standing in a fixed location. When standing inside these spaces, the concrete engulfs the torso, only allowing the visitor to see above which is globally illuminated. This gives the feeling of floating in a bath of soft concrete. When a second visitor enters, the occupants can see each other's disembodied heads, but have no idea if other visitors are down below, peeking in from the exterior, or feeling around for the unknown. Descending back down into the lower space, the second visitor is now puncturing the concrete volume, appearing as a living caryatid, structuring the space. This perception is in opposition to that of the upper space where it appears as if the human bodies are impossibly heavy, pulling the concrete volume down. While Round Room places architecture as a servant to provide an experience to the inhabitant, Microtherme inserts another layer of perception, that of a collaboration between inorganic material and the human figure to provide a new perception. While these visual discoveries distract the visitor, another sense creeps up on the visitor. After about 30 seconds of standing, the visitors' backs begin to roast while their fronts freeze. Unbeknownst to them, the concrete has been radiating radically different temperatures at their body, averaging out to room temperature. What allowed that perception to become evident is the fixed position of the body. Realizing the extremely uncomfortable circumstance, the visitors' only choice is to move, lowering back down to the bottom space and negotiating with the other visitors to trade positions. This lag in time encourages the visitor to explore space as an active participant.

While Microtherme and Round Room provide experiences to visitors through irreducible dimensions of space, there is a subcategory of this line of thought that offers another lens into dimensioning space. **Five Fields Play Structure** (Figure 5.7) raises a question about standardizing dimensions to the adult form. It adapts the potentials of restricted dimensions to offer levels of spatial engagement for a range of ages – from early childhood to adolescents and the adults that patrol them. While there are other strategies at play with this project, calibrating the dimensions of volumes allows kids to bound through spaces while parents have to shuffle sideways. The youngsters crawl under objects while the older kids can climb over

5.7
Five Fields Play Structure. Courtesy of Matter Design

them. This mindset of enclosure seeks out the potentials that reside in constraints over luxury, but it also places architecture at the interface between the human body and the inorganic matter that acts upon the body.

> Five Fields Play Structure is useful in exploring ways of tailoring space to a range of human dimensions, but it also tackles notions of perception inversions. I found it useful to exercise ideas of perception simultaneously with aspirations of play and imagination. For instance, an array of columns serves to structure an elevated volume in the play structure. If that was its sole purpose there should only be three columns, the ones that literally support the structure, but there are seven columns that extend beyond the volume into the landscape. These additional frivolous columns perform in two manners. The first is to hide the fact that they are supporting the hovering volume. By extending beyond, they appear to be intersecting and sliding past, instead of bolstering. This produces an illusion of levitation. The second is in undoing their own utility. Their mere presence and lack of purpose offers a scaffold for the children to imagine alternative meanings. I have found that exploring these ideas of cultivating imagination, notions of perception grab hold in meaningful ways for the design process.

BODY

> When the Dutch explorers first encountered the Island, they asked the people of Rapanui how their ancestors could have possibly moved those massive statues. The Rapanui said 'our ancestors didn't move those stones, the stones walked themselves'. Which is true! The statues, known as Moai, were transported standing, pivoting from side to side. As spectacular as the Moai are for visitors today, you have to imagine being there then, with colossal Moai marching around the island. Because the real memorial was not the objects themselves, but the cultural ritual of bringing a stone to life.[2]

This story encapsulates the third mindset, that of projecting life into inorganic matter. This mindset has similarities with the first mindset – object, but it moves beyond rendering matter to appear alive by introducing time and theatrical performance into the discussion. While the Moai of Rapanui offer a paradigm-shattering outlook on Western perceptions of labor, they also serve as a model for the fundamental challenges that surrounds megalithic wonders around the world. The key components of any megalithic wonder are the transportation of an impossibly massive stone across an unreasonable distance and the setting of said stone in an unnatural position.

In an effort to explore the potentials of thinking about architecture through performance, the following exercises are established around crafting public performances of the ancient, but straightforward, task of moving and placing heavy objects. The **McKnelly Megalith**[3] is the first in this series of experiments that explore transforming labor into a ceremonial act to build community. This megalith

5.8
McKnelly Megalith. Courtesy of Matter Design

is designed to be experienced in two states. The first is in a horizontal position, balanced on a rounded belly. This geometry is calibrated relative to the center of mass of the object, to ensure the megalith is stable, but can be pivoted with ease. It rocks and rolls within a range, producing the illusion that the colossal stone is alive. That nimble behavior is calibrated for a person to hang from the nose of the megalith to rock it forward, thus taking a step. The megalith can then pivot and release, walking in a bipedal manner. This ballet of pivoting and rocking is distractingly slow. The audience witnesses this unnatural motion resulting in progress from one side of the courtyard to a central position. Once in position, the McKnelly Megalith is tugged by a handful of people from its horizontal position into a vertical stance (Figure 5.8). This transformation is relatively rapid, but by no means immediate. As the object rises into a new state, the audience's perception of the object transforms from an animalistic creature on its belly to a human figure standing. The challenge was in designing an object that doesn't prioritize one state over the other, but serves as a complex resolution of both. By conceiving of this object through a performance, the design team is forced to consider the action of transportation and placement as the memorial. As a result, the performance crescendo occurred in the revelation that the object could in fact stand vertically. Immediately after, it became increasingly less interesting. The static object pales in comparison to the performing object. With this in mind, the intention is to breathe life into the object itself, thus distinguishing the architect as creating performances, not objects.

The second body experiment shifts from a terrestrial performance to aquatic. The **Buoy Stone** is designed to slip under the low bridges of the Charles River and drink river water to stand vertically. If the McKnelly Megalith served as a single event in the period of about half an hour, the Buoy Stone stretched over a much slower timescale. It begins with the curious act of being towed. The audience is

5.9
Buoy Stone.
Courtesy of Matter Design

first offered this curious floating stone. In its horizontal position, it presents itself on end as a single sphere, or on face as a long, tapered object. Both hover on the surface of the water, bouncing rapidly as waves ripple past. The Buoy Stone rests in this position for a week, garnering attention from passersby asking what it could possibly be. What purpose does it serve? How is it there? No information is provided. The second act of this performance occurs over the period of a day, when the belly becomes saturated with the very water it is swimming in. The Buoy Stone slowly and imperceptibly lifts its head out of the water, sinking its spherical belly under the surface (Figure 5.9). Because it rested on its side for a week, one half of the megalith is saturated causing the object to lean in the water. Over the course of another week, that water slowly evaporates away, allowing the Buoy Stone to stand vertically in the water. In its fully saturated state, the Buoy Stone weighs significantly more and is no longer skipping on the surface, but bobs at a pace beyond the rippling waves. It appears to be a solid stone poking out of the river, but if you look away and return, it is repositioned, rotating in the current. Over the course of another month, the saturated belly slowly leaks, returning this curious creature to its horizonal position. This lag in time provides an opportunity to explore perceptions of memory. By stretching the performance across time, the Buoy Stone capitalizes on slow transformations of behavior.

While the McKnelly Megalith and the Buoy Stone present themselves as solid, stone-like objects, they are clearly not as heavy as they posture. Coming in around one ton each (unsaturated) they are undeniably heavier than one would expect an object to tug across a yard, but substantially lighter than the 80-ton Moai. **Janus**[4] elaborates on the first prototypes by incorporating the potentials of significant mass – cast of solid concrete. Working with composers Federico Gardella and Simone Conforti, this collaboration merges sonic and physical animation to produce a performance of living spectacle. In an hour-long performance, the audience is enveloped in a spatial chatter that transitions from the noise of the crowd itself to a spirit like whispering that draws the audience's attention to an apparently gift-wrapped

5.10
Janus. Courtesy of Matter Design

object on stage. Janus is designed through a series of monstrous contradictions. This graphic box references the 'Arch of Janus' with a uniquely Roman color palette of pinks, oranges and blues. The box slowly rolls onto its back, exposing that it is merely the lightweight formwork for a massive object inside. From this rigid box, a vital concrete object springs itself to life (Figure 5.10). Janus wobbles on stage, breathing life into a solid sphere and hollowed ring sculpture until the momentum slowly fades and the wrecking ball of an object appears to hover on a single point for the amusement of spectators. This spectacle of witnessing Janus's rebirth projects a perception of life into this inorganic object.

What began as an attempt to conceive of architecture as breathing life into objects, or considering the inorganic matter to be a body itself, returned an inextricable link between the human bodies that surround, engage and interact with these objects, and the perception of life into collaborative objects. This complex relationship raised a number of questions, while launching a subsequent research project titled **Walking Assembly**.[5] The intention behind this work is to embed intelligence of transportation and assembly into the objects themselves. This premise might jump to self-assembly logics, but, by maintaining the human as a partner in the impossible assembly, the elements necessitated a number of design decisions in response to the human body. This is nothing new with regard to masonry elements. For instance, a brick is designed for a single hand to pick and place, or a concrete masonry unit is design to be lifted and set by two hands. But Walking Assembly introduces a schism to this logic by rejecting dead-lifting as the fundamental constraint. These elements are designed with soft forms to be pivoted and rolled into place (Figure 5.11). They are impossibly heavy in the paradigm of dead-lifting, but, with their forms gently calibrated, can be guided into place by mere mortals. The elements have so much inertia that it is unreasonable

5.11
Walking Assembly.
Courtesy of Matter Design

to force it into position. Instead, steady and constant pressure allows the element to perform as designed (Figure 5.12). Each element in the assembly has a slightly different behavior. Some move rapidly, while others are more stable and serve as counter masses. This work conceives of construction not as an act of labor, but as an act of wonder and whimsy. The goal of such a design strategy is to craft elements that retain information to perform tasks, while enticing humans to engage with them. The net result of this playful act is a construction site full of unwitting participants.

> I'm returning to the first person to offer a full disclosure. This body of work was constituted around a conscious effort I made to exercise Giedion's three space conceptions. I intentionally sequenced projects from object to room. This trajectory was not intended to shore up any positions that Giedion takes, but rather to employ that structure in pursuit of a more wholistic understanding of what constitutes architecture. Being unsatisfied with selecting from, or aligning with one of these particular definitions, I began to realize the importance of temporal perception in all of these experiments. That revelation launched the body mindset, which admittedly returns to the first space conception – object. Where object takes pride in a deceptive transformation, body embraces literal transformation to provide an otherworldly experience of the impossible. By liberating myself from the dogmatic assumptions that architecture must be associated with buildings, I was able to focus in on what I have found to be my own definition of the foundations of architecture: the complex relationship between people and their perceptions of inorganic objects.

5.12
Walking Assembly.
Courtesy of Matter Design

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NOTES

1. In reference to: Reyner Banham. *The Architecture of the Well-Tempered Environment* (Chicago: University of Chicago Press, 1969).
2. Extracted from my TED Talk – Brandon Clifford. 'Brandon Clifford: Architectural Secrets of the World's Ancient Wonders | TED Talk.' TED: Ideas worth spreading. (TED, 2019). https://www.ted.com/talks/brandon_clifford_architectural_secrets_of_the_world_s_ancient_wonders?language=en.
3. In collaboration with historian Mark Jarzombek and the Megalithic Architecture studio at the Massachusetts Institute of Technology.
4. In collaboration with CEMEX Global R&D.
5. In collaboration with CEMEX Global R&D.

6 Materiality and Objecthood

Reflections on the Work of Geoffrey Mann

Phillip Denny[1]

A moth's fluttering orbit about a flickering lamp; a tense dinner in a famous film; a bird taking to the air. Three works by Scottish artist and designer Geoffrey Mann emerge from these disparate, fleeting moments. Titled 'Attracted to Light', 'Crossfire' and 'Flight', respectively, these projects capture ephemeral events in lasting media. Working principally in glass, Mann (born 1980) engages old techniques derived from craft traditions whilst simultaneously plumbing the possibilities of more recent developments in computer-controlled additive methods, such as 3D printing. Mann's output manages to be both richly varied and precisely focused, reflective of his natural curiosity about the world in general, and his passionate dedication to the possibilities of a few materials in particular, principally glass, porcelain and bronze.

Mann founded his practice in 2005, following his training in ceramics and glass at the Royal College of Art in London. Since then, objects such as 'Flight', completed in 2009, have emerged from a studio dedicated to materializing natural phenomena in surprising ways. A sculptural form that evokes a bird leaping into flight, the project is also a tour de force of cast glass. Measuring approximately 14 x 16 x 26 inches (35 x 40 x 65 cm), the work approaches the upper limits of practicable casting and annealing. Casting exposes the liveliness of a material that is often seen as static and crystalline, even abstract. In the annealing process, the artisan carefully heats and cools a work in glass to ease internal stresses and thus strengthen it, delicately handling the material in a precarious state between solid and liquid, what Mann calls an 'amorphous solid'. During annealing, the glass alternately grows and shrinks as it is incrementally heated and cooled. Any sudden change in temperature – however brief – might cause it to shatter irrevocably. This delicate process takes hours of diligent labor.

Time and duration are abiding preoccupations of Mann's work, intertwined across levels of form, content and medium. 'Flight' delicately traces the path of a bird as it transitions from a state of rest, moving skyward. Viewed from one end, the profile of the perched creature is clearly visible; at the other side we see outstretched wings. The work offers a silent answer to the question of what time may look like. Or, as in Mann's elegant phrasing, it's an attempt to 'materialize objects from things that we can't see'.[2] Pronouncements such as this – and projects like 'Flight' – connect Mann to a rich historical genealogy of visualization and design. This piece in particular immediately calls to mind the experiments of 19th-century

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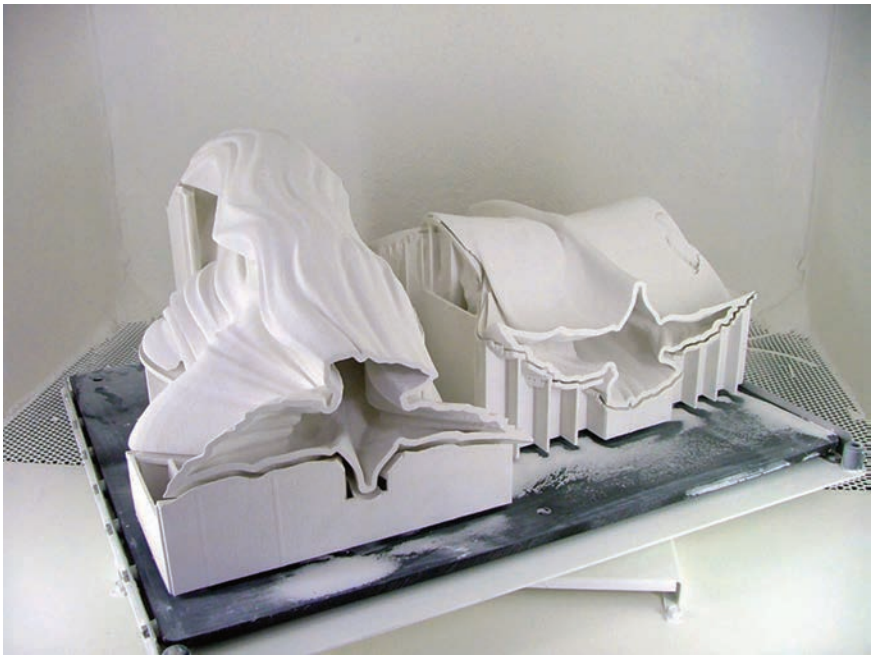
6.1
Flight. Courtesy of Geoffrey Mann. Photography by Sylvain Deleu

6.2
Flight. Courtesy of Geoffrey Mann. Photography by Sylvain Deleu

visionaries Étienne-Jules Marey and Eadweard Muybridge. These pioneers of chronophotography similarly attempted to bring the obscure to light; that is, to make visible things that we cannot see.

Marey and Muybridge were, by chance, exact contemporaries. Marey was born within a month of Muybridge in 1830, and their deaths too came only a week



6.3
Flight process.
Courtesy of
Geoffrey Mann

6.4
Flight wax process.
Courtesy of
Geoffrey Mann.
Photography by
Lhotsky Studio

apart in 1904. Though they lived the greater part of their lives at a distance – Marey in France and Muybridge in the United Kingdom and later the United States – they tread the same intellectual ground and profoundly influenced one another's work. In developing techniques of what would come to be called 'chronophotography', it was Muybridge who was first out of the gate, so to speak, training his lens on a galloping horse in 1872, at the behest of Leland Stanford, former governor of California and founder of the university that bears his name.[3] Stanford contended that, at full gallop, a horse's four hooves momentarily leave the ground, the animal effectively hovering for a brief moment. But without empirical evidence to point to, Stanford instead set out to produce some. Muybridge was a natural choice of collaborator, having built his reputation as a professional photographer producing images of the American West. His practice was known for its technical sophistication, with Muybridge making use of a specially designed mobile studio that allowed him to make images *en plein air*. He employed the labor-intensive, glass plate photographic processes available at the time, such as collotype, which yielded sumptuous images rich in detail and tone. Capturing the gait of Stanford's galloping horse required the ingenious use of a series of tripwires – the animal activating the shutters of arrayed cameras as it barreled past. The method worked well, setting the stage for further studies of 'Animal Locomotion': first galloping horses, and later flying birds.[4]

Muybridge's locomotion images are some of the most celebrated works of 19th-century photography, but they were also artifacts – catalysts even – of a paradigm shift in art and science. But it was ultimately the French polymath Marey who better understood the import of what Muybridge's photography had accomplished, and it was he who would be best known for popularizing what came to be called the 'Graphic Method'. Marey's empirical approach submitted natural phenomena to visual recording, thus transcoding physical phenomena into graphic form. In this way, worldly phenomena became available to fine-grained analysis and extended scrutiny, far beyond the abilities of the fallible human eye and the brevity of the event. In the Graphic Method, the labor of vision was delegated to a machine, the photographic apparatus. Marey's approach had many applications, spanning from medical imaging (Marey invented the modern cardiograph) to the transcoding and recording of sound in the phonograph – after all, the vinyl record's grooves are the line traced by a vibrating sound wave.[5]

Muybridge's and Marey's inventions and discoveries registered their impact in the world of artistic convention. The gait of a horse at full gallop was more or less a mystery prior to Muybridge's chronophotographic analysis at the end of the 1870s. One may think of the so-called 'flying gallop' problem of 19th-century painting, epitomized in Théodore Géricault's 'The 1821 Derby at Epsom' (1821). Here, Géricault delineates a misguided explanation for what he sees. Stanford's contention that all four hooves leave the ground is substantiated in the painting, but the animal's gait is described inaccurately.[6] In the 'Derby' canvas, the horse's forelimbs and hind legs are impossibly outstretched, pointing in opposite directions. Even the most acute observers, like Géricault, could misunderstand what they saw. The photographic camera offered a powerful corrective. Working independently, Muybridge and Marey continued to set their sights on bodies in

motion through the end of the century: men leaping and boxing, women dancing, birds flying. And the broad success of their work inspired contemporaries, such as the French engineer Gustave Eiffel, who conducted a series of aerodynamic experiments utilizing the method at his *Laboratoire d'Aérodynamique* after 1912, observing streamlines passing over solid objects in a wind tunnel of his own design, and photographing the results.[7]

But, even for Marey, who did more than anyone else to promote and exploit the potential of the Graphic Method in the 19th century, images by themselves were simply not enough. After 1887, Marey produced a series of 'movement sculptures', the best known of which, in bronze, depicts the phases of a bird in flight. The objects evoke the fluid action of wings rising and falling in a staccato of movement that presages Italian Futurist painting and sculpture, still decades to come.[8] These works, perhaps most relevant to Geoffrey Mann's 21st-century projects, mark a similar transit, from the observation of physical phenomena as visual phenomena, to their recording in images, and finally inspiring the creation of an unprecedented object.

The question remains: Why should an inquisitive observer of the world, whether Marey or Mann, not be content with images, but rather insist on material objects? As a didactic device, Marey's sculpture materialized a familiar phenomenon in a form that allowed it to be studied from all angles, and thus better understood. Similarly, Mann's 'Flight' gives material form to an ephemeral event. It suspends a fleeting process in time, inviting new perceptions of a dynamic world. For Mann, materiality is a fundamental facet of human experience. It knits together seemingly disconnected practices and histories, from the material economies of his native Scotland, to the movement of objects between distinct contexts of utility and interpretation. Moreover, things persist in time in a way that images tend not to. They engage with beholders in unpredictable ways. The work of artists and designers like Mann, his peers and his predecessors offers an occasion to consider current debates on the status of objects.

* * *

At the end of 2020, architectural historian and theorist Sylvia Lavin engaged in a public debate with philosopher Graham Harman, putative ringleader of the speculative realism movement, but more commonly known as the founder of object-oriented ontology (OOO), often referred to by its shorthand callsign: 'triple O'. Nominally convened to discuss Harman's book *Artful Objects* (Sternberg Press, March 2021), the conversation took place on the front lines of a simmering conflict between two schools of thought.[9]

On the one hand, Harman et al. have, over the past decade, developed a metaphysical framework which understands the world first and foremost as a universe of objects; the object being its fundamental ontological integer. OOO is meant to wrest us from our anthropocentric sleep, tearing off the blinders that keep us from recognizing the agency of the non-human, of objects, things, animals, viruses. In short, it is thought to be a corrective to the philosophical habits of mind which fail

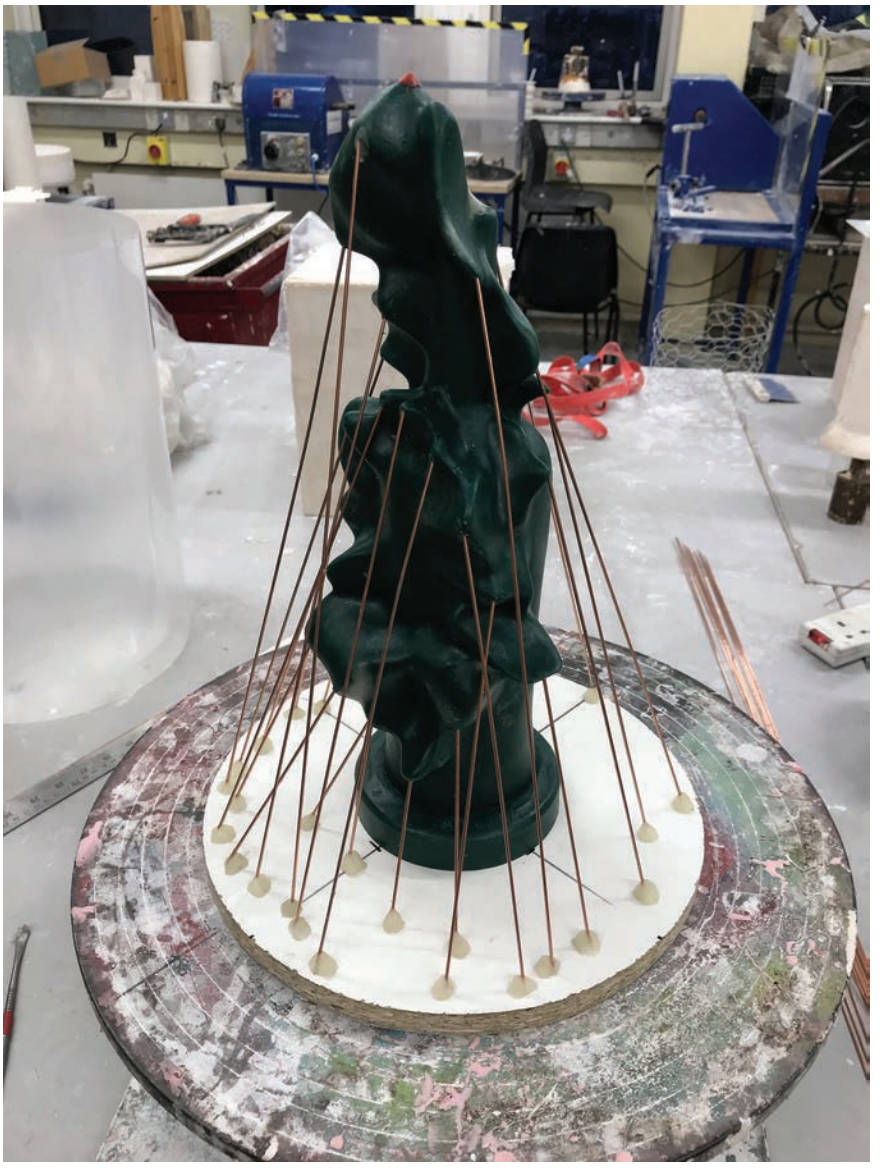
to account for the complex totality of the world as it really is – according to Harman, a collection of things, of which the human is merely one object among many.

On the other hand is the prevailing wisdom of what could be called social constructivist views – a wide array of frameworks which take the world as a social phenomenon sustained by objects large and small.[10] Proponents of social constructivism insist on the differentiation of things according to human cultural values, such as the distinction of the art object amongst mere things, a point that Lavin was eager to insist upon.[11] The core tenet of OOO – the subject of this debate, and of most discussions about the topic – is 'flat ontology', a notion evoked by the event's provocative title: 'Do all objects matter equally?' To Harman, the answer is unequivocally yes, because objects exist indifferently to the humans who might assign them social value: appraisals of beauty or banality, for instance.[12]

Mann's practice stakes out a third position in this discourse. When explaining his work, Mann is more likely to advance aspects of both camps in tandem rather than choose one over the other. Matter and materials are what allow him to grasp both poles of this debate simultaneously. For instance, Mann notes that 'much of his work is narrative-based', such as 'The Leith Pattern' (2018), an attempt to 'capture the social history of context and place'. Mann explains the work as a collection of socially significant choices, for instance, the chemical composition of the glass as a collection of endemic materials, or the history of the object's generic form – that is, a corked bottle of the Scottish variety – or even the historical conditions of that object's production in the circular economy of the urban region. At the same time, his materials tend to exceed the status of passive matter representing aspects of a narrative. Mann will often speak of his materials as if they were animate, sometimes offering resistance to his work, and at other times bending to his will. He recalls that, while a student at the Royal College of Art, he was often pestered with the question, 'Does the material *want* to do that?' Call it the tyranny of the dictum 'truth to materials'.

According to Mann, materials generally haven't been explored or exploited to their full potential, and thus have to be pulled in 'a different direction'. His practice is without doubt richly informed by history, and propelled by a desire to give that history lasting, tangible and material form. But it is also driven in another direction by the agonisms of materials and their properties – the tension between what materials want to do, and what Mann calls upon them to be. It bears repeating that it is difficult, after all, to cast glass in the form of a bird in flight. It takes a rare

6.5
The Leith Pattern, animation. Courtesy of Geoffrey Mann

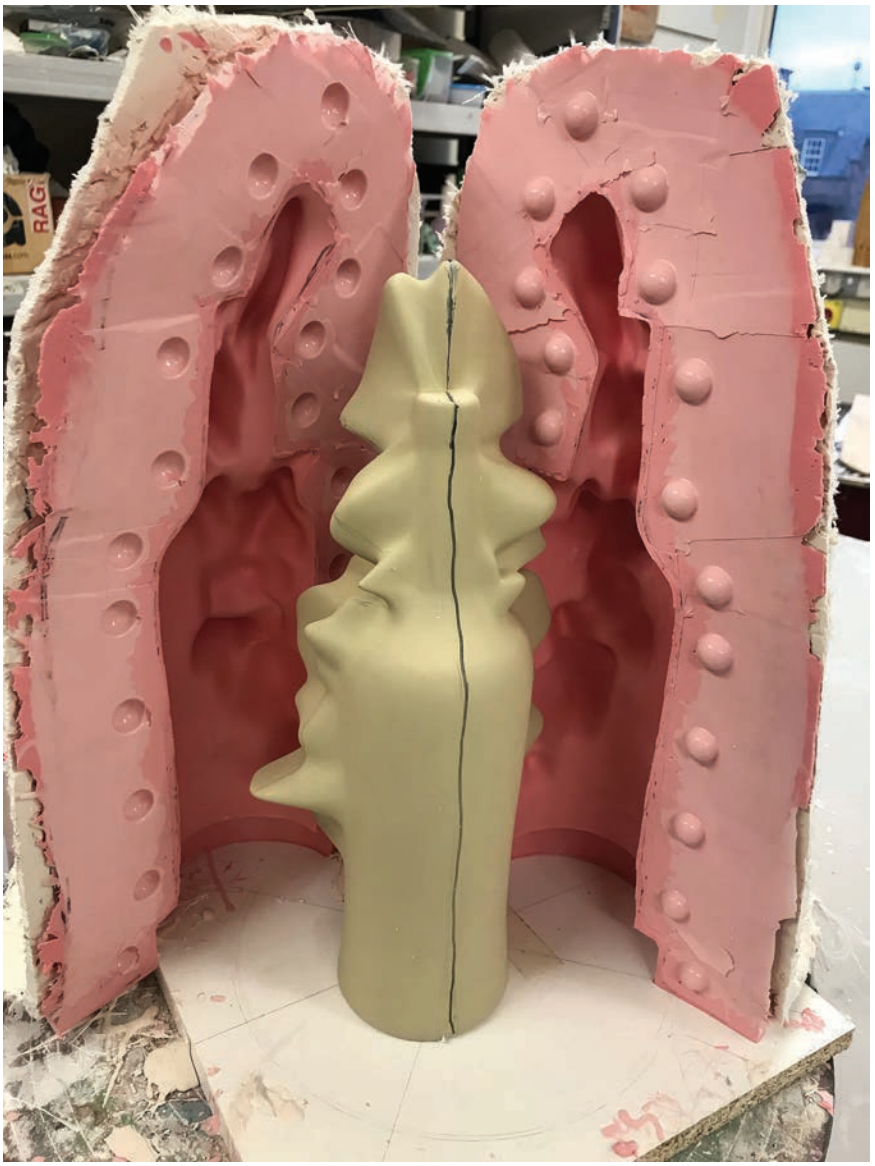


6.6
The Leith Pattern, wax. Courtesy of Geoffrey Mann

sort of alchemy to reconcile weighty material with such a lofty subject. This difficult interplay between what matter does and what it means is the contradiction – a collision, even – at the heart of Mann's practice, that is resolved with preternatural elegance in the form of alluring objects.

* * *

'Crossfire', a project from 2010, exemplifies the ways that Mann creatively undermines the expectations that we place upon objects and materials. The collected pieces in this series, titled 'Natural Occurrence', form the rudiments of a table



6.7
The Leith Pattern, 3D print. Courtesy of Geoffrey Mann

service: glasses and plates, flatware and serving elements in glass, silver and bone china. Each object is nominally recognizable as an example of its genre, whether a stem wineglass or a salad fork. But at the same time, each piece resists adhering to either the object type's generic form, or to the conventions of how its material is typically worked. The fork, spoon and knife, for instance, are not examples of stamped flatware, but rather are intricate objects, nickel-plated 3D prints in resin, more like handheld sculpture than utilitarian implements. The pieces do not bear the simple profiles of functional flatware, forks without either sharp tines or smooth handholds, but rather the form of each is fluid, organic, even deformed. 'Crossfire' challenges our expectations at the levels of their basic materiality and objecthood, whilst remaining vaguely familiar, recognizable.

6.8
The Leith Pattern 2. Courtesy of Geoffrey Mann

Architectural historian Antoine Picon has defined materiality as the 'relationship that humans have at a given moment in history, and in a given society, with the physical world'.[13] This capacious term encompasses a broad range of concepts, from the ways that human societies organize themselves vis-à-vis the world's natural resources, to the ways in which some materials are seen as appropriate to a given use but improper for another. In a general sense, materiality concerns the cultural expectations and conventions that humans develop in relation to matter. These notions sometimes emerge from habit and familiarity. For instance, the assumption that metal ought to be polished and reflective, or that glass should be smooth and clear, is a result of routinely encountering these materials in those forms in the everyday world. Moreover, the traditions of craft and even advanced production techniques that give materials those qualities reinforce our expectations of these same properties. Moreover, conventional metalworking and glassblowing processes are widely employed because they produce the finished effects that society has favored. As a result, it becomes very difficult, though not impossible, to imagine materials or glass as anything but shiny, polished, machined. The materiality of glass or metal is thus a hybrid product – part social, part physical – of the material's chemical composition, its properties of strength or brittleness, clarity or opacity, and the many ways that cultures have assigned it a conventional place and use; say, the stem glass as a proper vessel for consuming wine.

'Crossfire' bucks convention and instantiates an alternate regime of materiality. The glass stems, for instance, are not sharp and elegantly symmetrical, but rather freeform and amorphous. They evoke the material as it is known to craftspeople and artisans in the process of working it into shape. Here, the glass is still undefined, glass on its way toward becoming *a glass*. Materiality is indeed a hybrid construct, a culturally determined apprehension of matter made appropriate to human uses.

In this case, the relation between the human and its useful objects is imaginatively retooled. Rather than impassive utensils of human action, the pieces of Mann's 'Crossfire' series appear to be on the verge of speech, like lively witnesses to the world around them. What is to be given voice are precisely the narratives Mann refers to when he calls his work 'narrative-based'. In this series, Mann imagines the interior lives of the table service in a climactic dinner scene from director Sam Mendes's 1999 film, *American Beauty*. During this dramatic episode, Mendes's characters – a generic, white American family – belittle and provoke one another in a dynamic that is both banal and monstrous. In the film, the dinnerware is merely incidental to the circus of emotional trauma taking place around it. Passed back and forth, picked up, then laid down, the objects are no more than literal – mutely utilitarian. In Mann's creative restaging, these workaday objects are invested with the words and speech of the characters. Mann digitally models the sounds of the characters' speech from the film's soundtrack. Monologues and utterances are given form by digital software, and made to flow through the glass and china of wine stems, plates and servingware like ripples through water. The work imagines an empathetic regime of materiality in which objects are viewed as seamless extensions of their beholders' affects. The work thus challenges our basic assumptions of objecthood by unsettling the basic distinction, between objects and subjects, a maneuver with famous precedents in modern sculpture.

6.9
Crossfire, still.
Courtesy of Geoffrey Mann. Photography by Chris Labrooy

6.10
Crossfire, teapot. Courtesy of Geoffrey Mann. Photography by Stuart Johnstone

6.11
Crossfire, glassware. Courtesy of Geoffrey Mann. Photography by Shannon Toft

6.12
Crossfire, cutlery.
Courtesy of
Geoffrey Mann.
Photography by
Stuart Johnstone

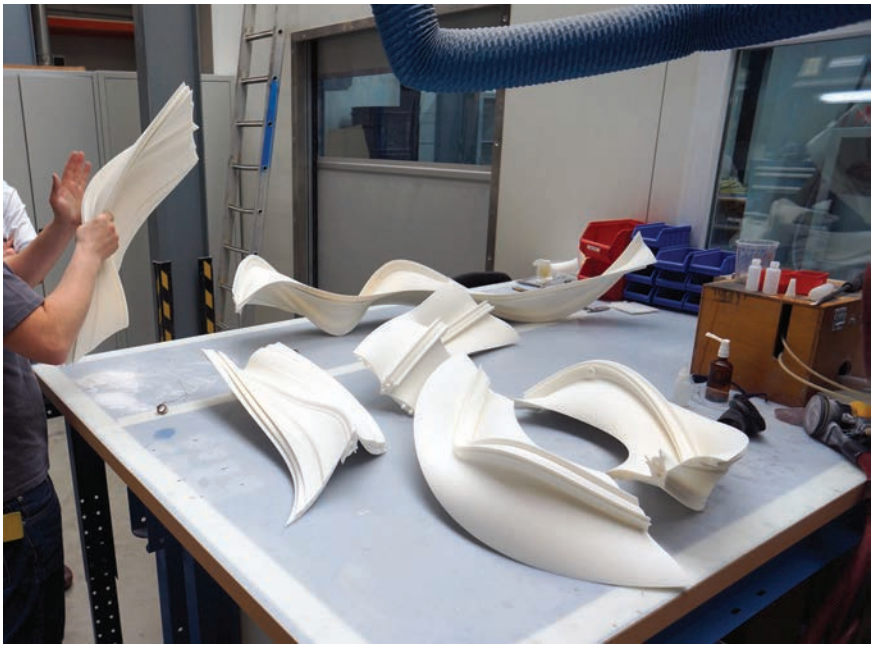
6.13
Crossfire process.
Courtesy of
Geoffrey Mann

In 1967, art critic Michael Fried dismissively labeled the sculptural work of minimalist artists such as Donald Judd and Robert Morris as nothing more than 'literalist'.[14] Fried condemned these artists for making a virtue of sculpture's objecthood as opposed to striving for objecthood's transcendence. In his estimation, the sum of their efforts amounted to nothing more than theatricality; that is, 'the

experience . . . of an object *in a situation* – one that, virtually by definition, *includes the beholder*'.[15] For Fried, at least, this was not a good thing. Literalist art produced two fundamental displacements with regard to modern sculpture: First, the singular art object was replaced by an unbounded, indefinite situation; second, detached perception was overtaken by embodied experiences that unfold in time. These two shifts in aesthetic concerns moved the three-dimensional works of artists like Robert Smithson, Judd and Morris toward what architectural historian Mark Linder has called 'properly architectural' questions of scale, duration and object-hood, among others.[16]

For Fried, theatricality meant the negation of modern ('true') art's precept of a discrete object capable of being understood instantaneously, 'not because one *in fact* experiences a picture by Noland or Olitski or a sculpture by David Smith or Caro in no time at all, but because *at every moment the work itself is wholly manifest*'.[17] By contrast, sculptures such as Morris's *Untitled (L-Beams)* of 1965 (to which Fried was, in part, responding) frustrate total apprehension. Viewers who are part of the situation can attain only partial representations of the whole – a view from this side, another from the opposite angle. The mobile beholder's changing position, close

6.14
Attracted to Light. Courtesy of Geoffrey Mann. Photography by Sylvain Deleu



6.15
Attracted to Light Process 1. Courtesy of Geoffrey Mann

then far, constitutes new relations among presences, bodies and sculptures alike. On that basis, Fried declares literalist sculpture to be 'paradigmatically theatrical'.

Mann's work, too, is theatrical, but not for the worse. Like theater, 'Crossfire', 'Flight' and 'Attracted to Light' are objects that stage experiences, necessarily implicating beholders themselves. Just as a curious onlooker examining Marey's bronze bird in flight may uncover a new understanding of beating wings' obscure mechanics, Mann's pieces invite an expanded perception of the world around us. What we stand to gain is not necessarily the revelation of a scientific truth, but perhaps, rather, a new ethical disposition, a newfound empathy with the things that surround us. This universe of objects is full of material things ready to speak of beliefs, traditions, conventions and knowledge. That may be, after all, the metanarrative that courses through these works. They are explorations of what is possible with a few materials. They are small wonders that manage to transcend their literal qualities, surpassing what materials want to do and demonstrating what they can be. They show that matter itself can be meaningful.

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NOTES

1. I would like to thank the editors of this volume, Lois Weinthal and Jonathon Anderson, for bringing Geoffrey Mann's thought-provoking work to my attention, and for inviting me to draft this essay.
2. All quotations attributed to Mann have been transcribed from an interview with the author, held 1 October 2020.
3. On Muybridge's experimental photography, see Dimitrios Latsis, 'Landscape in Motion: Muybridge and the Origins of Chronophotography', *Film History* 27, no. 3 (2015), 1–40.
4. Muybridge's exceedingly rare 'Animal Locomotion' portfolio was published in 1887. Comprising 781 unique plates, only 37 complete sets were ever produced.
5. A selection of Marey's chronophotographs, including the 'Study of the Movements of Air Around Various Shapes', which inspired Eiffel's own experiments, were published by Jackie McAllister in *Grand Street* no. 59, 'Time' Special Issue (Winter 1997), 174–180.
6. On the history of the 'flying gallop' and the impact of Muybridge's chronophotographs, see Irma B Jaffe, 'The Flying Gallop: East and West', *The Art Bulletin* 65, no. 2 (June 1983): 183–200.
7. Eiffel drew on Marey's 'smoke machine' experiments conducted at the turn of the century. On Eiffel's aerodynamics investigations, see Stuart Durant, 'Gustave Eiffel: Aerodynamic Experiments, 1903–1921', *Engineering History and Heritage* 166, no. 4 (November 2013): 227–235.
8. Marey exhibited his 'movement sculptures' in his *Physiologie du Mouvement: vol des oiseaux* (Physiology of Movement: Birdflight); see chapter 'Mouvements suivant les trois dimensions' in the 1890 edition published in Paris by G. Masson.
9. 'Graham Harman + Sylvia Lavin in conversation: Do All Objects Matter Equally' *SCI-Arc,* 28 October 2020. Available online as part of the SCI-Arc Media Archive. https://livestream.com/sciarc/events/9285921.
10. The work of Bruno Latour is representative; see for instance, Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory*. Clarendon Lectures in Management Studies. (Oxford; New York: Oxford University Press, 2005).
11. After all, Lavin completed her doctorate in art history with a dissertation on the French architectural theorist Quatremère de Quincy (1755–1849), and was advised by historian Robin Middleton. Her recent projects, such as the exhibition and publication *Architecture Itself and Other Postmodernization Effects* (Montreal: Canadian Centre for Architecture,

2019), have critically examined the roles played by objects and artifacts in the making of architectural history and culture.

12. Flat ontology erases the subject–object distinction, placing all things in the station of coequal objects. On the impact of Harman's work in contemporary design, see Joseph Bedford, ed., *Is there an Object Oriented Architecture?: Engaging Graham Harman* (London: Bloomsbury, 2020).
13. See Antoine Picon, *The Materiality of Architecture* (Minneapolis: University of Minnesota Press, 2020).
14. Michael Fried, 'Art and Objecthood' in *Art in Theory, 1900–1990: An Anthology of Changing Ideas*, eds. Charles Harrison and Paul J Wood (Oxford: Blackwell, 1992), 822–834.
15. Fried, 'Art and Objecthood', 825.
16. Mark Linder has identified Minimal sculpture's absorption of 'properly architectural' criteria under the rubric of 'productive improprieties', that is, translations between architecture and sculpture which catalyzed the transformation of both. See Linder, *Nothing Less Than Literal: Architecture After Minimalism* (Cambridge, Ma.: MIT Press, 2004).
17. Fried, 'Art and Objecthood', 832.

7 Soft Objects

PRAXIS: Assa Studio

Evan Pavka

There are hard objects and there are soft objects. As a property of matter, hardness is defined as being 'not easily penetrated' or 'not easily yielding to pressure'.[1] Hard objects are strict and unrelenting; they are 'incapable of being corrected or disciplined.'[2] Their edges and corners are sharp and defined. Such things presuppose a sense of rigidity and finality, no matter the material transmutation that has granted its current form. A hard object is fixed and limits intervention, its past and methods of production obscured. Its essence as a typology is both physically and conceptual firm.

But a soft object is decidedly more malleable. These things are difficult to define or encapsulate; their edges are permeable and diffuse. As a property, softness straddles both physical and digital space. An object's softness derives from elements that can be reprogrammed, rearranged and transformed. A soft object invites intervention, its form 'based on negotiation, conciliation, or flexibility rather than on force, threats or intransigence'.[3] Such things are elastic and pliable. A soft object consumes, ingests and metabolizes information. A soft object has a life, one that is both virtual and physical.

It's the latter that interests London-based Assa Ashuach. Since the early aughts, Ashuach and his eponymous research and design practice, Assa Studio, have investigated the limits of the latest techniques of digital fabrication across a range of housewares and furnishings. Often, his objects coalesce these various spheres of production, becoming records and stories of a process of continued structural, material and conceptual optimization.

Early on, these notions of enhancement were addressed through techniques of abstraction and subtraction. In the sinuous crimson 501 Chair, he abstracts the forms of earlier works like The Seatable Trousers, which was, in turn, an abstraction of the femur bones used to sit. While its name is a subtle nod to the line of denim by the brand Levi's, the chair is also a study in reduction. As the designer streamlines the object to conform to the essential geometries of the lower extremities, he also essentializes the shape as well as the quantity of material required for sitting.

The methods of curtailing the form and material of the single-molded seat later informed the Upica Chair and Sofa. Consisting of a continuous torqued GRP reinforced U-Pica Mat surface that appears to have been stretched across an unseen mold, the slim and lightweight series explores the potentials of subtraction.

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7.1
Upica sofa formwork. Image by Assa Ashauch

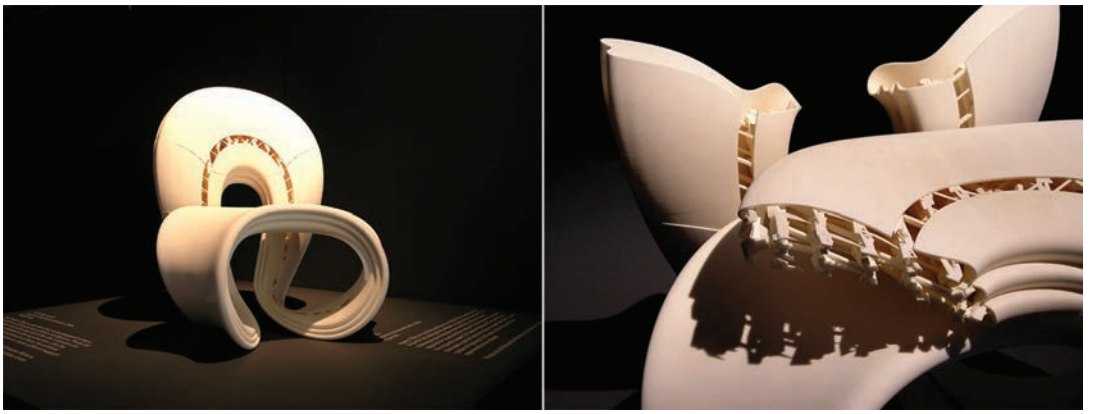
7.2
Upica sofa. Image by Assa Ashauch

Through finite element analysis applied to a digital model, both the Upica Chair and Sofa are conceptually and physically engineered to a precise point that, if any additional parameters are changed, the entire object would collapse. If the thickness of the seat was reduced, for instance, the surface would crack, while any further modifications to shape would result in the product's collapse.

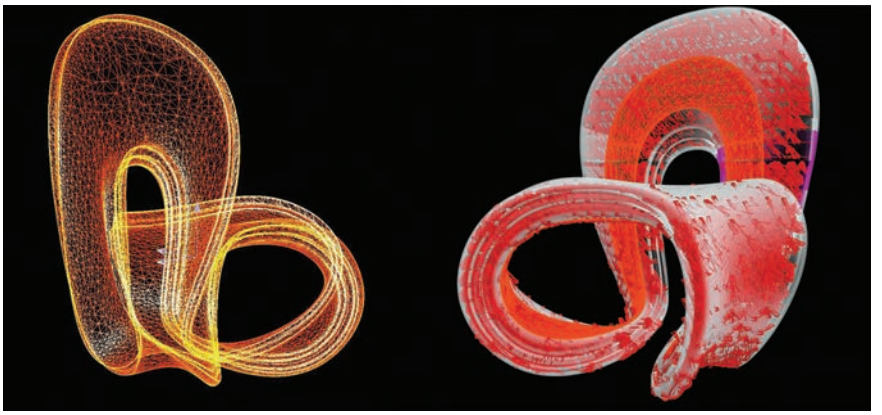
In Upica, the iconography of chair and sofa are pushed to their edges, reduced until the object is no longer purely perceived by its typology. Gone are the markers of the furniture category. Instead, the elements defining its order have each been compressed into a compound plane. Dematerialized and delimited until a single surface remains, the resulting cascading folds are not only optimized to the minimum material required to support the weight of intended users, but to the limits of which the object can be reduced until it approaches the threshold of disappearing, teetering at the edge of something else entirely.

In these pieces, the tensions inherent in the process of optimization – material developments and engineering – are made evident. Without access to additive manufacturing technologies, casting the GRP was the only available method to translate the object from virtual to physical space. As with the sedimentary layers of assembled substrates in early digital fabrication practices, they record and relay the narrative of production. In doing so, these objects reveal a technological history in addition to the forces that gave them form.

Threads of subtraction, dematerialization and enhancement manifest again in the Osteon Chair. Where the Upica series employed a low density, non-woven continuous strand laminate comprised of nearly 45 percent airy micro-balloons



7.3
Osteon Chair.
Images by Assa Ashauch

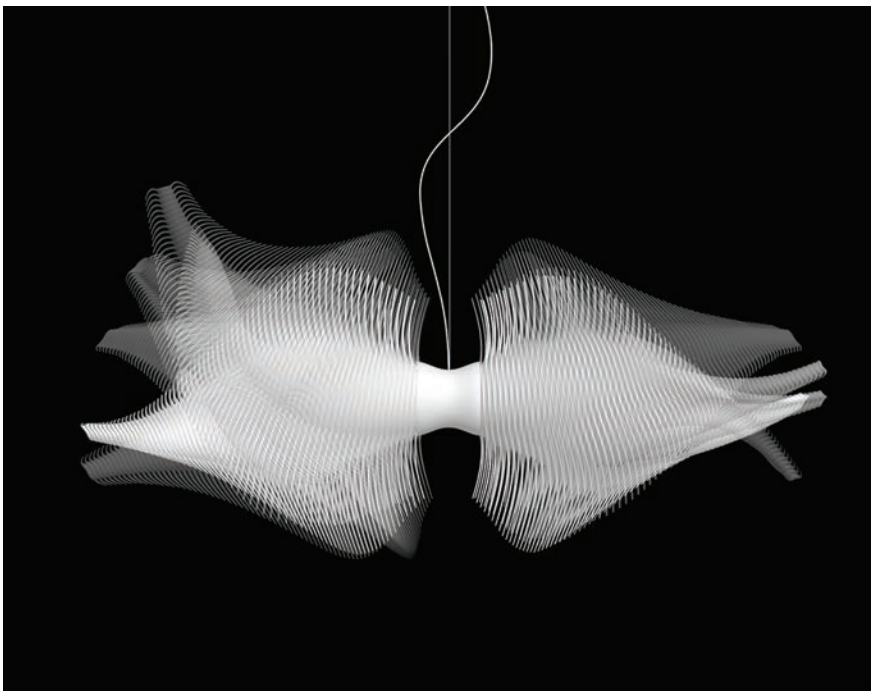


7.4
Osteon Chair.
Images by Assa Ashauch

(making the material inherently porous), Osteon was an exploration of engineering the interior substructure itself. Completed in 2005 through EOS laser sintering, the chair is supported by what Ashuach terms 'bespoke porosity', informed by the natural structures of bone. This permeable internal mesh, which reduces the required materials to a third, was created with a 3D AI algorithm applied to the virtual model of the chair and is wrapped in a continuous skin to visually unify the segments of the sweeping form. Osteon is evidence that, when treated as a file, the digital entity can be modified, optimized and inverted – its entire interior transformed – in ways a hard, traditionally manufactured object is unable to be.

Once fabricated and materialized, these virtual-cum-physical objects are not static. Though the process of translating a digital file into a physical entity could be seen as the death of the object, for Ashuach, this is only the beginning of its life. In the case of 2006's AI Light, the product continues to adapt, transform and learn in relation to its environment. Building on the pioneering advancements made in his award-winning 2003 Omi.MGX light for Materialise, which was among the first products to incorporate selective laser sintering and conceived with a flexible shade that can be sculpted and resculpted, the AI Light is equipped with an 'AI Brain' in its ceiling mount that allows the fixture to read the surrounding space and movements of its occupants. The then nascent machine-learning technology was introduced to empower the pendant fixture to operate in fundamentally new ways in relation to its environment and subsequent inhabitants.

After analyzing and recording user habits, living patterns and spatial movements over a period of time through its five sensors, the object then responds to this training, adapting to new modes of being. Like Ashuach's digital objects, the



7.5
AI Light. Image by Assa Ashauch

AI Light is informed by the dynamic inputs from its surrounds. Scripts and other algorithms, which impact the virtual entity's form, are substituted for physical stimuli. Absent of a switch or controls, the fixture gently illuminates in response to environmental factors, user needs and its acquired set of behaviors. Carefully, its two mobile appendages, resembling a bulbous vertebra, fold and bend in space to adjust both light intensity and directionality. It's not commanded but instructed. When placed in another environment, the AI Light repeats this process, reading the boundaries of the site and usage patterns to correct itself by establishing new trajectories and learned actions.

Training can also occur in myriad ways in an object's digital environment, an opportunity unique to virtual territories and the vector of time it affords. In 2009, Ashuach co-founded Digital Forming, a company that leverages 3D modeling software of the same name to empower users to customize, personalize and co-design objects by intervening with the digital file before production. The technology allows for a digital model or original design object to be conceived within a virtual framework that can then be modified and reconfigured, becoming a collaborative endeavor containing '3D openness within safe boundaries', according to Ashuach. The designer produces a digital object within the program, designating which aspects of the product are 'locked' to ensure the outcome remains functional and which elements are 'unlocked' or available for mediation by users.

For the Loop Light and the Loop Light Table, users are given the capacity to modify the shade brightness through altering the spacing between the striated enclosure, while also controlling the overall profile, base shape and colorway. Similar parameters impact the flexible Helix Bracelet, allowing users to adjust the profile of its amorphous spiraling line. The result is a collection of soft objects that are open within a specified or partially restricted context. For instance, Ashuach's Lemon Squeezer consists of a stable internal reamer surrounded by an adaptable enclosure to capture liquid. Established variables enable this unlocked profile to change dramatically while the locked interior remains consistent, leading to

7.6
Helix Bracelet.
Image by Assa Ashauch

7.7
Lemon Squeezer.
Image by Assa
Ashauch

objects with rippling, undulating or seamless perimeters in various positions that retain their functional properties.

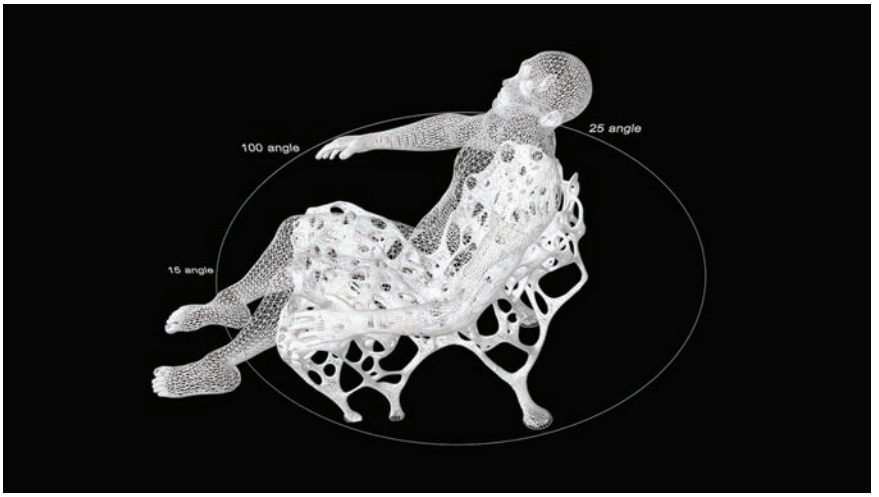
With Digital Forming, the virtual object is conceived of as a set of code, an assemblage of mathematical calculations with no set boundaries or perceived edges. Similar to an embryo, streams of data along with dynamic parameters and inputs allow the file to be incubated and reconfigured entirely in response to the needs or desires of different consumers. It has, in this sense, an entire digital life prior to its production, one where its essence is directed by both its designer and end user. What is achieved is a suite of soft objects – physical and virtual – that are forged within predetermined constraints, products of negotiation, conciliation and reconfiguration.

A soft object thus requires an equally soft process. Beyond merely integrating emerging technologies within his works, Ashuach has been invested in altering, adapting and optimizing the manufacturing process itself. Bridging user as well as designer, the Digital Forming software also includes an 'online dashboard' which transfers the digital file to a selected manufacturer by converting the object into a mesh-based file format. In the process, an integrated automatic pricing algorithm determines the material cost and use as well as time and overall energy required for production. Like the software, the algorithm is pliable, allowing the manufacturer to constantly update the variables for the 3D printing process as developments arise.

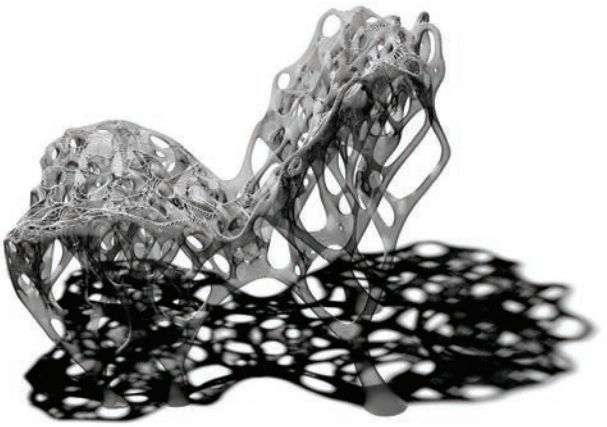
As such, whether physical or digital, Ashuach's objects are always conceived in dialogue with their respective environment. These items are not autonomous but products of their surroundings, and similarly draw on the biological processes organisms employ to negotiate their specific conditions. These natural metaphors find fitting parallels in virtual domains. Like a digital entity, the seed of the Phyllostachys genus of Asian bamboo is imbedded with vast amounts of information. This particular breed is noted for its rapid maturation and capacity to sense its environment. External parameters such as water and light enable it to expand and grow in relation to its surroundings. Changes in sun direction or moisture levels

are met with adaptation from the plant. As it grows, it reconfigures to this information while slowly optimizing its self-supporting structure and morphology. Bamboo stems become increasingly porous when attaining greater heights, modifying in form to bear the shifting structural load. As it grows, it learns. However, digital environments can be as dynamic as this natural one.

In 2017, working with macromolecular and biomaterial scientists at Kyoto Institute of Technology's D-Lab in Japan, Ashuach developed an algorithm that mimics the internal structure and growth patterns of the bamboo species. Enlarging the microscopic structures 3000 percent, the designer applied the inherent biological intelligence to a range of seating. The form of the resulting STEM 45 Chair reflects the biological template: Six stems create the legs of the chair, slowly splintering into branch-like appendages that further transform into a network of interlocking members that resemble a seat and backrest. The striations evident



7.8
STEM 45 Chair.
Image by Assa
Ashauch



7.9
STEM 45 Chair.
Image by Assa
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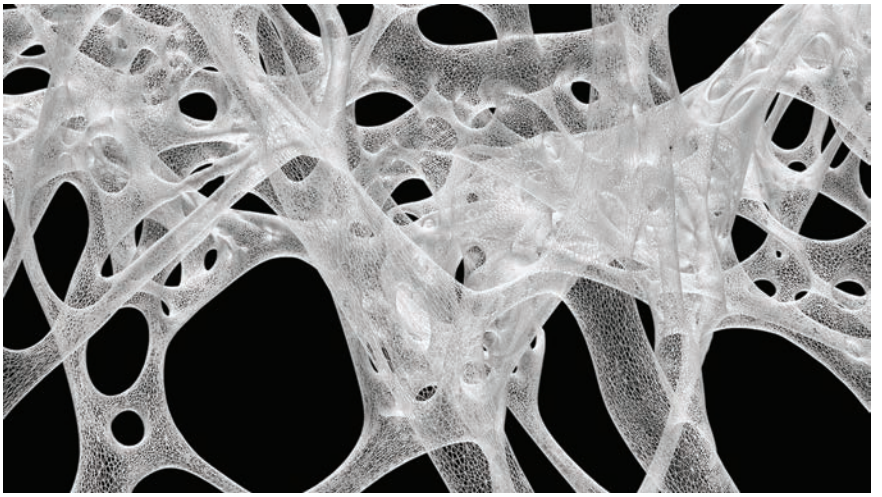
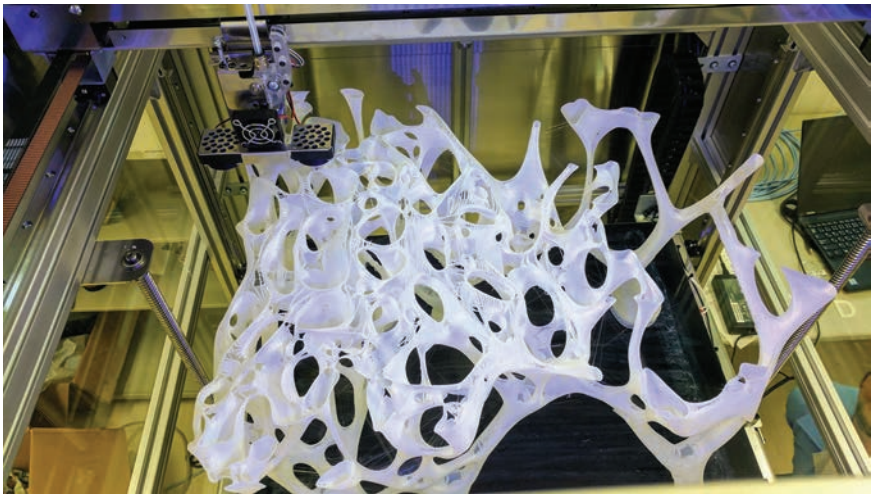


7.10
STEM 45 Chair.
Image by Assa
Ashauch

in its profile allow us to read the tool path and infer, if only loosely, the additive growth of the object over its 20-hour printing. As opposed to stimuli such as sunlight or moisture, the generative algorithm responds to force, stress, weight and ergonomic factors.

As in his earlier work, subtraction is at play here – not only in the removal of material but a conscious dissolution of any indicator of the object itself. STEM 45 is an approximation of a chair. Its traditional indicators – rails, posts, stretchers and legs – are replaced by a choreography of sinuous branches. Like the Upica collection, it plays with the typologies and categorization. It's vague and ambiguous; it's soft.

As modifications to the algorithms and scripts have informed the underlying aesthetics of STEM 45, the series, which also includes a stool, resides in a liminal space between human and machine intelligence. Notably, the 0.8-millimeter-thick structure was printed at a maximum 45-degree angle due to the constraints of the



7.11
STEM 45 Chair.
Image by Assa
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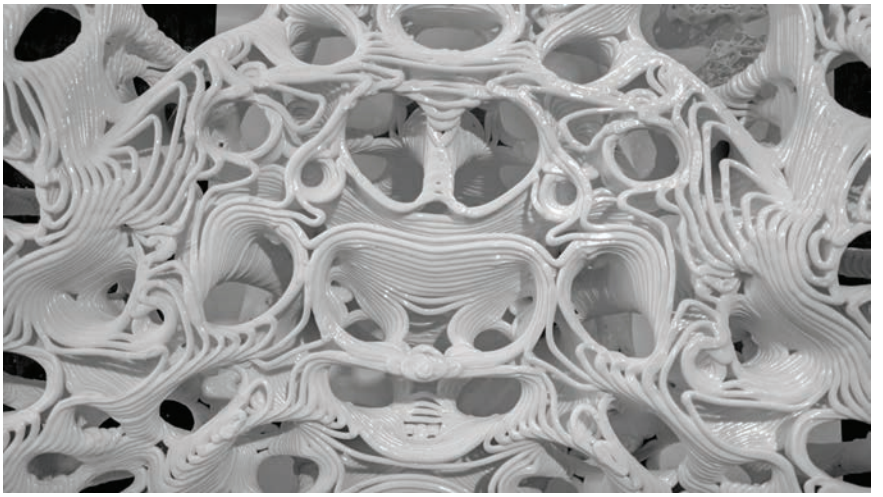

7.12
STEM 45 Chair.
Image by Assa
Ashauch

machine's capacity to move vertically. At the edge of human capacity, the machine enters to both economize form as well as manifest it. At the edge of digital fabrication, human intervention reorients the process. Both the manufacturing and the resulting object are elastic, part of a spectrum of modifications, optimizations, arrangements and rearrangements.

By approaching the virtual object from its status as information, Ashuach renders each aspect of the life of the file – from its conception in virtual space through additive manufacturing and realization – soft. The mathematical code comprising these entities can be modified, reused or deleted entirely. They can radically change their material properties, respond to shifting structural needs, read data, grow and remake themselves if needed. As opposed to being solid, fixed or resistant, they are pliable, fleeting, even fugitive outcomes of a constant interaction from surrounding forces. These are objects, yes, but they are also something more.

NOTES

1. Merriam Webster, 'hard, a.', last modified October 2020, accessed 6 October 2020 https://www.merriam-webster.com/dictionary/hard
2. Merriam Webster, 'hard, a.', last modified October 2020, accessed 6 October 2020 https://www.merriam-webster.com/dictionary/hard
3. Merriam Webster, 'soft, a.', last modified October 2020, accessed 6 October 2020 https://www.merriam-webster.com/dictionary/soft

8 The Rise of the Generalist

Imaginative Architectural Practices in the Age of Digital Technology

Elena Manferdini

It is not unusual to see that architects are not only successful in designing buildings, but also exhibitions, books, furniture, fashion, games and applications. You name it. The idea that architects would pursue a multidisciplinary or a multi-scale production is not a new one: we have been always looking beyond the boundaries of our discipline, appropriating materials, methods and processes from other arts and industries. As the philosopher Daniel Dennett once stated: 'What you can imagine depends on what you know.'[1] Architects face a similar challenge and we cannot progress our discipline without first moving beyond it.

From the Renaissance to the present, architectural practices have always been inherently exploratory. Vitruvius in *The Ten Books on Architecture* called for the architect to

> be educated, skilful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinions of the jurists, and be acquainted with astronomy and the theory of the heavens.[2]

Architects, since antiquity, have been expected to have a broad education and this expanded cultural field would ultimately be claimed as architectural territory. However, since modernity, architects have increasingly embraced their position as generalists. Operating in a time of rapid innovation has allowed architecture to cross its disciplinary bounds significantly past those originally imagined for the profession.

An example of how the era of technological acceleration has widened the field of architecture can be found in the philosophy of the Bauhaus. In 1919, Walter Gropius declared that architects should be free of divisive barriers between craftsmen and artists and that the fields of architecture, sculpture and painting should be united.[3] The school cultivated a totalizing concept in which architecture was not only one aspect of design but promoted the idea of the architect as someone who could and would design buildings, cities and objects with the same involvement. Gropius strived to deliver a visionary world through the institution:

> the Bauhaus was inaugurated with the specific object of realizing a modern architectonic art, which, like human nature, should be all embracing in its scope. Within

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> that sovereign federative union all the different 'arts' (with the various manifestations and tendencies of each) – every branch of design, every form of technique – could be coordinated and find their appointed place. Our ultimate goal, therefore, was the composite but inseparable work of art, the great building, in which the old dividing-line between monumental and decorative elements would have disappeared forever.[4]

The conception of the Bauhaus marked a critical shift from Vitruvius's idea of broad education; instead of being cultured in diverse fields, Gropius's approach dramatically expanded architects' scope of work. The school workshops included a range of courses such as cabinetmaking, textiles, metalworking and typography. The students and professors of the institution did not simply follow the precedents of these disciplines, but they innovated and produced their own avant-garde designs including furniture, lighting fixtures and tableware that have had lasting influence on the larger design world beyond architecture.[5]

Rapid European industrialization at the end of the 19th century and throughout World War I made the innovations of the Bauhaus possible. The technological advancements of these decades increased the possible materials architects had at their disposal, such as the development of steel, and the popularization of mass production increased the influence architectural design had on the general public. Architects, were thus able to work as generalists through the application of specific technology. The Italian phrase '*Dal cucchiaio alla Citta*' meaning 'from the spoon to the city', a quote largely attributed to Ernesto Roger, was born precisely from the meeting between the nascent Prussian industry and the visionary educational model developed in Dessau.[6] The slogan defined an attitude that Italian designers developed in the 1950s and have sustained since then, encouraging design that traversed scales and disciplinary boundaries. The new philosophy was fueled by the optimistic belief that the newly born industrial production of Europe, once applied to architecture, would be able to produce a better and more affordable standard of living for many people. The possibility of a transformed society was enticing after the horror and suffering caused by global economic depression and two world wars. Unprecedented design symbolized a break from the past, devoid of historical reference; it took on the political position of resistance against the totalitarian regimes of the war towards a new aesthetic and production of modernity.

After World War II, Americans did not have to contend with the wreckage of broken cities as Europe did. Their government had not been deposed and dreams of radical change in society did not take hold in the majority of the population. As a result, the new technologies and industrial powers Americans developed for the military were reconfigured and exploited for their potential to generate capital. A large market emerged in the United States as the population surged from 140 million in 1945 to almost 192 million in 1964.[7] Postwar Americans displayed an insatiable desire for new suburban homes and consumer goods, especially of the latest technology. This environment encouraged the growth of generalist architectural practices that worked to fulfill these broad desires by deploying the specialized technology produced in the world wars. The widespread enthusiasm for technology further encouraged architects to expand their practices through experimentation.

An example of this manifestation is the famous Californian competition that John Entenza's *Arts & Architecture* magazine sponsored: The Case Study Houses Program, which from '1945 until 1966 commissioned major architects of the day to design and build inexpensive and efficient model homes for the United States residential housing boom caused by the end of the war and the return of millions of soldiers'.[8] Architects Richard Neutra, Charles and Ray Eames, Pierre Koenig and Eero Saarinen were among the participants. With an increase in permanent population, family growth and a shifting economy, the country needed fast, affordable and effortless construction. The announcement of the program clearly indicated that the technologies to be used for the design of future dwellings were the ones developed by the military industry during the war:

> We, of course, assume that the shape and form of post-war living is of primary importance to a great many Americans, and that . . . the house[s] . . . will be conceived within the spirit of our times, using as far as is practicable, many war-born techniques and materials best suited to the expression of man's life in the modern world.[9]

The innovative processes of the Southern California military industry were adapted to civil uses, and its technology was pragmatically transformed into a source of economic prosperity. Consequently, much of the innovation and changes in architecture during that time stemmed from appropriating processes from the technology invented by and for other industries. Charles and Ray Eames's Case Study House #8, for example, incorporated 'pre-fabricated steel windows, Cemestos panels, Truscon steel beams and joists, chicken-wire, factory-standard glass, and parts from a marine catalog to create the stairway.' The material Plyon, which was originally marketed as fuel cell liners in military aircrafts, was used as paneling on the interior.[10]

This cross-disciplinary design approach present in Southern California offered a profoundly different meaning of the phrase 'from the spoon to the city' compared to the utopian meaning it held in Italy. One clear illustration of the Americanized concept of this phrase is found in the nine-minute film called *Powers of Ten* produced by Charles and Ray Eames in 1977.[11] The film describes a design methodology of viewing ideas from an infinitesimal to a cosmic perspective. Starting with a sleeping man at a picnic, the film takes the viewer on a journey out to the edge of space and then back into a carbon atom in the hand of the man at the picnic, all in a single shot. In this movie sequence, architectural boundaries are reimagined and understood through the eyes of a thinker. The blue-sky approach towards design is typical of the American pioneer culture that relentlessly explores new territories of research and development, as opposed to focusing solely on craftsmanship and the refining of production.

As of today, we have yet to see the realization of the social agenda promoted by the utopian phrase 'from spoon to the city'. The 'total environment' inspired by the Modernist architects of Gropius's day appears to have been a short-lived dream. Methods of mass production have drastically improved the level of comfort for much of society, but over time they have served to generate profits more often than

continuously improving our quality of life in meaningful ways. Most recent Italian design, for example, focuses on the refinement and stylization of products that have been in use for decades. The 'Made in Italy' tag line has become dependent on repeating the innovations of the past, specifically those that are closely associated with status and luxury; profit has led production more often than vision. On the other hand, the United States is facing a moment where the moorings of global capitalism are coming undone. The country is experiencing the ramifications of a society valuing production, products and profits over quality of life, while wars are still capitalizing the energy of industry and its innovative capabilities. The assumed inherent good of production is being questioned.

What has remained consistent is architects' dedication to continue to expand their disciplinary range through the use of technology. The promiscuous attitude of the generalist architect to cross-pollinate various fields of design has become increasingly evident in the past three decades, when the rapid and diffuse adoption of the same set of digital platforms in different design fields has given architects unprecedented access to a wider spectrum of work. Today, most creative industries adopt the same software packages to design projects that in the past would have been unique to different trades and professional fields (consider today's architects using Autodesk's Maya which is also used by professionals in the film and gaming industry). In addition to digital design, CNC fabrication has rapidly become a privileged access to a new kind of craftsmanship that is not dependent on manual skills or local know-how; rather than being merely artisans, architects now look to robotic capabilities to transform ideas into reality. It is not uncommon to see the generalist architect working in other industries based on a shared technical skill set; architects are able to jump between design and prototype construction almost seamlessly. Once again technology has proven to be a game changer that – like it or not – has pushed architects beyond their confining, and often too comfortable, disciplinary turf.

This unrestricted approach to design that reemerged in architecture along with the democratization of skills brought by the digital revolution has recently found an even more obvious ecology for dissemination in social media. Online trafficking of images, codes, filters, editing apps, games and stickers has filled our time and phone memory. Today we are capable of experiencing design as fully democratized. Access to education and technical skills are continuously increasing through our use of technology. We have experienced the proliferation of amateur 'how to' videos online and in 2020 we have discovered that it is possible to continue formal education remotely as well. Skills are becoming less and less insulated within their respective professions as voluntary collaborations flourish. We have declared the end of experts, that our knowledge is collective, and we – not only architects – are all generalists. And while, in the past three decades, architects have gained new territories, it is clear that contemporary digital trafficking has also been raising some controversial questions: Is this historical moment a renaissance of design? And if we believe it is, does all this produce increasing richness or does it flatten what we do as architects? And, more importantly, what do we do as architects?

Today in many academic institutions we have witnessed a reactionary push-back against an expanded notion of architecture and towards a tighter definition

of our historical disciplinary boundaries. This intellectual posture comes from the fear that architecture could lose cultural power and dissolve into other disciplines by spreading too thin. These academics hold architecture at an elevated status in relationship to the other scales one can design, distinct from and superior to non-building operations. Winston Churchill famously said, 'We shape our buildings, and afterwards our buildings shape us.'[12] Buildings in the past shaped communities; they were the primary place of gatherings, exchanges and debate. However, in our society there is no longer a privileged space for this depth of function – built architecture has lost its position as the sole proprietor of daily life. Ephemeral platforms – such as those of social media and group messaging apps – have absorbed many of these functions. We can now walk through museums virtually, download books from the library on our phones, play board games with our friends online and reach wider audiences through the internet.

Our disciplinary boundaries are most definitely blurred; we are moving through unprecedented and uncertain territory, yet this is not a condition to be feared. Generalization holds greater potential for growth and for the realization of imaginative futures that would not be possible if we stopped expanding our skills and knowledge today. Holding onto strict anachronistic definitions of what is and what is not architecture only serves to limit our creative potential. The inevitable march of technology advancement pushes us to democratize our discipline, expanding the number of voices and the subject matter of our conversations. We are beyond the time of the single genius; our strength is no longer held in the few, but in the crowd.

THE SCALED WORLDS OF ATELIER MANFERDINI

The generalist architect is an adventurous soul, possessed by an uncurbed enthusiasm for anything interesting. This continuous search for the compelling is intensified by the belief that there is more beyond our present reality. This attitude is characterized in the protagonist Gulliver of the classic novel *Gulliver's Travels* by Jonathan Swift. The protagonist displays an insatiable curiosity to explore, and in the pursuit of his cultural voracity travels through worlds of drastically different scales, each with their own unique rules.

The idiosyncratic journeys Jonathan Swift took readers through, gigantism and miniaturization, serve to break down the anthropocentrism in Gulliver's and our minds as the character realizes that 'nothing is great or little otherwise than by Comparison'.[13] The revealing of alternatively scaled worlds diminished the superiority and centeredness of human's place in the universe as well as the perceived stability of our current reality. This false permanence is further disrupted by making the familiar strange and naturalizing the strange. Sebastian Dieguez describes this recontextualization best:

> What seemed familiar and unnoticeable in a standard context is made, by altering the body–environment scaling, exceptional, incomprehensible, and remarkable. New types of usage and interaction emerge, making in turn the unfamiliar familiar again: in general, characters embroiled in the Gulliver theme strive to adapt.[14]

The act of scaling immediately reorients our relationship to the world by forcing us to occupy a different point of view than our normal one. Established and assumed to be stable conditions are no longer a simple matter of fact, and, as a result, alternatives to the current reality are easier to imagine and explore.

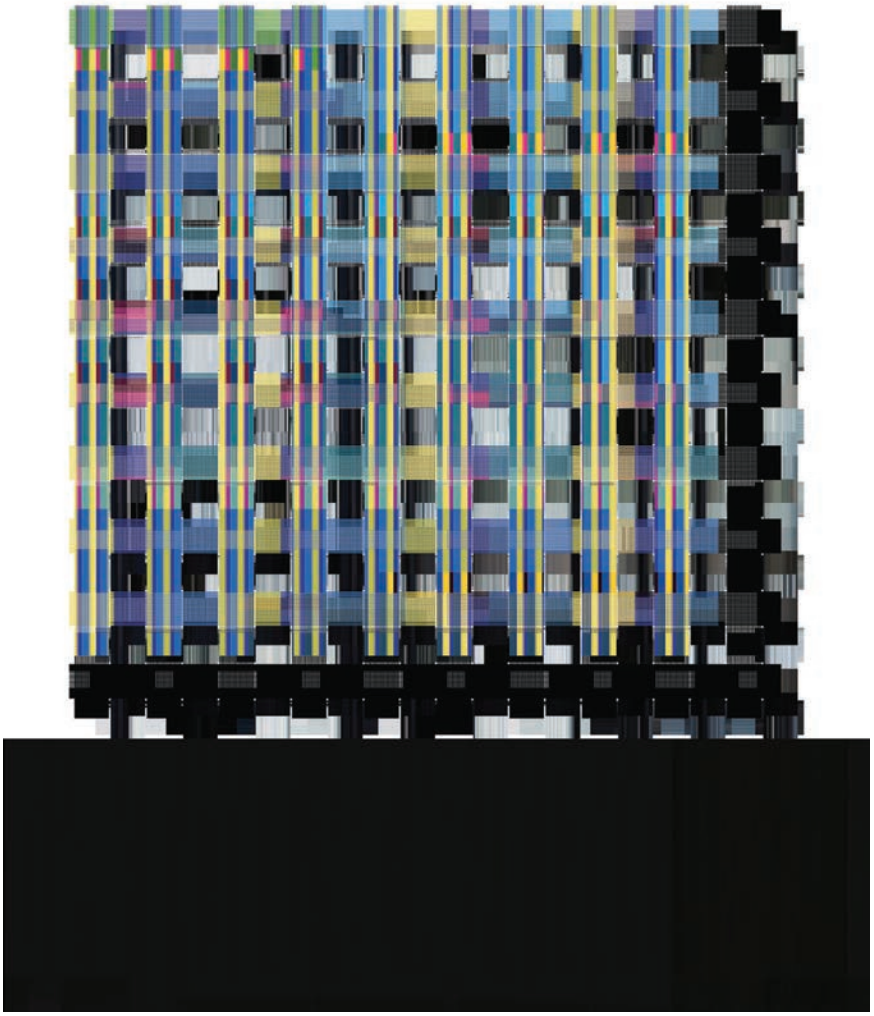
Gulliver's Travels thus presents a powerful way of thinking about architecture and expanding disciplinary boundaries through changes in scale. If the *Powers of Ten* film defines the realm of possibility for architecture, the work of Atelier Manferdini is exploring what is possible at these disparate scales. These investigations which happen largely through the use of architectural drawings and pictures begin to create a reality that encourages a reorientation and reimagining of possible futures.

Architectural drawings embody the generalist spirit of bringing seemingly diverse fields together. Illustration, animation, photography and graphic design are among the disciplines that often inform the conception of a two-dimensional representation. Diverse materials, scale shifts, design expertise and fabrication methodologies further shape the creative process. The geometrical drawings of Atelier Manferdini are inherently multi-scalar and constitute a core medium to generate a multitude of architectural projects. The resulting scalar shifts throughout the practice's work expand our definitions of what encompasses architecture and challenges complacency in the discipline.

The abstract flatness of architectural drawings helps to make them irreducible to a singular interpretation, especially if the drawing is a starting point and not the result of a reductive process, such as moving from three dimensions to two dimensions. The uncertainty of this flattened space encourages multiple formal interpolations and fantastic intellectual interpretations. Here there is no defined status or scale and the drawing exists as surface, exhibiting unrestrained depthlessness. It is in the absence of such definitions that everything becomes endlessly complex; there is not a single manifestation of the flat drawing into physical three-dimensional space. Digital tools capitalize on this complexity and abstract geometric drawings are rapidly reconfigured into a wide variety of unique designs.

In the work of Atelier Manferdini it is apparent that architectural drawings do not function as discrete explorations. Instead, a single composition often operates as a point of departure for a family of projects that transverse a multitude of scales and applications. For instance, in the 2015 *Building the Picture* (Figure 8.1) exhibition shown at the Art Institute of Chicago the digital operations and intricate scripted line work used to create the installation have informed many ensuing designs. The drawings of *Building the Picture* began with the cartesian grid of Mies van der Rohe's most famous elevations. The grid's domination in the modern American cityscape and architects' seemingly unlimited faith in its transformative powers has made this ordering system an obvious place of aesthetic and functional intervention. The geometrical structure of the grid is able to be retained throughout changes in scales and applications, ranging from the intricate details of architectural elevations to entire city plans; Mies's application of the grid is clearly evident in the façades and fenestration of his mid-century designs. Beyond practical application, the Miesian grid embodied a political meaning in our discipline. His elevations projected an egalitarian image of the built environment and his façades reinforced the

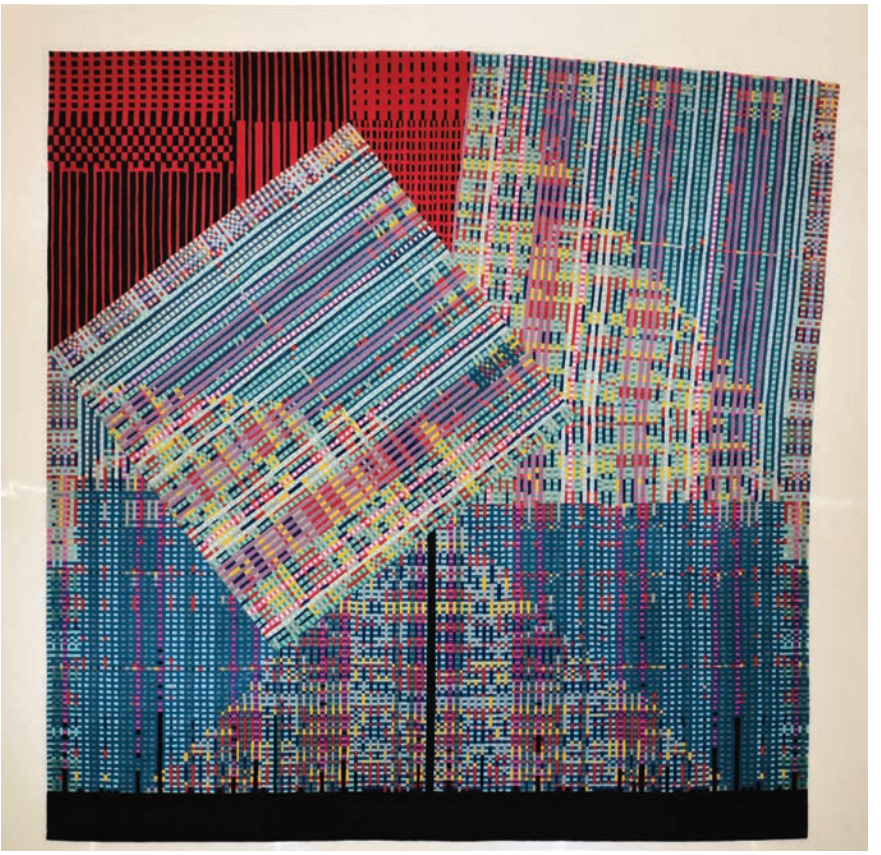
idea of technical efficiency and social democracy. The work exhibited in *Building the Picture* reimagined the Miesian vision. The highly ordered geometrical drawing of the grid was coded into a script that produced complex patterns of colorful intersecting lines, depicting alternative possibilities to the building façades that we currently know. The collection plays with the graphic potentials of woven grids and scripted vector lines, while exploring the canonical relationships of shape vs. form, ground vs. figure, pattern vs. coloration, and orientation vs. posture. The project exists simultaneously as architectural research and as autonomous artwork; it is presented in intimate two-dimensional studies and translations into larger three-dimensional forms. These 2D and 3D drawings can be understood as scaled down reproduction of buildings, and at the same time as full-scale printed artifacts. This installation culminated in the production of an imaginary new skyline for the city of Chicago, that in the following years has informed Atelier Manferdini' s various modes of production.



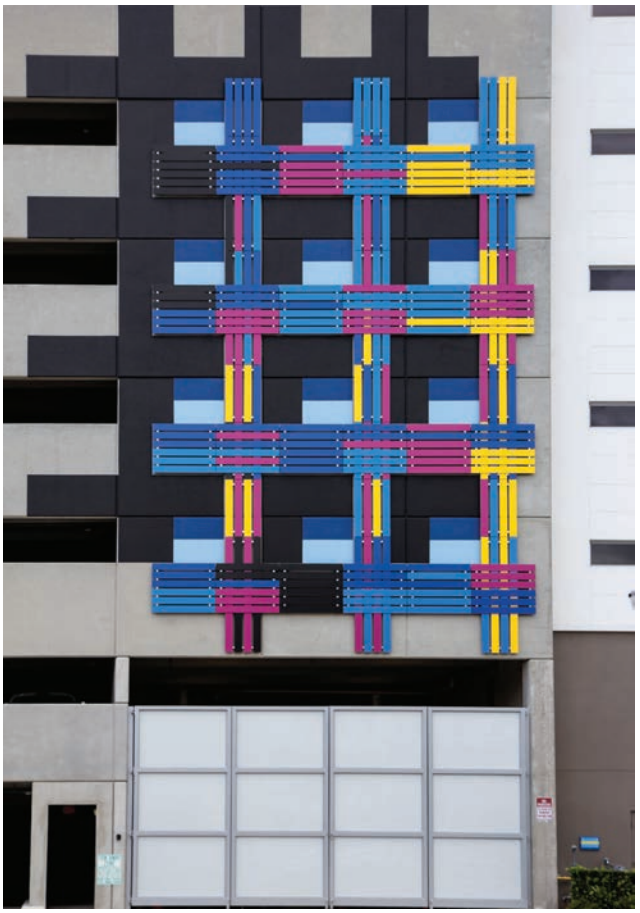
8.1
Building the Picture. Scripted drawings of fictional façades for an imagined Chicago skyline. Courtesy of Atelier Manferdini

The abstract studies of *Building the Picture* have been deployed across multiple scales through digital reconfigurations. In the project *Urban Fabric Rugs* (Figure 8.2), instead of covering the distant and untouchable walls of a gallery, the intricate lines were transferred to the domestic space, occupying the underexplored area of the floor. The elevations became floor projections made of soft hand-tufted wool that encourage tactile experiences. The project *Blank Façades* (Figure 8.3) transformed the same visual language of *Building the Picture* to a third, much larger, scale. In this project the drawing is now imagined at the scale of a building (a 40′ by 80′ wall to be more precise), partially enveloping the banal space of a parking garage.

It is evident in the work of Atelier Manferdini that new modes of imaginations are increasingly made possible by technological advancements and the adoption of a generalist approach to design. Digital tools within the space of the computer allow design to be liberated from architectural disciplinary boundaries or a singular scale, and like Gulliver, we are able to adapt our thinking to these shifting scales. Several interpretations for diverse applications and materials can emerge within this equivocal space and then be deployed physically through digital fabrication. The methods of fabrication then offer further variations. These digital tools and methods of fabrication are informed from diverse sources and through the architect's desire



8.2
B3 Urban Fabric Rugs. Model B3, one of 12 hand-tufted, hand-carved 100% New Zealand virgin wool rugs designed by Elena Manferdini and produced in limited edition by Urban Fabric Rugs. Courtesy of Urban Fabric Rugs and Atelier Manferdini. Photography: Andrei Zerebecky



8.3
Blank facade. Permanent artwork façade for Hermitage garage designed by Atelier Manferdini and commissioned by the Allen Morris Company. Courtesy of Atelier Manferdini

to collaborate with other disciplines. This multidisciplinary methodology of design and scale transferring is evident between Atelier Manferdini's *West Coast Pavilion* in the 2006 Architecture Beijing Biennial (Figure 8.4), the coffee table *Tracery* (Figure 8.5), and the teapot *Greenhouse* (Figure 8.6). The design technique and visual language developed in the pavilion, which was created in part to explore the potential of fabricated twisted steel, is applied to the later works that operate on more intimate scales.

Digital drawings contribute to the development of an aesthetic of order that maintains its code through the various scales of design, where the logic of the small is relevant to the logic of the large. Flatness and digital fabrication contribute to the multiscale approach. A drawing can be understood as a tool path and jump from scale to scale, thickening up its section. The G-code translates the digital information of a drawing into a myriad of materials such as paper, glass, fabric and metal. Once translated, the possibility of three-dimensional transformations are opened up and operations such as folding, draping and seaming can take place. The projects *Blossom* (Figure 8.7) and *Hibiscus* (Figure 8.8) are both translations of geometric floral motifs into metal constructions of different thicknesses using laser cutting and

8.4
Beijing Architectural Biennale. West coast pavilion design by Atelier Manferdini for the Beijing Architectural Biennale. Courtesy of Atelier Manferdini

8.5
Tracery. Outdoor table in cast aluminum designed by Atelier Manferdini for Driade. Courtesy of Driade and Atelier Manferdini

CNC machining, respectively. *Blossom* is a stainless steel fruit basket produced by Alessi in 2011. The ordered reflective pattern of the openwork basket creates the illusion that an object on the outside is actually on the inside. The later 2017 project *Hibiscus* deployed a digital drawing derived from similar explorations for the design of shading panels for the Alexander Montessori School façade in Miami, Florida. The drawing in this project serves to modulate the sunlight that enters the building during the day and the amount of light that is emitted from the building at night. In both projects we can understand how the transfer of a drawing via G-code to different materials provokes various optical effects – that were not present in the

8.6
TWG. Gold and ceramic teapot designed by Atelier Manferdini for TWG. Courtesy of Atelier Manferdini

original drawing – through the use of reflections on stainless steel in *Blossom* and through the use of the void cut out of metal in *Hibiscus*.

While drawings exist within an approved arsenal of tools in architecture, pictures are more closely associated with fine art disciplines. They are the place of the familiar and the figural and offer a privileged connection with a wider audience. In Atelier Manferdini's public artwork, pictures are leveraged to challenge the predictable borders of abstraction in architecture and present raw potential for shaping our imagination. Digital visualization tools can be implemented to recontextualize imagery we are intimately familiar with, such as flowers and butterflies. Altering the scale, color, material and finish of the familiar objects reorients us to be more open to possible realities. The resulting pictures are not drawings nor images. Instead, they exist in the place of the pictorial, offering glimpses into alternate possibilities and serving as catalytic agents as they expand our notions of fantasy.

In the work of Atelier Manferdini a taxonomy of scales often emerges from a familiar subject matter. The *Secret Gardens* (Figure 8.9) line of textiles and clothing, produced by Bella Tessuti and designed by Atelier Manferdini for the A+D show in 2012, captures the likeness of flowers, beetles and butterflies and applies them to the human form. The plants and insects were found in nature and 3D scanned, before being altered in various modeling software. The resulting photorealistic images are scaled close to their real-world dimensions and remain familiar. *Inverted Landscapes* (Figure 8.10) instead scaled up and expanded on the imagery of *Secret Gardens*, shearing pixels of the images across walls and past the boundaries of the façade onto the plaza of the San Fernando Valley Family Support Center. These techniques are further explored in *Living Picture* (Figure 8.11) – the design of an interactive wall in the lobby of KAIDA Center of Science and Design in Dongguan, China. Here the pictures of natural elements are layered on top of

8.7
Blossom. Stainless steel fruit basket design by Atelier Manferdini for Officina Alessi.
Courtesy of Alessi Photographic Archive

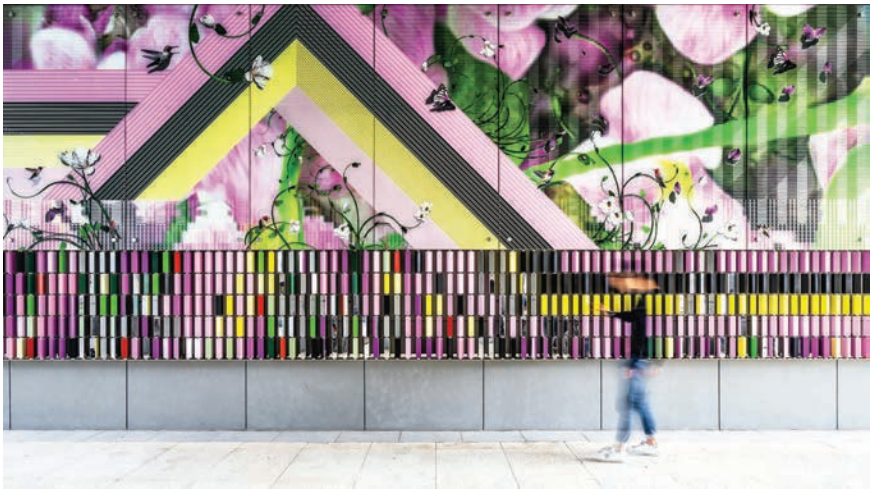
8.8
Hibiscus. Shading panels by Atelier Manferdini for Alexander Montessori School.
Photo by Artofmart

larger, lower-resolution versions of themselves. The images dissolve into swathes of color and into moments of playful spinning pixels that allow visitors to alter the final picture.

The act of viewing and audience participation are integral to the work of Atelier Manferdini, especially in the most recent projects that are facilitated by the latest mixed reality advancements. *Dahlia* (Figure 8.12), which was presented in a 2020 group exhibition by SIGNS in Istanbul, is one such project that invites the public to come closer and interact with the installation. A wall of the gallery is highly saturated with the seamless picture of intricately modeled floral elements, which through its complexity resists reductionist thinking. Tripartite close-ups of the flowers rest on the wall while the audience is able to rapidly reposition themselves between the multiplicity of scales before them. The gallery visitors can hold a tablet up to the canvases to see them come to life. The augmented space disrupts our established ritual of viewing still lifes and generates a theatrical engagement with the wider public. In doing so the audience becomes the final collaborator and the ultimate author of the generalist project. Among the many contemporary technical

8.9
Secret Gardens. Fabric design by Atelier Manferdini for Bella Tessuti. Courtesy of Atelier Manferdini. Photography: Patrick Martin; Model: Sabine@ Nextmodels; Hair & Makeup: Sussy Campos

8.10
Inverted Landscapes. Civic artwork design by Atelier Manferdini for Zev Yaroslavsky Family Support Center. Courtesy of Atelier Manferdini



8.11
Living Picture. Interactive wall design by Atelier Manferdini for Kaida Center of Science and Design. Courtesy of UAP

8.12
Dahlia. Installation view, 'When You Touch About Me, I Think Myself', SIGNS Istanbul, 2020, Dahlia © Elena Manferdini. Courtesy of SIGNS and Atelier Manferdini

advancements, social media represents the latest digital turn in our world. It is a medium dependent on collective participation and promotes the democratization of experience. Architects who use it are loosening control over their work, there is no guarantee of how their project will be received and where it will arrive. The generalist architects are best prepared to rise to the promise of this new medium as they know how to collaborate with diverse fields and how to expand the boundaries of architecture in unprecedented ways.

Special thanks to Devangi Kansagra and Allison Hoagland for their contribution to the text.

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9 The Role of the Hand in Digital Design

Karl Daubmann

Designers are mediators and, as a result, design can be understood as an act of mediation through the lens of the body. Designers must preconceive of an outcome and mobilize material and labor to bring that conception into reality.[1] It is through the body that designers understand the world around them, understand scale, and simulate and translate their ideas into built form. In *Making*, Tim Ingold poetically describes the ability of the hand to both sense and make. He states:

> The more eloquent the eyes, the less they see; the more they see, the less they give away. But with the hand there is no such trade-off. Not only is it supreme among the organs of touch, the hand can also tell the stories of the world in its gestures. . . . Indeed, the more gesturally animate the hand, the more it feels (Ingold, 2013, 112).

There are wonderful examples of designers referencing the anatomy of the body, such as Francesco di Giorgio Martini's drawing of a male figure overlaid on the plan for a church.[2] The interest here is not about exploring the measure or image of the human form, but the performance of the human body as it relates to the connection between the labor of design and the choreography of construction labor as the materialization of those design efforts.

The first step to understanding the performance of the body as a means of informing design is to first accept the notion that design and making need not be separate. At the heart of this mindset is the misconception that humans think first and then act, that one's response always originates in the brain and moves to the hands. Frank Wilson argues that the artificial split between thinking and making is the result of common misunderstanding about our own physiognomy – a misconception that the hands and the brain are disconnected. He describes the human nervous system as a connected network where the hands and brain are one with sensing, processing and translating (Wilson, 1999, 65). We can know things with our hands that do not need to be processed intellectually. He goes on to articulate this point through evolutionary biology to describe that the opposable thumb is not the result of an enlarged brain in chimpanzees, but, instead, that increased brain capacity is a result of the opposable thumb (Wilson, 119, 34).

As one reunites the split in Western philosophy between thinking and doing where one precedes the other, the same unification or reordering might be

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necessary between conception and production.[3] In any organization or economy where there is a specialization of labor, craft can only exist on the production end. Design–build relationships minimize this split but, in any scenario, where pre-planning[4] is required to simulate likely outcomes, the design link to labor may be tenuous. Automation potentially further divides design from making through additional layers of mediation. Through digital fabrication, this divide is minimized or erased through the direct connection between design files and computer-controlled instructions fed directly to a manufacturing or output device – typically considered file-to-factory. When this workflow becomes increasingly connected either through time or repetition, one may become a clear extension of the other. While industrial robots have been historically deployed in mass-production manufacturing sites, these same automation tools can be used for low-run, mass-customized applications if the design and process is appropriately conceived. These types of applications will allow more designers access to the tools, allowing designers more modes of output, and thereby potentially augmenting the design process. In the architecture realm, the new possibilities dictated by the emergence of advanced tools of production has the potential to turn the file-to-factory process into a file-to-field paradigm, where the construction site might become the literal extension of the designer.

One additional artificial dichotomy to be considered is that of the divide between digital and physical. Rather than posit these as oppositions, digital could be considered both an extension and a transformation of the physical (Sterling, 2005). The digital transformation also known as d(x) includes both simple digitalization of converting analog approaches to digital approaches and the more transformative digitization which seeks to extend the capabilities of those aspects that are natively digital.[5] Related to basic digital design functions, most tools have their origins in the physical. The iconic image of Ford engineers drawing full-scale templates at the Willow Run bomber plant shows an engineer laying on top of a drawing with a metal edge with weights on it to define the curve. It is here that we see the scale of the body, the dialog with the gesture of the body, and the curve definition that can be made analogous to the Bézier points on a digital curve. These analogies exist for most tools within digital design software. While there may be vestigial analog holdouts, most things produced in a first world economy originate digitally, allowing for communication, collaboration, visualization, prototyping and manufacturing.

The Bauhaus textile artist Anni Albers suggests that materials might initiate a design process as opposed to simply be the result of it. She says, 'design is often regarded as the form imposed on the material by the designer. The material itself is full of suggestions for its use if we approach it unaggressively and receptively'.[6] Taking the clue of how Albers discusses materials, this mindset can be expanded to include the hand as both output and input. Afterall one key aspect to materiality is tactility and that can only truly be judged through touch. Like Tim Ingold's expressive hand that can both produce and sense, digital design processes of conception and making should be able to engage the body and materials in a multiplicity of ways. The following projects seek to define this relationship between the designer's body and the labor of making.

ROBOPINCH – DISEMBODIED CRAFT – THE HAND

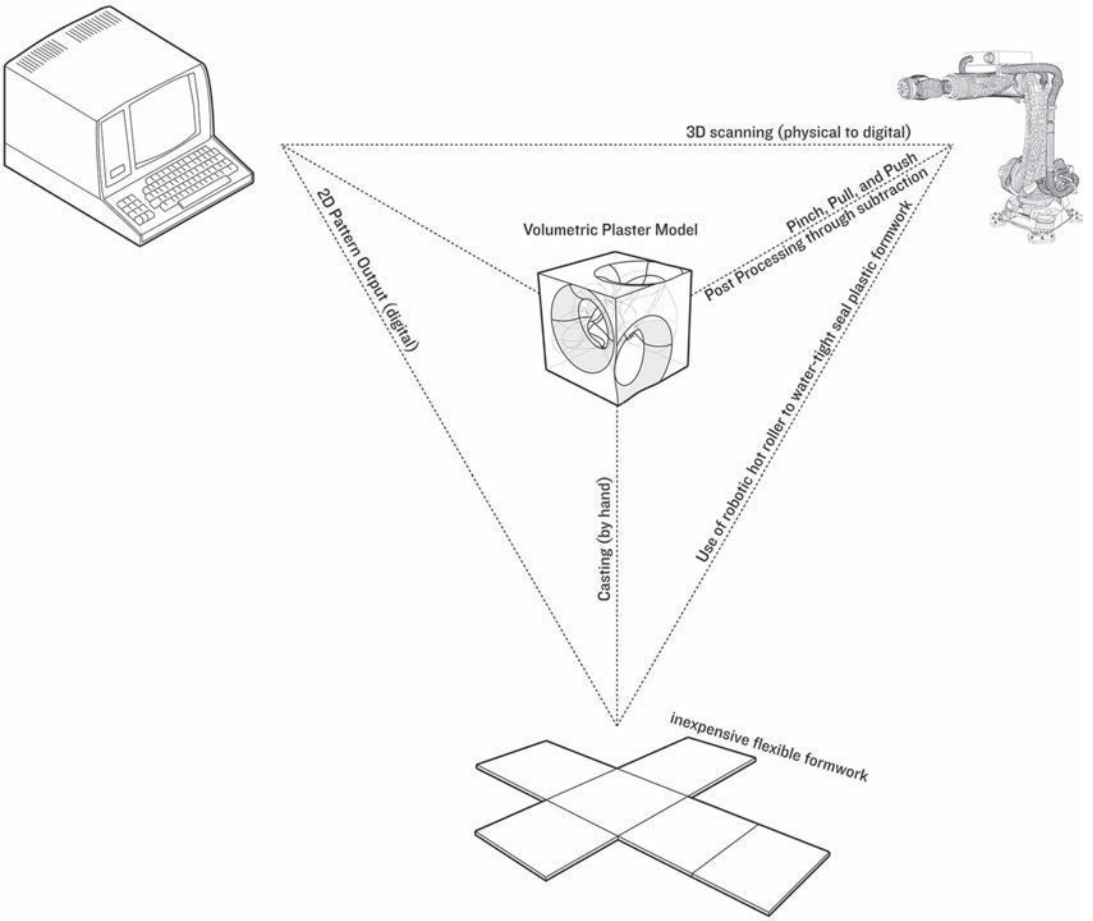
The iconic Le Corbusier Unite d'Habitation model image of a hand sliding a unit into a frame highlights the ominous and omnipotent hand of the architect. While we don't expect a giant hand lifting parts of buildings into place, we understand a crane might carry out that function. As Kahn considers at Richard's Medical Center, the crane can be understood as an extension of the architect's body.[7] This mediation is then one of the body (hand becomes crane) and one of time (design phase simulates construction phase). It is then this notion of craft tied to the hand that one must translate to the digital age where buildings or even prototypes can be made by robotic hands and the information is shared by file as opposed to drawing. Disembodied craft then represents the interactive making/design/making cycle in the digital age.

It was in an undergraduate design studio charged with the exploration of a building's site and a building's form that Stella Zhang began creating some unique physical models. The studio introduced plaster[8] as a modelling material. Stella filled balloons with plaster and held the balloons with her hands until the plaster cured. Her frozen gestures were the formwork for the building's massing. Similar to the scalar problem introduced earlier through Francesco di Giorgio Martini's drawing, Stella's project was inextricably tied to the scale of her hands. Through subsequent

9.1
Plaster studies by hand. Stella Zhang's hands. Courtesy of Karl Daubmann

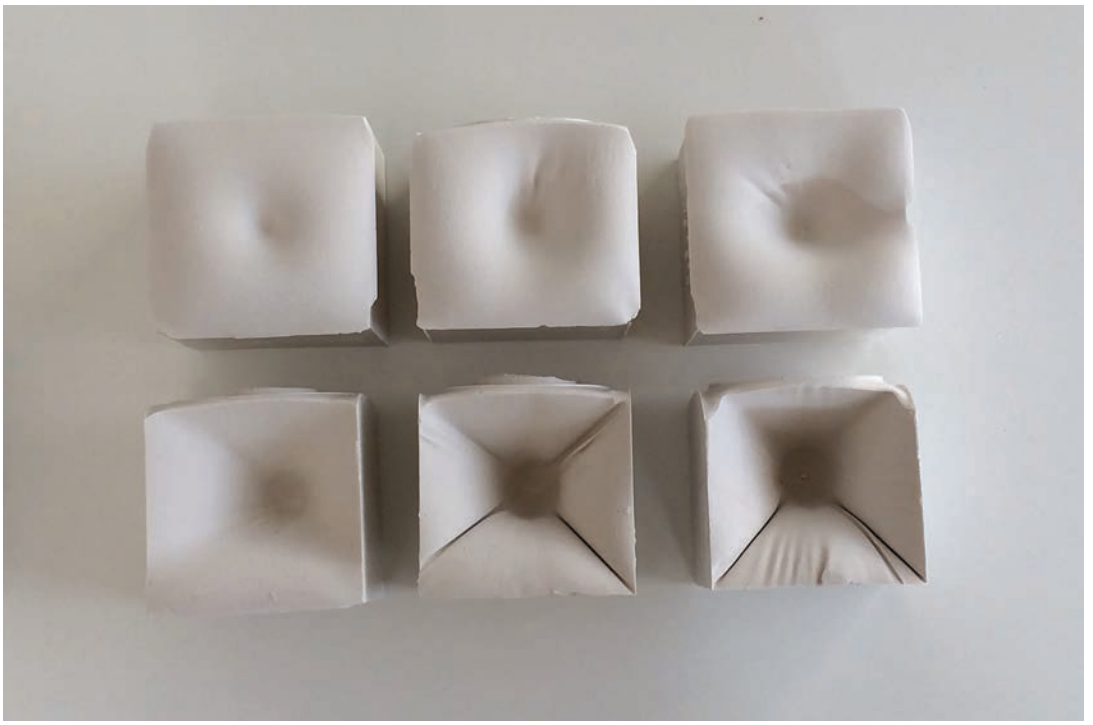
translations of scale and complexity, the handheld plaster models would be understood to be much larger building forms. The massing models were made as solid plaster volumes but, through translations to become architecture, the solids forms were reconceptualized as hollow, allowing space on their interior.

Struck by the strain on Stella's face as she fought to hold the plaster forms long enough for the plaster to cure, the RoboPinch project was initiated. The four Ds[9] related to automation were the impetus to explore the limitations of the hand and the opportunities of the robot as supported by a Taubman College Research Through Making Grant[10]. So much of the early stages of design are iterative trial and error through making. Often it can be difficult to go back and replicate a particular aspect. The research investigated the potential role of small industrial robots to iteratively and parametrically make small architectural plaster models that are digitally native with a craft-based output. Previously at Taubman College, the small KR6 robots were used as a low-impact training cell prior to working with larger robots at scale. The intention was to leverage the small robots to imagine larger-scaled architectural work through the architectural model.



9.2
Interconnected workflow of RoboPinch. Courtesy of Karl Daubmann

Flexible formwork became the medium for RoboPinch due to the economical formwork and because of the nonlinear nature of the formwork's initial condition and the resulting organic or fluid forms. The hanging chain model of Gaudi (Smith, 2015) was a central precedent because of the way that gravity and forces act on the physicality of the model, informing architectural choices. The flexible formwork would then be deformed by the weight of the plaster and the internal hydrostatic pressures, resulting in the gap between an initial digital state (or action) and the final demolded form. This also means that if the same volume of material used the same flexible mold cast on its side or vertically, gravity would affect it in different ways resulting in different final forms. In addition to orientation, deformation was used as a second means of formal manipulation through a focused and applied force. These deformations evolved from the simple actions of the hands: poke, pinch, pull or twist. Rather than model the resulting geometry, only the actions were modelled simply as robot instructions, allowing the resulting form to be just that, resulting, without a predetermined geometric outcome. The models could then be scanned after being demolded. The robot actions were conceived as parametrically reproducible so that any action could increase or decrease in magnitude or change its angle or inclination, to be refined or redeployed in a subsequent case. In some instances, the range was modelled as simply a trajectory (simple line) that could have a point along its length representing the limit of a robotic action. This is simply demonstrated in the image of six cubes being poked, the same action modified by depth (Figure 9.3). In other cases, the parametric and reproducible



9.3
Parametric plaster studies of one simple action – the poke. Courtesy of Karl Daubmann

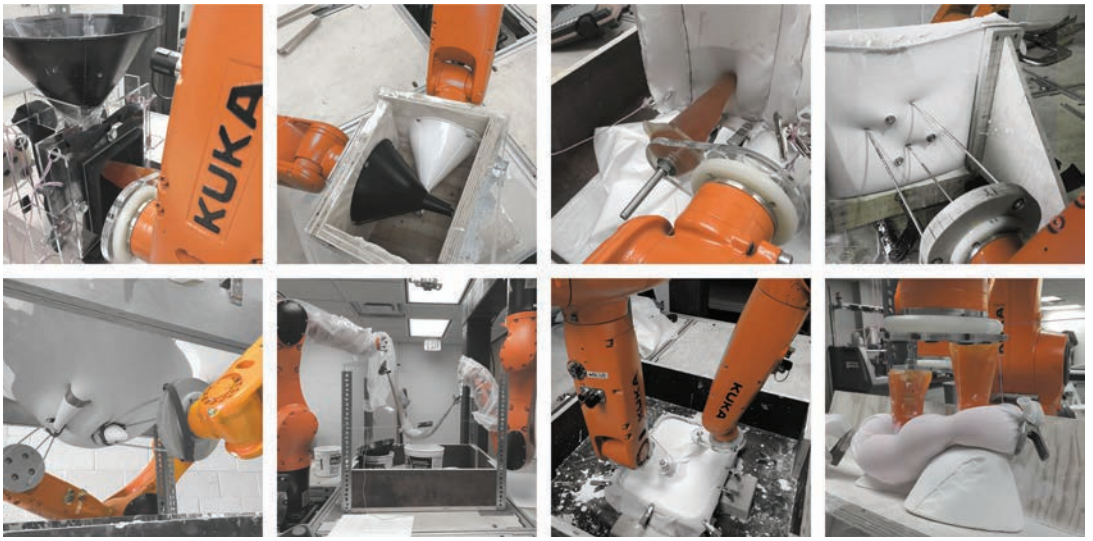
action might be a twist between the interaction of the two robots represented by angles from a common reference point. The reproducibility was played out later in the project through collections of parametrically similar parts aggregated into the same model (Figure 9.4).

The small cubic studies illustrate the simple parametric action of the poke, but they also highlight a fundamental difference in modes of making. With these studies the form results from a deformation of fluid material. If these forms were made with CNC milling (for example) the cube would begin as a solid and the material would be extracted, resulting in wasted or removed material. The applied robotic force displaces material resulting in zero waste or displaces volume resulting in less plaster needed for the cast. Through enough iterative making, the geometrically modelled applied action(s) could be understood in relation to an unmodelled/undefined final geometric outcome.

The opportunity of the Kuka workcell was that it included two KR6 robots. The use of two robots allowed for holding at two points or positioning with one robot while deforming with the second. As the robot actions were combined and modified, the designers were able to devise, speculate and produce outcomes that could mix and match deformations leading to outcomes that were both diverse (expansion of the population) and refined (reusing and increasing intelligence of the robot actions). Additional iterations were developed where a cast element was held in space and a second model cast around it or an earlier cast model was used to deform a second cast model.

From its inception, the RoboPinch research project was imagined as a workflow. This workflow was intended to make early-stage proto-architectural models that could be digital in nature and iterative in their creation, and the physical outcomes would lead to a process of discovery where a designer might find something more than they initially imagined. The material process was intended to be inexpensive so that iterative tests would not be cost-prohibitive to make. The formwork material was always inexpensive, usually off-the-shelf fabric: cotton, felt, Lycra or plastic. The plaster was purchased in 50-lb bags for about $25, meaning that individual models would cost just one or two dollars. While the process could be

9.4
One of the final plaster models from RoboPinch. Courtesy of Karl Daubmann



9.5
Process documentation of various end effectors and robot casting. Courtesy of Karl Daubmann

replicated and was precise, the inexpensive material meant that the actual output never became precious. Precise not precious allowed for post-processing of cutting, sanding, trimming, even breaking, allowing designers to engage or redeploy parts in new arrangements, discovering new opportunities for the projects being explored.

In her short essay 'Work with Material' from 1937, Anni Albers ponders the craftsperson's collaboration with industry where work done in direct contact with material can foresee its manufacture while also impacting a broader audience (Albers, 2000b, 8). The RoboPinch workflow sought to digitally and robotically automate a handmade craft modelling approach. The scale, material and inclusion of handwork coincided to produce work that continues to feel both conceived by and created by the body. The iterative way of working also felt as though the learning was an extension of the body rather than in binary opposition to it.

BORROMINI – BAROQUE TRANSLATIONS

Francesco Borromini grew through the sculpture, stone cutting and masonry traditions to emerge as one of the most well-known Roman Baroque architects. It was this crossover from mason to architect that led to the author's proposal of a year of research at the American Academy in Rome to explore the geometric rules and procedures deployed by Borromini. Anthony Blunt, Borromini scholar in 1979, described the architect's process as 'discovering new beauties, new refinements, new ingenuities, and always in the end coming to the conclusion that what seemed at first sight to be freaks of fantasy were in fact variations based on an almost ruthlessly logical method' (Blunt, 1979, 9). If these ruthlessly logical rules could be understood to be parametric in nature, Borromini's work and process could be

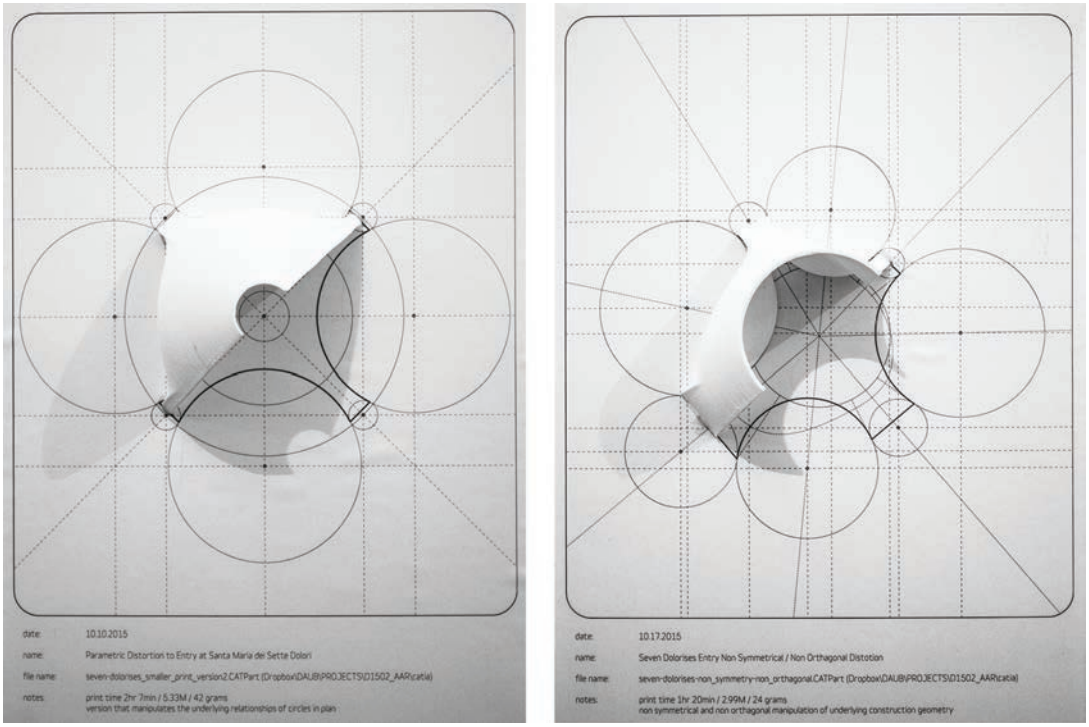
deployed through contemporary techniques. The speculation with the proposed residency evolved into 'What would Borromini do with a robot?' with the assumption that his preconceptions of the craft tradition might remain while he might deploy contemporary and available tools.

Geometric/Parametric Analysis

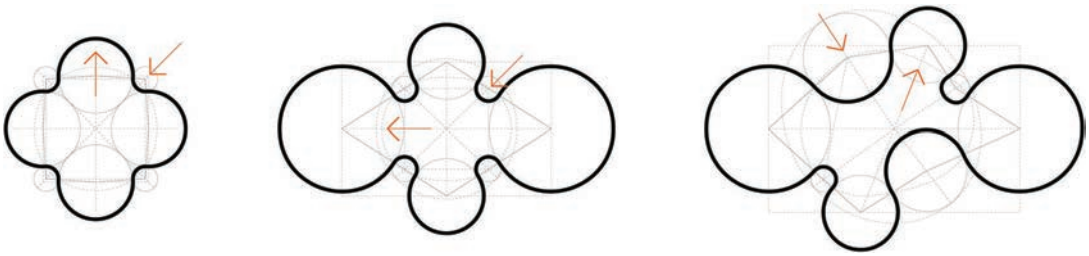
The first activity upon arrival in Rome was to visit the churches designed by Borromini. Spending time in the spaces allowed for observation, looking for geometrical clues that pointed to any underlying logics or rules. These visits were supplemented by studying the architect's drawings and using them to initiate parametric plans of the churches. The interior church volumes were digitally rebuilt not to simply recreate the volume but to articulate the geometric parameters and rules embedded within. Searching for clues for the rules gave greater purpose for additional site visits to verify or document aspects not clear in published drawings or scholars' diagrams. Four Borromini interiors were developed through this process: San Carlino, Saint Ivo, Santa Maria Setter Dolori and the crypt in San Carlino.

Thinking like a mason (inspired by Borromini's own history), the parametric drawings and models of the Borromini churches are procedural in nature, using very simple incremental operations to build up the complexity of the space. This incremental buildup was inspired by Borromini's own drawings that appear to delineate the decision-making process through simultaneous variations embedded within a single drawing. The analytical digital drawings operate to connect the stake and chain method for the inscription of a circle on a construction site to the scaled version of the compass of an architect. While both methods result in circles of different scales, the compass might also be understood as a reduction in the scale of labor required to make the circle (one hand versus that of two laborers on site). Like the hanging chain models of Gaudi, that are an analogue for the physical distribution of forces, the compass in the hands of Borromini initiates a conversation about construction. While it is simple enough to define perpendicularity in CAD, working like a mason on site with a geometric theorem, perpendicular geometry was only created where the simple Pythagorean 3,4,5 method could be used. These analytical digital models, developed in CATIA, are geometric scripts that deploy simple operative steps to recreate existing spaces. These models functioned as a test of the procedural modelling approach and were validated visually against the existing spaces. The drawings that began as a method of recreating the spaces included 3D surfaces and solids as a means to define the space. Fragments of the solid models were 3D printed and incorporated into the drawings.

The drawings and models built up a knowledge of constructive geometry[11], how the buildings might have been laid out on site, connected with how they were drawn by Borromini. Unlike designing with fixed and explicit terms, geometry conceived through rules produced ranges and inherent allowable deviations, and it was both the rules and relaxation of rules that led to further speculation. An example of this speculative deviation would be to relax the bilateral symmetry allowing the resulting form to distort or allowing the radius of four repeated circles to shrink or grow with four different radii. Not only did this function answer 'what if'



9.6
Defining and relaxing the procedural rules for the construction of space. Courtesy of Karl Daubmann



9.7
Relaxation of symmetry rules in a quatrefoil geometry – a motif used by Borromini. Courtesy of Karl Daubmann

scenarios, this method could also test the robustness of the geometric constraints defined within the digital system. The ruthless logic and geometric rules could be maintained while derivative forms could be produced. If the same methods, rules and labor could be deployed, the resulting deviations could still be authored by Borromini with a belief that they emerge from the same choreography of on-site trade labor.

Body in Space Analysis

While the previous analysis of drawing and modelling was about the geometry of construction, a secondary analysis and documentation was related to the body

based on experience. This analysis was photographic and in person; spending time in the space and considering ritual and repetition of movement of the body in space. If the previous analytical drawings prescribed actions to construct a space, this photographic analysis sought to understand the experience of an action or gesture in a specific space.

This analytical work generated hundreds of long exposure photographs created by moving a DSLR camera with an open shutter. The length of the open shutter depended on the amount of the light in the space. Early versions of the photographs were done with a tripod and a simple rotation but given the digital stabilization mode of the camera and the specifics of the spaces, a handheld gestural approach was adopted. Gestures were repeated with varied success and varied effects. In every instance, this simple gesture (like a simple sweep from right to left) would start with an open shutter and then close the shutter at the completion of the gesture, repeating this 10 or 20 times. The images were not digitally manipulated or superimposed, but accepted as exposed, and reviewed when back in the studio. The repetition of action was conceived as being able to be programmed for robotic execution, using a robot to make repetitive exposures

9.8
Long exposure photographs of Borromini's San Carlino. Courtesy of Karl Daubmann

9.9
Long exposure photographs of details at Borromini's San Carlino. Courtesy of Karl Daubmann

with minor deviations of the duration, speed, complexity or path from one exposure to the next. The final step would be selection of specific exposures based on resonance between the gesture and the space, dynamics of light, and detail captured.

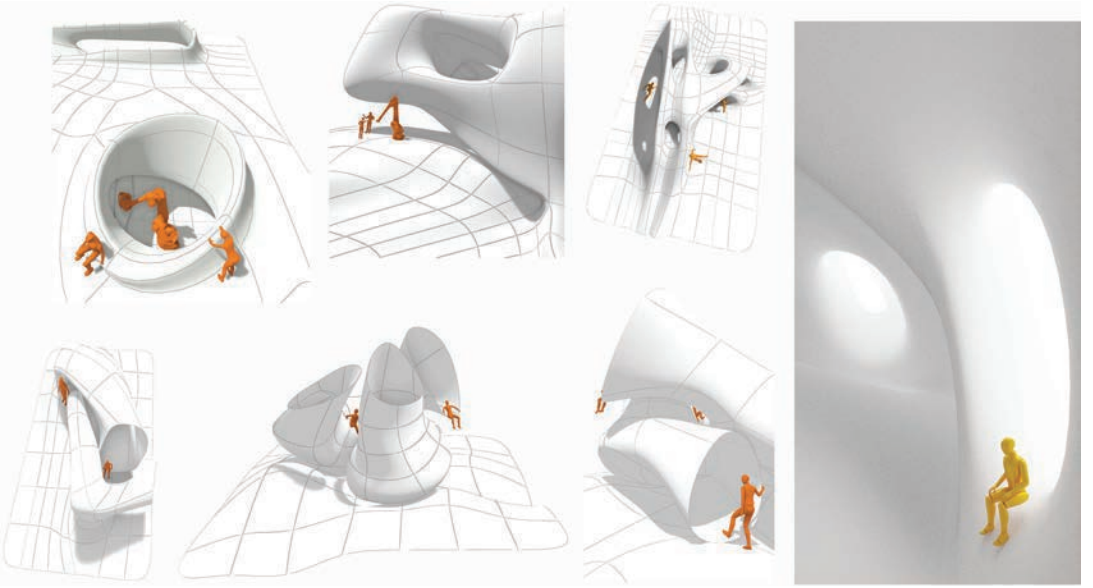
This activity was inspired by a couple of photographers who included the human body and the element of long exposure photography in their work. Frank Schott's photography project of Joseph Paul Jernigan, titled 12:31, uses long exposures to create hauntingly beautiful and contorted images of the human body. Given the historic and thematic fascination with labor and repetition, the photographs and 'work simplification studies' of Lillian and Frank Gilbreth were of particular interest (Gilbreth and Gilbreth, 1917). Their work from the early 1900s sought to find efficiency in human activity through documentation by adding lights to the body as a precursor to motion capture. Inspired by both photographers, this analysis attempted to capture the dynamic nature of time within the thickness of static images.

GESTURES BECOME GEOMETRY

New input technology may help to bridge the divide between the digital designers and the handcrafted luddites. Perhaps the issue has never been about the computer or digital but instead about the means of input. While a mouse is effective for navigating a document, webpage or spreadsheet, design requires the seamless and simultaneous capture of x, y and z. Gravity Sketch, as one example, is a new VR technology being accepted by transportation designers for initial ideation and sketching. This immersive design space allows for the capture and modification of the designer's gesture all while being natively digital. Geometry from Gravity Sketch can be seamlessly passed to more advanced modelling software or to a robotic prototyping or fabrication process.

The RoboPinch physical models were used as inspiration for a series of digital models to explore the potential of Gravity Sketch. While many preliminary models were developed using 3D-sketched curves, the topological models shown below all use one continuous surface to amplify the surface pokes, pulls and pinches – distortions of actions. The subdivision modelling approach allows for infinite distortion of the surfaces through the increase or decrease of connected patches. The modelling occurs within the immersive VR space which allows a design to continually navigate and occupy the space, activating gestures to produce digital geometry. In these examples, ready-made Gravity Sketch humanoid mannequins and robots are poseable to both calibrate the space to human dimensions and to illustrate possible affordances for human activity.

At the Lawrence Technological University – College of Architecture and Design there are discussions about the development of an introductory drawing course akin to a traditional charcoal life drawing course that will use Gravity Sketch. The intention is to break down the segregation of analog and digital in early design curriculum. It will be years before this simple curricular change might have the intended professional reverberations, while in the short term our students will leverage digital capabilities much sooner in their education.



9.10
Digital design concepts modelled in Gravity Sketch, inspired by the physical models of RoboPinch. Courtesy of Karl Daubmann

CONCLUSION

To many of us that have been designing digitally for decades, it feels as though there has been an extended debate, and in some circles an outright rejection, of the computer as it relates to design. Some designers still advocate for a design process that initiates with hand-drawn sketches to later digitize these desires, because in their mindset possible computer incorporation too soon might corrupt a designer's pure thoughts. It is clear that the computer allows for a connection to visualization, documentation, prototyping, fabrication, collaboration and most recently to robotic assembly and construction. Given the wealth of downstream capabilities, it is silly to initiate our design process in a non-digital manner. Digital design (and especially that of VR technologies) creates a direct connection between designer and output, coupled with the increasingly adept ability to capture and sense our movements, gestures and intentions. Rather than distancing the designer from their intent, the computer allows for the purest form of human output.

If the output process (construction, fabrication or manufacturing) were to remain analog (crafted solely by hand) an anti-digital holdout position may not feel so conservative, however, fortunately, output has seen the greatest incorporation of these technologies. Strangely, even in areas with advanced manufacturing beyond architecture, these digital holdouts still persist. As an example, the automotive industry continues to hire young designers based on their analog hand-sketching abilities because the lines in the body styling of cars are the direct result of fluid gestures. That gesture, the flick of the wrist, undergoes a transformation of scale and transmogrification to stamp the form through tool, die and sheet metal, none of which is done by hand but on a vast, automated, industrial

scale. One has to imagine that we (as humans) subconsciously can view the origins of these forms in our own gestures and therefore place aesthetic value on the retention of these sketched lines regardless of the material and subsequent procedural transformations. It also seems possible to codify the mechanics of the human gesture to digitally generate a class of curves rooted in those that can be constructed 'by hand'.

The selected projects presented here attempt to highlight the fact that while digital design and subsequent complex manufacturing processes proliferate the designer's workflow, a robust digital design process need not be devoid of the human body related to anthropometry of input or labor of output. And it is in this connection between design and the sensibility, mechanics and limitations of the human that might be able to humanize the ecosystem of making and manufacturing (Albers, 2000a, 19).

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NOTES

1. According to Robin Evans's theorization, architects occupy a metascale in which drawing is used as an intervening means to translate design and ambitions in something that is in the world. In the same way, composers are separated by the instruments. These professionals act as 'in-between people' connecting intentions and outcome.
2. While this example clearly demonstrates the relationship between human form and the plan of a church, a massive jump in scale must be rationalized. The mediation of scale translation undermines the importance of the body.
3. The author Wendell Berry, in the 2003 publication called *Citizenship Papers: Essays*, summarized the current system of knowledge to which we belong by stating that: 'the great destructiveness of the Industrial Age comes from a division . . . in our economy, and therefore our consciousness, between production and consumption'.
4. Nowacki + Lefevre, *Creating Shapes in Civil and Naval Architecture* (2009), 5. Building and shipbuilding projects are usually of such magnitude that they require a major workforce with many specialized skills and hence a strong division of labor. This workforce needs coordination and synchronization. Prehistoric boats date back at least 40,000 years.
5. For further information, see the Gartner's *IT Glossary* definitions of: Digitization, Digitalization and Digital Transformation.
6. Anni Albers is reported in the essay 'Design: Anonymous and Timeless', in the 2000 book edited by Brenda Danilowitz, *Anni Albers: Selected Writings on Design*, 38.

7. Available in the tape of the Voice of America Radio Lecture Series On Architecture: recorded 19 November 1960 and available at the Louis Kahn collection, University of Pennsylvania. In a lecture focused on structure and form, Kahn states: 'One day I visited the site during the erection of the prefabricated frame of the building. The crane's 200-foot boom picked up 25-ton members and swung them into place like matchsticks moved by the hand. . . . Now I am glad of this experience because it made me aware of the meaning of the crane in design, for it is merely the extension of the arm like a hammer.'
8. A reference used to develop the project is the work of Rowena Reed Kostellow. She uses plaster as a material means to explore concavity and convexity. For further information, see: GG Hannah, *Elements of Design: Rowena Reed Kostellow and the structure of visual relationships* (New York, NY: Princeton Architectural Press, 2002).
9. The 4D jobs are those less valuable in the job market. They can be described as 'dull, dirty, dangerous, and difficult'. For further information, see: JG Keramas, *Robot Technology Fundamentals* (Albany, NY: Delmar Learning, 1999), 12.
10. The Research Through Making Grant was initiated by Mónica Ponce de León at University of Michigan – Taubman College of Architecture and Urban Planning as a means to give designers the chance to develop projects grounded in the culture of making. For further information, see: https://taubmancollege.umich.edu/research/research-through-making/2015/robopinch.
11. Description of constructive geometry by Jonathan Hales in the paper 'Baroque Constructive Geometry? Borromini's Design for the Elevation of San Carlino', from *Finding San Carlino* (2020), 73.

10 Emerging Objects

Virginia San Fratello

CREATING AN ICONOGRAPHIC OBJECT

I would like to start by telling a story about a very simple object that has a remarkable history. The story is about a very humble teapot, manufactured by Friesland Porzellan and sold by the Melitta Group in Germany in the 1970s. The teapot was purchased in Salt Lake City at the Zion's Cooperative Mercantile Institution, the first department store in the US, by Sandra Newell. For his work, her husband, Martin Newell, needed a simple mathematical model of a familiar object and Sandra suggested modelling the teapot since they were sitting down for tea at the time. This teapot has gone onto become the most important object in computer graphics history and is commonly referred to as the Utah Teapot. The curves, handle, lid and spout of the teapot all come together to make it a perfect object for digital, graphical experiments. Newell sketched out an elevation of the teapot on graph paper and then entered the sketched coordinates – called Bézier control points, first used in the design of automobile bodies – on a Tektronix storage tube, an early text and graphics computer terminal. The result was a beautiful, virtual teapot.

The teapot model proved useful for Newell's own research, but he also took the important step of sharing their model publicly. As it turned out, other researchers, scientists and animators were also in need of interesting 3D models, and the digital teapot was perfect for testing. At the same time, the shape was simple enough for computers to process in the 1970s. The teapot quickly became a beloved staple of the graphics community. Teapot after teapot graced the pages and covers of computer graphics journals. 'Anyone with a new idea about rendering and lighting would announce it by first trying it out on a teapot', writes[1] animator Tom Sito in *Moving Innovation.* 'We saw the teapot rendered as if made of alabaster, red brick, leopard skin, and animal fur.' Most famously, a 1987[2] paper introduced an image casually described as the five Platonic solids plus the 'newly discovered Teapotahedron'. Although technical progress has meant that the act of rendering the teapot is no longer the challenge it was in 1975, the teapot continues to be used as a reference object for increasingly advanced graphics.

The Utah Teapot has come full circle from being a computer model based on an actual object to being an actual teapot based on the computer model. In 2015, Emerging Objects, 3D-printed the Utah Teapot out of tea waste solids with the objective of returning this iconographic object to its roots as a piece of functional dishware while showing its status as an icon of the digital world.

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The Utah Teapot is an object that lives in both the physical and digital world, it is both old and new and is part of a lineage that tells a story about design evolution. It has a deep history, meaning and value in both worlds and it is an object that has transformed in both worlds because of contemporary concerns. In the 1970s, software engineers were concerned with translating from the physical to the digital, in the 1980s and 1990s artists and designers were concerned with rendering texture, lighting and shading, and in the early 2000s there was a contemporary concern with bringing the digital back into the physical. And as we enter the mid-2000s we are concerned with not only the physical, but the specific material makeup of the physical and how the materials and methods we use can be sustainable, equitable and healthy.

Through the development of materials for 3D printing, we are able to make physical new objects, and the objects we make are imbued with new histories and meaning because of the materials they are made of. Our process raises important questions about the historical and contextual meaning of objects and when such questions are asked of objects, it leads to creativity and speculation about the future. By developing materials for 3D printing that are historic and are local, such as mud, clay and cochineal, or in the waste stream, such as chardonnay, coffee and tea, we are responding to contemporary concerns such as the impact of production, consumption and disposal of goods upon the earth's resources and the creation of an ecological balance.

Tea

Materials, such as tea, have the ability to be transformed through the budding technology of 3D printing. The production and consumption of materials like tea and coffee offers many opportunities to harvest waste – tea leaves and stalks from the field, tea fluff from factory floors and used tea leaves from afternoon teatime, are all suitable materials for 3D printing. The Utah Teapot is made of the sold tea waste from industrial production surrounding instant tea, and because a teapot was produced, teacups and teaspoons were also printed to complete the *Utah Tea Set*. The teaspoons are exactly 1 teaspoon by volume – 5 cubic centimeters.

10.1
Utah Tea Set.
Courtesy of
Emerging Objects

10.2
Teaspoons – 3D printed using tea solids. Courtesy of Emerging Objects

Wine

Pomace is the solid remains of grapes after pressing the fruit to make wine. It contains the skins, pulp, seeds and stems of the fruit. Grape pomace has traditionally been used to produce brandies, such as Grappa, which the Italians have done since around 1000 AD, but even after its second use, remnant material remains. Pomace can be used as fodder and fertilizer, but much like the coffee cherry, grape skins and seeds are often unproductive and remain a waste product of wine production and can be used in binder jet 3D printing. Each year, California wineries produce more than 100,000 tons of pomace, which translates to about one ton of pomace for every five tons of grapes that are crushed.

The *Chardonnay Wine Goblets* are drinking cups with a foot and a stem that can be filled with wine to be drunk during special occasions. Throughout history, goblets have been made of many different materials – earthenware, gold, silver and glass. These wine goblets are printed from upcycled chardonnay grape skins and seeds. The skins and seeds are collected from vineyards in Sonoma County and are dried in a kiln and then pulverized to a particle size of 200 microns and are then blended with wheat paste and poured into the build bed of the printer. The mixture is approximately six parts pomace and four parts wheat paste by weight. In this case, both the wine and the goblets themselves can be studied for color, viscosity, texture, notes and body. The goblets have the pineapple and herbaceous notes of an unoaked chardonnay.

Tea and wine are two of the most consumed beverages in the world, and each of these beverages has played a substantial role in the modern era of colonization. Tea shrubs and grapevines were planted by Europeans in India, Australia and South and North America beginning in the 15th century as European migration and occupation proliferated around the planet. These plants experienced one of the earliest 'assisted migrations' in mass quantity in the history of the world. Because of the

10.3
Chardonnay Wine Goblets – 3D printed using chardonnay grape skins. Courtesy of Emerging Objects

global proliferation of these plants, and the extensive beverage industries that have grown up around them, there are now vast amounts of agricultural waste generated each year as agricultural byproducts of these industries that can be used in additive manufacturing.

Curry

The Furry Curry Casserole Dish is an object 3D printed out of curry and turmeric, out of which wafts a soft, spicy, rich and woody aroma with overtones of citrus and ginger. The dish is not only intended to season the interior of the spaces it occupies but it can also be used to season food prepared or served in the vessel as well. The odor of the dish is enduring and penetrating, it triggers one's olfactory memory immediately because of the innate pungency.

Material Ombrés

Emerging Objects has also experimented with 3D-printing material ombrés. Questioning how one can move seamlessly from one material to another and examining how material shading might enhance our understanding or perception of not only material, but also color and culture in objects. To begin this research of creating material ombrés using 3D printing, we started with chardonnay and cement. Cement being the most ubiquitous material used in building construction and chardonnay being an abundant local agricultural byproduct from Sonoma County. Tiles were 3D printed out of cement, chardonnay and both a mixture of cement and chardonnay. The aggregation of the tiles created a large ombréd surface but raised the question: Could single objects be printed as material ombrés?

10.4
Furry Curry Casserole Dish.
Courtesy of Cooper Hewitt Smithsonian Design Museum

Is it possible to create a smooth transition from an agricultural material to a geologic material without any joints, adhesives or mechanical fasteners? Depending on how the supply bed of the 3D printer is filled, and the particle size of the material, and saturation levels for specific material matrices, one can control the material ombre of a single print. It is now possible, in a formally complex 3D print, to move seamlessly from a full-bodied chardonnay to a more subtle tint and finish with a pale, crisp cement.

The Ombré Decanters demonstrate a graduation from 3D-printed chardonnay to 3D-printed cement. The forms of these decanters are inspired by ancient ceramic wine carafes and amphorae, and the surface textures are inspired by the diamond-pressed texture frequently found in objects such as wineglasses and decanters. Cement is sometimes used in vinification culture. Wine can be fermented in concrete vats; because of its thermal mass, concrete allows wine to ferment at a slower pace to retain the flavor of the fruit. The concrete's porosity allows the vats to breathe, naturally fermenting the wine. The oldest fermentation vats from ancient Greece and Rome were made of ceramic materials; thus, the return of cement-based materials for the storage and serving of wine is looking backward and forward at the same time.

It is also possible to print with other material combinations as well, for example, curry and cement, both customized recipes using off-the-shelf materials, that demonstrate the ease of creating evocative, multi-sensorial objects using 3D printing.

10.5
Ombré Decanters.
Courtesy of
Emerging Objects

10.6
Curry Grolla.
Courtesy of
Emerging Objects

NEW FRONTIERS

During the last 35 years, additive manufacturing, and particularly binder jet printing as shown in the previous projects, has become more and more commonplace as a tool for creating models and full-scale working prototypes, and in very rare instances, as a method of manufacture by specialists to fabricate custom objects. However, additive manufacturing is still not close to being a commonplace method of manufacture, due to the expense associated with the purchase of 3D printers and the proprietary materials associated with them. Many materials such as concrete, bulk filament and pellets, and proprietary powders are expensive when used for large format printing and in instances where these materials must be shipped long distances. Finally, 3D printing requires expertise in 3D modelling and coding, which means additional costs and time must be spent mastering advanced software applications. For many end users, these obstacles have precluded the use of additive manufacturing as a way of making.

In recent projects Emerging Objects has attempted to overcome these three obstacles. First, through the use of very local, indigenous, and sometimes free materials such as cochineal, wild clays and soil for 3D printing. Second, through the scripting of an easy-to-use G-code generator for developing 3D printable files. And third, through the development of a lightweight, inexpensive and mobile robotic setup capable of large format 3D printing. When combined, these three approaches enable a more accessible, portable and ecological approach to additive manufacturing.

Cochineal

American cochineal is a small parasitic insect that feeds on the prickly pear cactus and was for centuries the source of the most coveted red pigment in the world. Instilled with artistic, cultural and economic significance for indigenous peoples of Mexico and the Andean highlands of South America, cochineal was transformed into a widely traded global commodity upon European contact in the 16th century. For more than 300 years it was used around the world to impart color onto a variety of goods, mostly textiles. The cochineal is used here to infuse color into 3D-printed resins and nylons. The forms are inspired by traditional cooking pots and baskets used to boil and extract the pigment. In the Crimson Clay vessel, the cochineal is paired with micaceous clay mined from the American southwest, a region where the cochineal insect thrives naturally.

Micaceous Clay Cookware

This collection of 3D-printed Clay Cookware pieces takes advantage of wild and local micaceous clays from northern New Mexico and the easy-to-use G-code generator called Potterware. The clays have been used by the Taos and Picuris Pueblos to make pottery and cookware for thousands of years. The fact that mineral mica in the clay absorbs thermal shock is one of the reasons pit firing and cooking over fire with this clay body has been successful for so long. This collection presents an alternative possibility for additive manufacturing – one that recognizes that indigenous material practices can be a vital component of contemporary technology-based

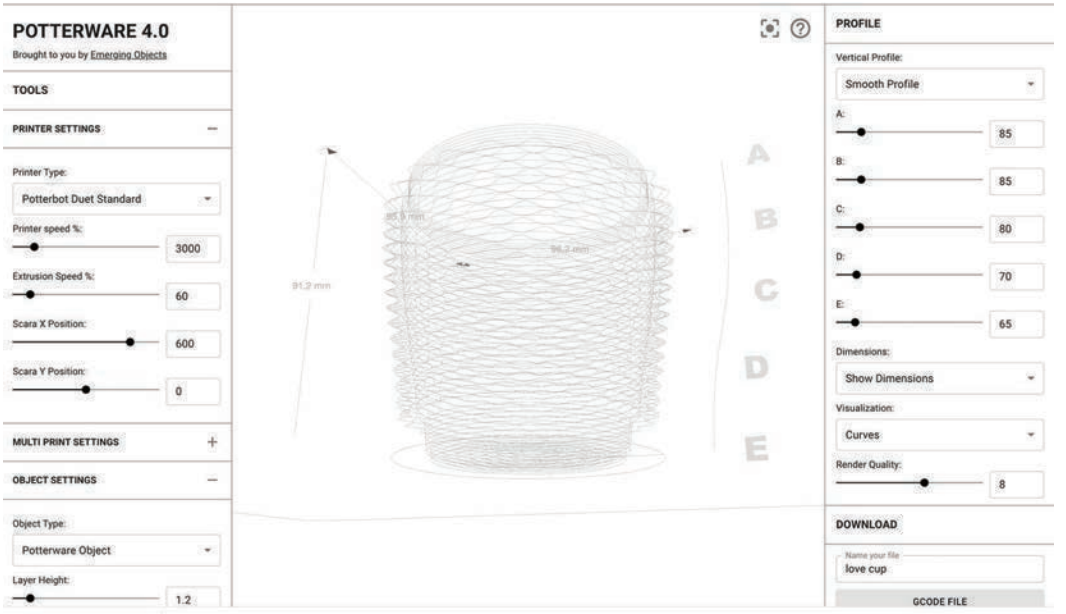
10.7
Candied Apple, Top: Clear resin infused with cochineal; Bottom: White resin infused with cochineal. Courtesy of Cooper Hewitt Smithsonian Design Museum

10.8
Crimson Clay, Top: SLS Nylon infused with cochineal; Bottom: 3D-printed micaceous clay.
Courtesy of Cooper Hewitt Smithsonian Design Museum

design and craft practices. This collection demonstrates that coupling advanced manufacturing technology with traditional craft can be a way forward to create meaningful and functional designs. Each piece is designed using Potterware software which is an intuitive design application for 3D printing ceramics. With Potterware, users do not need to learn 3D modelling software, lowering the bar to 3D printing and allowing anyone to design sculptural or functional 3D-printed pottery quickly.

Casa Covida

The Casa Covida, a house for cohabitation during the time of Covid, takes advantage of local and indigenous materials such as mud and churro sheep wool, it uses a slightly more robust version of the Potterware software for design and modelling, and it capitalizes on a lightweight robotic fabrication setup. The Scara robotic 3D printer that was developed for this endeavor is combined with a continuous flow hopper that can print wall sections and enclosures up to 2200mm in diameter and 2500mm tall, structures considerably larger than the printer itself. The set up can be carried by one or two people and relocated in order to continue printing. The printer is able to 3D print local soils directly from the work site in order to demonstrate the possibilities of sustainable and ecological construction. The structure was produced with the intent of connecting the forefront of digital manufacturing with the craft of



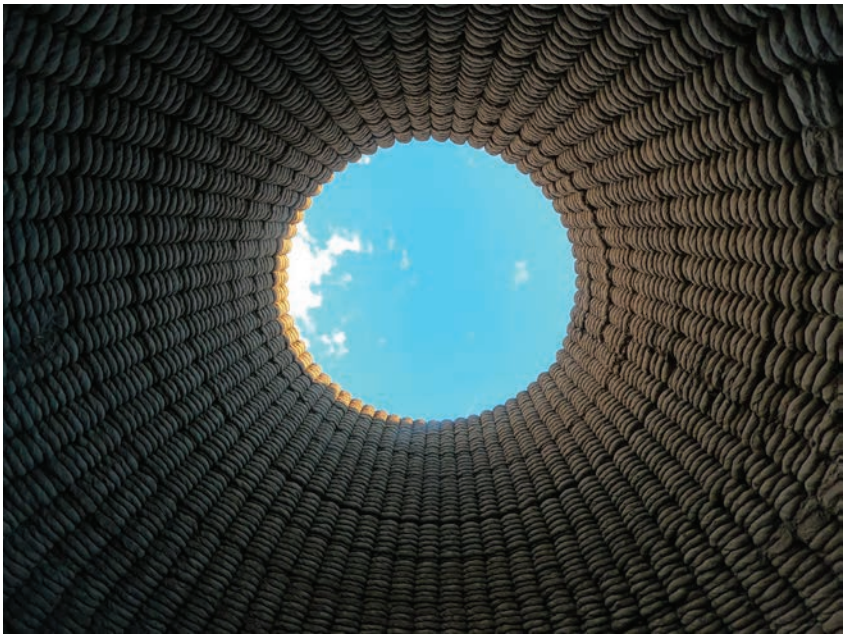
10.9
Potterware file for 3D-printed micaceous clay Beanpot. Courtesy of Emerging Objects

10.10
3D-printed micaceous clay Beanpot. Courtesy of Emerging Objects

traditional coiled pottery techniques and adobe architecture of the historic borderlands where Casa Covida is located. The house is located in the high alpine desert of the San Luis Valley which spans southern Colorado and northern New Mexico in the United States. The Casa Covida explores ways the technology can expand beyond the limitations of the existing robotic printing setup, for example, a manual fourth axis was created to allow for more rapid printing because it is no longer necessary to wait for the coils of mud to dry before printing continues. Additionally, the robot was elevated to sit on a wooden plinth, which allowed for a 3700mm-tall structure to be printed, considerably taller than the robot itself.

10.11
The forth rail setup for expedited 3D printing during fabrication.
Courtesy of Emerging Objects

10.12
Casa Covida Exterior and Churro Blanket. Courtesy of Emerging Objects



10.13
Oculus view. Courtesy of Emerging Objects

There are three components to the enclosure itself: an entrance space with built-in seating and a hearth, a room for bathing, and a room for sleeping. Each room has an oculus that frames a view of the sky and each room has a richly textured mud

surface on the interior. The hearth is filled with micaceous clay pottery for cooking and gathering. The room for bathing has a deep tub for soaking and star gazing and is surrounded by polished river rocks. Hidden in the river rocks are black porcelain 3D-printed candle holders. The room for sleeping has a built-up adobe platform that is covered with sheepskins for warmth and softness. The pillows and blankets are woven from local churro wool and take on a graphic pattern inspired by the floorplan and reflected ceiling plan of Casa Covida itself.

10.14
Casa Covida.
Courtesy of
Emerging Objects

10.15
View of the hearth from above.
Photography Credit:
Elliot Ross Courtesy
of Emerging
Objects

10.16
Casa Covida Room for Bathing. Courtesy of Emerging Objects

Casa Covida and its interior objects exemplify the potential of using local materials and accessible hardware and software to craft environmentally conscious building and interiors that stitch together indigenous building technologies with digital fabrication techniques for the creation of a sustainable, equitable and healthy future.

CONCLUSION

Casa Covida and the other objects in this essay speak to the possibility of a future that is just emerging, a future that takes advantage of tasteful materials that come from waste, and other ubiquitous or traditional materials. They are on a journey to becoming part of a 21st-century architectural terroir that influences the meaningful crafting of objects and buildings. As pointed out by Gareth Williams, 'In order

to retain relevance in the modern world, craft must engage with contemporary concerns. One of the most pressing issues today is the impact of production, consumption and disposal of goods upon the earth's resources and ecological balance' (Williams, 2003, 61). 3D printing also raises questions about its role in craft and how it might make bespoke architecture more accessible, as the objects and buildings produced are not necessarily handmade but are customized, however the close connections between design, iteration, technique, material behavior, analysis and manufacturing suggest that 3D printing, especially when coupled with modes of production that employ materials from sustainable resources and waste streams, is a contemporary form of manufacturing with increasing relevance.

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NOTES

1. https://books.google.ca/books?id=WOwyRnZ1oxoC&lpg=PA66&vq=teapot&pg=PA66&redir_esc=y#v=snippet&q=teapot&f=false
2. http://artis.imag.fr/~Cyril.Soler/DEA/Ombres/Papers/Arvo.Sig87.pdf

ENCLOSURE

11 Emergent Enclosures

Granular Architectures

Karola Dierichs and Achim Menges

GRANULAR MATERIALS

Can architecture work with emergent or self-organizing systems? Designed granular materials offer a new route towards emergent enclosures in architecture since they configure not by predefined geometries but rather by their innate behavior (Dierichs and Menges 2012; Hensel and Menges 2008b, 2008a).

11.1
Non-convex particle types. Karola Dierichs, ICD, University of Stuttgart. A basic geometric type, such as a non-convex many-armed particle, can be varied by adjusting the individual parameters of the geometry. In this series the dimension of the convex hull, the arm amount, arm length and arm taper have been varied. These subtle variations lead to changes in the packing density and the compressive strength of the overall granular material. Courtesy of Achim Menges, ICD, University of Stuttgart

Granular materials are large numbers of individual particles larger than a micron which are only in loose contact. The individual particles are thus not bound to each other. Thus, granular materials can have the properties of both a liquid and a solid, moving between these states based on variation of intrinsic and extrinsic factors (Gennes 1998, 1999; Jaeger, Nagel and Behringer 1996a, 1996b). In a designed granular material the component particles are defined in their geometry and materiality (Jaeger 2015; Hensel and Menges 2006b, 2006c) (Figure 11.1). Designing the individual particle allows the calibrating of the behavior of the entire granular material – and thus its characteristics with respect to self-organization and emergence (Figure 11.2).

Self-organization is understood as the establishment and sustentation of structure in a system without an extrinsic control mechanism (Wolf and Holvoet 2005). This process is 'dynamic' and 'adaptive' (Wolf and Holvoet 2005). Emergence is understood as the appearance of novel phenomena on the 'macro-level' of a system which result from interactions between system elements on the 'micro-level' (Wolf and Holvoet 2005). These emergent phenomena are new if one considers the component elements of the system itself, that means that the effects cannot

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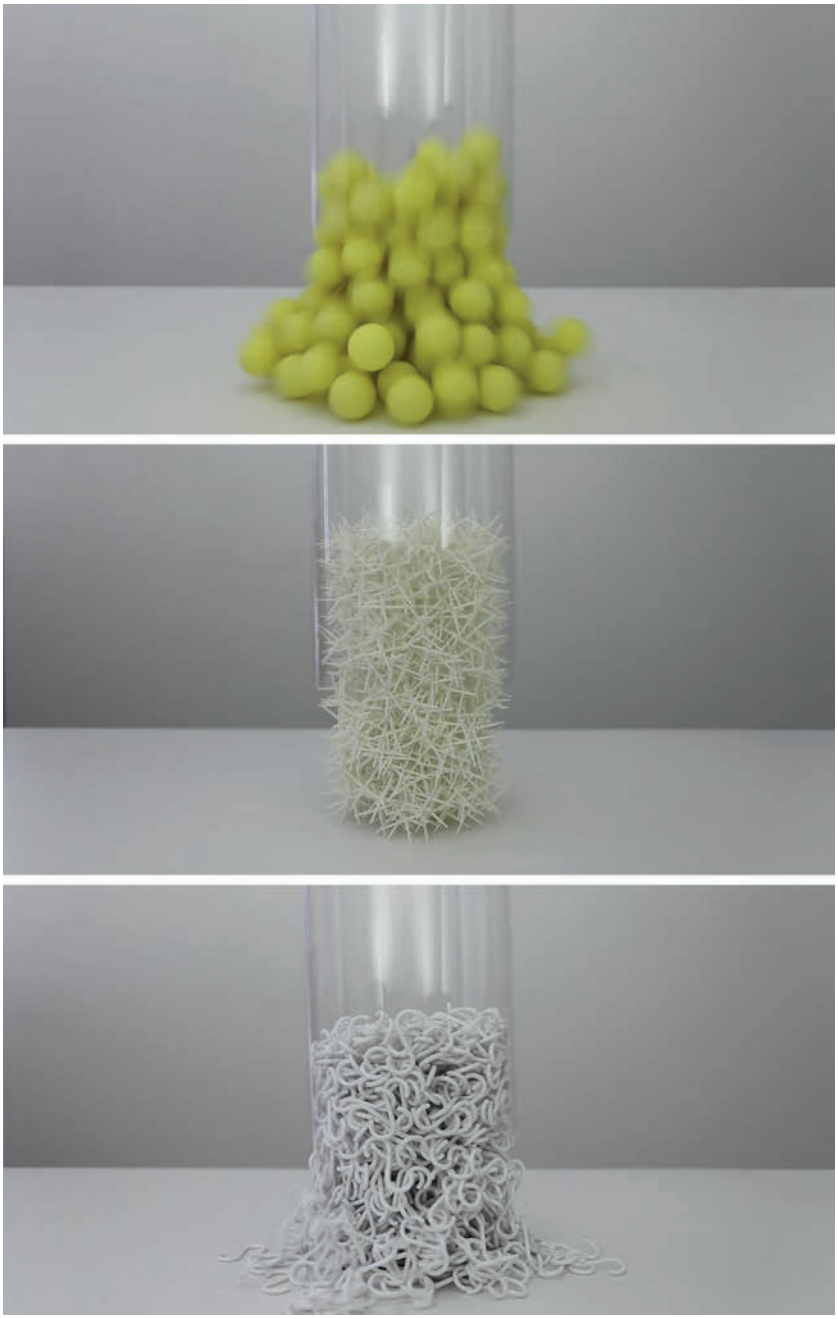


11.2
Designed granular materials. Karola Dierichs, ICD, University of Stuttgart. Particle geometries can be convex, non-convex or double non-convex. Depending on their basic geometric type of the particle, the granular material can have different degrees of stability. The particle shape of the component particles is thus one of the main factors of tuning the behavior of a granular material. Courtesy of Achim Menges, ICD, University of Stuttgart

be directly derived from the parts themselves (Wolf and Holvoet 2005). Granular materials – by virtue of their ability to form both solid and liquid states – can be both recycled and reconfigured. This renders them a highly pertinent strand of research in spatial design, responding to a call for sustainable and adaptive systems. In a designed granular material these and other properties can be calibrated through defining the geometry and materiality of each individual particle (Jaeger 2015). In the context of emergent enclosures, designed reconfiguration and especially the

model of reconfiguration – whether it is self-organizing or emergent – is relevant. The goal is thus the development of full-scale material systems from designed granular materials that eventually allow self-organization and emergence as driving forces of design.

Precedent research on designed granular materials in architecture was conducted at Cranbrook Academy of Art, the Architectural Association, Rice University and the Swiss Federal Institute of Technology Zurich (Aejmelaeus-Lindström et al. 2016; Gramazio and Kohler 2014; Hensel, Menges, and Weinstock 2010; Hawkins and Newell 2008; Hensel and Menges 2006a, 2006b; Matsuda 2008; Tsubaki 2012).

In granular physics a wide range of particle shapes and materials has been investigated (Weiner et al. 2020; Lingyi Meng, Shuixiang Li and Xiaohu Yao 2017; Murphy, Dahmen and Jaeger 2019; Trepanier and Franklin 2010; Galindo-Torres et al. 2009; Gravish et al. 2012; Malinouskaya et al. 2009; Wouterse, Luding and Philipse 2009; Athanassiadis et al. 2014; Blouwolff and Fraden 2006; Philipse 1996; Franklin 2012; Murphy et al. 2016; Zhao, Barés and Socolar 2020). Here, also the inverse optimization of particle geometries has been undertaken, that means that a specific target performance of the overall granular material has been defined and the particle geometry has been derived to achieve this performance (Miskin 2016; Miskin and Jaeger 2013).

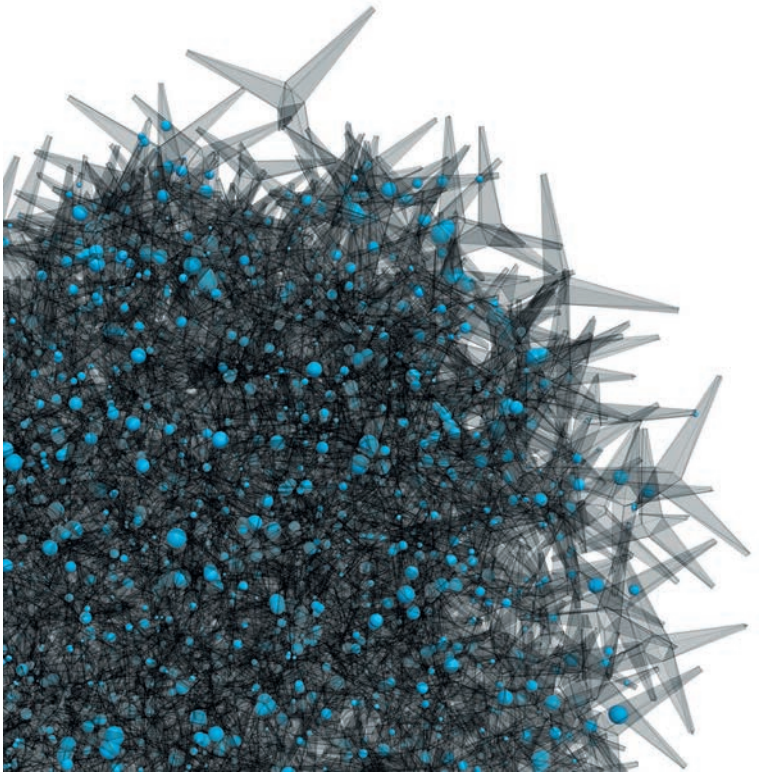
While it has been proven that structures can be constructed from designed granular materials at full architectural scale, the self-organizational and emergent capacities of granular materials in general and of designed granular materials in particular have not been fully embraced as an active agent of design thinking and practice.

In this context, the article will introduce several key projects working with designed granular materials and point the way towards an architecture embracing self-organization and emergence as core design paradigms.

Granular materials as architectural material systems with self-organizational and emergent behavior require new methodologies of observation and interaction rather than definition and control by the designing architect (Hensel and Menges 2008a, 2008b).

Three main strands of methodological approaches can be distinguished. Tools of observation allow the recognition of patterns rather than the preconceived definition of them. Tools of interaction enable the dynamic response to these evolving patterns rather than the predefined action on an inert substance. Tools of approximation allow the analysis of material behavior which is merely probable rather than entirely predictable.

Techniques can be sourced from the realms of experiment and simulation using analog as well as digital means of exploration. In an experiment and a simulation an 'object' and a 'target' are defined: The 'object' is the system that a researcher is operating on; the 'target' is the system on which she or he intends to collect information (Winsberg 2009). The distinction between the two is in the premise which the similarity between 'object' and 'target' is based on: In an experiment 'object' and 'target' are the same kind of system, whereas in a simulation the model relating 'object' and "'arget' needs to render correct results (Winsberg 2009).

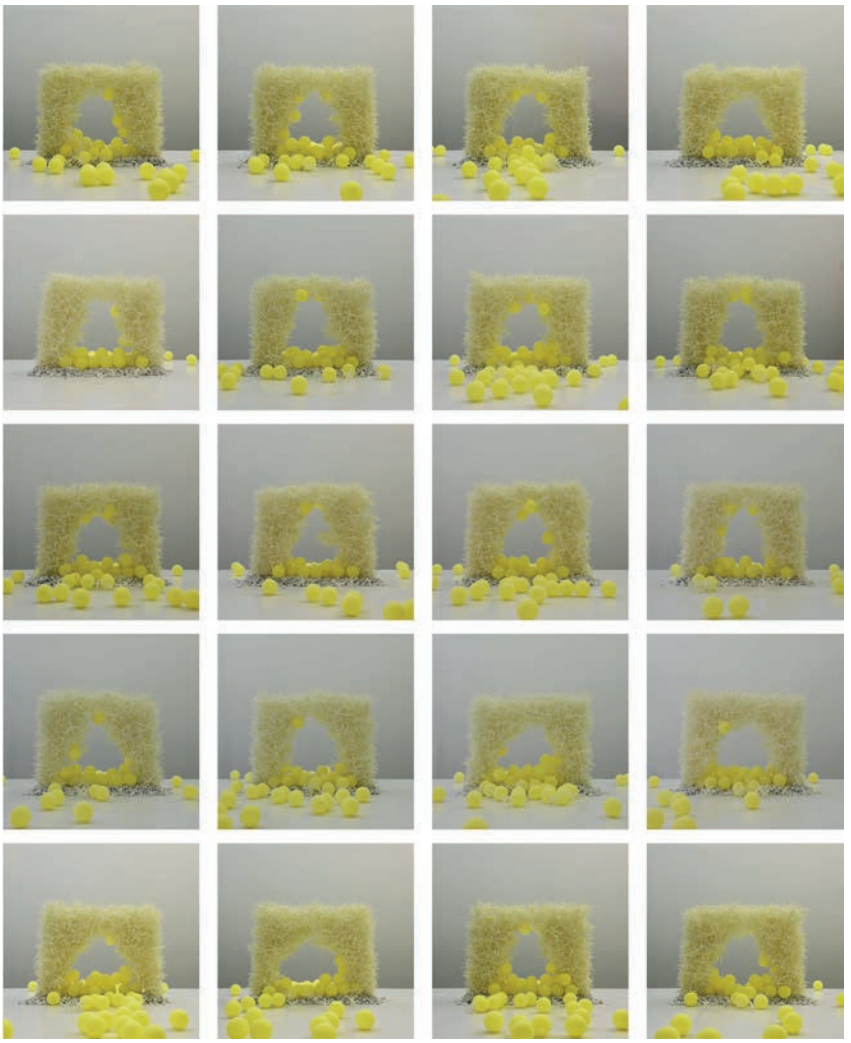


11.3a and 11.3b *Experiment and simulation of tetrapods in a cylinder. Karola Dierichs, ICD, University of Stuttgart with ITASCA Education Partnership (IEP) Research Program. Both experiments and simulations have been deployed in the development of the designed granular materials. Experiments render actual data on packing density and compressive strength. Simulations are calibrated to match these as closely as possible and can then be used to obtain additional information such as the amount and distribution of contact points in the designed granular material.* Courtesy of Achim Menges, ICD, University of Stuttgart

Analog media process information in a continuous manner, digital ones discretize this information (Loleit 2004; Steinmann 2004). Based on these definitions, both experiment and simulations can deploy analog or digital media (Dierichs 2020).

Suitable techniques – such as specific experimental setups for analog testing or numerical simulations for digital analysis – frequently need to be sourced from the field of granular physics and transferred to the realm of architectural design research (Dierichs and Menges 2010) (Figures 11.3a and 11.3b).

The projects which are used as case studies in the context of self-organization and emergence have been conducted both in research and teaching. Case study 1 introduces a full-scale architectural structure, the ICD Aggregate Pavilion 2018. Case studies 2–4 are smaller-scale investigations into integrating self-organizational and emergent behaviors into computationally-controlled fabrication processes. Statistical series serve to establish quantitative data sets on relevant sub-aspects of a project (Figure 11.4). Full-scale prototypes are verifications of a newly developed



11.4
Statistical testing of arch formation. Karola Dierichs, ICD, University of Stuttgart. The formation of arches has been tested in a statistical series. These methods are relevant as a design tool when working with self-organizing and emergent behaviors where each individual experiment or simulation is similar to but not the same as all other samples in the series. Courtesy of Achim Menges, ICD, University of Stuttgart

material system and its related construction processes. In the case studies statistical series have been combined with full-scale prototyping.

DEPLOYING SELF-ORGANIZATION

The ICD Aggregate Pavilion 2018 explored the formation of spatial enclosures with designed granular materials (Figure 11.5). It was constructed in a converted industrial hall (Dierichs 2020; Dierichs et al. 2019). Two different designed granular materials were deployed: one consisting of convex particles and one consisting of highly non-convex ones. The convex particles can flow and were used as a removable formwork, the highly non-convex particles can interlock and thus formed the remaining spatial structure of the pavilion (Figure 11.6).

11.5
ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. For the ICD Aggregate Pavilion 2018 convex and non-convex particles were combined. The convex particles served as a formwork for the interlocking, non-convex ones. The particles' dimensions are in the range of circa 10 to 30 centimeters. After the entire structure had been poured in situ, the convex particles were removed from the inside of the pavilion and a stable vault formation remained standing. Courtesy of Roland Halbe

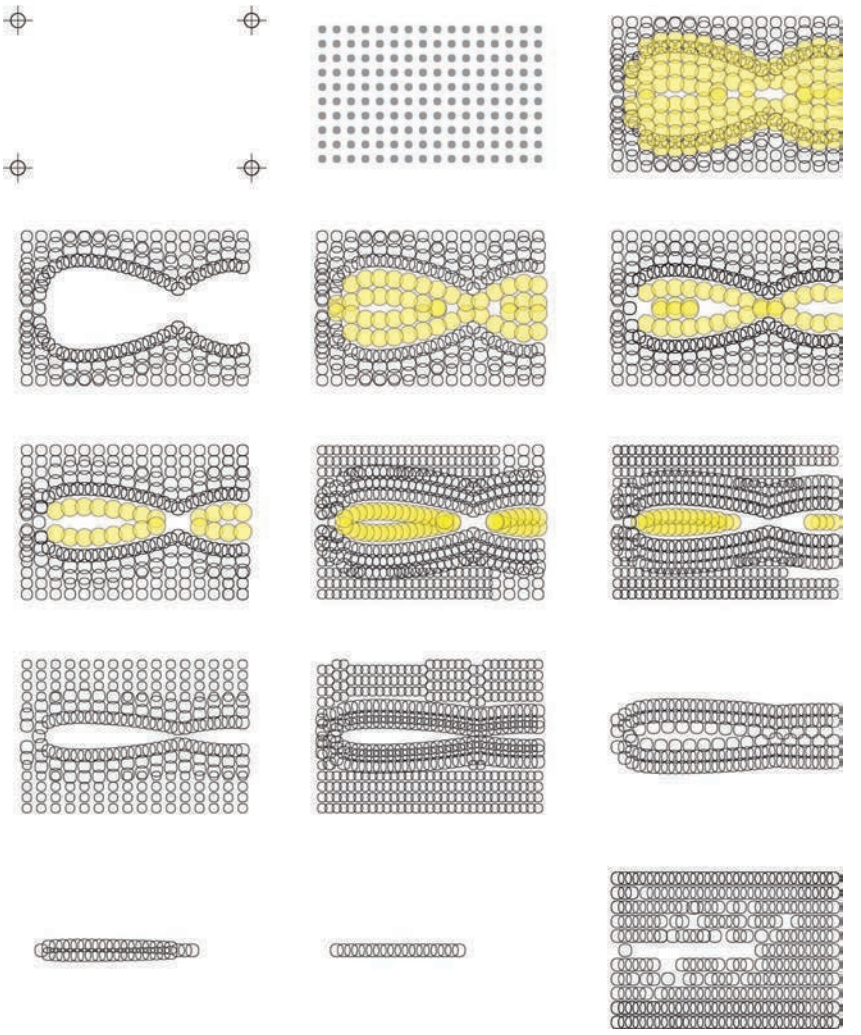
The particles were distributed using a cable-driven parallel robot which was mounted to the walls of the industrial hall, converting the entire space into a construction site (Figure 11.7). The storage boxes of the particles were mounted onto the flange of the robot, thus turning them into an 'end-effector'. After the particles had been deposited, the boxes were dismounted and used as an outer container for the entire structure. The ICD Aggregate Pavilion 2018 consisted of two interconnected inner vaults which were embedded in a rectangular volume. The inner vaults were initially filled with convex particles – spheres – the rest of the construction volume was filled with non-convex ones – hexapods. Once the entire construction had been completed, the convex particles were removed from the inside of the pavilion and the two inner vaults remained standing. The construction process was surveyed using a remote-controlled camera on top of the structure. This allowed to observe how the particles were distributing upon falling out of their

11.6
Detail of the ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. The ICD Aggregate Pavilion 2018 was constructed from granular materials only. In the outer layer of the structure smaller particles are distributed to form a gradient transition with the larger particle type which has mainly been deployed. Courtesy of Roland Halbe

11.7
Construction sequence of the ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. The ICD Aggregate Pavilion 2018 was constructed in layers using a cable-driven parallel robot which had been mounted inside a former industrial hall. The particles were dropped directly from their storage boxes which were turned into an effector. After particles had been dropped, the boxes are used as an outer formwork for the entire structure. Courtesy of Achim Menges, ICD, University of Stuttgart

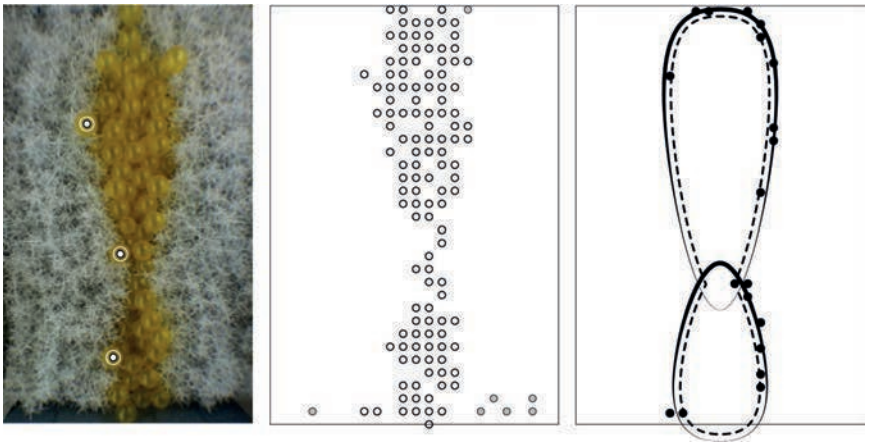
boxes. Several interaction models were considered during the development stage of the pavilion, which ranged from a very high to a very low degree of control over the final geometry.

In the first model, spheres which are lying outside the line of the spatial geometry would be removed. This would increase stability of the structure and control over the final geometry. In the second model, spheres can be dropped onto spheres which have fallen outside the defining line of the spatial geometry. This operation would decrease both stability and control. The third option was to remove hexapods which have dropped inside the space-defining line which would decrease structural stability and increase control over the final outcome. A fourth model played out the option of adding hexapods onto hexapods which had fallen inside the line defining the inner space. This would increase the stability of the resulting structure yet decrease the control over the spatial geometry.



11.8
Particle deposition points for the ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. During construction the drop pattern for both convex and non-convex particles was adjusted depending on variations in height of the particles. This process can be automized in a next iteration of the project. Courtesy of Achim Menges, ICD, University of Stuttgart

Ultimately the first interaction model was selected for the construction of the pavilion: It is not based on the emergent behavior of the granular materials, which would imply a relatively low degree of geometric control, but rather on its self-organizational capacity, which implies a relatively high degree of geometric control (Figure 11.8). This decision was mainly driven by the fact that the ICD Aggregate Pavilion 2018 was intended as a first demonstrator of spatial enclosures – this could only reliably be implemented by directing the final spatial geometry as much as possible towards a predefined design (Figure 11.9).



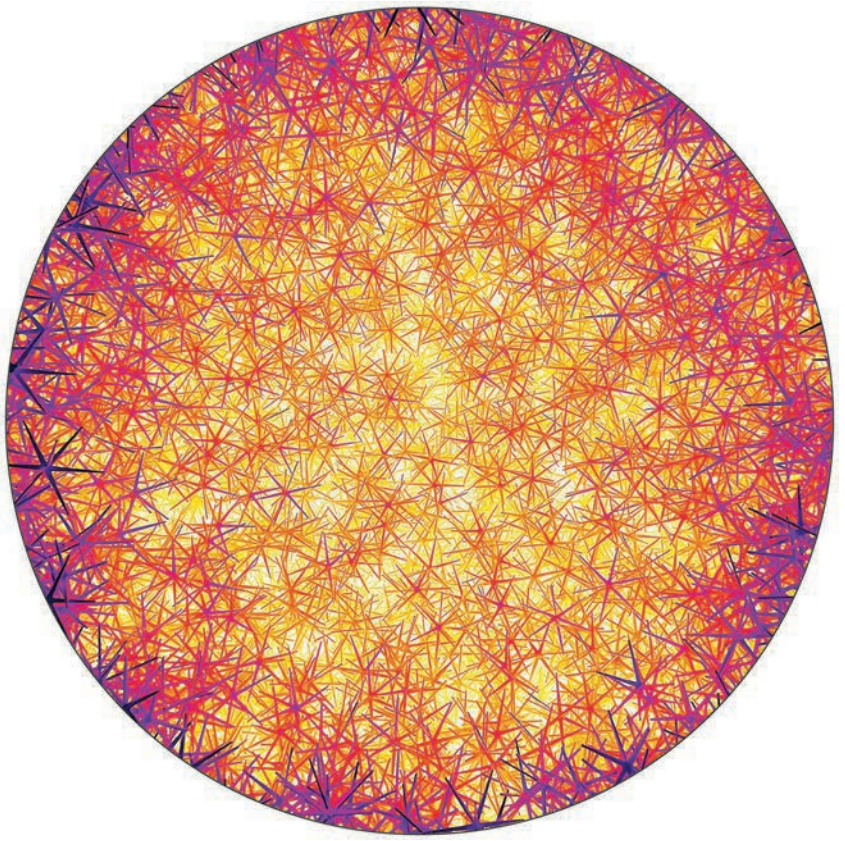
11.9
Image segregation for the ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. A remote-controlled camera was used to take pictures after the completion of each layer of the pavilion. Yellow spheres were chosen in order to form color-contrast to the white hexapods. This enabled filtering out spheres which had fallen outside the space-defining curve. This technique can be used to establish a fully self-organizing robotic construction process. Courtesy of Achim Menges, ICD, University of Stuttgart

This points the way towards deploying self-organization as a design principle, the structure of the system – the designed granular materials and the robot – is set in place and maintained in a 'dynamic' and 'adaptive' manner. However, part of this process was conducted manually based on the data gathered by the robotic system – so that one cannot speak of a fully self-organizing system yet.

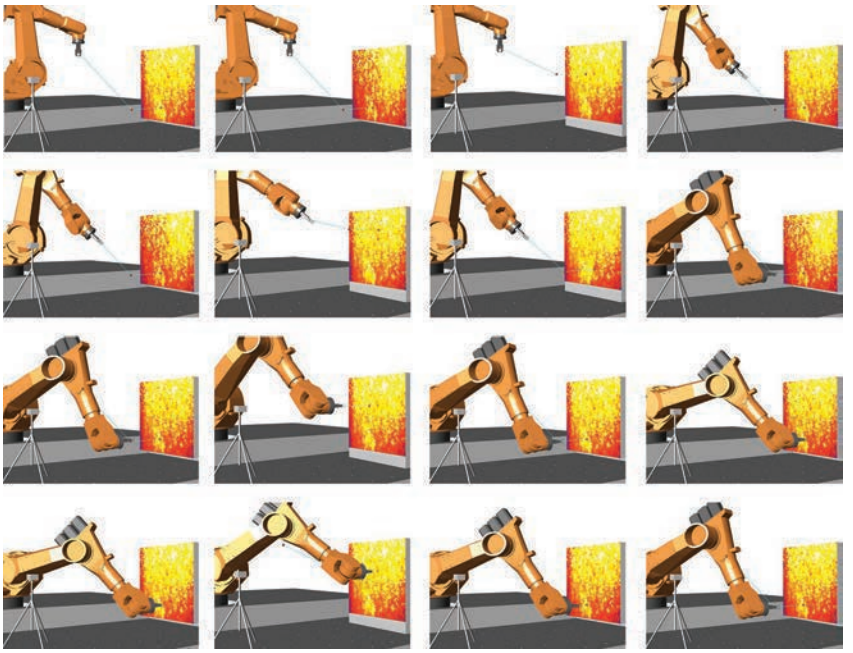
EXPLORING SELF-ORGANIZATIONAL AND EMERGENT BEHAVIORS

Several Master's theses conducted in the Integrative Technologies and Architectural Design Research Program (ITECH) at the University of Stuttgart have begun to explore both self-organizational and emergent behaviors as a design driver for the formation of spatial structures.

Graded Light is a Master's thesis conducted by Desislava Angelova in the Integrative Technologies and Architectural Design Research (ITECH) program at the University of Stuttgart; completed in 2014, it explores luminance patterns in a wall constructed from a designed granular material (Dierichs and Menges 2015, 2016; Angelova, Dierichs and Menges 2015; Angelova 2014; Dierichs, Angelova, and Menges 2015) (Figure 11.10). A six-axis articulated robot is programmed to remove particles from the wall to match a predefined luminance pattern in a continuous feedback loop (Figure 11.11). The comparison is made between actual luminance values which are extracted from image data and a predefined target luminance.



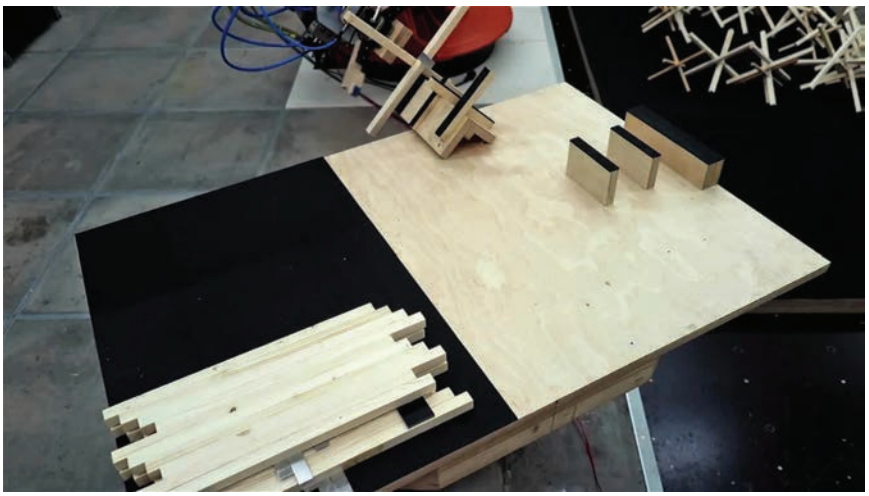
11.10
Luminance values in a dome. Desislava Angelova, ITECH, University of Stuttgart. Luminance values were extracted from a black-and-white image of a dome made from designed granular materials. The conversion is based on a formula that allows to translate pixel-values into numeric luminance-values. Courtesy of Achim Menges, ICD, University of Stuttgart



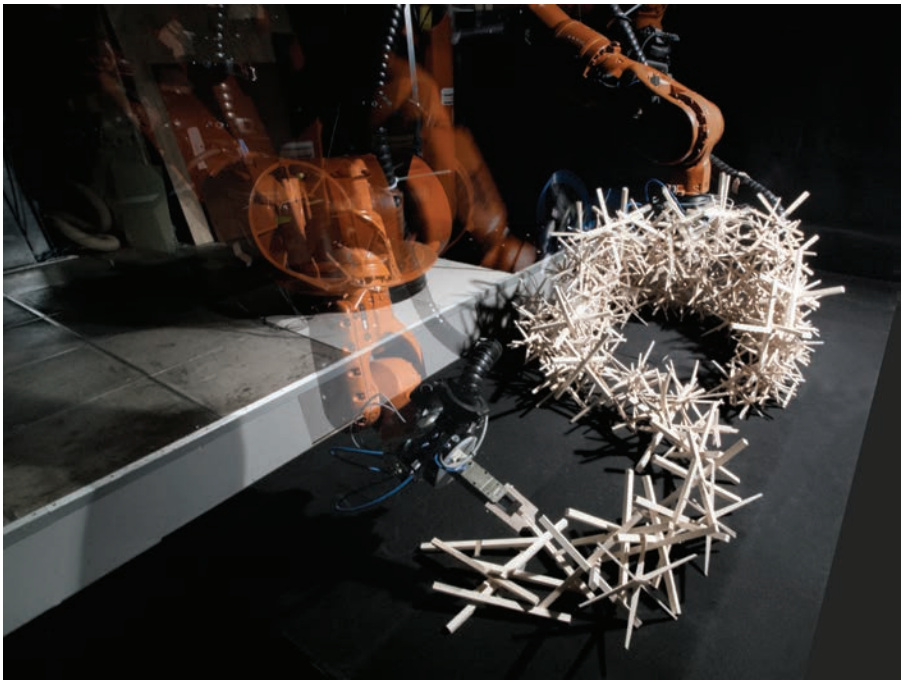
11.11
Sensory-controlled robotic construction using luminance data. Desislava Angelova, ITECH, University of Stuttgart. Luminance values were taken from a wall constructed out of designed granular materials. These were fed to a six-axis articulated robot and compared to a target luminance model. Particles were removed by the robot using a gripper in order to approximate the desired luminance map. Courtesy of Achim Menges, ICD, University of Stuttgart

Based on this comparison, the particle extraction points are calculated for the robot. In this project, the robot and the structure itself can be considered part of a self-organizational system which allows achieving and maintaining a certain luminance state without an additional external factor contributing to that state. Systems of this kind can approximate but most likely not fully reach a certain luminance state since the statistical variations embedded in a designed granular material are relatively large. As a design approach, this principle of self-organization can be well suited to gathering fundamental data on a given granular material's behavior with respect to a definite evaluation criterion.

The ITECH Master's thesis *Regenerative Matter* by Ondřej Kyjánek and Leyla Yunis was conducted from 2014–2015 (Dierichs and Menges 2016, 2017; Kyjánek and Yunis 2015). It investigates the non-sensory-controlled production of designed particles and their sensory-controlled aggregation and disaggregation. Non-sensory control denotes the steering of a robot through a predefined program which is not altered during the course of production. Sensory control is defined as the integration of sensors into the robot's program which allows the interaction with a workpiece based on input data retrieved from these sensors (ISO/TC 299). A six-axis articulated robot is programmed using non-sensory control to assemble particles from wood sticks which are fastened by wax joints (Figure 11.12). These particles are deposited using sensory control allowing the robot – for example – to react to variations in height of the growing structure (Figure 11.13). After installation, the particles can be disassembled using a heat gun, the remaining sticks are detected and collected back into stock material. This entire process is managed by one machine – a six-axis articulated robot. Especially in the theoretical developments of the thesis, the aggregation model integrates both the self-organizational and emergent behavior of the designed granular material. While a global geometry is given, locally emergent variations of that geometry are responded to in the interaction model of the robot. This



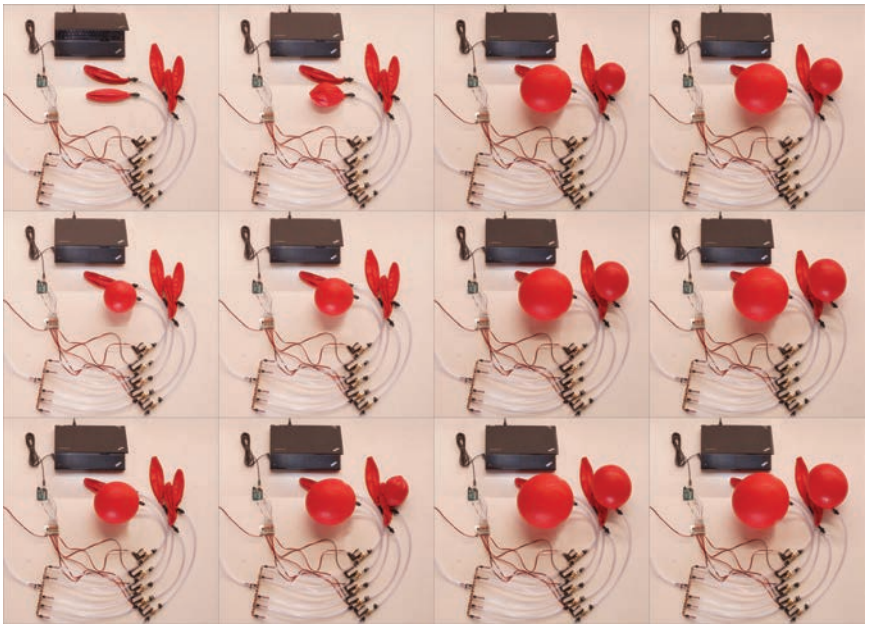
11.12
Non-sensory-controlled particle fabrication. Ondřej Kyjánek and Leyla Yunis, ITECH, University of Stuttgart. Non-convex particles are produced from stock by a six-axis articulated robot. The non-sensory process allows the rapid production of similar or same parts with predefined tool-paths. Courtesy of Achim Menges, ICD, University of Stuttgart



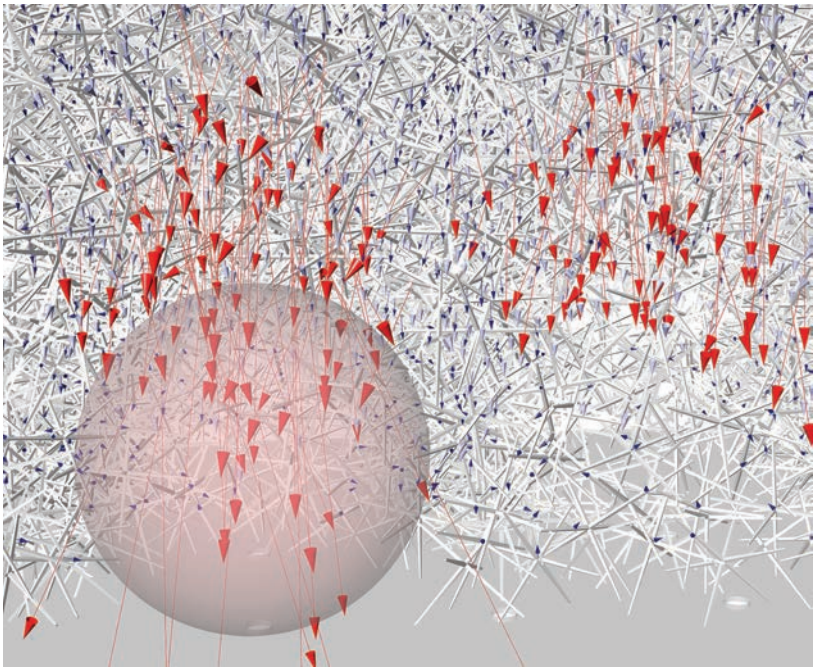
11.13
Sensory-controlled particle deposition. Ondřej Kyjánek and Leyla Yunis, ITECH, University of Stuttgart. Previously fabricated particles are deposited by a six-axis articulated robot using sensory control. This allows the robot to respond to variations in the forming structure which cannot be predicted by numerical modelling in advance. Courtesy of Achim Menges, ICD, University of Stuttgart

approach is an advancement from the previous project in as far as it acknowledges the emergent properties of a granular material and incorporates into a goal-driven production process. Yet it does not present a shifted design paradigm so that the emergent behavior of the material becomes the design driver.

Gergana Rusenova developed the notion of 'Emergent Space' in her IETCH Master's thesis conducted between 2014–2015 (Dierichs and Menges 2017; Rusenova et al. 2016; Rusenova 2015). It explores the integration of numerical simulations with a physical model of domes constructed from a designed granular material. The simulations are based on the Discrete Element Method (DEM). They are repeated to establish statistical values for predicting the collapse of a dome structure upon deflation of an inflatable formwork. These numerical data are used as an input for the control of a physical inflatable formwork which is connected to the simulations through a parametric modelling software (Figure 11.14). The spatial configuration is thus entirely driven by the emergent behavior of the designed granular material as it is modelled in the simulations (Figure 11.15). The project thus points the way towards a paradigm shift in design: Spatial configurations are no longer considered as entities that can be predefined or planned with respect to their geometry and duration, but rather the formation of space is treated as an emergent event.



11.14
Numerically-controlled inflatable formwork. Gergana Rusenova, ITECH, University of Stuttgart. An inflatable formwork was deployed for the formation of domes in a designed granular material. The formwork was controlled through a parametric modelling software that allowed simulation data to be sent directly to the valves controlling the inflation and deflation of the balloons. Courtesy of Achim Menges, ICD, University of Stuttgart



11.15
Discrete Element Modelling (DEM) simulation. Gergana Rusenova, ITECH, University of Stuttgart with ITASCA Education Partnership (IEP) Research Program. DEM simulations are used to model the behavior of domes consisting of designed granular materials. The simulation allows modelling how they drop over a spherical formwork which is removed. The remaining structure is analyzed with respect to the speed and direction of the particles which parameters give an indication of the stability of the dome. These simulations are repeated with statistical repetition and are eventually fed into a parametric model controlling a physical inflatable formwork. Courtesy of Achim Menges, ICD, University of Stuttgart

On a practical level, in all three projects a numerically-controlled system was combined with a designed granular material. In the first two, an existing six-axis articulated robot was employed, whereas in the last one a system was custom-developed for the task. The integration of a numerically-controlled system and a designed granular material is crucial for the development of design models that work with either self-organizational or emergent properties of a material.

On a methodological level, all three projects develop tools of observation and of interaction. In the first two projects the observation is conducted by sensors collecting data from the physical granular material, in the third case study, these data are collected through numerical simulations. Interaction models are – as already outlined – moving from self-organizational principles towards those embedding emergent behavior. Tools of approximation are only embedded in the third project in the form of simulations repeated with a statistically relevant number of repetitions.

On a conceptual level, the projects move from self-organization towards emergence as design drivers. This is mainly apparent in the aforementioned interaction models, which in the first two projects have definite goal-geometries, whereas the last project has local rules of interaction between the numerically driven inflatables and the designed granular material which allows the structure to evolve over time in a manner which is not predefined. One could take this concept further by cyclically altering the local interaction patterns based on the emerging structures.

TOWARDS EMERGENT ENCLOSURES

Granular materials are already always imply a certain loss of control over the system if compared to conventional assembly systems, where both the element position and overall geometry are clearly defined (Keller and Jaeger 2016). In this context, the three Master's theses present a progression from a design paradigm aiming at definite geometries towards one that embraces merely probable configurations. Here, the former design paradigm is fostered by self-organizational models whereas the latter is strongly engaging in emergent ones.

Emergent enclosures are innate in spatial structures constructed from designed granular materials. These would entail either the formation and reformation of the granular material by a user or user group or else by a robotic system. In the first case, the user or user group would directly interact with the granular material, thus act as an element in the emergent system itself. In the second case, the robotic system's actions would be based on an interaction model, which is founded in the principles of emergent behavior. From an architectural perspective, emergent enclosures question the practice of planning defined spatial geometries and even of aiming at a self-organized formation. They would challenge the user – the body – to spontaneously and actively interact with its emergent spatial enclosures (Figure 11.16).

11.16
Exterior view of the ICD Aggregate Pavilion 2018. Karola Dierichs, ICD, University of Stuttgart. The exterior of the ICD Aggregate Pavilion 2018 has been cast into vertical walls. This is a structurally sound process during construction since it allows for the vaults to form based on probabilistic interlocking of particles in a redundant mass. After the vaults have settled, loose particles can be removed either manually or by a sensory-controlled robotic system. Courtesy of Roland Halbe

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12 Three Ensembles

Ashley Bigham and Erik Herrmann

Architecture is a background art. Despite exceptional moments when its contributions (or shortcomings) are foregrounded in the public imagination, architecture is most often consumed with fleeting and detached attention. Yet despite its diminishing ability to compete in the attention market of our media-saturated world, architecture still undergirds dimensions of our lived experience, igniting certain possibilities and excluding others. As conceptual artist Daniel Buren offers, 'Architecture of any sort is in fact the inevitable background, support and frame of any work' (Buren, 1983, 73). Given architecture's paradoxical role as both overlooked and indispensable, what are the possible relations to the draw between buildings and the activities and cultural work they facilitate? These questions are at the center of any act of architecture, particularly the design of architectural interiors where so much other work takes place. At the scale of interior architecture and furniture, architecture's conventional modes of bespoke design are displaced by the logics of mass production. The products that outfit contemporary interiors are designed principally around concerns of performance and orderliness. The interior realm of contemporary architecture is increasingly regimented by patterns of productive use and conventions of social order that dictate the nature and scope of other work. Aspects such as the scale, weight, shape, texture and orientation of interior elements govern the activities that are possible within a space. In other words, the interior is where architecture fabricates social, formal and material norms.

In our practice, we've recently designed and fabricated a series of modest projects that reconsider relationships of form and use in interior architecture, a scale we consider critical to interrogating architecture's norms for the reasons outlined above. Our practice works in a broad range of unconventional design venues, combining low-resolution formalism, crude off-the-shelf materials and industrial-grade finishes to stage playful interventions inverting typical relationships of form and use in interior architecture. This chapter documents three recent projects informed by recent reappraisals of participatory art and its destabilizing tactics used to challenge social norms in the late 1960s. The chapter concludes with a reflection on how this work relates to new formats of postdigital design.

Active in France from 1960 to 1968, Groupe de Recherche d'Art Visuel (GRAV) was an interdisciplinary collection of artists (mostly from the Op Art tradition) researching new modes of participatory art in postwar France. Tenets of their early

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manifestos shared many tenets of their revolutionary contemporaries in France, including a rejection of the solo artist, a suspicion of artistic hegemony and a distaste for the institutionalization of art. GRAV situated strange kinetic and optical objects in city streets for public engagement. Criticism of GRAV's work often centers on the practice of producing spectacles by exploiting an unwitting public.[1] This critique, while fair, ignores the more nuanced achievements of GRAV's work.

In her recent book on participatory art, art historian Lily Woodruff argues that the artists of GRAV 'attempted to invent and manipulate social situations that variously used interpellation and alienation, often together, so as to create instances of unity around forms of rejection' (Woodruff, 2020, 259). She offers further that GRAVs works used 'sensorial and physical instability' to challenge their political and social context, not to overthrow the system, but to negotiate these systems toward their societal aims (Woodruff, 2020, 262). GRAV's work is not a naive representation of community but instead a body of work questioning the norms of both art and society.

The following collection of three projects (Another Stack, Cranbrook Pedestals and Intermission) uses tactics of estrangement to confront interior architecture's norms. Specifically, we are interested in how the design of interior objects can suggest uncanny relationships between objects and humans, redefine attitudes toward readymade materials, and manipulate the conventions of scale through changes in dimensions and proportions. Each project employs a strategy of ensembles – collections of objects which should be used and viewed as a whole rather than individually. A chair represents a certain model of spatial individualism – one body in space – with assigned values of use and ownership. In our work, we prefer an ambiguity of both use and ownership, employing elements that must be shared and their use negotiated. These ensembles are composed of parts that harmonize through material and formal correspondences that suggest collective behaviors, often stacking, interlocking or piling in unique aggregations. The works are assertive, even occasionally aggressive, with exaggerated scales, crude forms and industrial finishes. The designs employ low-resolution shapes, not as a geometric idealization, but to ensure the qualities of the individual parts are ancillary to the collective coherence of the environment.

Through a series of public projects, these works consider the paradoxes of interior architecture: How can an environment be both a background (a support or frame for uses and activity) while at the same time a foreground (a design that asserts new social orders and implies novel forms of collectivity)? How can a design foster participation and interaction without reducing participants to entourage or spectacles? How can we generate environments for collective gathering without inciting conformity? In the following projects, we show design propositions developed and documented through animations, drawings, scripts, post-occupancy photographs and procedural geometry.

ANOTHER STACK

Another Stack is an experimental furniture environment for hosting large public events, lectures, workshops. The environment's defining feature is a collection of

oversized circular and square platforms manufactured from SIPs (structural insulated panels) and embossed with Day-Glo graphics. A suspended fabric projection drum, LCD screens, assorted plants and 'ground effects' lighting complete the environment. The installation is situated at the base of a large public atrium designed by architect Preston Scott Cohen lined with a complex tangle of stairs and ramps on the campus of the University of Michigan. Another Stack serves as the school's everyday 'living room' with its lightweight foam platforms continually reconfigured and stacked as terraced landscapes floating on the atrium floor (Figure 12.1).

The circle – an archetypal form of spontaneous gathering – is a recurring motif in Another Stack's low-resolution ensemble. The chunky collection of Day-Glo platforms evade easy identification. Are they giant donuts? Or sandwiches? Are they tables? Are they benches? Are they models? Without a single-term definition or archetype (like the aforementioned chair), user interaction is not prescribed by prior behavior or rules of thumb, but learned through group negotiation and modest acts of individual trial and success. The furniture platforms eschew idealized furniture archetypes, conventional seating arrangements and other norms of institutional gathering. Another Stack was imagined instead as a setting for dynamic encounters of 'bodies in space' framed by objects of unconventional scale and materiality.

12.1
Spectators gather for a presentation in the Another Stack environment. Courtesy of Outpost Office.

12.2
The terraced furniture of Another Stack distributes the audience as 'bodies in space'. Courtesy of Outpost Office.

12.3
Participants sit amongst the nooks and crannies of Another Stack. Courtesy of Outpost Office.

Design began with an exhaustive catalog of collective activities: sitting, working, talking, deliberating, presenting, eating, snacking, meeting, speaking, listening, resting, sleeping. In stacked configurations, faculty and students intermingled together in various spatial relationships staged in and around the holes, offsets, cracks and steps of Another Stack. In other words, the organization and hierarchy of seating at these events is not dictated by orthographic delineation, but negotiated through adjacency, tangency, proximity and density of objects and bodies in space (Figures 11.2 and 11.3). For example, there is no clear or discernable 'front row' or 'back row' in Another Stack. Viewers are often on the same plane as the presenters, and in-the-round configurations create intimate relationships between audience and presenter (Figures 12.4 and 12.5).

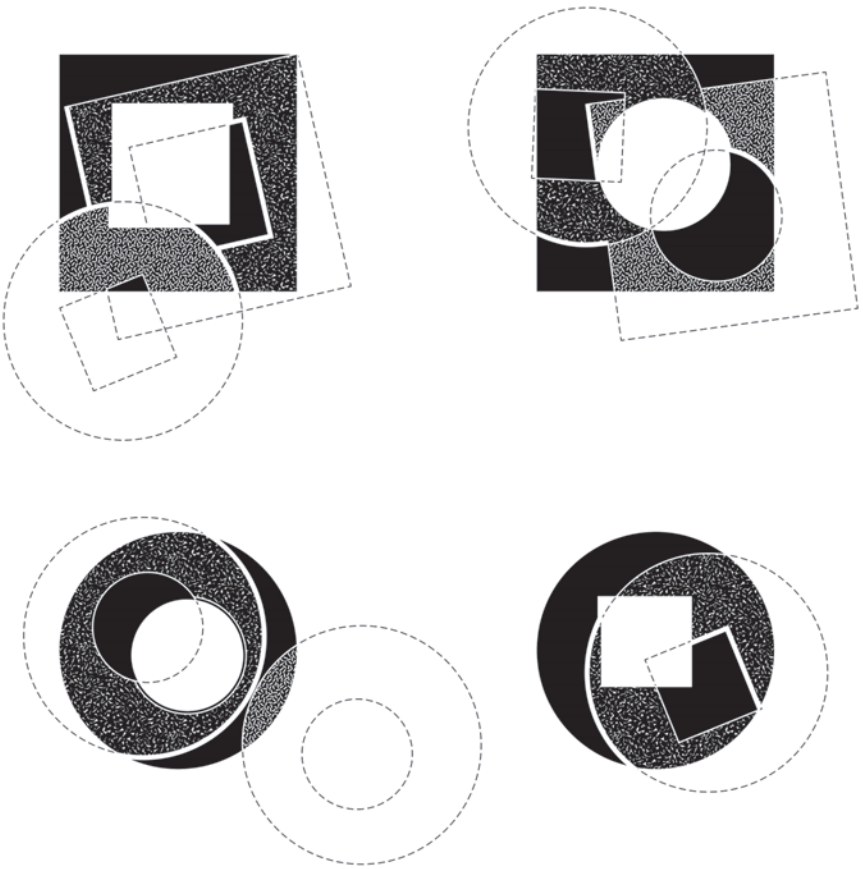
A desire for maximum flexibility with minimal customization framed the development of a synthetic kit of commensurate parts. The platforms are cantilevered to maintain the appearance of 'floating' islands and calibrated to sustain asymmetrical loads without capsizing. Another Stack conscripts participants into new social bodies based on limits of size and weight. The number of people that can

12.4
Workshop participants improvise new uses for the voids of Another Stack.
Courtesy of Outpost Office.

12.5
Organization strategies for Another Stack, including arrangements for presentations, lectures and workshops.
Courtesy of Outpost Office.

sit on each platform is about six. The number of people it takes to move a platform is three to four. The number of people that can occupy the center of a platform is about two.

Another Stack's platforms are digital and industrial readymades. Collectively, the platforms generate an offbeat landscape described as akin to occupying a digital drawing. The primitive platforms are overlaid with CMYK traces of digital drawing tectonics – the stroke and the fill – which are misregistered to one another. The offset pattern produces new relationships between the parts with color blocking used to heighten these effects (Figure 12.6). There is no correct or incorrect way to organize the pieces, but there are moments of alignment which suggest certain correspondences. When viewed from above, these patterns flicker in and out of alignment on the atrium floor. The project has a notable part-to-whole methodology: Its individual parts don't add up to a whole (like a puzzle), but are instead a



12.6
Graphic overlay studies for the patterns of Another Stack. This method ensures the elements of Another Stack relate, but do not add up into a cohesive whole. The result is a collective whole of misfits. Courtesy of Outpost Office.

collective whole of misfits. They have irreconcilable differences and not everything necessarily adds up. In other words, Another Stack does not have an ideal or correct arrangement; it settles into provisional organizations through agonism and negotiation.

The platforms are fabricated from SIPs, a building material typically hidden in exterior wall assemblies. SIPs are composed of a rigid foam laminated with structural board and have an incredible strength to weight ratio. Manufacturers of SIPs cut the panels to size off-site and can include rough openings for windows and other apertures. Each platform is composed of two SIPs panels of differing thicknesses to provide seating and writing surfaces at appropriate heights. SIPs panels are offered in a variety of thicknesses based on insulation values. The use of SIPs produced unusual framing of design criteria, like what is an ideal R-value for sitting?

Another Stack occasionally sits dormant as activity swirls on its periphery, but even in these quiet moments, the project still engenders a spirit of playfulness, exploration and levity. Like a musical score, Another Stack is activated through performances or remains dynamic in its latent potential.

CRANBROOK PEDESTALS

Located in scenic Bloomfield Hills, Michigan, The Cranbrook Educational Community occupies a historic campus principally designed by Finnish architect Eliel Saarinen. The spiritual center of the campus is the Saarinen House, Eliel's Art Deco masterwork that served as his family's home until the 1950s. Saarinen's Cranbrook pedagogy unified traditional craft with industrial techniques in an active curriculum of making. The house is considered a total work of art and includes original furniture, tapestries (designed by his wife Loja), millwork and metalworks fabricated on-site in Cranbrook workshops.

Today, its collection of schools, museums and historic houses is a National Historic Landmark and Cranbrook operates the Saarinen House as a house museum with public tours, exhibitions and events to put the house and its contents in historical perspective. The Cranbrook Pedestals are a collection of display pedestals commissioned by the curator of Cranbrook's three historic house museums in order to exhibit contemporary interpretive materials as part of site-specific interventions in the Saarinen House. The Cranbrook Pedestals are designed for exhibiting in a confined and challenging interior setting; the house's preservation status prohibits painting or affixing anything to its walls. The house is seamlessly woven into the campus fabric, making its exterior spaces of equal importance to its interior. The five lightweight, weatherproof display pedestals can be situated throughout the home's interior or its exterior courtyards and

12.7
The Cranbrook Pedestals situated in the Saarinen House's interior.
Courtesy of Outpost Office.

12.8
The Cranbrook Pedestals in repose in the Saarinen House's courtyard, playfully responding to the central sculpture. Courtesy of Outpost Office.

gardens in situations that range from the rigid and formal (Figure 12.7] to the spontaneous and impromptu (Figure 12.8). Oftentimes, the pedestals are used by the curator as a loose collection of wayfinding objects. Their presence indicates an event or activity is close by and visitors interpret their location, posture and orientation in order to guide their movements through the campus's nooks and crannies.

The project integrates contemporaneous interpretive materials into a meticulous setting. The pedestal forms are generated from a rudimentary telescoping pattern, a dynamic geometric motif adorning Cranbrook's Art Deco campus. Each pedestal's plan profile is a basic geometric form: a square, a triangle, a circle, a cruciform and a pill. Their formal strategies take cues from compositional themes in Saarinen's work, but their exaggerated scale and distinct silhouettes make them unmistakably distinct from their context. The low-resolution pedestals are crystalline supports for images, text, books, prints and other artifacts with telescoping shelves that provide ideal viewing angles for display.

The pedestals are milled from thin sheets of EPS foam with a rounded bevel at the top edge of each layer. A plywood base plate is mounted to the bottom for attaching optional wireframe legs. Finally, the foam layers and base plates are stacked, epoxied and coated with LINE-X spray-on truck bedliner in a custom pearl finish (Figure 12.9). The LINE-X coating is not corrosive to the EPS foam and produces a strong enamel coating. The final pedestals are lightweight, weather resistant and durable. Despite their modest scale, the forms possess a certain monumentality. These delightfully bulky forms can often be found scattered around the house and its grounds with interpretive materials gently reposed on the terraced forms.

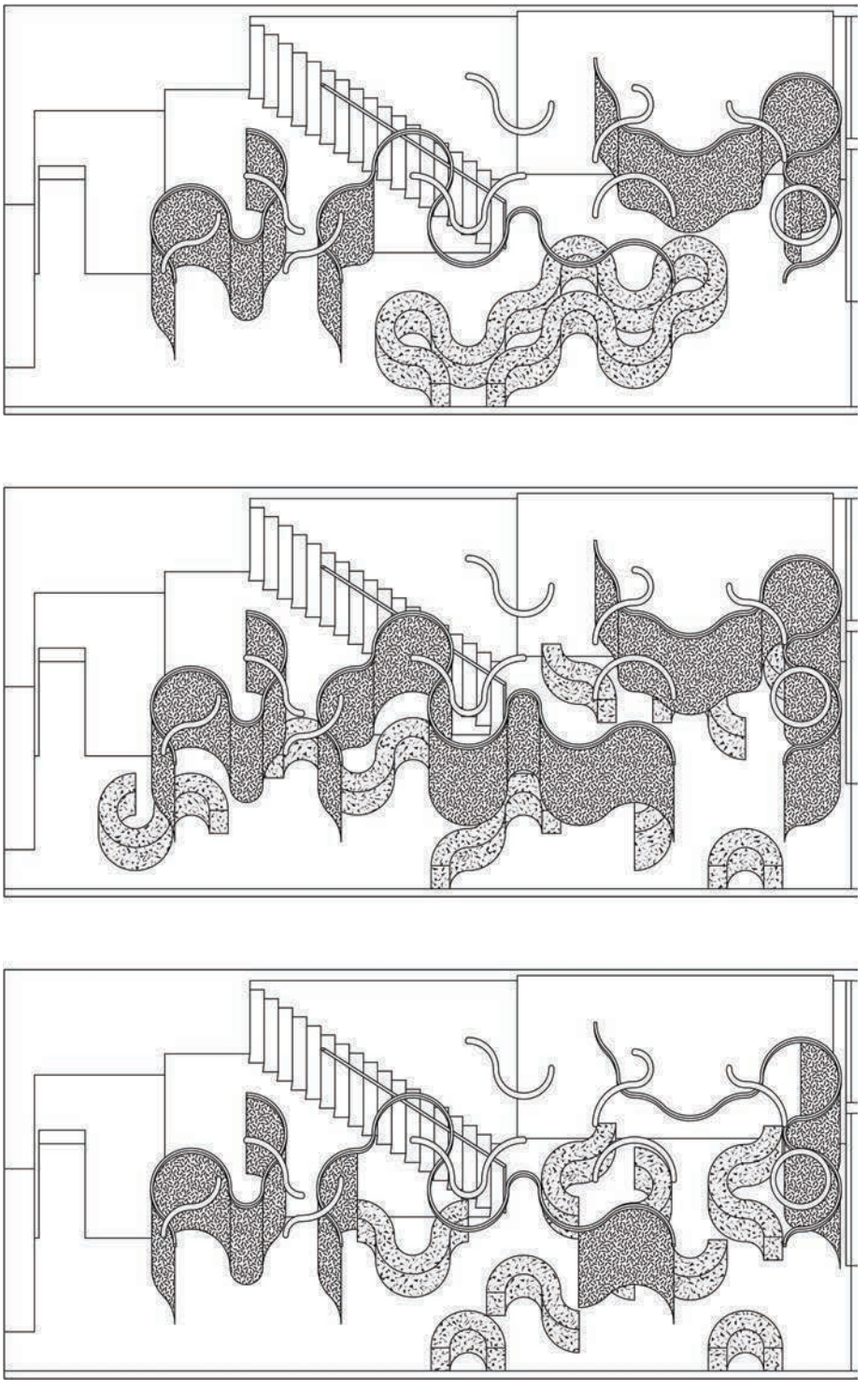
12.9
The industrial-grade custom pearl coating of the Cranbrook Pedestals produces a subtle, tactile finish. Courtesy of Outpost Office.

INTERMISSION

Intermission is a storefront exhibition celebrating the midway point of a five-year project awarding grants to community activists, artists and leaders. The exhibition gallery is a slender retail storefront with access to semi-private offices above. Rather than mount the exhibition on the storefront's walls, Intermission fills the entire volume with a dense ensemble of seating, curtains and neon lights that generate a dynamic, flexible field for exhibitions and public programming.

Intermission is a backstage party made public. In the spirit of public engagement and celebration, the design utilizes elements of a traditional theater (lighting, curtains and seating) and overlays them into an immersive, non-hierarchical landscape of light, color and shape (Figure 12.10). The design turns a private party into a public event, drawing visitors off the street and through the entire space, beginning at the gallery's storefront window facing a large public market.

The principal organizing feature of Intermission is custom printed curtains on tracks mounted to the gallery ceiling. The stacking of curtains triples the length of linear exhibition space squeezed into the storefront. Hundreds of feet of curtains meander through the gallery, delineating a series of chambers, alternating as curtains and portières. With a few simple strokes, the curtains transform the gallery from a large, open space to a series of smaller rooms. Curtains are organized in a gradient timeline extending from the entrance to the rear of the space. Exhibition graphics inkjet printed on the sheer fabric include information on the organization's staff, grantees and supporters, combining the exhibition's content with its spatial organization and allowing the user to directly manipulate the environment while manually 'scrolling' through the exhibition. Images were printed at a variety of scales so that some required the visitor to stand very close to the curtain and others could be seen from outside on the street (Figure 12.11).



12.10
Oblique drawings illustrating three scenarios for the use of Intermission for events ranging from exhibitions to community meetings. Courtesy of Outpost Office.

12.11
The open interior of Intermission is a flexible field of lights, curtains and benches. Courtesy of Outpost Office.

12.12
A furniture prototype for Intermission.
Courtesy of Outpost Office.

The flexibility of the curtains and the lightweight furniture permits the organization to keep the installation up for several months while still hosting workshops, talks, lunches and other events in the storefront. Several scenarios or 'models' were developed early in the design process to accommodate a large range of uses. By interchanging benches and stacking or expanding curtains, organizers are able to reorganize the space into new, coherent arrangements with little labor, planning or coordination (Figure 12.12).

The benches were wire cut from EPS foam blocks with an industrial robot arm, then coated with a custom LINE-X truck bedliner. The neon lights were produced locally by a second-generation neon craftsman. The curtains were produced from custom printed sheer fabric and hemmed by a seamstress. The curtain tracks utilize a flexible rail system mounted to a rigid custom wooden frame with lapping joints. The entire curtain assembly is mounted to the gallery ceiling with metal rods.

BUILDING BLOCKS OF ARCHITECTURE

In a recent essay on postdigital pluralism (Joselit, 2013, 6), art critic David Joselit suggests that contemporary art might be best understood through three lexical formats from the tradition of conceptual art. Joselit describes the three building blocks of contemporary art as the proposition, the document and the readymade (Joselit, 2013, 6). The proposition transfers the value away from the object and toward the work's possibilities. It 'functions like a score, which can generate a profusion of enunciations or remain without issue, as pure potential' (Joselit, 2013, 8). The document is an artifact that stores 'an event or experience that was initially durational' (Joselit, 2013, 8). It stores time. The readymade, the distillation of commercial design and consumption patterns, is used as a palette of elements. Readymades are 'a crystallization of labor, use-value, and desire' (Joselit, 2013, 9). Joselit's reconstitution of contemporary art through these three entities provides a framework through which we can examine our own approach to digital architecture and the altered formats suggested by novel workflows.

Propositions are promissory notes; they describe potential through instructions. In a proposition, user reaction is irrelevant to a work's value. Algorithms allow us to carefully craft instructions and control the possible outcomes. The value comes from the multitudinal elaboration of the potential of the work. Similarly, in our practice we prefer Joselit's term 'documents' to the traditional understanding of architectural drawings. Few relationships have been more fundamentally altered in digital architecture than the relationship between drawings and objects. In the current paradigm of digital practice, an authoritative drawing of a project may not be produced until construction is complete. In Another Stack, a single drawing was issued to the SIP manufacturer along with a single specification of material thickness. Yet the project's proposition relies on various media: animations, geometric scripts, offset formulas, post-occupancy drawings, photographs. For temporary, installation-based or interior work, the document often lasts longer than the work itself. Typically, the duration of interior architecture is longer than an exhibition, but shorter than a building. Any one arrangement is temporal and lasts only at the will of its users and their collective power to rearrange their surroundings. The document, on the other hand, endures long after the material decomposition of the parts.

Contemporary documents in architecture differ from a previous generation's use of 'paper architecture' in that they do not attempt to portray the work at a specific ideal moment in time; instead, we use various media formats to document past and future possibilities for the work or its transformation through time. (The fact that none are created on paper notwithstanding.) Through potential, multitudes and a certain openness, our work stores time. Post-occupancy animations attempt to delay, remap or engage the act of 'coming to know' the thing. They resist immediacy with delayed gratification. In the animation, the image comes into being through formal manipulations, but it does not index how the thing is made. Rather, the animation provides possible formal lineages and futures without indexing or chronology. Documents are fabricated and fictions; they are not attempts to store truth or generate authenticity.

Our readymades are digital; digital readymades are embedded with the value systems, economies, biases and tendencies of digital modelling systems which circulate certain entities with ease and eschew others. For example, primitive geometries are digital readymades. In this case, digital readymades can be transformed by simple manipulations of scale. The suspension of normative scale relationships alludes to a digital environment where the uncanniness of scale creates encounters of exaggeration. Readymades can also be specified like an architectural material. We often treat architectural materials as readymades, using the specification process as an abstracted mode of materialization. We think about materials through performance criteria: How heavy? How strong? How dark? How light? Working with digital readymades allows us to work against common cliches of digital fabrication: versioning, iteration, mass customization, parts, information, etc.

In conclusion, the projects discussed in this essay are suffused with traces of digital design from the primitive default geometries to the exaggerated scale and uncanny colors of the architectural readymade. These objects, fabricated to convey ideas of mass and material, seem at once suspended in digital space and linked to their specific site – conceptually, if not physically. In our interior architecture projects, traditional relationships between representation, fabrication and design are destabilized through tenets of postdigital creativity. Like GRAV, we aim to dismantle traditional conceptions of furniture without reducing the visitor to a spectacle. We are invested in patterns of socialization, to change social hierarchies, group movements and physical expectations.

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NOTES

1. For a critical view of participatory art, see Claire Bishop, *Artificial Hells: Participatory Art and the Politics of Spectatorship* (London: Verso, 2012).

13 Occupying Categorical Limits

Material, Attitude and Assembly

PRAXIS: FreelandBuck

Viola Ago

When I think of enclosures, I think first not of homes, offices, schools, nor any other places of everyday life, labor and leisure. Instead, I think of enclosures from historical accounts: live/work environments where known figures created important work. Of late, I think of the Paris hotel room where Simone de Beauvoir lived during the Second World War while working on *The Blood of Others*;[1] Edith Stein's covenant in Speyer, where she philosophized about a world that looks back at the self;[2] Gjergj Fishta's Franciscan Church in Shkodër, where he wrote his life's most prominent epic;[3] and perhaps most notable in the popular collective, Heidegger's hut in Todtnauberg, which marked his infamous *die Kehre* or 'turn'.[4] Faint and commonplace descriptions of these spaces can be found in books focused on the historical figures, but there is little writing specific to the enclosures that housed the person and the work. These mild accounts of extraordinary places have continuously attracted my attention; information absorbed through tangential stories can be long-lasting.[5] I am by no means suggesting that these interiors were accountable for the great works of the intellectuals they housed. However, the more our immediate surroundings, specifically interior finishes – or rather, the outermost surface layer on a wall assembly as experienced from the inside – coagulate globally (drywall finishes and stucco are the stronghold standard in the developed and developing world alike), the more our collective imaginations are drawn to moments in history when this was not the case. Narrated by authors and their biographers, the qualitative experiences of these enclosures have now carved a modest, but architecturally significant, place in the monumental works produced by the people that occupied them. Literary imageries of these enclosures defy crushing normalcy, everydayness, order and other regulations of domestic and workplace conditions that are imposed upon our beings today. Universal standards are now proliferated and enforced by almost all of the commercialized, corporate and global practices of the built world; a Gensler-designed interior will look the same in Los Angeles as it will in Kuala Lumpur.

The standardization of interior wall assemblies and finishes has slowly removed material and fabrication specificities that are conducive to imagination and has created a resultant lack of relational constructs in our experiences of enclosures.[6] By contrast, FreelandBuck's work recharges and reasserts the authority of enclosures as experiential agents of interiority. Their projects break with what the higher powers of the neoliberal architecture practice continuously enforce as the standards of

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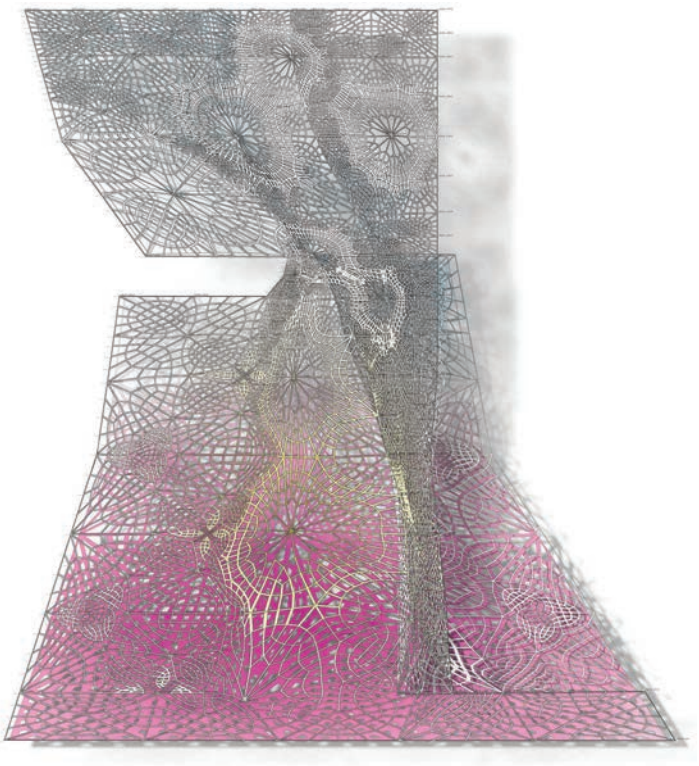
architectural finishes and wall assemblies – off-white walls, clear glass windows, gloss furnishes, aluminum framing, etc. FreelandBuck's work joins a recent shared interest in the field on exterior and interior surfaces especially within emergent practices.[7] It is encouraging to sense a return of sorts to Gottfried Semper's assertion that the façade of a building, and by extension the outermost layer of the built fabric, can serve as a visually communicative datum.[8] Even more interestingly perhaps, is FreelandBuck's definition of surface – not as a condition, but rather as an integrated, all-encompassing system where the interior and the exterior are not understood as fixed binaries. FreelandBuck's installation work is exuberant and experientially intense and resists normalcy in aspects of design, material specification and construction methodology. Instead, their work attains an unparalleled level of experiential intensity by way of methodology and process.

COLOR AS MATERIAL

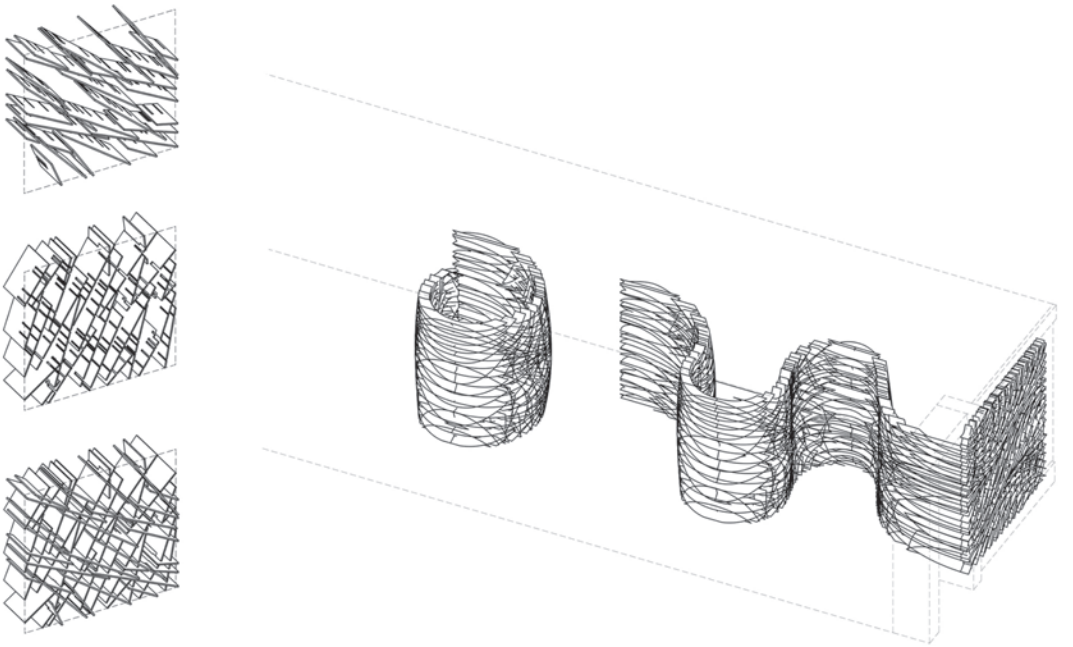
One immediately apparent aspect of the installation work of FreelandBuck is the use of color. An impenitent encounter with color is inevitable in nearly all of the office's work, from the most exuberant pieces such as PS1: Out of the Picture to



13.1 *Technicolor Bloom, 2008, originally installed at Silver Gallery, Vienna.* Courtesy of FreelandBuck. Fabricated and installed with Rob Henderson, Dumene Comploi, Elizabeth Brauner, Eva Diem, Manfred Herman, Maja Ozvaldic, Anna Psenicka and Bika Rebek. Photography by Christoph Gaggl.

13.2
Technicolor Bloom, 2008, originally installed at Silver Gallery, Vienna. Courtesy of FreelandBuck. Fabricated and installed with Rob Henderson, Dumene Comploi, Elizabeth Brauner, Eva Diem, Manfred Herman, Maja Ozvaldic, Anna Psenicka, Bika Rebek. Photography by Christoph Gaggl.

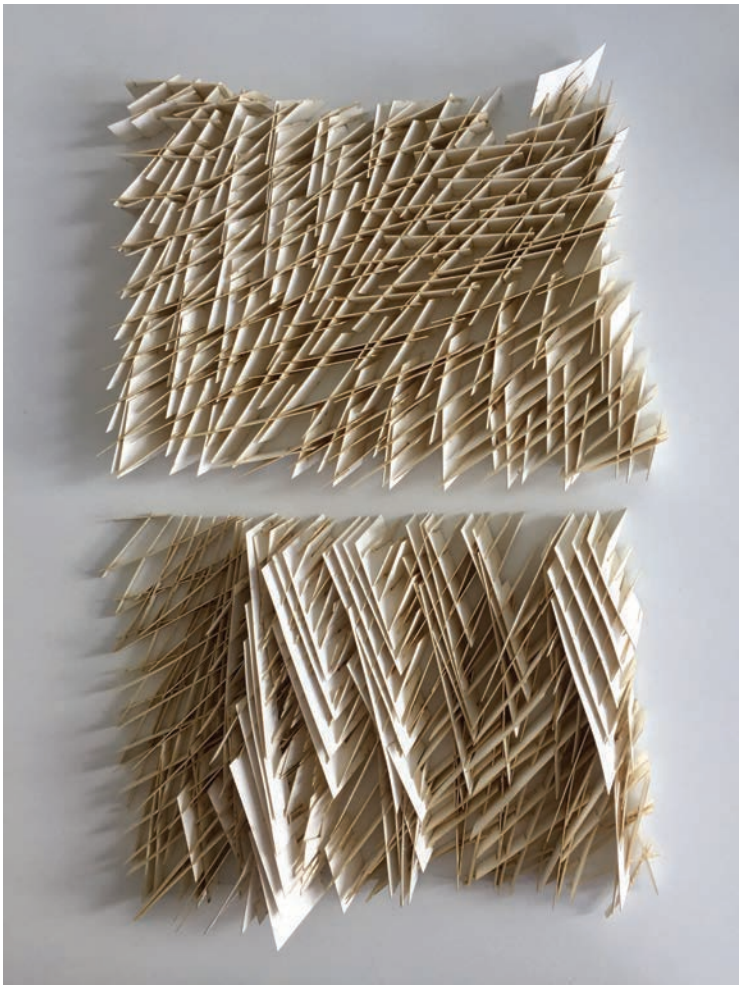
the more subtle and controlled ones like Technicolor Bloom. Color is more than a surface-level, optical experience in FreelandBuck's work. Instead, the confrontation with color is an immersive experience that spills onto the physical space of the occupant/observer within a given installation. In other words, FreelandBuck's use of color activates the space of the observer and by extension expands the affective capacity of interiority and architecture at large.[9]



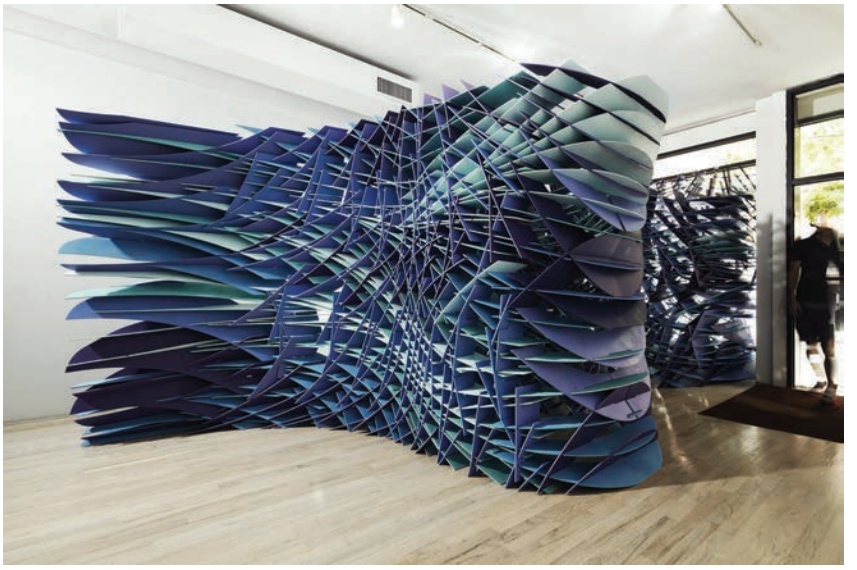
13.3
Slipstream, 2012, Los Angeles.
Courtesy of FreelandBuck.

In addition to the affective qualities of FreelandBuck's use of color, there is a technical dimension to it as well. In the design discipline, color is generally understood as a quality that occupies a field defined either by a hard-edged boundary or one that adjoins another adjacent color field; and as something that can either be inherent in a given material or applied to a surface (such as a paint layer, coating or veneer sheathing a substrate). From a technical standpoint, FreelandBuck's use of color can be understood through three main axes: color as vector rather than raster (as in the *Technicolor Bloom* project), color as material rather than appliqué (as in the hues of the composite panels that make up *Slipstream*), and color as figure that emerges from layering and overlapping conditions (as in the multiple layers of porous planes that create abstract figures in *Parallax Gap*). In this way, FreelandBuck eschews conventional architectural treatments of color and pushes chromatic schemes into dimensions that extend well past the explicit and physical boundaries of the work.

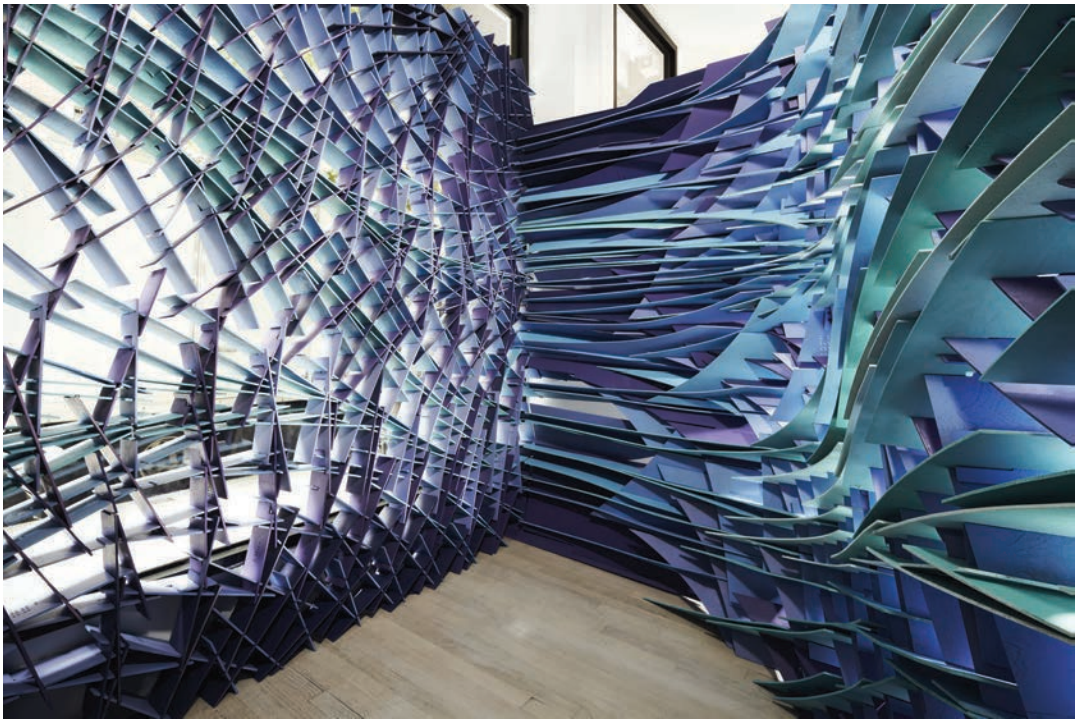
FreelandBuck's ability to reposition color as a design agent can be attributed to their process. The office works through projects in a way that seems to allow little room for afterthoughts. In other words, all three axes of the work's approach to color are interdependent and one can safely assume that they are conceived early in the design process. In this, the removal or alteration of one of the three chromatic elements would dilute the overall work in significant ways. It is therefore surmisable to say that FreelandBuck's use of color is deeply embedded in the genesis of their praxis, and it is precisely this deep level of engagement with color that promises a refreshing stance in contesting our contemporary visual culture's chromophobia.[10]



13.4
Slipstream, 2012, Los Angeles. Courtesy of FreelandBuck.



13.5
Slipstream, 2012, Los Angeles. Courtesy of FreelandBuck. Photography by Kevin Kunstadt.



13.6
Slipstream, 2012, Los Angeles.
Courtesy of FreelandBuck.
Photography by Kevin Kunstadt.

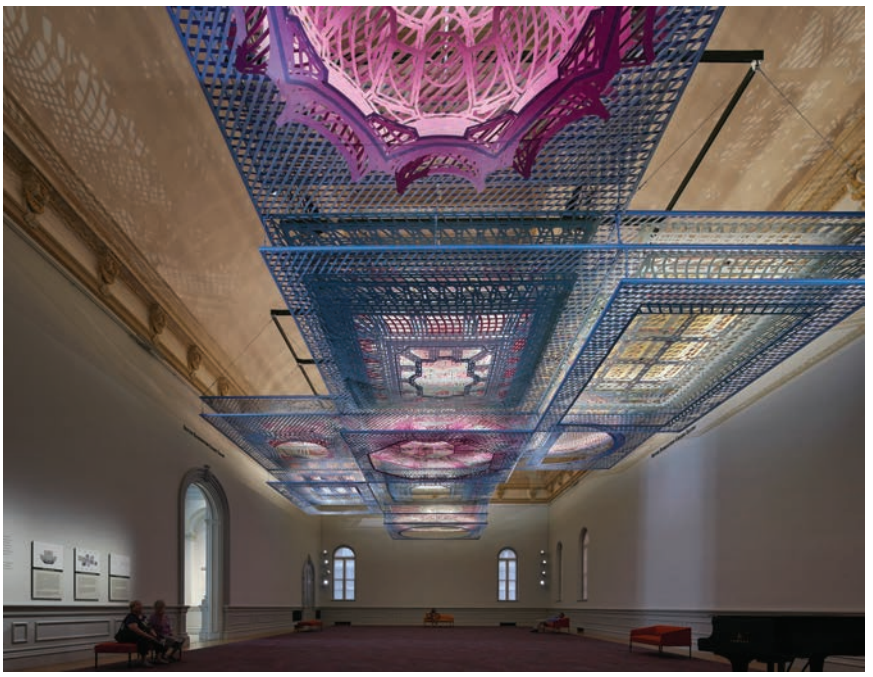
13.7
Slipstream, 2012, Los Angeles.
Courtesy of FreelandBuck.
Photography by Kevin Kunstadt.

FIGURE IN INHERENTLY DIGITAL PROCESSES

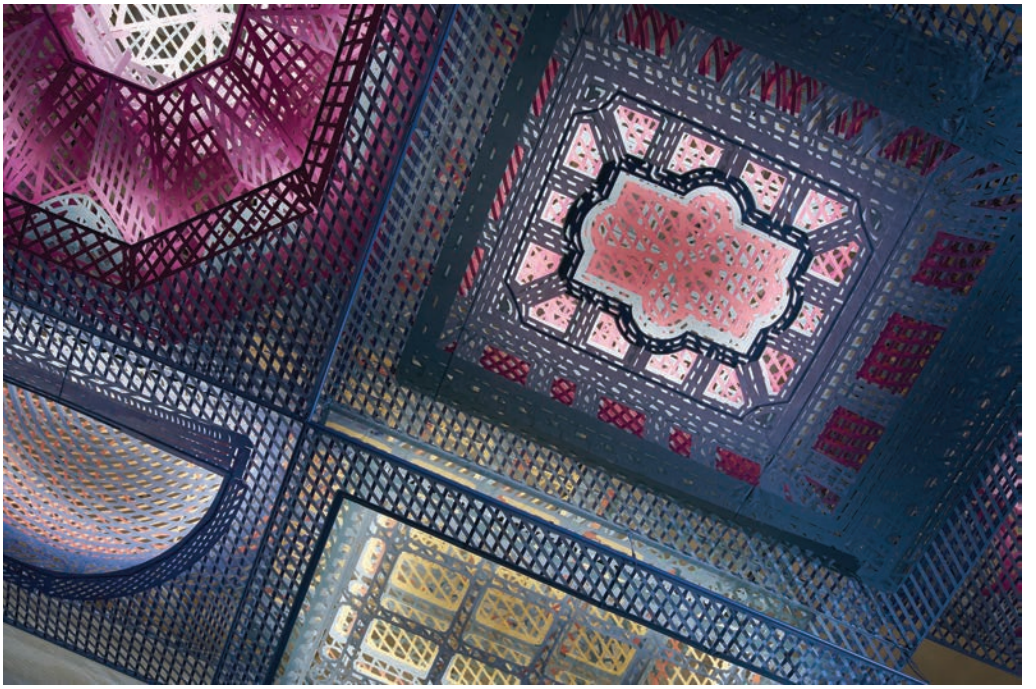
Only revealed upon a closer reading, a second aspect of the work by FreelandBuck is the emergence of different geometric figures as one experiences a given piece from various vantage points. Geometric projection in relationship to vantage points has been exhausted in both theoretical takes and design exercises in architecture. What's unique about FreelandBuck's work is the experience of the emergence of forms, which is orchestrated to be in conversation with the technical and the affective elements of color mentioned above. Further, the geometric figural component and its emergence over time should also be understood as a generative byproduct of a design exploration that begins and ends in the digital.[11] Though FreelandBuck uses vetted visual studies mechanisms such as parallax, anamorphosis, perspectival projections and moire, the deployment and intensity of these effects would not be possible to simulate nor physically model without the use of advanced algorithmic processes. For example, in *Parallax Gap*, one's perception of 3D volumes and 2D figures oscillates as the viewer circulates underneath the installation. Similarly, the *Yale Assembly Pavilion* looks round, non-porous and fully clad from some perspectives around its perimeter. However, if viewed from the original point-position of the projection that generated the geometry in digital space, the pavilion panels disappear completely with just the material thickness left on offer. To illustrate further, in *PS1: Out of the Picture*, the viewer will, at times, only see abstract linear compositions, and at other moments, they will see architectural façades and streetscapes.

13.8
Slipstream, 2012, Los Angeles. Courtesy of FreelandBuck. Photography by Kevin Kunstadt.

13.9
Parallax Gap, 2017, Renwick Gallery at the Smithsonian Museum of American Art. Courtesy of FreelandBuck.

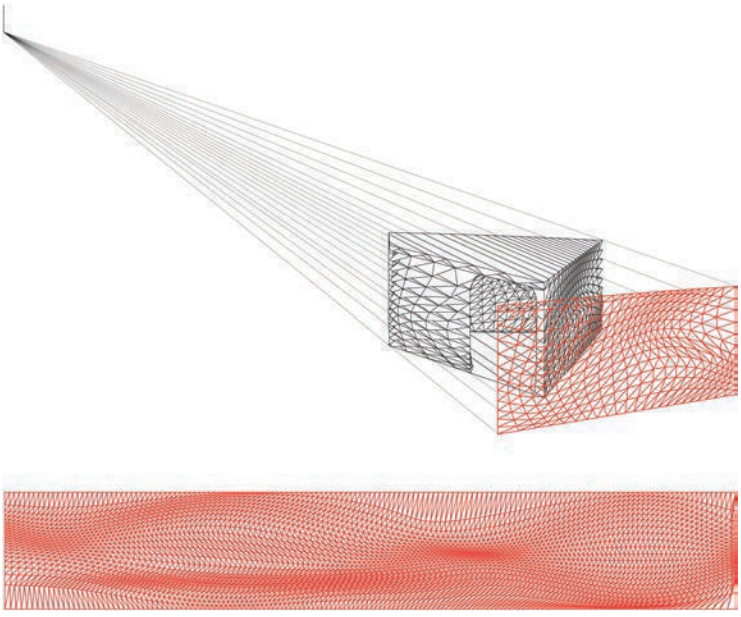


13.10
Parallax Gap, 2017, Renwick Gallery at the Smithsonian Museum of American Art. Courtesy of FreelandBuck. Photography by Kevin Kunstadt.



13.11
Parallax Gap, 2017, Renwick Gallery at the Smithsonian Museum of American Art. Courtesy of FreelandBuck. Photography by Kevin Kunstadt.

13.12
Parallax Gap, 2017, Renwick Gallery at the Smithsonian Museum of American Art. Courtesy of FreelandBuck. Photography by Kevin Kunstadt.

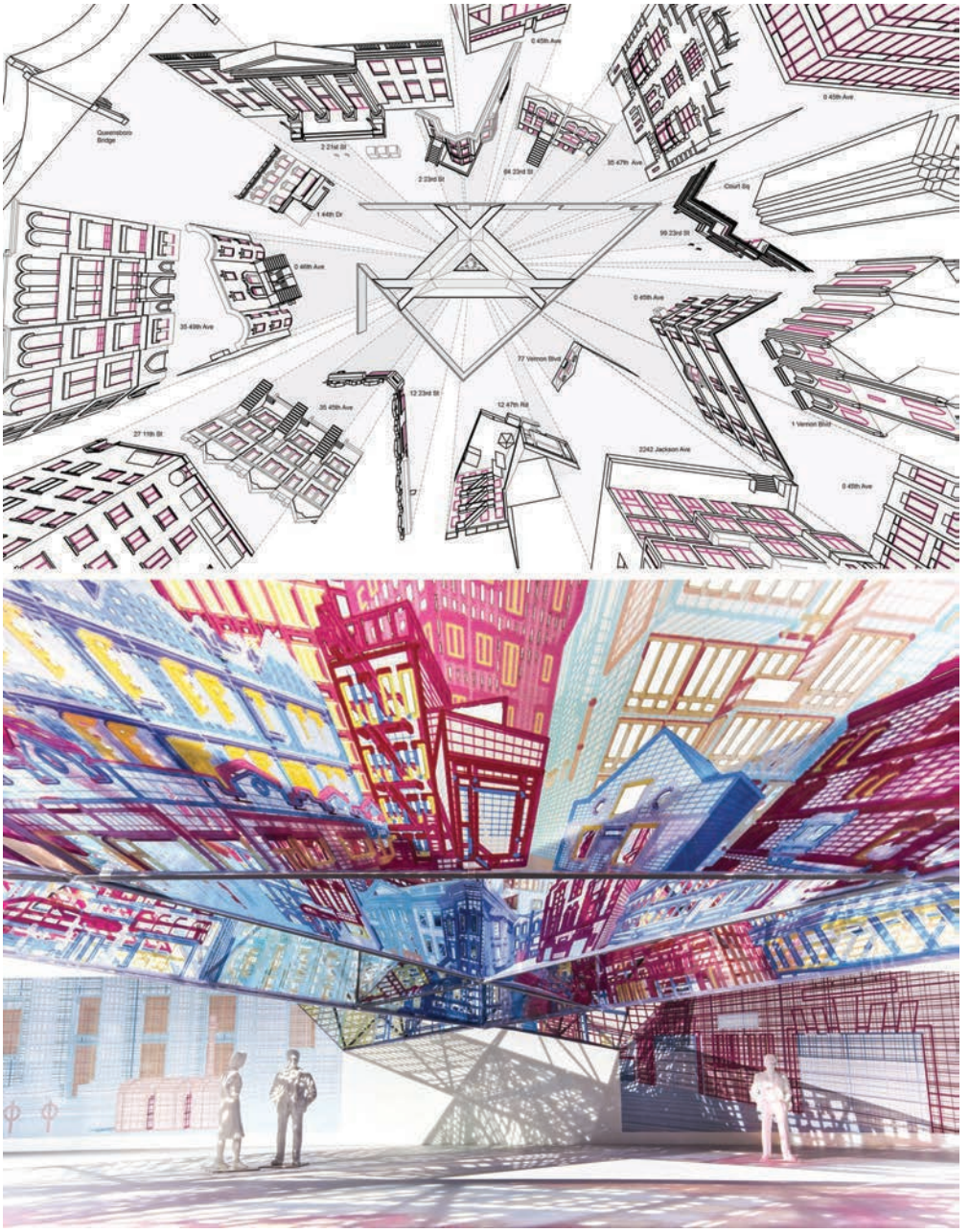


13.13
Assembly One Pavilion, 2012, New Haven. The drawing on top diagrams the triangulation extruder through the pavilion. The drawing on the bottom shows the initial structural triangulation. Courtesy of FreelandBuck. The Assembly One Pavilion was designed and built by Yale School of Architecture students under Brennan Buck's instruction: David Bench, Zac Heaps, Jacqueline Ho, Eric Zahn, Jacqueline Ho, Amy Mielke, John Taylor Bachman, Nicholas Hunt, Seema Kairam, John Lacy, Veer Nanavatty, Rob Bundy, Raven Hardison, Matt Hettler and Teoman Ayas.

13.14
Assembly One Pavilion, 2012, New Haven. Courtesy of FreelandBuck. The Assembly One Pavilion was designed and built by Yale School of Architecture students under Brennan Buck's instruction: David Bench, Zac Heaps, Jacqueline Ho, Eric Zahn, Jacqueline Ho, Amy Mielke, John Taylor Bachman, Nicholas Hunt, Seema Kairam, John Lacy, Veer Nanavatty, Rob Bundy, Raven Hardison, Matt Hettler and Teoman Ayas. Photography by Chris Morgan Photography.

13.15
Assembly One Pavilion, 2012, New Haven. Courtesy of FreelandBuck. The Assembly One Pavilion was designed and built by Yale School of Architecture students under Brennan Buck's instruction: David Bench, Zac Heaps, Jacqueline Ho, Eric Zahn, Jacqueline Ho, Amy Mielke, John Taylor Bachman, Nicholas Hunt, Seema Kairam, John Lacy, Veer Nanavatty, Rob Bundy, Raven Hardison, Matt Hettler and Teoman Ayas. Photography by Chris Morgan Photography.

13.16
Assembly One Pavilion, 2012, New Haven. Courtesy of FreelandBuck. The Assembly One Pavilion was designed and built by Yale School of Architecture students under Brennan Buck's instruction: David Bench, Zac Heaps, Jacqueline Ho, Eric Zahn, Jacqueline Ho, Amy Mielke, John Taylor Bachman, Nicholas Hunt, Seema Kairam, John Lacy, Veer Nanavatty, Rob Bundy, Raven Hardison, Matt Hettler and Teoman Ayas. Photography by Chris Morgan Photography.



13.17
Out of the Picture (Finalist Proposal for MoMA Young Architects Program), 2018. Drawing courtesy of FreelandBuck. Photography by Kevin Kunstadt.

PS1: Out of the Picture can be understood through a three-part procedural sequence: 1 – image abstraction (the façade streetscapes are redrawn in line vectors), 2 – projection (skewing the resultant vector geometry of the abstraction from step 1), 3 – positioning and layering of the (abstracted and projected) geometry from step 1 and 2 onto a final composition to be installed as a canopy at the MoMA PS1 Courtyard. In the proposal, it is apparent that the viewer might see a streetscape fabric, a building façade, a grid of windows and a cornice, either all at

once or as individual episodes in isolation. In addition, the viewer might experience these objects as flat picture planes or volumetric 3D forms.

The figural explorations in FreelandBuck's experimental works are facilitated by the availability of scripting tools in the digital environment. Perhaps the most productive aspect of the pursuit of these elusive, spectral figures through the use of digital layers and multiple projections is that FreelandBuck is not looking to invent novel methods of projections in the contemporary landscape, but rather, they seek to discover entirely new visual apparatuses given the advanced tools that are available in our contemporary field.[12]

DIGITAL FABRICATION

Another primary and prominent facet of the work that is directly related to the digital nature of its design exploration is the role of fabrication in the conception and actualization of the projects. Though FreelandBuck works with vectors and other linear and infinitely thin digital geometries, the moment when those geometry representation entities[13] must be reconsidered with material thicknesses is inevitable. The phase in which planes are offset and lines are extruded is the miraculous moment in the process of making work where the digital and the physical meld because it is precisely the material thickness (for example the thickness of the Sintra board in *Slipstream*) that negotiates the scale of the entire installation and its assembling mechanism.

The fabrication of the intricate geometries present in FreelandBuck's installation and pavilion works illustrates a method of domesticating design processes that resists conventional fabrication and construction methods. That said, it is important to note that the fabrication methodology changes significantly from one work to the next depending on the design process and project ambitions. What makes this work so interesting is precisely that the design and visual apparatuses are at the forefront of FreelandBuck's objectives and that the digital tools, methods, workflows and processes, though highly integrated in the design experimentation, are not primary drivers of the work. Neither are they in service of the design mandate. Instead, the work considers visual studies, procedural thinking and fabrication methodologies all at once, with varying parameter matrices from one project to the next.

CONCLUSION

It is clear that FreelandBuck offers our contemporary landscape new mandates for design thinking, visual exploration and digital fabrication. Returning to an earlier proposal, it is also important to consider the material and experiential specificity that their work examines. This level of specificity – one that changes unapologetically and productively from one project to the next – is able to resuscitate the agency of surfaces that make up enclosures. Though many emergent practices are developing their own modus operandi, FreelandBuck is dedicated to exploring surface conditions that move past the finish plane: the drywall, tape, primer and paint assembly, for example. A unifying factor in all their work that we have looked at in this essay

is the dissolution of the finish plane such that every layer in the installations is cut through or perforated.[14] In other words, FreelandBuck avoids global homogenous surface applications in yet another effective attempt to conflate all of the underlying systems needed to construct their work. Tectonics and assemblies are just as important to their design project as color, figure and fabrication. Structural members are never treated as isolated from the scheme, but rather they are seamlessly integrated into the overall proposal (the structural framing in *PS1: Out of the Picture* is drawn as lines that are part of the overall composition). This return to thinking through unconventional approaches towards assembly logics and surface articulations as design imperatives that conflate visual ambitions, digital processes and fabrication methodologies, helps us imagine new architectural worlds while responding to larger disciplinary and practice-based concerns.

Perhaps the most useful contribution of FreelandBuck's oeuvre can be attributed to their ability to straddle the fringes of multiple neighboring disciplines. Though frequently referenced, we can find an agreeable parallel in the late 1970s diagram that Rosalind Krauss conceptualized on the malleability of the categorical boundaries of sculpture, architecture and landscape.[15] Through this, it's important to remind ourselves that work which challenges disciplinary divides offers productive momentum that catapults thought experiments into new territories. Analogously, FreelandBuck's fringe-bridging of interior design, architecture and contracting – which can be thought of a discipline in its own right – uncovers new paradigms for interiorly or exteriorly occupied enclosures.

NOTES

1 Sarah Bakewell, *At the Existentialist Café: Freedom, Being, and Apricot Cocktails with Jean-Paul Sartre, Simone de Beauvoir, Albert Camus, Martin Heidegger, Karl Jaspers, Edmund Husserl, Maurice Merleau-Ponty and Others* (New York: Other Press, 2016), 140.
2 Edith Stein, *Essays on Woman: The Collected Works of Edith Stein, vol. 2* (Ics Publications, 1996), 20
3 Gjergj Fishta and Robert Elsie, *The Highland Lute* (London: IB Tauris, 2005).
4 Adam Sharr, *Heidegger's Hut,* (Cambridge: MIT Press, 2006).
5 Norman Doidge, *The Brain That Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science*, (London: Penguin, 2007).
6 Nicolas Bourriaud, Simon Pleasance, Fronza Woods, and Mathieu Copeland, *Relational Aesthetics*, (Dijon: Les presses du réel, 2002).
7 A few recent projects that align with this proposed exploration of finishes include: *Haus Gables* by Mall, *Hedges of the World* by Current Interests, *Eat Food* by Lamas, and *Glimmering Wildness* by Hume Architecture.
8 Gottfried Semper, *The Four Elements of Architecture and Other Writings*, (Cambridge: Cambridge University Press, 1989).
9 For more on the concept of activating interior space, see: Sylvia Lavin, 'What You Surface Is What You Get.' *Log* 1 (2003): 103106.
10 David Batchelor, *Chromophobia* (London: Reaktion Books, 2000).
11 Here I refer to focused design exploration generally speaking and not the design process of just one work.
12 For more on the false promise of novelty through the use of novel technologies, see: Viola Ago, 'Series and Other Unit-Based Alternatives: Notes on Contemporary Digital Operations.' *Architectural Design* 89, no. 2 (2019): 110–117.

13 Here I refer to the part of the coding structure where declaring variables can operate as representation of the geometrical units. For example, BRep in McNeel's Grasshopper stands for Boolean Representation because it is calling upon a geometrical Boolean unit.
14 Kyle Miller, Kelly Bair, Kristy Balliet, and Adam Fure, eds, *Possible Mediums* (New York; Barcelona: Aktar Publishing, 2018)), 172–173.
15 Roaslind Krauss, 'Sculpture in the Expanded Field.' *October* 8 (1979): 31–44.

14 Conical Hinges

Shaping Ambiguous Enclosures

Sean Canty

This piece considers how ambiguous enclosures can open up space for architectural propositions that question traditional notions of domesticity and relations within American building practices. As Robert Venturi states in *Complexity and Contradiction in Architecture*, ambiguity and tension are everywhere. Venturi elaborates:

> Architecture is form and substance – abstract and concrete – and its meaning derives from its interior characteristics and its particular context. An architectural element is perceived as form and structure, texture and material. These oscillating relationships, complex and contradictory, are the source of the ambiguity and tension characteristic to the medium of architecture.
>
> (Venturi, 1977, 20)

This piece looks to tease out the distinct types of ambiguity present in different projects designed through Studio Sean Canty. The act of opening up a space for multiple interpretations through the production of ambiguity can lead to many different types of misinterpretation. Rather than producing vagueness, these projects aim to cultivate ambiguity through a high level of formal fidelity. This approach draws from William Empson's *Seven Types of Ambiguity*, where different nuances within ambiguity are articulated typologically.

In the work of the studio, ambiguous enclosures act similarly to linguistic conjunctions: adding ambiguity to the relationship between two parts and their constructed whole. One of the primary formal methods for creating these conditions is the integration of curvature into vernacular forms and existing residential typologies. Curvature invites a certain kind of inscrutability of form. Curvature resists edges and, as a result, the limits of the form (or where form begins and ends) is called into question. Each of the projects discussed in this piece will consider how curvature adds ambiguity to the sense of enclosure that is typically anticipated within a multifamily domestic setting.

One particular instance of curvature is the cone. Within the work of the studio, the cone is used as a type of hinge to produce ambiguous enclosures of different effects through tangency and geometric adjacencies. A moment of conjoinment between axial and rotational geometries, the conical hinge blurs vernacular form with geometric abstraction. Each geometric surface shapes a constant interplay

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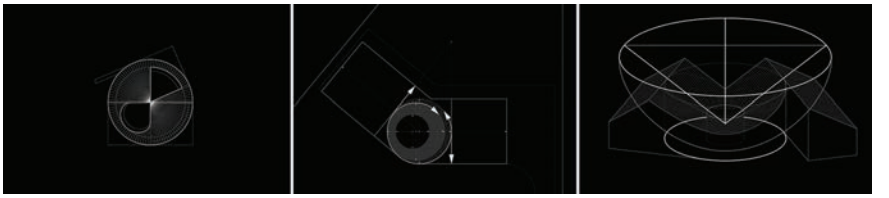


14.1
(Left) Diagram of Nested Conical Hinge (Middle) Diagrammatic Plan, Nested Centers (Right) Inverted Conical Hinge and Cylindrical Drum. Courtesy of Studio Sean Canty

between diametrically opposed readings of the form: flat and volumetric; thick and thin; axial and rotational; intimate and collective. These dynamic readings are activated through the playful combination of geometric primitives (plane, cone, cylinder, square, rectangle) and their subsequent synthesis into new spatial wholes. At this juncture, connections or separations happen between programmatic volumes. Both curved and flat surfaces are tethered along points of shared tangency.

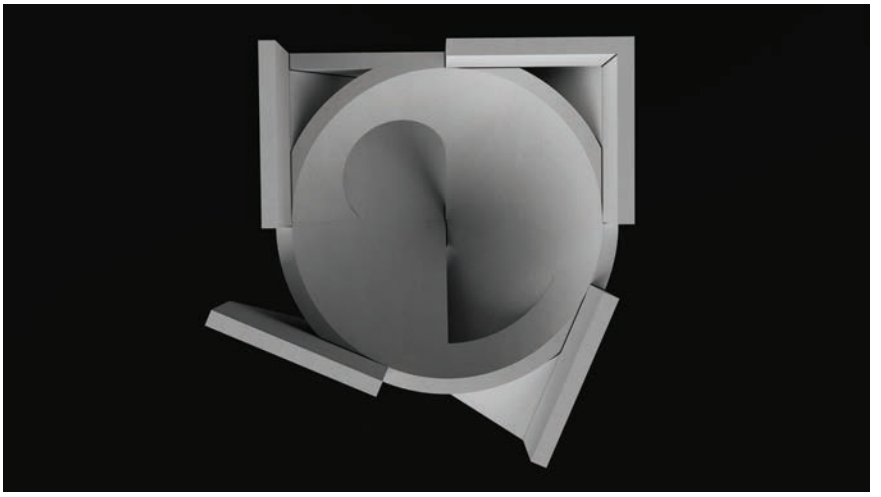
This gesture is subtle. Smoothing out juxtaposition through continuity of surfaces, the conical hinge blends diversity in plan and continuity in elevation (or the inverse). Both a conceptual and formal motivator, the conical hinge disrupts obdurate domestic typologies in favor of visual and perceptual movement, programmatic collectivity and transparency. In each project, a cylindrical rotunda paired with a conical roof signifies the most communal space. This combination also creates a perceptual shift in scale that monumentalizes domestic space within the interior. These rotundas act as spatial joints: contorting to accommodate sight lines (the Concord House), to be seen in the round (the Folly Pavilion), or to conceal the insertion of a secondary typological framework (the Janus House).

The projects of the studio build upon American building practices (and its ingenuity with wood-stud frame construction) and pair this with a renewed attention to mass timber and structural cassettes. This combination enables the exploration of questions of curvature, precision, and fidelity to a figure within the context of domestic spaces. The parallel conjunction of these two building practices – wood-stud framing and structural cassettes – privileges certain kinds of efficiencies in construction. Moreover, this conjunction offers new formal possibilities for rethinking domestic typologies, nudging the private home towards more collective reveries.

SUBSUMED ENCLOSURES: THE FOLLY PAVILION

The Folly Pavilion explores a type of ambiguity where 'two or more alternative meanings are fully resolved into one' (Empson, 1947). Formally, the pavilion oscillates between a turret and a simple shed. In particular, the pavilion investigates how methods of constructing turrets can inform design techniques to create new spatial experiences. A turret often composed of a cylindrical tower projected vertically from a building is typically capped by a conical roof and assembled with standard two-by construction. In application, turrets are often positioned at a corner of a building and perceived as ancillary to the main building envelope as a turret is both internal and external to a building's overall massing. In the Folly Pavilion, this element is scaled up to become a pointy dome supported by four identical pinwheeling walls. Its character is hidden within a subtly torqued shed.

14.2
Exterior Perspective of the Folly Pavilion. Courtesy of Studio Sean Canty



14.3
Two sibling oculi, one in the shape of a teardrop and one in a wedge shape, choreograph light into the space below the Folly Pavilion. Courtesy of Studio Sean Canty

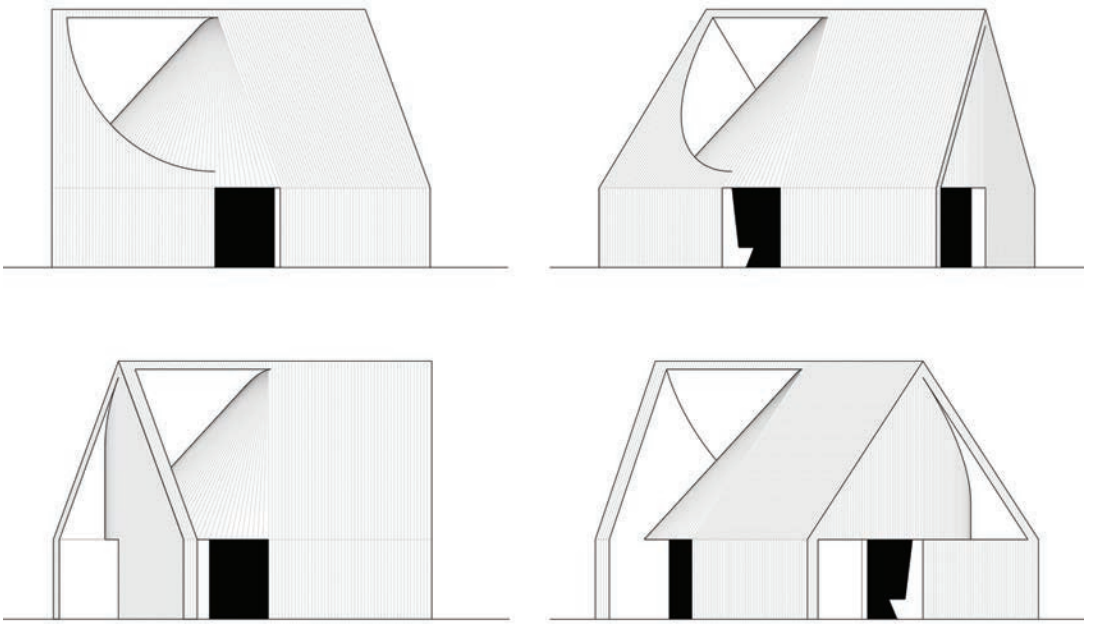
Traditionally, follies were functionless architectures in the landscape, built to be viewed from a distance and composed from fragments of other buildings that were often a reconstitution of a prior historical universe. The Folly Pavilion hybridizes ancillary architectural elements into a new whole that aims to be equally out of time. The pavilion plays with competing levels of legibility as one moves between the exterior and the interior. From the outside, the turret appears abbreviated. From the inside, the shed is abbreviated. It is only from inside that one can perceive a sense of a complete figure of the turret. The radial reflected ceiling plan impresses upon the rectilinear plan.

The turret is rooted in the English picturesque. Landscapes with such structures were integral to orchestrating a series of spatial tableaus situated within a garden. Key to their visual purpose was the embodied movement of a human subject

and an architectural promenade situated in the open field. As Robert Levit notes in his essay *Language, sites, and types: A consideration of the work of Álvaro Siza*:

> The focus of the subject's attention in the garden shifted away from the apprehension of ideal geometries, or the formal relationships that seemed more important in the conceptual schema of architecture, to a focus on the continuous changing passage of sensation. A person involved in the appreciation of his or her own sensations will distinguish between these sensations, corporal and intimate, and the remoteness of an architecture's abstract autonomous conceptual order – unless of course, that order, as the eighteenth-century garden theorists sought for their gardens, is dedicated to the peripatetic subjects' perceptions.
>
> (Levit, 1996, 232)

In the picturesque context, the architectural promenade and the moving subject facilitated a constant interplay between subject and object and the unfolding of spatial experience. As an elaboration of this concept, the Folly Pavilion is composed of architectural fragments that undergo a constant transformation as one moves around its perimeter. The Folly Pavilion is meant to be seen in the round. Moving around the pavilion, one can see a gable roof integrating with a conical rotunda and tucking into two rectangular openings. Above the eave line, surfaces are either merge with the turret or adhere to the shed. The contrast between the short and long elevations articulates a series of formal gestures that abbreviate the



14.4
Exterior Elevations of the Folly Pavilion. As one moves around the pavilion, each object, the shed, or the turret, is revealed in varying ways, framing and occluding each other. Courtesy of Studio Sean Canty

14.5
Interior Perspective of the Folly Pavilion. Courtesy of Studio Sean Canty

geometric figures in different ways. Along the pavilion's short elevations are gabled profiles. The long elevations are shaped by a subtle rotation of the plan which produces two distinct elevations. One elevation is concave, pulling exterior space in and prominently revealing the surface of the conical turret. The other elevation is convex, bulging out to the landscape with a centralized opening that negates the convex corner.

As one moves into the pavilion, the space oscillates between the intimate and the monumental. Internally, space is less about surfaces and more volumetric, defined by the overscaled conical turret above. Inscribed on the cone's underside are two sibling oculi, one in the shape of a teardrop and one in a wedge shape. The combination of oculi funnels light into the rotunda below.

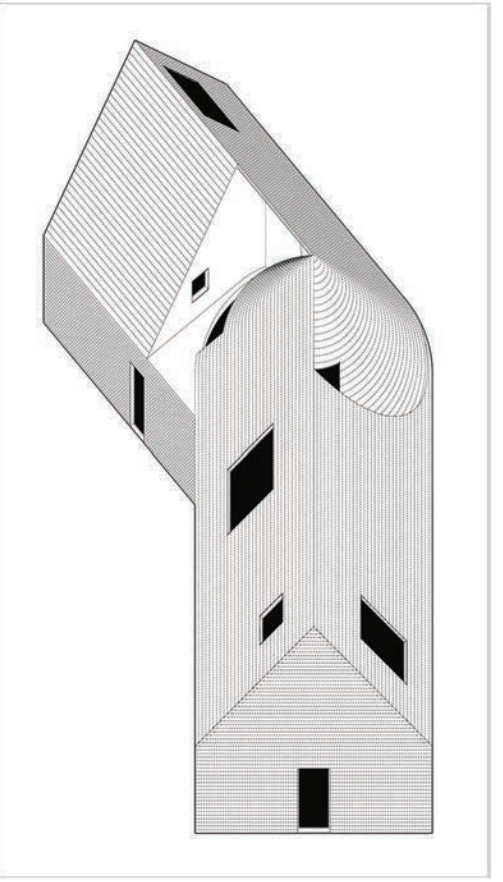
HIDDEN ENCLOSURES: CONCORD HOUSE

Elaborating on the use of conical gables, the Concord House explores a type of ambiguity where 'two apparently unconnected meanings are given simultaneously'

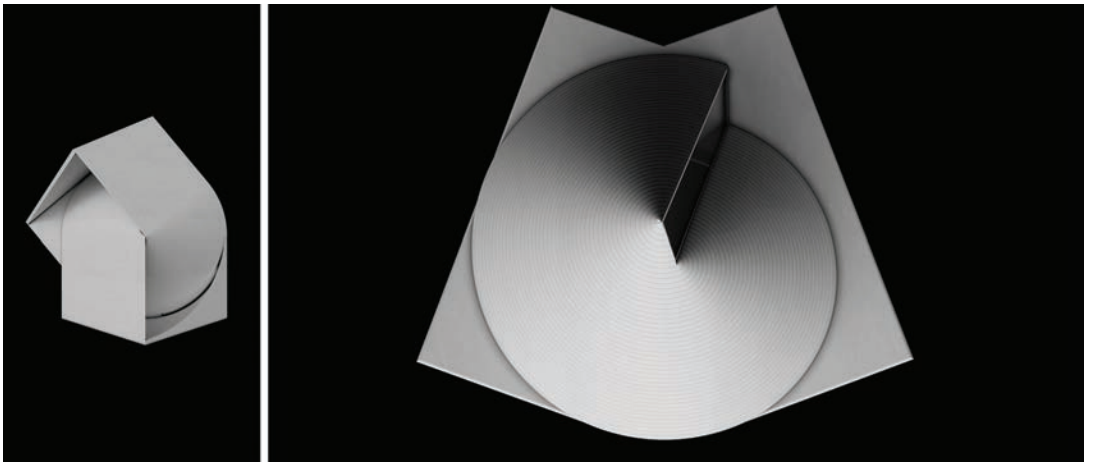
(Empson, 1947). Formally, the house uses its conical hinge (a cylindrical volume with a conical roof) to connect multiple residences through a shared interior commons. Rather than an object viewed in the round, the Concord House is a highly sided multifamily residence with a clear front and back. Situated at a corner lot whose property lines are not parallel, the house is an exercise in stealth density, packing three residences of different sizes into a single volume. The shared interior commons introduces a moment of connection while providing physical separation between the residences.

In considering the relationship of spaces within the Concord House, Kazuo Shinohara's house in Higashi-Tamagawa provides a reference for an ambiguous relationship between the vernacular and the geometric. The house indexes the vernacular, the city and geometric blanks within its composition of three roof forms: a pure gable, a flat roof, and a rotating prism. The addition of a flat-roofed commercial space – a medical office – on the corner of the lot creates an ambiguous relationship between the gabled roof and the rotated prism. The effect moves between reading the gable as a doubled form and distinguishing the rotated prism through its abstraction.

In the Concord House, the figure of the commons similarly draws comparisons between the two wings of the house. The complexity of this insertion, although



14.6
Axonometric Drawing of the Concord House.
Courtesy of Studio Sean Canty



14.7
The conical hinge separates and conjoins two sides of the Concord House's plan.
Courtesy of Studio Sean Canty

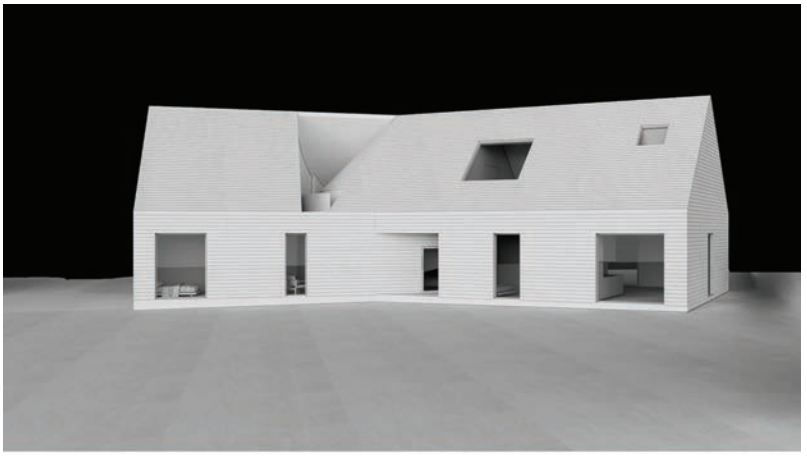
programmatically different from the house in Higashi-Tamagawa, similarly creates ambiguity about the programmatic and formal relationships of the two conjoined wings. The rotunda is partially revealed at moments of entry on the exterior. Rather than the gable tucking into two figured openings, it tucks into one semicircular opening and one rectangular opening, a cue to the formal conjoinment in the plan, projected to elevation. At the roof, the commons is articulated through a gabled figure that tucks into the roof in two distinct ways, creating a connection to the exterior. The surfaces tuck away into rectangular voids on both the convex and concave elevations of the house. This is one way in which we get a sense that something is not as it appears to be.

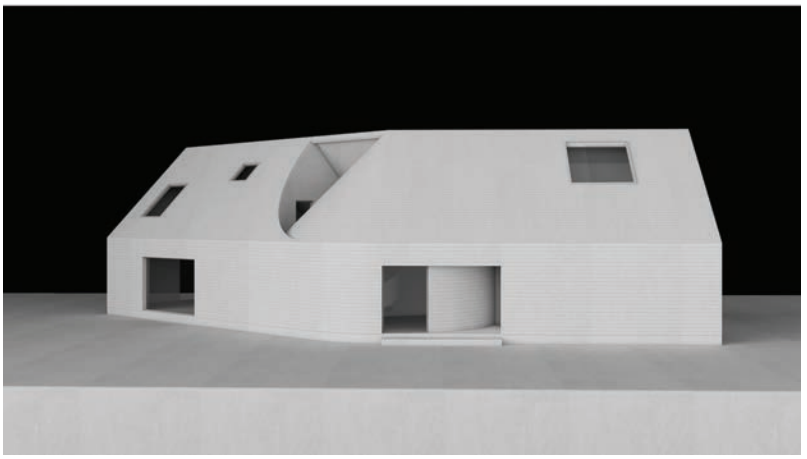
To mask the three dwellings, the front façade plays with scale in three ways. First, its silhouette and height of the overall massing matches the homes of the existing context. Second, the exterior cladding is a consistent grain of horizontal siding, mimicking the pervasive use in the surrounding area. Third, and most importantly, the elevation is mostly blank with several framed openings that vary in window format: some landscape, some square, and some portrait. This unifies the entirety of this elevation as one composition rather than articulating the grain and individuation of the program behind.

As one moves around the house, the conjunction of axial and centralized figures that make up the house's overall volume is revealed. The entrances to each wing of the house are placed tangentially to the circular commons. The two wings of the house are rotated around the commons to align in parallel with the respective lot edges. At the exterior, the front façade subtly bends and contorts the convex exterior. The elevation along the back is, in contrast, a concave corner.

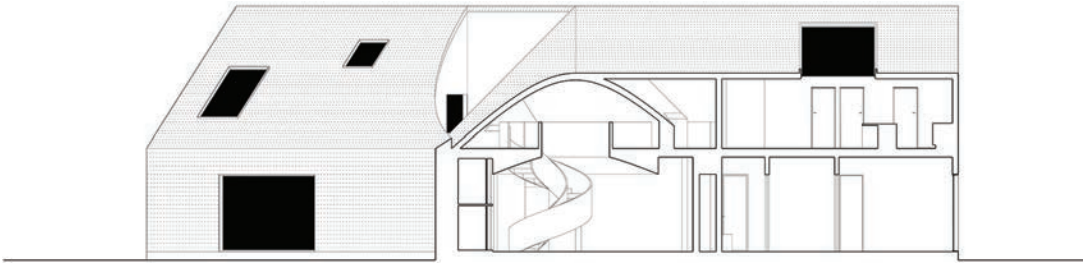
Inside the rotunda, one is enclosed within the commons, but outside of the enclosure of a specific residence. The shared common space is both foyer, rotunda, circulation, and a collective space of gathering. As one moves through this initial enclosure into more private layers of the home, the sense of enclosure shifts. Each component of the house – the commons and the two wings – is isolated from the other. The three distinct residences are split across the two wings. On the second

14.8
Exterior Perspective of the Concord House. Courtesy of Studio Sean Canty





14.9
Concord House Model Perspectives. Courtesy of Studio Sean Canty



14.10
Longitudinal Section of the Concord House.
Courtesy of Studio Sean Canty

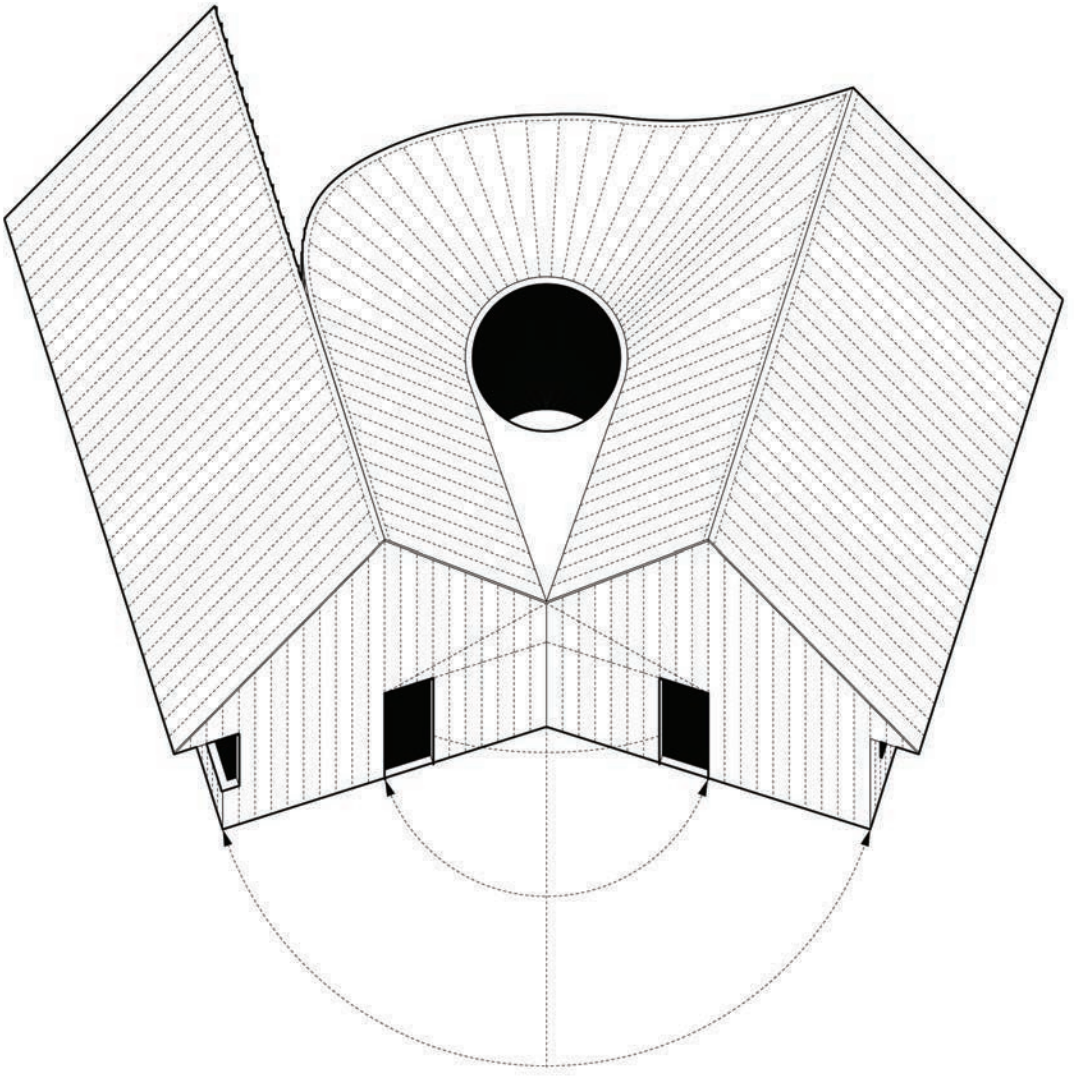
level, a combination of residential entries and semi-private exterior balconies play with the set of surfaces that shape enclosure at this level. Visibility of the gabled figure, which sits between a wall and a roof, creates a sense of enclosure that is more urban than suburban.

TWINNED ENCLOSURES: JANUS HOUSE

The Janus House engages the conical hinge to create an exterior, open courtyard whose ambiguity is produced when alternative meanings combine to make clear a complicated state of mind in the author' (Empson, 1947). This is a fortunate confusion in the Janus House that stems from the project's typological hybridity. In this project, the conical hinge produces a valley within the form of the house rather than a peak. A pair of twin residences on a generous suburban lot, the Janus House is doubled along its front and tripled around the back. The Janus House's front elevation conceals the relationship of exterior expression to interior domestic space through a cast of doubles: two gables, two doors, and two of all the required pieces of domestic equipment.

The plan of the Janus House arrives at its composition by merging key traits of two recognizable housing types in a single volume: the axiality of a dogtrot house and the centrality of a courtyard typology. The house's twin logic is established through the transformation of the dogtrot, an ordinary American housing type. Inherently symmetrical in plan, a dogtrot house is characterized by two gabled wings, separated by a covered open space. In the Janus House, this organization is signaled but immediately altered. There is no open breezeway between the two house fronts. Instead, the gabled volumes pinch together, first compressing the formerly open space to zero, then replacing it with a shared projecting conical awning.

Conjoining half a gable from each home, this conical hinge unifies the moment of convergence in both. The house's roof plan reveals a double of two cones – one elliptical and one circular – which conjoin the residences. Each pairing shares formal, spatial, material and organizational properties with relative degrees of sameness and difference. The front façade shows twin-gabled volumes that share an elliptical awning covering the entrances to each house. Like the Concord House, there is a formal disjunction between the front elevation and the back, although in reverse, a concave corner on the front, and a plastic and animated back. The front façade doesn't forewarn an observer of the enclosure's changing attitude from front to back, deceivingly belying the plan. Instead of articulating its dual residences with



14.11
Axonometric Drawing of the Janus House.
Courtesy of Studio Sean Canty

the obvious legibility that characterizes the rest of the neighborhood, the Janus House renders its paired components with medium resolution.

Within the two residences, the experience of enclosure is modulated in relationship not to an exterior factor but to the proximity of the other residence. Within each gable of the house, the outer edges (far left and far right) provide a stronger sense of enclosure and privacy. The sense of direction within the residence and the rhythm of the rooms is well established. As one moves closer to the interior of each gable, a sense of collectivity opens up through visibility of the other residence.

A shared characteristic amongst all three projects is a sort of blankness afforded by the conical hinge. Alleviating the composition of openings, the resultant blankness is a type of red herring that signals a finite sense of enclosure while concealing the complexity within. Instead of a study of fenestration, each project

14.12
Model Perspectives of the Janus House. Courtesy of Studio Sean Canty

14.13
Perspective of Interior Courtyard at the Janus House. The courtyard is shared programmatically by the two residences. Both bedrooms look out into the courtyard as well as other public and private spaces. Courtesy of Studio Sean Canty

considers the way enclosure is shaped not just by demarcations in plan, but the qualities articulated through elevation. Apertures are consolidated on secondary faces or situated within a conical hinge. This relocation of porosity (at the roof and at the transition from wall to roof) shapes distinct senses of enclosure that reflect subtle shifts in spatial perception and shifts in the relationships between those that inhabit these spaces.

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15 The Figure in Translation

Nader Tehrani

THE IDENTIFICATION OF THE FIGURE

At a first glance, the *body*, the *object*, and the *enclosure* would appear as a menagerie of three random things, but what I will attempt to draw out of them is a common investment in the art of figuration. Behind this investment lies a discourse on the nature of representation and how reality is depicted from within a medium: that is to say, that our perception of reality emerges from the particularities of a medium, but also that when a shift in medium occurs, there is also a change in technique, method, and the need for translation. The histories behind the quest for the 'real' are laid out in traditional art history courses; the evolution of the body in Egyptian sculptures, and their requisite transformations in the Greek kouros, from the archaic frontal pose to the eventual contrapposto position marks a passage of

15.1
Hatshepsut King/ Daughter of Amun/RA (Left); Doryphoros Polyclitus c. 450 BCE Classical Greek (Right). Courtesy of the Rogers Fund, 1929 (Left); Minneapolis Institute of Art (Right).

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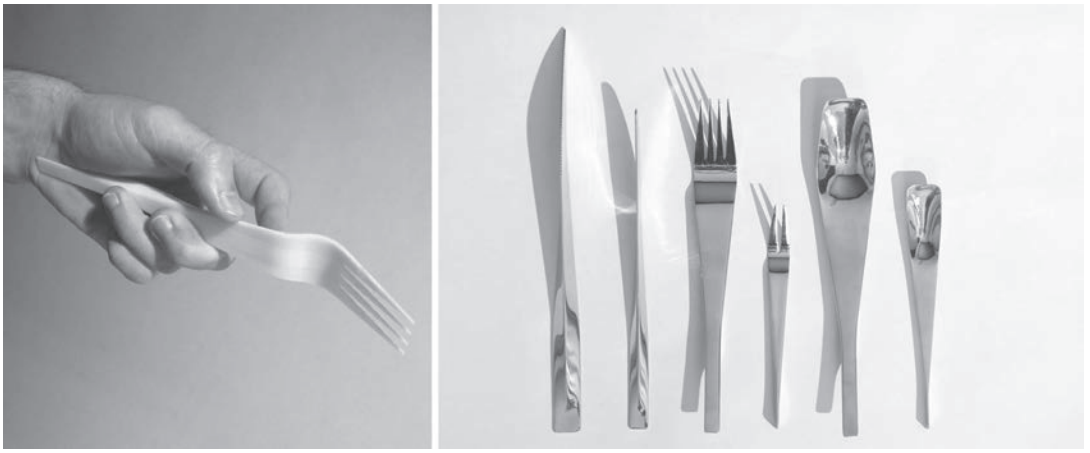
technical and intellectual cognition. Embedded in this historic arc is a narrative of the human's pedagogical vicissitudes – albeit over centuries – learning eye-to-hand coordination on the one hand and establishing a conceptual dialogue with the real on the other. With the human figure under observation, this involved the invocation of an idea about optics and 'how' to see, centering the eye itself as a subject of art – with an ability to transpose one three-dimensional reality onto another. The inexactitude of that translation has been prone to significant debate through history also, with the idea that verisimilitude is subject to a range of possible interpretations, from the abstract to the hyperreal. Also embedded in this history is the idea that the body, as subject, is prone to two very different forms of registration: The first as a pictorial icon, whose recognizable parts speak to the narrative of the whole; and the second as an index, whereby traces and imprints of the body may be present without any visual resemblance to the body itself. Whereas the former relies on optics and visuality as the center of artistic production, the latter recenters cognition through conceptual avatars that register the production of knowledge through other means and senses.

THE BODY IN ARCHITECTURE: THE ERGONOMIC INDEX AND THE PROJECTED FIGURE

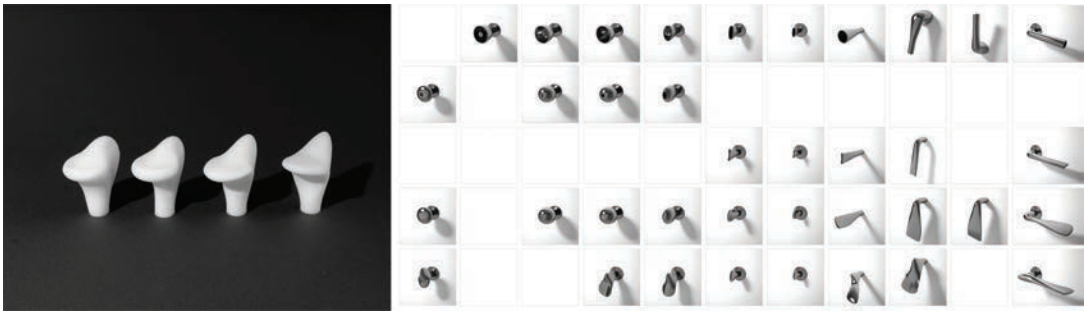
By way of translation, the presence of the body in architecture is registered in both explicit and implicit ways. On the one hand, within the doctrine of humanism, there is a history of Western architecture whose treatises are centered on the human. This is as much evident in the sketches of Leonardo da Vinci's Vitruvian man as in Le Corbusier's 'Modulor'; notwithstanding the ideological sway this narrative has offered the history of architecture, it is poignant in its identification of dimension, scale, and ergonomics as the basis of architectural measure. In it, we have also witnessed the lacuna of other subjectivities whose bodies are absent, be they the result of gender, species, or other living ecologies. Still, if an alien were to discover the remains of the planet earth in some future history when humans no longer roam, they might still discover the registration of an inexact body that is a subject of architecture itself. How that registration occurs is worthy of closer inspection.

The morphological particularities of the body offer a productive clue via thier engagement with architecture, if only that the interface between the human and its environment may begin with the body as a system of parts: the torso, limbs, digits or head all establish a special relationship with the built environment. With the hand as maybe one of the most dexterous instruments of intelligence, it is also the most prone to architectural engagement, not only in the tactility of surfaces around us, but in the mechanical protocols of hardware, instruments, and vessels that mediate between the human and its environment: doorknobs, pulls, flatware, cups, and many industrial design artifacts are the first registration of such encounters.

The Num Num Flatware draws from a history of silverware products whose impression of the figure is the result of a latent tension between the material technologies at work in the production of metal and the mechanics of the hand as it navigates the world around us. With two dominant modes of production, metalworks have been defined by a 'stamping' of sheet metal on the one hand,



15.2
Num Num Flatware. Courtesy of NADAAA



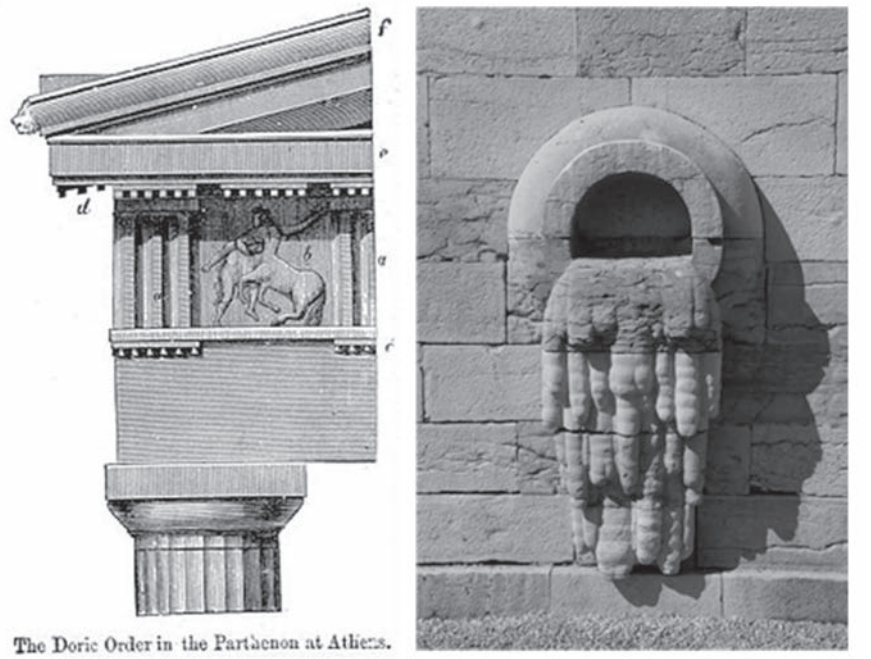
15.3
Nob Nob Door knobs. Courtesy of NADAAA

and the casting of liquid metal on the other – obviously involving two very different requisite figurative opportunities. In the Num Num Flatware (Figure 15.2), we took advantage of casting protocols, not only to exacerbate the figural properties of the utensils, but to radicalize their ergonomic potential in confrontation with the hand. If the traditional stamped flatware is balanced out like a dumbbell, with an hourglass figure around which the hand can conform, the Num Num series establishes a hand-to-glove relationship between fingers and utensils, creating a center of gravity within the central mass of the flatware, and triangulating its facets so that three digits may hold it with ergonomic facility: The figure of the utensil becomes an index of the hand. Similarly, the Nob Nob Door knobs (Figure 15.3) series offers a research matrix of relationships between the body and hardware, some of which are related to conventional canons, while others are related to novel ways of engaging the body. If the lever and round knob types emerge from well-established historical models, they create a generic rapport with the body, biasing either mechanical or geometric performance. However, some of the more speculative renditions of knobs in our matrix escape the platonic bias of generic versions in search of manual morphological twists whose mechanical and ergonomic performance come

into dialogue. In both instances, the Num Num and Nob Nob series conceal the image of the hand itself, if only to reveal it as an index, imprinting its performance on the body of the hardware itself. As we scale up to the architectural framing of installations and furnishings, the presence of material aggregation impacts its relationship to the body, in part becoming an even more important protagonist in the embodiment of form. Consider the stacking of plywood as a tectonic idea, translating butcher block technology into more contemporary terms, and how this may be interpreted through three projects. The Vero Dresser (Figure 15.4) and the Laszlo Files (Figure 15.4) are both milled projects, whose excavation of plywood offers a space of intervention for finger pulls. The Vero Dresser is premised on a simple principle of horizontal stacking in combination with a hierarchical stacking of drawers whose dimensions vary in ascending order, allowing for programming of different sized artifacts. The monolithic tendency of this tectonic is amplified by the masonry logic, whereby the drawers are composed as masses of solid ply, without indication of the very void that activates its programming. The challenge, then, was how to create pulls for these drawers while maintaining a fidelity to their tectonic logic: The discrete sinuous carving that veers in and out of the outer surface of this mass accomplishes this precise feat. Instead of adding metal pulls, as convention might mandate, we adopted the ethic of a mono-material strategy, forcing distortions in the stacked ply to enable pulls from within the logic of its morphology; the finger engages geometry practically, but the geometry does not emulate the body per se, instead it invites the body into its logic. In contrast, the Laszlo Files rotate stacked plywood vertically, if only to take the opportunity to mill into the depth of a generic surface. This allows for the projection of an external figure, unrelated to the body entirely, to impress itself on the surface. The routing of multiple layers of ply allows each laminate to gain a voice, such that in their repetition, they can produce a pattern whose affinity with textile can be amplified by the organic logic of the milled surface. Not unselfconsciously, the lightness of the animate figure of undulating fabric is meant to offset the weight and depth of stacked monolithic ply technology. In this instance, the drawer pulls are smuggled into the 'textile' surface by way of a shear, a tear in the surface within which the fingers can intervene. Here the human figure, and the figure of a liquid veil come into conversation, both alien to the innate materiality of the plywood itself – but also distinct from each other in both figurative and performative terms.

15.4
Vero Dresser (Left); Laszlo Files (Middle); Gwangju Biennale Cube (Right). Courtesy of John Horner (Middle); NADAAA (Left and Right)

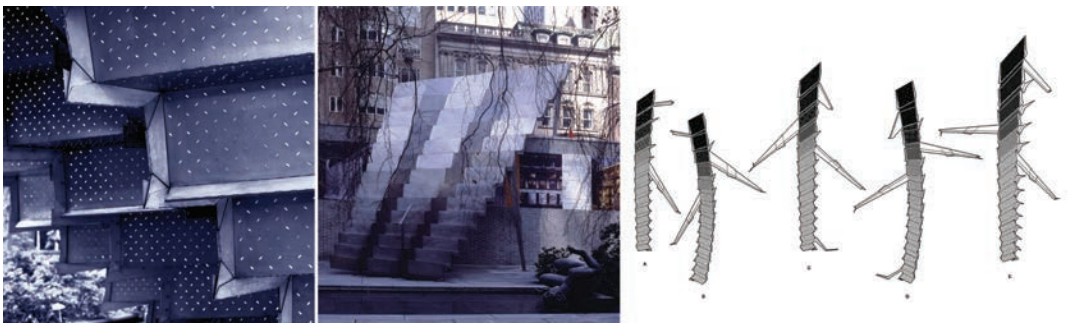
The projection of external figures and forces onto architecture is nothing new of course. The petrified aqueous surge of Ledoux's Saltworks in Chaux (Figure 15.5) is a reminder that even the most tectonically integral of details such as the triglyphs of the Acropolis (Figure 15.5) are but mere figurative projections onto the body of architecture. However, the narrative they produce is a critical part of what we inherit in tectonic thinking: effectively, that the expression of architecture is always in tension with the performance of its structural, material, and constructive parts. If this is seen as a liability, then I will argue that this is precisely the power of figuration in the arts, whereby the simultaneous presence of semantic and performative attributes contributes to a complex narrative not reducible to the pure claims of a moral high ground. Still, what is maybe most important about the Laszlo Files is that the clad figure and the body's digits are being interpreted as two different entities, where the first can be seen as an external projection onto the architectural artifact, and the latter is seen as a projection of its metrics, as constraints, onto the body of architecture itself. The Gwangju Biennale Cube (Figure 15.4) presents such a hybrid, whereby the position of the body in variable states of repose are called on to create a liquid surface, whose geometry evades precise semantic claims and only establishes momentary conditions of ergonomic comfort in an otherwise continuous surface. The continuous surface masks what is hybrid accumulation of furniture types, here fused together as chaise longue, bench, chair, among other such categories. By concealing the seams between each object type, we are able to reconcile them into an organic whole, erasing typological and semantic differences entirely. In turn, the use of a singular material allows them to be brought into unison, both symbolically, and ergonomically.



15.5
Triglyph (Left); LeDoux's Saltworks (Right). Rosengarten, 1898 (Left); Courtesy of Connie Dekker (Right)

THE FIGURATIVE OBJECT: THE MEANS AND METHODS BEHIND ARCHITECTURAL PROTOCOLS

While traditional interpretations of architecture conventionally revolve around the scale of building, landscape, and urbanism, the architectural invariably somehow insinuates itself onto the 'object' – be that the object of sculpture, installation, furniture, or even more intimately aligned with the body, that of clothing. What is of importance in this change of scale is not always the size of the artifact itself, but an understanding of the discrete forms of production that lie behind the fabrication of these realms, what is referred to as the means and methods of construction in architecture. Insofar as the design discipline is invested in its design intent, I would argue that if the discipline wishes to lay a claim on the integrity of its deployment, then it must also produce a process that guarantees a precise mode of fabrication that is aligned with its intent. In part, this requires of the architect a deeper understanding of materials, their methods of assembly, the trades that produce varied systems, and the actual labor involved – the sum total which comprises the means and methods.



15.6
Fabrications. Office dA. Courtesy of NADAAA

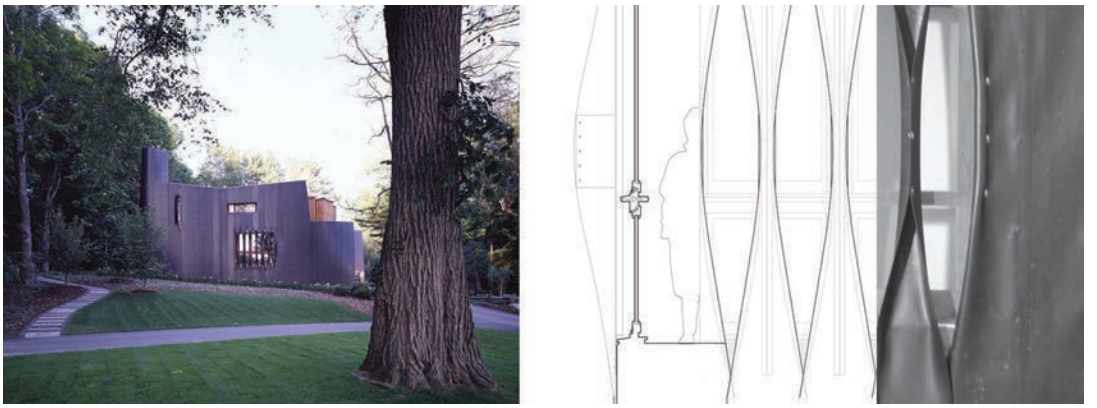
15.7
Immaterial/Ultra-material. Nader Tehrani. Courtesy of NADAAA

While it is assumed that the means and methods of architecture emerge from within the discipline – in the arena of casting, welding, millwork and other such trades – some of the more speculative forays into inventive terrain emerge from the transposition of one discipline onto another. In the context of the installations at MOMA and Harvard's GSD – Fabrications and Immaterial/Ultra-material respectively (Figures 15.6 and 15.7) – techniques of the sartorial were adopted to find ways of creating a meaningful relationship between that which clothes the body with that which clads a building. Insofar as clothing is possibly the most intimate scale of architecture, sheltering the body as it were, its confrontation with fabrics, and its requisite methods of pleating and darting suggest innovative ways of translating its thinking to the architectural scale. For the Fabrications project, we had the opportunity to work with steel in non-standard ways in the early days of digital fabrication; in trying to evade predictable assemblies composed of stock extrusions such as I-beams, angles and channels, we proposed a folded structure whose origami-like composition could offer it structural stability through its own geometries. Given the limitations of sheet steel dimensions, this also meant that we needed to subdivide the installation such that the continuity that is intuited in its reading is actually fabricated out of discretized parts. As such, the subdivisions were concealed within the stringers of the folded plates, and in turn those very stringers served as the jigs to ensure tight tolerance for the folded plates wrapped around them. Most importantly, the folds were enabled by an offset laser-cut incision within the steel that allowed for a meticulous pleating pattern. If the body serves as a template for clothing, here the concealed jig serves as the installation's measure, and in turn, if the pleat helps to contour the body, the steel pleat allows for structural rigidity in the installation. For the Material/Ultra-material installation, a similar subdivision of panels was needed – this time because of the compound nature of the curvatures we had conceived. The curvatures corresponded to three conceptual segments of the site: the guard station, the threshold and the column wrap. For a single surface to navigate this complex geometric terrain, we strategically elected to conceive it through a developable surface, hence adopting darting to create conical derivations of the ruled surface. Interestingly, the combination of wood laminate and the darting process produced its own dynamic of strengths and weaknesses, depending on the grain of the wood, and the orientation of the darts. Here, the figurative is invoked not only in the body's connection to the sartorial techniques that facilitate the installation's conception, but also in reference to the organic body of the installation itself composed of a continuity of smoothed tessellation.

THE ARCHITECTURAL ENCLOSURE: THE RECIPROCITIES OF SPATIAL AND FORMAL FIGURES

As the scale of design increases, so too does the complexity of parts that constitute the fabrication process. The building's tectonic systems, differences between interior and exterior finishes, varied performance criteria and basic conventions begin to insinuate themselves on the body of a built enclosure. To this end, it is also often increasingly difficult to maintain the level of fidelity to figurative strategies as they tend to get compromised by the very conventional systems that get imposed

onto them, fragmenting the singularity that a figure requires. To the degree that part-to-whole relationships matter in the conception of a figure, this also brings up interesting representational predicaments at the heart of this essay: namely, to what degree is architecture bound to communicate its content on the form of its body, what of the interior gets represented on its skin, and how do the organs of a buildings systems become registered in the morphology of the envelope? Even if history has already grappled with such questions, it remains a conceptual weight on the discipline today.



15.8
Rural House. Office dA. Courtesy of John Horner (Left); NADAAA (Right)

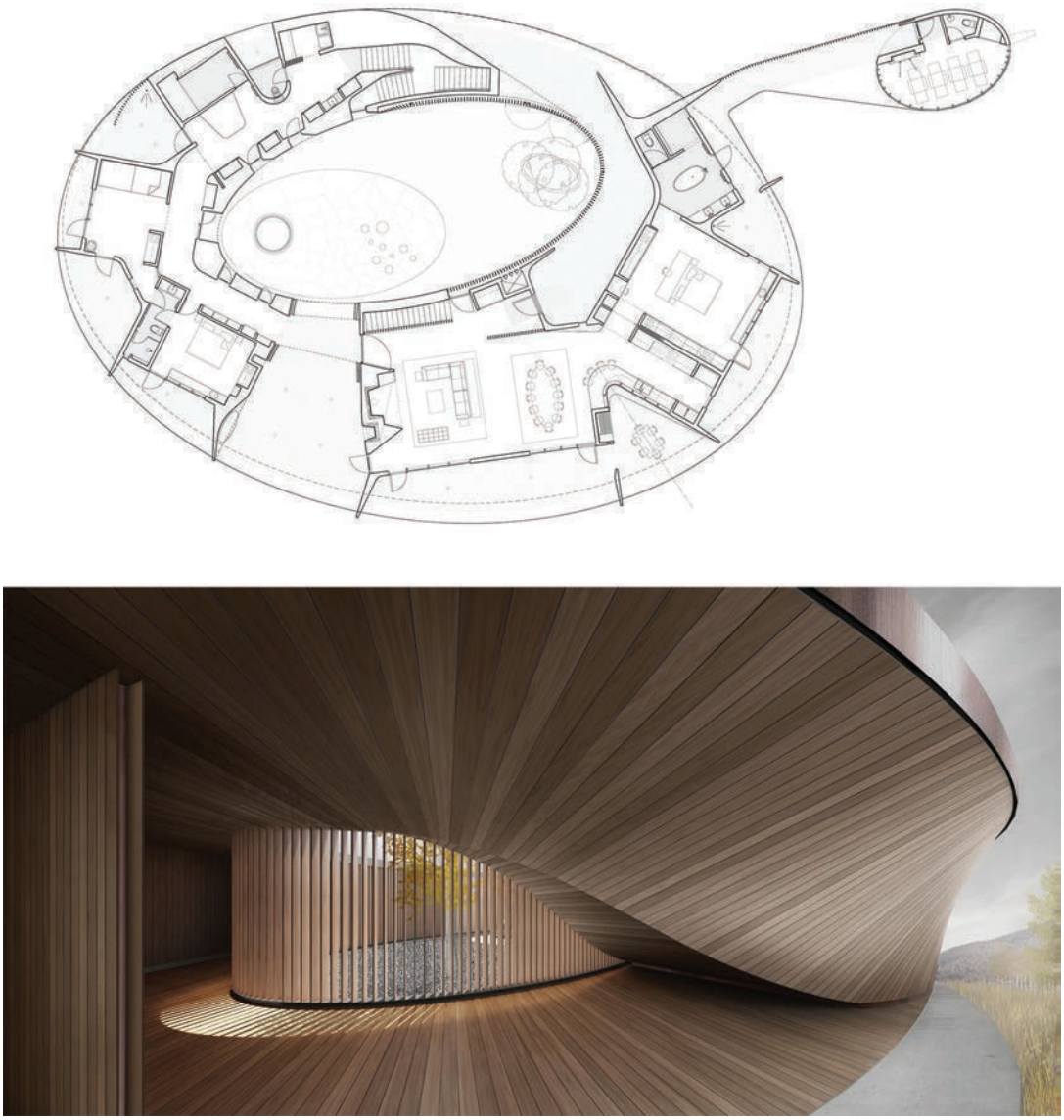
15.9
Tongxian Gatehouse. Office dA. Courtesy of NADAAA

In the context of the Rural House (Figure 15.8), we were able to sustain such a fidelity, in great part because of the disciplined transposition of a roofing system into a rain-screen façade. Adopting a striated rubber membrane system, we were able to run continuous ribbons of membrane over the ledge of the roof, allowing the water to drain down the elevation unfettered. As an extension of the sartorial exercises, this experiment leveraged the malleability of rubber as a plastic medium to mold around organic metal stirrups, whose function was to maximize the views through what are otherwise conventional windows looking out from the interior. Here, the agency of materiality defines the figurative potentials of the building's body, and in turn its language. At the same time, it is primarily a skin, shrink-wrapping a contained program, composed of a living room with a fireplace, and entry portal at the two extremes of the façade, both of which give more figural latitude to establish formal and spatial reciprocities between the program and its expression.

In thinking closely about the relationship between the body, the object, and the enclosure, our research on the stair as an object-type revealed to us a certain conceptual consistency that helps to advance this argument. This is explored in the Rural House, the Tongxian Gatehouse (Figure 15.9), the New Hampshire House (Figure 15.11), and Villa Varoise (Figure 15.10), as they all share a common trope: They adopt the anomalous spatial and sectional condition of the stairwell to sculpt and enclose the space as a legible figure. In doing so, they imbue a particular agency to the stair as an instigator of both spatial and symbolic form. To begin with, they are all observant of a salient spatial quality that only a stair can produce: Its diagonal organization produces a residue of space both beneath the stair, as well as above, where headroom is required. To the extent that architecture is not driven by necessity alone, the figurative impulse frames the peculiarity of this space for the exploration of morphological invention, and in turn, finds ways in which the stair is able to be indexed onto the enclosure of the building. In observing the condition of the residue in the Rural House, the stair and corridor are planimetrically overlapped to share the same zone, and in doing so, effectively configure the stair in the space of the envelope, telegraphing its enclosure onto the exterior of the building, however allusively. In the Tongxian Gatehouse, a similar sharing of stair and

15.10
Villa Varoise. NADAAA. Courtesy of John Horner (Left); NADAAA (Right)

corridor zone collapses the circulatory sequence into a figure-eight pattern; while the body's motion is indexed in the enclosing faces of the interior, it also reveals itself at the destination atop the building, where the envelope molds itself around the architectural promenade. In the New Hampshire House, the elliptical morphology of the courtyard house is culminated by a stair, whose ascent to the roof offers unmitigated panoramic views onto the Presidential Mountian Range. The underbelly of the stair takes advantage of two architectural opportunities: First, to use the residual space to create a monumental portal into the house; and second, to translate a New England vernacular cladding system (the vertical tongue-and-groove) into a contemporary configuration whereby the main enclosure of the façade is called on to migrate from wall to ceiling by way of the ruled surface. Here, the body of the



15.11
New Hampshire House. NADAAA.
Courtesy of NADAAA

stair establishes the metrics of the stair–riser relationship, while the dimensions of the wood siding defines the parameters of the ruled surface. Metaphorically, the reciprocity they offer is less hand-to-glove and maybe more hand-to-mitten, allowing for a loose fit that is yet attendant to the problem of formal registration between the interior organs and the exterior expression. Finally, in Villa Varoise, another rendition of the same stair is adopted as a hinge on two corners of the house, conjoining the upper and lower plans into a continuous donut. Similar to the New Hampshire house, the staircase on the northeast corner of the house forms a critical juncture of arrival: It mediates the sloped topography of the site by lifting the upper level over the lower, and using the stair itself as a structural pylon for the upper wing of the house whose main façade serves as a beam cantilevering over the continuous landscape below. Here, the envelope is no longer conceived as a shrink-wrapped condition, but rather as the raw matter of architecture: The structure is the envelope itself. In turn, the grained registration of board-forming for the formwork serves as an index of the structural geometry at work in the building. In all cases, these stairs do not serve mere circulatory functional purposes; rather, they emerge as protagonists, offering a trigger for creating a critical link between the body in motion, the object to be specified and the enclosure to be formed.

THE DIGITAL FIGURE

In closing, I return to the main prompt of the book and its challenge to bring the body, the object, and the enclosure into critical conversation. While I have deliberately not yet focused on the digital, it must be underlined that the historical project behind figuration precedes contemporary technologies. As such, it underscores the way in which the arts can be motivated through two modalities: on the one hand, through the longue durée and a conversation with history; and on the other, through the instrumentality of a particular medium whose techniques prompt us to think differently because of the way they allow for different forms of intellection. In part, the work presented here attempts to bridge this false dichotomy by bringing long-standing debates into conversation with emerging means and methods of production, but also in looking closely at the protocols of production today to see how they might redirect historical thinking altogether.

If the quest for the real in sculpture adopted nature as its foundation, it is because it had the human figure as a model from which to probe questions of representation. In architecture, I would argue there is no 'natural' foundation: The architectural discipline emerges from a discursive moment where acts of design and building slowly evolve into a state of self-consciousness, demonstrating the artifice of representation itself. The 'real' of architecture is registered in the contingencies of the discipline, and how they impose themselves onto the discourse. In the context of this article, I have only referred to a few conceptual terms: the presence of type, material agency, the structure as catalyst, the architectural promenade, the relationship of form to content, among other things, none of which emerge from nature as such.

Accordingly, in confronting these discursive disciplines, much of architectural pedagogy has evolved around the principle of visual literacy, effectively connecting

ideas with techniques to create form, space and material; in turn, to the degree that forms, spaces, and material have the capacity to mobilize ideas through their own agency, pedagogical models revolve around critical methods to bring them into discourse. At the same time, it must be underlined that the discipline has thrived for several hundred years almost single-handedly with a bias toward optics, composition and how architecture is formed through visual means. In effect, the means and methods of its representations have been visual whether drawing by charcoal, pencil or even the digital mouse in the context of software such as Rhino. The more interesting and critical transition that has occurred since revolves around the advent of computation, artificial intelligence, and the interface between the virtual and the physical, in great part because many of the initial protocols they are founded on are rooted in non-visual means – scripts and algorithms – such that the architect's traditional command over composition becomes secondary to the ability to navigate codes. More interestingly, it is the confrontation of the computational and the physical (the non-visual and the compositional) where the agency of this age comes to fruition. The figurative results of code are no less seductive, or meaningful, than that of the composed image; however, they do not rely on the authority of precedence, nor a visual model, but rather rule-based constraints whose parameters may become the source of both play and discipline. If that discipline is non-visual in the first instance, its impact on the figure is no less radical in the second.

The digital problematizes the project of representation in that it displaces its fidelity to the figure, foregrounding the importance of a generative process whose commitment to the figure no longer necessitates a faithfulness to the semantic regimes of years past – even if its byproducts may yield associations that cannot be controlled. In the context of this essay, the presence of the body and the stair are merely provisional figures whose presence in the discipline are demonstrative of this dilemma, and they demonstrate how the body is at once a visual and indexical register. If the index was conceptualized in a pre-digital era, then the digital contribution to the index was to systemically refine the modalities in which figurative constraints and outputs would become registered onto the body of architecture.

Endnote – Trajectory

Cradling Bodies: Trajectories of Minds, Objects and Enclosures

Dana Cupkova

Technology is a tricky thing. Tricky, because it camouflages its human roots with projections of superhuman precision and extra-human abilities. As such, it operates as our extension into the world, complicit in its transformation, knowledge making and unmaking. Technology carries different aspects of humanity, including our ignorance, bias or empathy, exacerbating our best and worst tendencies. The problem with technology is perhaps that it is too human; once beyond our control, it uses its power to turn the world around us into our own image. 'Nothing is stranger to man than his own image', claims science fiction writer Karel Čapek. In his 1920s play *R.U.R.*, the demise of the human race is caused by its own invention of biological cyborgs that render humans ignorant of their purpose on earth. *Robots* – a term coined by Čapek rooted in Slavic etymology, *robota* meaning forced labor — are creatures of synthetic matter, biotechnological humanoids that gain sentience and ultimately rebel against their enslavement and their human-imposed bad fashion of ambiguously crinkled suits. After the human race is killed off and robots must face survival on their own, the lingering question still remains: Did human design fail, or did Čapek improve upon the future of post-human resilience through another technological innovation?

In the century-long process of humankind humanizing nature, the power of our technology has asserted control over natural systems, and is finally reaching a breaking point. As Gregory Bateson states: 'The major problems in the world are the result of the difference between how nature works and the way people think.' Now the vengeance of the Anthropocene is looming over us with an ever more increasing threat of violence. In this reality that has been forced upon our generation, not unlike that of the R.U.R. uprising, we are in a race to avoid the imminence of death while attempting to lend a soul to our machines in the hope that humanity can design a way into the future. It is this state of crises that inspires new identities in design, new forms of designed naturalities, or object characters that go beyond the 'robots as functions of man' (Čapek, ibid.). Herein lies the trajectory of design thinking – as we move away from nature metaphors and image appropriation, we expand to embed different forms of communication, new layers of meaning, into the objects and environments around us.

The trajectory of *Digital Fabrication in Interior Design: Body, Object, Enclosure* engages the effects of technology's poetics and pragmatics on style, materiality, formal language and spatial concepts. It brings forward innovations with ambitious

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narratives of the body, its corporal interiorities, or material and behavior transfers while engaging machinic automation and computational ubiquity. Technological frameworks in these projects are not applied; they are situated deeply within the work. They are not demonstrative of technological capabilities; but rather effortlessly absorbed in the socio-technological design thinking. When – within a cognitive landscape of design – we start seeing technology as fundamentally connected to other intrinsic natural processes, our horizon shifts. We might begin to see the role of designer not so much as a problem-solver, but in more general terms as orchestrator or composer, as redirector of energy and shaper of matter, tuner of machines, transcriber of code – with sympathy for the future without a singular solution.

In the effort to engage entanglements from resources to experiences to object-making, my work has affinity for episodic connectedness across scales. With a focus on waste and energy streams, the projects I engage with feed off of constructing cognitive pathways from landscapes to enclosures to prototypes, situating design as continuous material and ecological process. As computational processes profoundly impact our understanding of the world, they precipitate new forms of awareness, empathy and interactions with the built environment. The ambition of my work is to make architecture that inquires into embodied energy as a primary inspiration for the formation of matter, while acknowledging material pathways and behavioral potentials. By resituating design within a hyperlocal framework of material resources and linking the process to anthropogenic lifecycles, architecture becomes a vehicle for ecological and communal restoration. Promoting a shift away from purely data-driven rationales, my work hopes to engage with environmental ethics and sensory subjectivities as part of our collective aesthetic and ecological experience.

Environmental aesthetics and aesthetics of nature are branches of philosophy that study appreciation of the world at large as it is constituted not simply by the particular objects but by environments they are conceived from. Environmental empathy is rooted in concepts of otherness and difference. Design grounded in environmental empathy leads to more diverse paradigms in the redistribution of resources, new forms of co-shared domesticity, as well as social equity within our collective urban space, while becoming closely entangled within its socioecological functions.

The two projects included here are positioned within an expanded field of architecture as it relates to ecology and technology, bleeding across traditional didactic precincts. Here, architecture, while physically static, is situated as a reactive form in which computational models, simulation techniques and digital prototyping are used to advance the built work and draw connections between space-making and its contingency on invisible forces. Interrogating ways that architectural shaping can support different forms of collective behavior through spatializing temperature and sound, these design investigations engage non-figurative drawing in a description of architectural systems to understand thermodynamic behavior and a larger set of multidimensional relationships. Drawing connections between human occupancy, engagement, perception and physiological well-being, the intention is to design spaces tightly linked to the creation of biosynthetic or naturalized environments that more diversely shape our collective experiences within small-scale enclosures.

Structured as two trajectories of Inside-Out and Outside-In, *Sentient Concrete* and *Vaulted Acoustics*, respectively, are projects that trace design approaches using sourced data sets relative to our individualized perceptions of thermal comfort and shared acoustic spaces, working towards a more individualized cradling of bodies through architectural shape-making.

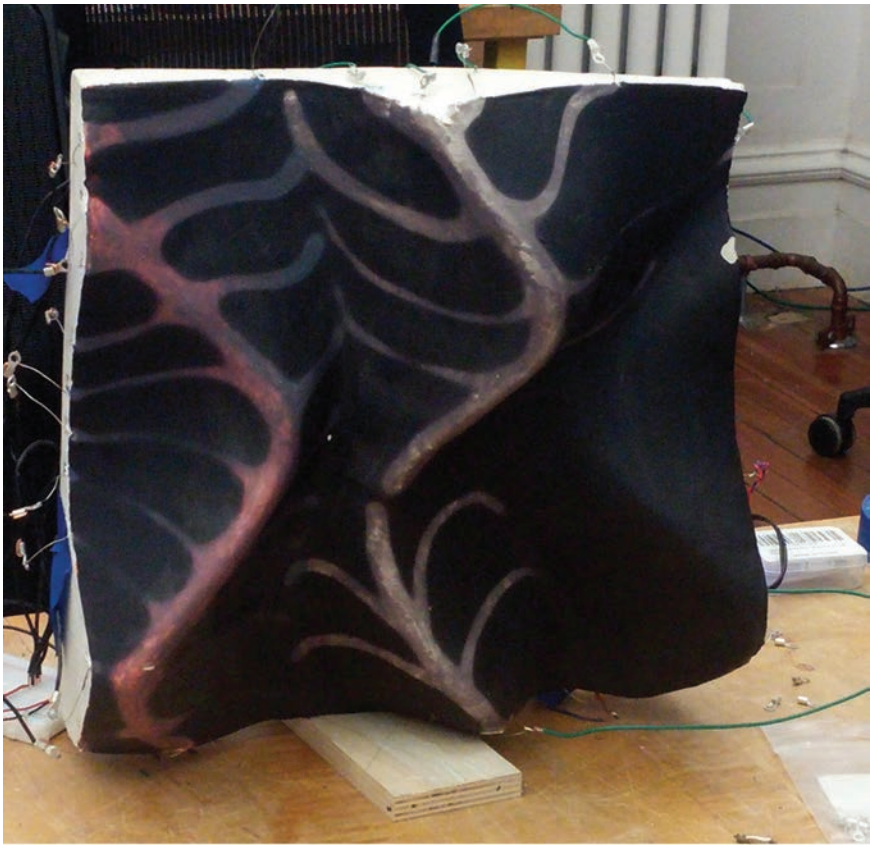
INSIDE-OUT: CORPORALITY OF COLORS AND MINDS

Enclosures could operate just like living systems, change color and self-regulate temperature while balancing human and environmental needs. This responsiveness of body to mind, adaptive spatial change to subjectivity of perception, set up a framework for what we named a *psychosomatic architectural response* (Byrne and Cupkova 2019). We are interested in new forms of corporality that draw connections between energy and human emotiveness, and that propose different forms of embedded material responsiveness. This project proposes to design architectural enclosures that effect connectedness of subjectivity, thermoregulation, aesthetics and energy usage.

Temperature is energy, and energy is both empirical and perceptive. The *Sentient Concrete*, a material research project conceived in collaboration with Daragh Byrne, is a wall panel prototype that uses embedded computation and digital fabrication to actuate temperature and thermochromic color change in real time, in response to human thought.

The ambition of this project was to introduce thermodynamic communication between human physiology and the building interior, shifting the definition of thermal comfort away from engineering industry standards. Desire for uniformity in mechanical systems performance within buildings does not allow for adaptive subjectivity in the distribution of heat or cooling. Different people from different cultural contexts typically perceive the same thermal condition in diverse ways. A psychosomatic systems framework intends to redirect the design of mechanized building systems by way of architecture's capacity to trigger and respond to subjective perceptions of thermal gradients. Perhaps we can think of this as architecture behaving as a *mood ring*, sensing the presence of bodies, offering to renegotiate a sense of individual and collective perceptions in lieu of a singular spatial and thermal average norm. Currently, the ASHRAE TC standard defines thermal comfort relative to the metabolic rate of a 40-year-old white male, enabling the architectural mechanical systems to bias our experiences relative to gender, age, race or cultural identity (Karjalainen 2011). In other words, architecture really does not care who you are or how you feel.

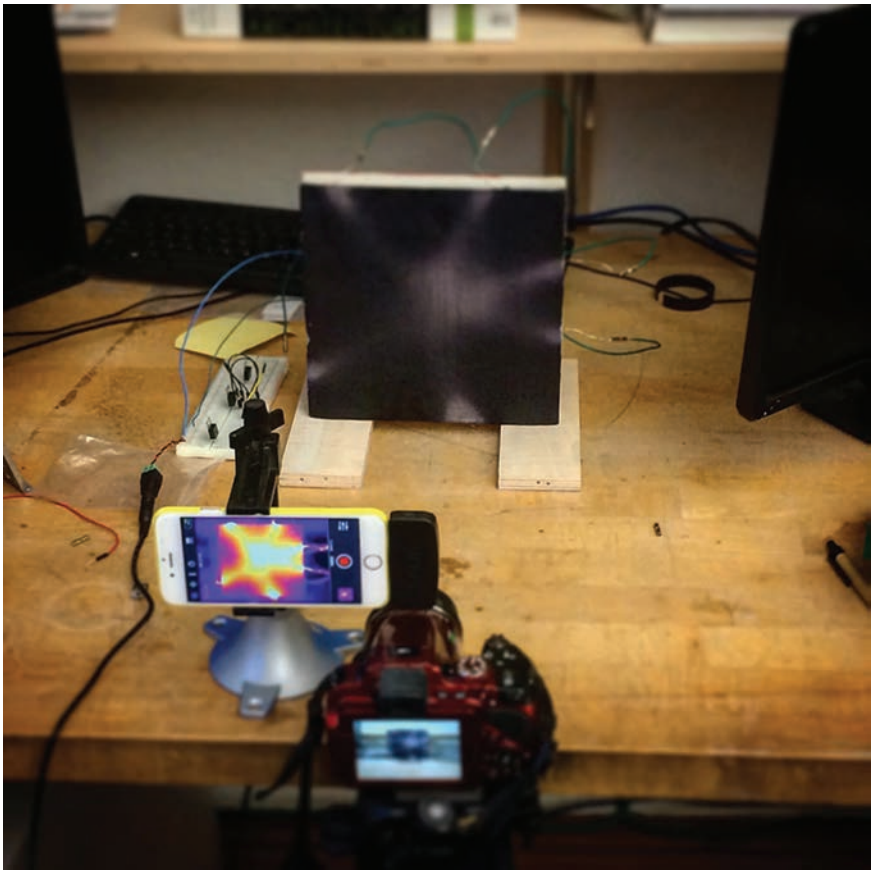
Inspired by the scientific framework interested in bodily changes triggered by emotional experiences, the intention of *Sentient Concrete* was to demonstrate a potential to draw literal pathways between material expression and neurosensorial feedback, using brainwave signals (Kainerstorfer, Sassaroli and Fantini 2014) to actuate material change. The *Sentient Concrete* panel combines the passive and active radiant behavior of heating from within with cooling passively. Surface figuration is coupled with effects of passive convection that can speed up or slow down the effect of heating and cooling using geometry, and is



E.1
Sentient Concrete Panel showing real-time color pattern change reactive to surface temperature. Panel actuated by a combination of its geometry and an embedded electromechanical radiant system that can dynamically produce localized thermally reactive and thermochromic responses relative to different conditions in space. Project and Design Lead: Dana Cupkova and Daragh Byrne. Project Team: Dan Cascaval, Josh Kim and Ammani Nair. Project supported by Carnegie Mellon School of Architecture, Margaret B. Gruger Award and Fund for Research and Creativity CFA.

indexed through the surface thermochromic layer (Cupkova and Promoppatum 2017). Embedded electromechanical systems within the body of a panel enable directed communication based on relationship of material mass, biofeedback and sensed human brainwave.

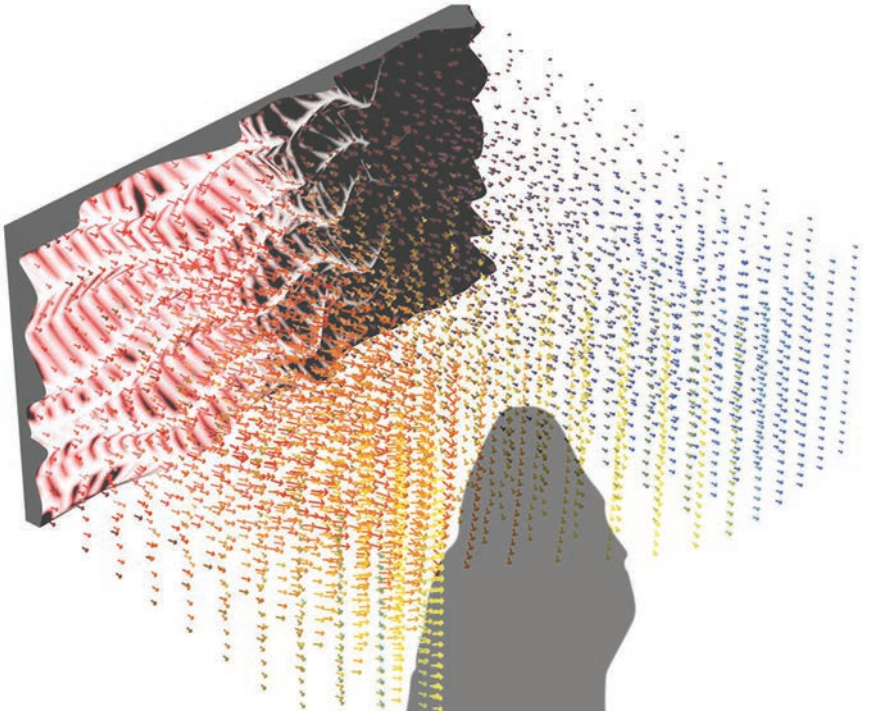
The article 'Bodily maps of emotions' describes monitoring topography of human emotions mapped onto the temperature gradients of human bodies, positing that our emotions have a corporal temperature scale, so 'we experience emotions directly in our bodies' (Nummenmaa et al. 2014). This work represents a potential bridge between the cognitive, perceptual and thermodynamic, through architectural enclosure. Enclosure might care about overstimulation or understimulation of human sensory experiences, and can relate to aesthetics of spatial experience. Spatial stimuli have been linked to changes in breathing, increased heart rate, and changes in pulse and blood pressure (Mahnke 1996). Environmental



E.2
Thermochromic temperature actuation experiments in concrete panels showing the relationship of color range change. We can activate surface temperature by sensing human presence and link surface visual effects to an emotive human response, thus creating a new form of communication between the environment and the human perception of thermal and physiological. Project and Design Lead: Dana Cupkova and Daragh Byrne. Project Team: Dan Cascaval, Josh Kim and Ammani Nair. Project supported by Carnegie Mellon School of Architecture, Margaret B. Gruger Award and Fund for Research and Creativity CFA.

under-stimulation has been linked to restlessness, irritability and difficulty concentrating. Instead of what would be a futile effort to give architecture a soul, we are hoping to make it care.

Parallel to an emergence of interdisciplinary applications that engage building systems within the 'internet of things', this project attempts to resist the positivist attitude of pure responsiveness to data representation. It does not presume that, by having access to the 'right' actionable knowledge, will we act accordingly, all ethically bound to improve the world and reduce our energy consumption. It hopes instead for more agile forms of collectivity, those that acknowledge our differences to create spatial frameworks that carry temporal traces of our individualized imprints in space. Allowing for a collage of collective thermal moods to form unexpected tapestry of our emotive histories is more in line with Krueger's



E.3
Digital and physical model using point cloud mesh of surface topology embedded with geometries of thermal pathways to be programmed independently or relative to human proximity. Project and Design Lead: Dana Cupkova and Daragh Byrne. Project Team: Dan Cascaval, Josh Kim and Ammani Nair. Project supported by Carnegie Mellon School of Architecture, Margaret B. Gruger Award and Fund for Research and Creativity CFA.

E.4
Digital and physical model using point cloud mesh of surface topology embedded with geometries of thermal pathways to be programmed independently or relative to human proximity. Project and Design Lead: Dana Cupkova and Daragh Byrne. Project Team: Dan Cascaval, Josh Kim and Ammani Nair. Project supported by Carnegie Mellon School of Architecture, Margaret B. Gruger Award and Fund for Research and Creativity CFA.

definition of 'responsive environments', where 'experience is controlled by a composition which anticipates the participant's actions and flirts with their expectations' (Krueger 1977).

Transcribing biometrics and emotiveness onto the architectural substrates has the effect of individualized thermoregulation by locally activating the surface temperature in buildings; this offers a different model of spatial collectivity. Just as complex geometries can be used to improve both the aesthetic and thermodynamic performance of passive heating and cooling systems, they can be used as a design strategy to define new forms or typological collectivity, further flirting with Banham's conceptual bond between fire and architecture within the interiority of our building landscapes (Banham 1984, 18).

OUTSIDE-IN: ENCLOSURE OF SOUNDS AND BODIES

There is a whisper meant just for you, that you can hear despite the crowd. Or maybe, by chance, it bounces off and subtly transforms its meaning, just like in a game of Chinese whispers. It travels to them, as they sit alone at the small table, softly muted by geometry of hard surfaces all around. To walk into SenYai is to walk into the acoustics softness of many.

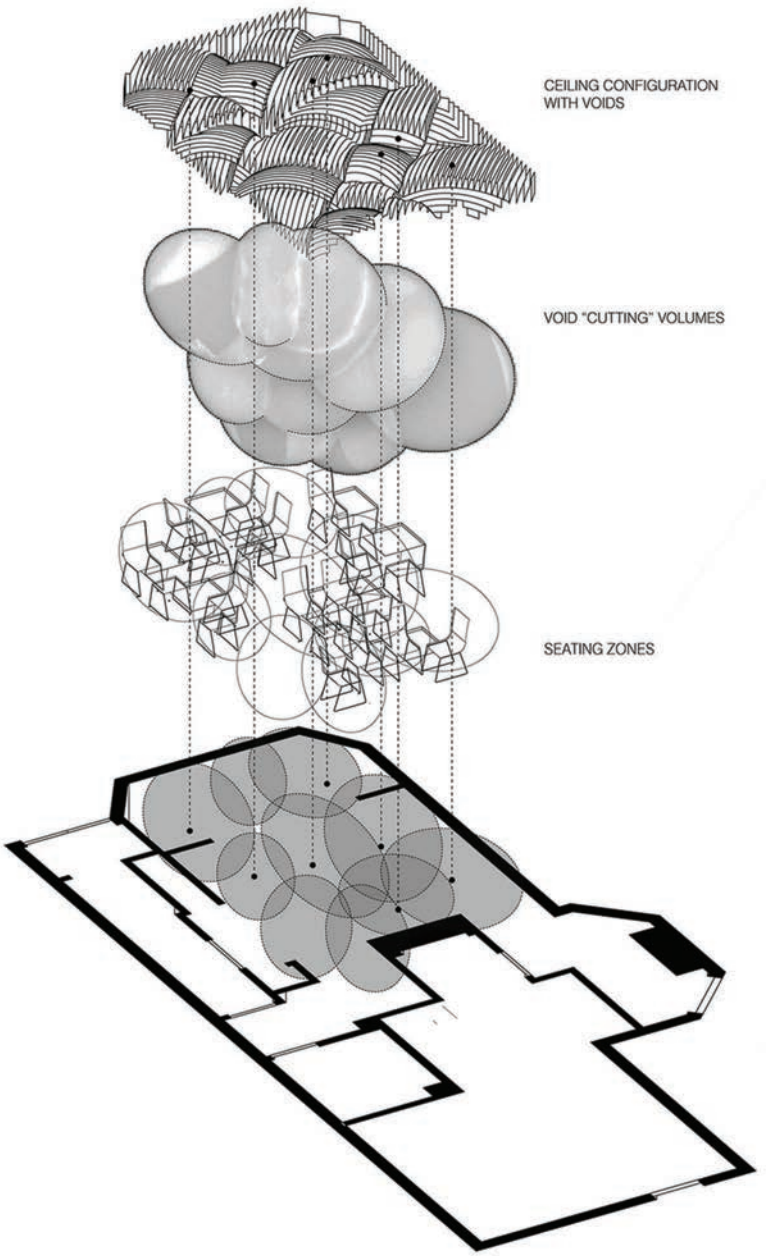
The history of acoustic spaces is excitingly vast, engaging ancient caves, elevated spirituality and gossip alike. From rogue echoes to the architecture of eavesdropping and whispering walls, the explicit use of surface geometry has never been more enchantingly exhilarating than in that moment when we hear the faraway words, whispered to you by vaulted cupola, words you were never intended to hear. From 1673, since Athanasius Kircher's writing on echoes and his *Phonurgia Nova* diagram of elliptical ceiling codification of sound ray reflections, the scientific approach to acoustics in architecture has primarily focused on finding the ideal position within the geometry, a singular position to be best heard from, elevating one voice above all others, from pulpit to musical maestro. Associated with Baroque aesthetics, grandeur and status, the use of sound reflections in large, sacred buildings transformed architecture into an acoustical instrument. Using what is now common knowledge about the acoustic behavior of curved surfaces, the *Vaulted Acoustic*'s ceiling geometry is about a collective commonality. It intends to uphold many instead of one, weaving words, smells and tastes together. This project experiments with transposition of foci-based geometry to afford the possibility of a series of uninterrupted conversations within intimate proximity to each other. It strives to find a collective multiplicity of parallel conversations in a small space, rather than prioritize a single position within its spatial hierarchy.

SenYai is a small 340-square-foot restaurant dining space, aspiring to create a unique atmosphere in the developing urban district of Pittsburgh. The ceiling, inspired by the vaulted geometry of ancient Thai architecture, is designed to enable a collective social experience while simultaneously supporting the individualized acoustic privacy of a quiet conversation. The effect of acoustic softness is achieved by coupling ellipsoid geometry with standardized cost-effective flat-sheet material. S*patial experience produces a soft ambient effect through* visual layering of the ceiling fins, suggestive of movement while reducing the reverberation of sound in

E.5
Interior view of SenYai. Design Lead: Dana Cupkova. Copyright: Epiphyte Lab, LLC. Project Team Lead: Gretchen Craig. Project and Fabrication Team: Maranatha Putu Dawkins, Colleen Clifford, Sinan Goral, Tom Sterling and Trent Wimbiscus. Photography Credit: Massery Photography Inc.; CNC fabrication supported by dFab Lan at the Carnegie Mellon School of Architecture.

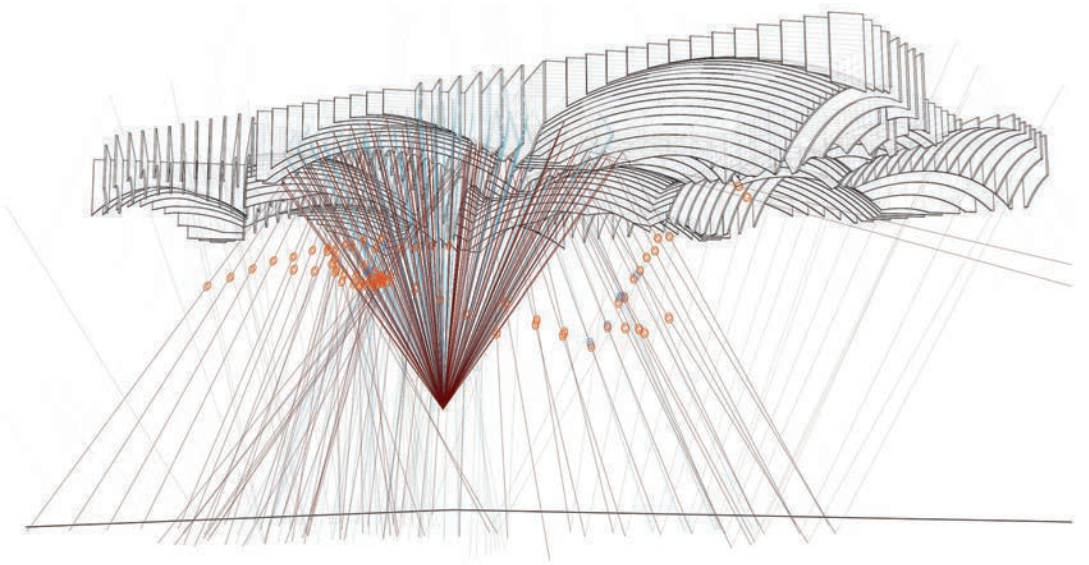
individual vaulted zones. This allows for localized acoustic privacy within the overall dynamics of the space. The ceiling acts like a giant spatial diffuser.

The acoustic diffusion of global sound occurs through the varied depth of each individual double-curved vaulted zone. The ceiling structure is formed by 275 unique vertical slats, which changes sectionally in the perpendicular direction through a series of irregular planometric rectangles – so no two slats, and no two vaults, are alike. Composed as a non-uniform diagrid, the reflected ceiling plan allows standardization of highly varied component-based construction into a very rational installation sequence. The global texture of the surface and color plays with light to create a sense of spatial weightlessness and visual expansion, as the eye travels beyond each articulated edge. At the same time the slats appear as a continuous surface, mimicking an active body of water, or, in homage to the restaurant's name – Sen Yai, which translates to 'big noodles' in Thai – a bowl of hot noodles in broth.



E.6
Organizational strategy using irregular diagrid layout mapped onto elliptical space bubble geometry coupled with raytracing simulation of slotted ceiling fins. Design Lead: Dana Cupkova. Copyright: Epiphyte Lab, LLC. Project Team Lead: Gretchen Craig. Project and Fabrication Team: Maranatha Putu Dawkins, Colleen Clifford, Sinan Goral, Tom Sterling and Trent Wimbiscus. Photography Credit: Massery Photography Inc.; CNC fabrication supported by dFab Lan at the Carnegie Mellon School of Architecture.

The computational surface of each pure ellipsoid within the series of the ceiling diagrid is materialized through a series of diagonally cut slotted fins that mitigate sound reflections in the space related to high-frequency sounds. The fins increase the area of the elliptical surface to maximize the number of sound reflections, trapping them sectionally within their depth and thus holistically performing as a spatial diffuser. As each bay within the diagrid has a varied size and depth, each bay produces a different frequency of reverberation, making the global diffusion more pleasant, cutting off high frequencies (high noise levels) in the space. The intention

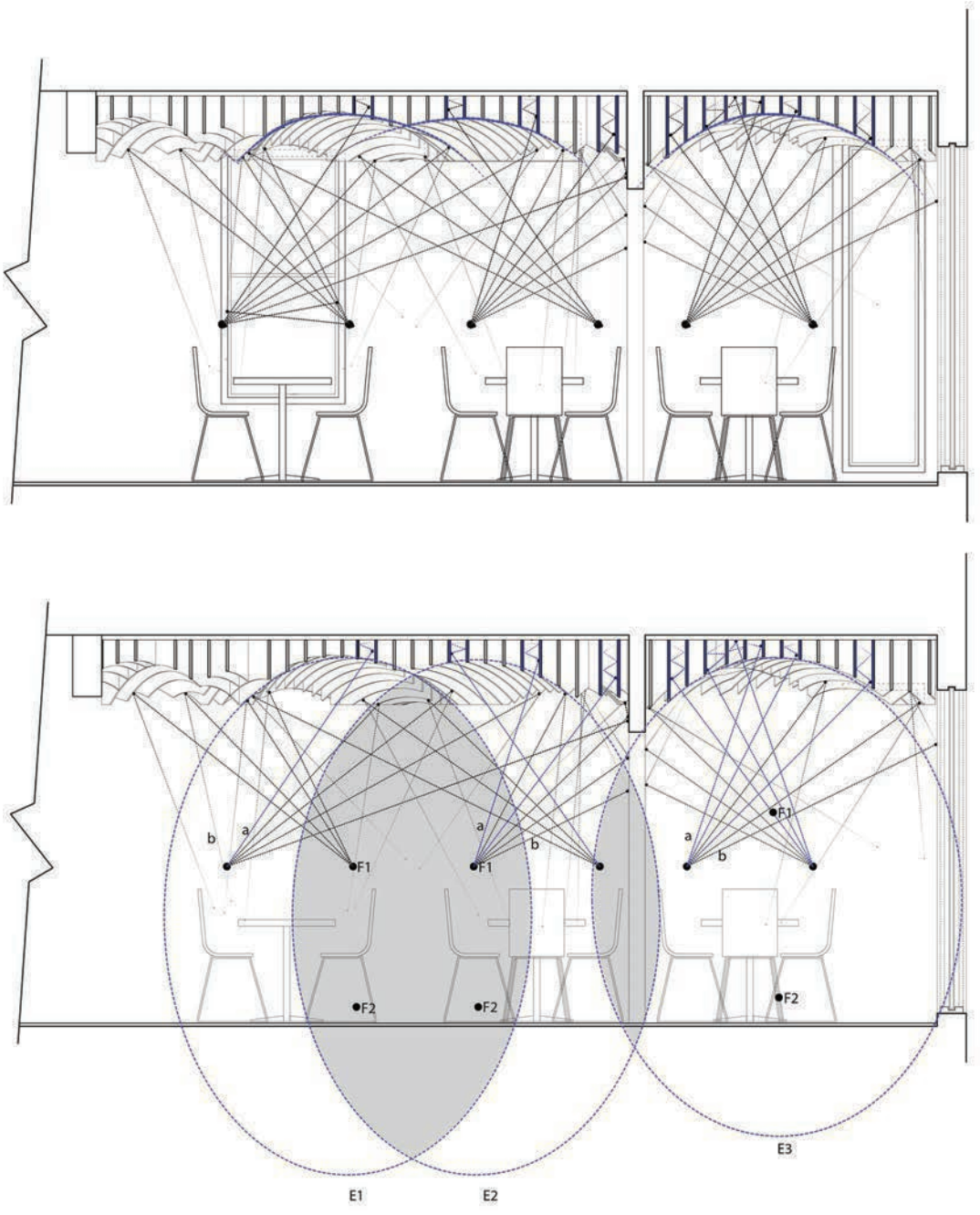


E.7
Organizational strategy using irregular diagrid layout mapped onto elliptical space bubble geometry coupled with raytracing simulation of slotted ceiling fins. Design Lead: Dana Cupkova. Copyright: Epiphyte Lab, LLC. Project Team Lead: Gretchen Craig. Project and Fabrication Team: Maranatha Putu Dawkins, Colleen Clifford, Sinan Goral, Tom Sterling, Trent Wimbiscus. Photography Credit: Massery Photography Inc.; CNC fabrication supported by dFab Lan at the Carnegie Mellon School of Architecture.

was to create a geometry that would both act as a holistic sound diffuser throughout the small room with the potential to direct the localized sound intensity towards the elliptical foci, and cut off the fall-off of sound towards the neighboring zones. Hence the depth of the fins varies, thinning towards the top vertex of the ellipsoid and thickening towards its edges. The scalar variation along the collective ellipsoidal geometry produces a series of sound effects dispersed along the larger space.

Historically, double-curved vaults were used to create echoed reverberation effects with a series of successive reflections on hard, smooth surfaces. In this case, we are using geometry to simultaneously reflect and diffuse the sound to effectively soften the acoustic spatial quality. The slotting geometry eliminates the echo effects that would be otherwise produced, while still allowing for a concentrated privacy of sound within the loose boundaries of a three-dimensional bubble. The relationship of the global geometry to the variation of the surface subdivision allows for both: easy digital fabrication through the use of CNC technology, as well as tighter coordination of performative effects.

Both of these projects embrace the design as an act of cradling care and spatial tension, combining traces of data set within mundane static materiality. Less interested in automation, and we embrace strategies of shaping and reactivity as a form of spatial communication. The ever-increasing emergence of embedded computing, sensing and biotechnology is concurrent to the discussions on post-humanism, discussions that often parallel the history of science fiction. There is a need for disruption of our industrial technologies of making in order to naturalize



E.8

Utilizing three-dimensional ellipsoidal vaults, the ceiling geometry supports a sense of individual presence within the small collective space and creates a localized effect of privacy while diffusing sound through the dynamic character of geometry. An ellipsoid is a double-curved surface that, in its idealized version, concentrates the direction of the sound to travel back to the foci points at which the table is located. Design Lead: Dana Cupkova. Copyright: Epiphyte Lab, LLC. Project Team Lead: Gretchen Craig. Project and Fabrication Team: Maranatha Putu Dawkins, Colleen Clifford, Sinan Goral, Tom Sterling and Trent Wimbiscus. Photography Credit: Massery Photography Inc.; CNC fabrication supported by dFab Lan at the Carnegie Mellon School of Architecture.

humanity after it humanized nature to its breaking point. 'Do you think that the soul first shows itself by a gnashing of teeth?' asks Fabry of Helena as she pushes for R.U.R. robots to carry more and more resemblance of humanity, to have a soul. This seemingly familiar narrative engages the projection of technological evolution, poetically spatializing the demise of human existence. Technologies of making parallel the evolution of human thought relative to the environment. They are a critical toolset that enable the production or demise of particular cultures; mediate communication; sense and validate the invisible; and create tangible effects, new spatial intelligence and affective qualities. This work argues for the design of objects to engage processes of making and embrace the disruptions that carry significant consequences into our political landscapes of collective living.

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