Systole and Diastole: Multimedia Environments and Manifold Form

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In recent years, architecture has engaged energy. Increased access to sensing technologies, microcontrollers, and navigable processing languages has initiated a host of investigations into responsive architectures that react to differential energies. Liberated from the stasis of conventional construction and static notions of form, these experiments are redefining architectural space as variegated fields, which change with the environments they exclude and the bodies they contain. In a general sense, this research highlights an increased communicative capacity, connecting buildings, bodies, and environments in unprecedented ways. The ability to sense temperature, light, and position unlocks a field of forces surrounding architectural occupants that can be activated to produce fluctuating micro-environments.

Along these lines, we have been conducting research into responsive architecture that uses sensing technology to establish sensory links between different dimensions of a multimedia work. This research has manifested most recently in an interactive installation called *Veer* that involves sound, space, material, and light. Funded and presented by the Akademie Schloss Solitude in Stuttgart, Germany, *Veer* uses sensors to track position and trigger shifts in spatialized sound and light, activating the sensory pressures of the participant and amplifying the dynamic contours of a spatially variegated environment

The theoretical implications of this research are threefold. First, our multidisciplinary design process creates links between the sensory output of *Veer's* constituent mediums: architecture and music. By simplifying architectural and musical experience into base sensory stimuli (visual, sonic, and proprioceptive (sense of movement)) we are able to relate the effects of each medium and bridge the conceptual divide stemming from our differing disciplinary expertise (Adam Fure is trained as an architect and Ashley Fure is trained as a composer). The theories of philosopher Brian Massumi guide this work; specifically through his argument that design should create unique interfaces that relate various senses. In Massumi's model, *logics of form* are replaced with *logics of relation*, which guide the organization of sensory stimuli into emphatic experiential moments.

Second, *Veer* attempts to structure an aesthetic experience where subject and object emerge in a dynamic process of becoming. This approach looks to the work of philosopher Henri Maldiney, who in turn relied on philosopher Erwin Strauss' definition of experience as a mix of sensation and perception. For Maldiney, aesthetic experience is a play between varying attentive states that unfold in rhythmic relationships. Artists, by filling space with material intensity, structure this relationship, giving form to an experiential unfolding. In *Veer*, such rhythmic relations are designed through the productive interplay of conflicting temporalities from music, interactivity, and architecture.

Lastly, *Veer* provides an opportunity to reconsider notions of topology in architecture. From its introduction into architectural discourse in the late 1990s, topology has served as a geometric reference point aiding the theoretical basis of computer-generated, non-Euclidean, architectural form. Although canonic, such theories have limited topology's relevance in alternative domains of architectural speculation, elevating surface continuity above all other goals. *Veer*, as a variably charged, temporally multiplicitous, spatial and sonic field, demonstrates the benefits of thinking topology *spatially*. A *manifold*, a type of topological space and the working metaphor for *Veer*, is a multi-dimensional mathematical object representing all possible behaviors generated by the interrelated components of a complex system. *Veer's* variables of sound, space, texture, light, and color closely resemble the multiple dimensions of a manifold, while their interplay produces experiential effects that demonstrate the potential of a *spatial* architectural topology.

Each of these three theoretical lines serves to expand the discursive territory surrounding research into responsive architectural environments. The potential brought about by recent interactive technology is profound, affording opportunities to rethink one of architecture's most established conventions—its notion of form—as well as its relation to other mediums, and its capacity to enhance experience.

SENSATION AND THE LOGIC OF RELATIONS

As architect and composer, we share an acute interest in the aesthetics of material saturation and perceptual immersion. Solo attempts to engage these issues in our respective disciplines encountered limitations. Working within a single medium inherently limits multi-sensory depth. While speakers may surround listeners in a concert hall, and architecture may affect acoustic reception, rarely do these secondary layers match the impact of the primary. This perceived limitation prompted us each to seek out expertise from other fields. Though the conceptual basis for our collaboration was clear, the practicality of co-designing multiple experiential layers raised questions: how could we align our respective mediums without a shared technical vocabulary? How could we coordinate individual choices toward collective aesthetic goals? The relation of inside to outside, skin to structure, spatial compression to expansion—all the purview of architectural expertise—did not directly translate to sonic issues like timbre, frequency, and duration. We needed a common conceptual language to ground our collaborative process, one that eventually centered on sensation.

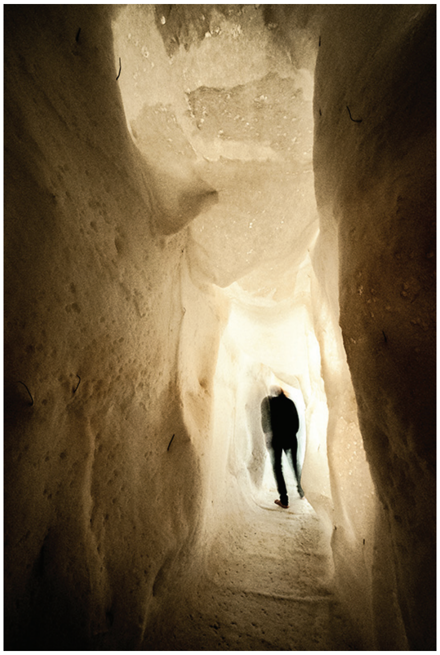

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Figure 1: A moment of 'compression' within *Veer*

Shifting away from concerns specific to our respective disciplines (language that was only superficially translated between us), we focused on the aggregate sensory experience to be felt by inhabitants of the installation. Sonic, visual, and proprioceptive cues were aligned in phenomenological moments of 'compression' and 'expansion.' The first compressed moment, for example, is created by a low ceiling that forces participants to crouch while passing through. Sharp intensifications of color and light punctuate this off-kilter movement and trigger a flood of thick noise projected from speakers (Figure 1) hidden just inches behind the material walls. Conceptualizing physical sensation as either 'compressed' or 'expanded' yielded myriad decisions informing sound (volume, frequency, duration, timbre, and gestural shape), space (changes in dimension and curvature), color (hue, tone, and coverage), and light (hue, tone, and brightness). Ultimately, we arrived at a new conception of design—one governed by logics of sensory relations rather than disciplinary logics of form.

The philosopher Brian Massumi, in a provocative portrayal of a Charles Sanders Pierce story, offers an account of sense experience instrumental to the logic of relations at work in *Veer* (Massumi 2000). As a thought experiment, Pierce asks his audience to imagine a cave in pure darkness with no gravity, filled with variable temperatures and smells (Pierce 1992). Devoid of vision and conventional movement, one floats through the cave sensing both their body and the environment in continual flux. In time, inhabitants begin to encounter various changes in smell and temperature. At first indiscriminate, the fluctuations begin to coalesce into recognizable patterns, a process Massumi describes as the movement from an undifferentiated 'smooth' space to a more structured 'striated' space, terms borrowed from philosophers Gilles Deleuze and Felix Guattari (Deleuze and Guattari 1987). Just as the thermal and olfactory gradients are coming into full focus, the inhabitant of Pierce's cave moves through a topological fold that delivers them, like a worm hole, to another cave, complete with its own mixture of unfamiliar heat and scent.

Using Pierce's cave as an analogy, Massumi posits a general theory of design based on the arrangement of sense data. For Massumi, the primary act of design is the uniting of senses in discrete emphatic moments:

In the course of a movement or an unfolding of an event, regions of experience overlap in a way that contracts them into remarkable, recognizable emphases. Each emphasis of experience selects different regions of experience or sense qualities or continua, overlaps them to different effect in variable emphasis and from that weaving together and overlapping, variations emerge into constellations and coalesce into more or less stable, re-accessible worlds of experience (Massumi 2000).

Designers select which senses will be addressed and activated and how those qualities will overlap with other senses.

The task is literally to bring forth a world of experience, to select from continuums of sensation, build in ways in which they can interact, overlap, reciprocally define each other in mutual emphasis leading to emergent, never before experienced forms, new constellations, forming a singular world of potential perceptions ... to design is to world, it's a worlding"(Massumi 2000).

Designers create worlds by organizing material qualities into memorable, emphatic moments. Massumi's notion of design as the correlation of senses calls for a *logic of relations* to replace a *logic of form*. Applied to *Veer*, this theory suggests that the internal variables of specific mediums—frequency, timbre, and duration in music or core, structure, and skin in architecture—must give way to a relational logic of sensory effects.

In *Veer*, sensors enable the logic of relations described above and bridge the gap between the temporal realm of music and the static realm of architecture. Fourteen pressure sensors are distributed (unseen) across the floor, detecting the position of participants as they move through the space. These sensors send binary signals (on or off) through an Arduino microcontroller to a custom software patch created in Max/MSP (an open platform interactivity software) that controls sixteen channels of audio distributed to sixteen speakers (hung and unseen throughout the space) and twelve RGB variable LED strips attached to the ceiling. Materially, *Veer* is constructed from polyester batting that wraps a branching steel structure, creating a soft, interior sleeve for a room twenty-seven feet long, nineteen feet wide, and twelve feet high. The space is roughly divided into five zones (referred to below as Zones A-E): a tapered entry tunnel on axis with the doorway (Zone A) leads to an open central space (Zone B) with three flanking tunnels; one short (Zone C), one long (Zone D), and one that leads back to the doorway (Zone E) (Figure 2).

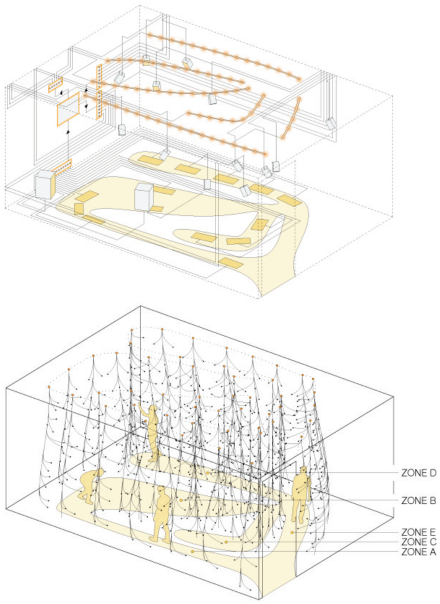

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Figure 2: Diagram illustrating placement of sensors and speakers (top) and overall placement of branching steel structure and spatial definition (bottom)

Physical characteristics in the material walls are mirrored in localized sonic responses that are triggered as participants move through the space. Layers of recorded noise are spliced and sculpted to exhibit different densities and degrees of harmonic warmth. Across the space, gradations in color move from near white to burnt orange and fuchsia (Figure 3). These changes are mapped to shifts in both the register (high/low) and spectral density of the accompanying sounds: blanched pale walls are linked with soft white noise; regions saturated with color emit thick multiphonic screeches. Speaker placement follows the curvature of the ceiling. At moments of spatial compression, therefore, sound projects from speakers just inches from the ears of participants. As participants rise into cavernous regions, sound recedes to speakers high above head-level. Throughout *Veer*, sensors modularize the temporal forms of sound and light and embed them within shifting spatial contours.

Indicated by the description above, each zone of Veer is characterized by a parsing, calibration, and alignment of its qualitative aspects—from material texture to sonic grain to spatial proportion—producing variegated sensory intensities akin to Massumi's 'emphatic moments.' By coalescing our intentions in terms of sensate experience we are able to combine our individual expertise into a hybrid design process governed by logics of sensory relation.

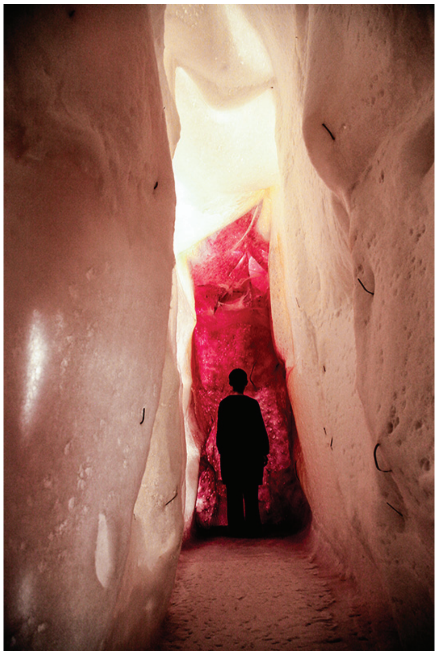

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Figure 3: Zone D

FORM AS FORMATION

Arguably more than any other art form, music exposes the subjective nature of temporal experience. As Susan Langer famously wrote, "music makes time audible," and the variability of its expression belies the stability of functional clock time (Langer 1953: 110). Yet for all the temporal gradations articulated through harmonic, textural, or melodic devices, western classical music traditionally follows a strict internal ordering—with beginnings, middles, and endings preordained by a composer and (relatively) unchanged from performance to performance. The listener is subjected to this precomposed dramatic shape with no input into the details of its formation.

Responsive environments, on the other hand, empower subjects to affect the temporal unfolding of events in a space. Through sensing technology, participants' actions can be mapped to material changes in a perceptual field. From more evident call and response mechanisms to the nuance of complex algorithmic alterations, such environments blur the boundary between subject and object and destabilize the temporal identity of conventional artistic forms.

Temporality in architecture is a more elusive topic, dependent on a myriad of factors external to the design of a specific building. Architecture is moved *through* more than looked *at*, rendering the specificity of structure, material, and space tangentially important to the formation of experience. Even in the context of a museum, where participants habitually attend to stimuli more slowly, the experience of a visitor varies greatly. Architecture—as an assemblage of spatial and material configurations—can encourage movement, but cannot limit it to a predetermined path. Formal markers common to music (such as beginnings, middles, endings, returns, proportions, transitions) may be suggested through the design of a space but cannot be forced upon perceivers with similar exactness.

A design that accommodates these temporalities—one highly structured by internal parameters (music), one marked by localized temporal connections (responsive environments), and one loosely defined by a series of obstacles (architecture)—must be guided by a conception of form that accommodates multiple, simultaneous arcs of change. The French philosopher Henri Maldiney, articulates a notion of form that assumes movement and change. For Maldiney, form is not defined by the legible contours of a discrete object, but rather is a dynamic process where form forms itself, its "autogenesis" (Bogue 2003: 119). Form is experienced in motion, a rhythmic cascade of sensation and perception that unfolds in time.

To describe the states of experience at play in form, Maldiney draws on philosopher and neurologist Erwin Straus' distinction between sensation and perception outlined in his book *The Primary World of Senses: A Vindication of Sensory Experience*. Straus' theory characterizes human experience as a movement between two fundamentally different states: sensation and perception. Straus describes the former as a primary, non-linguistic being-with the world, while the latter is a secondary organization of those sensations into preexisting systems of meaning (Straus 1963). To elucidate their differences, Straus offers two spatial analogies: geography and landscape.

Perceptual space is geographical, marked by clearly defined objects positioned in objective space and time. The landscape, on the other hand, is characterized by perspective and shifting horizons. One does not *know* their position in the world as much as they *sense* their presence within it.

For both Maldiney and Straus, human experience is marked by the emergent formation of subject and object in movement. The objective comprehension of space and time is never a default state, but rather a pole on a spectrum of experience that moves from non-rational sensation toward rational perception. Movement between these poles characterizes our experience of the world.

In aesthetic experience, artists structure movement through the design of formal and material intensity. According to Maldiney, this experience happens in three phases (Maldiney 1973). The first is a vertiginous revealing of the chaotic world of sensation: a non-lingual, visceral reaction to environmental stimuli that cannot immediately map to preexisting concepts and structures, a stage similar to Straus' sense world. The second phase is what Maldiney calls a systolic condensation of elements toward definite shapes, which can be likened to Straus' unfolding of world and self (Straus 1963). As one begins to articulate discrete boundaries and objects, a third phase, a diastolic eruption of force, dissolves those shapes. Systole and diastole are physiological terms that refer to the rhythmical contraction and expansion of the heart. In Maldiney's theory, these terms lend aesthetic experience a natural, cyclical movement wherein a primary, disorienting world of sensation converges (systolic contraction) toward recognizable shapes only to have those shapes open into (diastolic expansion) the sense world from which they came.

The pattern of this experience—the sequence and pacing of the three phases—defines an artwork's rhythm. In this context, rhythm does not refer to an external measure such as cadence or meter. Rather, the interplay of systolic and diastolic movements establishes the temporal framework of any artwork. Thus, designing form is not the delineation of shape, line, and color, but rather the structuring of an experiential field to be perceived in time.

Maldiney's concept of rhythm bears many resemblances to the experience of Pierce's cave described in the previous section. Both depict an emergent subject: one that forms through sensory relations to an environment that is imperceptible in total. In Pierce's cave, changes in scent and temperature are perceived incrementally, successive moments in an intensive unfolding. These intensities eventually give way to a secondary logic of relation, akin to Maldiney's systolic contraction of chaos into perceivable forms. Ultimately, like Maldiney's diastolic eruption of forces, Pierce transports his inhabitants to a completely different cave, only to repeat the defamiliarization/familiarization process. The repetition in Pierce's cave is important, for one never dwells long enough to fully know their environment. There are forever more folds and more caves. This repetition, this continual movement between 'smooth' and 'striated' space, in Deleuze and Guattari's terms, characterizes our fundamental experience of the world generally (Massumi/Pierce/Straus) and art specifically (Maldiney). The world is unknowable in total. Our

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Figure 4: Zone B

experience is a constant unfolding of self and world structured by the variable intensities that surround us.

In *Veer*, rhythm in Maldiney's sense, is articulated through the commingling and overlap of three distinct temporalities: the participant's gait, influenced by spatial changes; the triggering of sound and light reactions caused by a participant's position in the space; and the composed sound itself, complete with its own internal temporality. Spatially, movement is encouraged in some places more than others. Tunnel shapes were deployed as a means of influencing movement down a particular path. This allows us to design linear progressions of material, sonic, and spatial change despite the minor differences that occur with each participant. The central space, Zone B, is open and promotes more variation of movement (Figure 4). Here participants wander and perceive differences in the spatial field as they discover the walls are lined with sensors initiating subtle changes in sound and light. Participants may stay in Zone B for a few moments or considerably longer, a marked difference from the relatively predictable pace and progression of the tunnel spaces.

Both the internal structuring of individual sound events and their aggregate impact as dramatic gestures are designed to be temporally elastic. Each local reaction is composed of four overlapping sound-files on loop. The durations of these internal layers are distinct, ensuring their repetitions are misaligned so that the composite sound constantly morphs. Each tunnel (Zones A, C, and D) is conceived as a disaggregated musical phrase that fuses through the movement of the participant. Beginnings, middles, and ends are composed into separate sensor reactions, but the rate at which they unfold is controlled by the gait of the participant. The dramatic contour of Zone A, for example, will be similar whether a participant sprints or crawls through the tunnel. In other words, the duration of the phrase changes, but the arc of its intensity is preserved; it is temporally elastic.

Throughout *Veer,* various temporalities are linked in dynamic relationships instigated by position and movement. No archetypal interactivity dominates. The participant initiates a cascade of spatial/sonic relations structured with different temporalities. Like Straus's world of sensation, *Veer* delivers an initial jolt of sensory stimuli. As one move's through the installation, these stimuli begin to coalesce into logical relations—Maldiney's systolic contraction of the senses into perceivable forms—only to be undone, in a diastolic eruption of forces, as new temporal relations are revealed through alternate interactive models. The time of *Veer* is a manifold time, characterized by overlapping temporal shapes that fade in and out of focus in a dynamic play of experiential tension.

MANIFOLD SPACE

Lastly, *Veer* affords an opportunity to rethink the conceptual relevance of topology in architecture. Though its impact on contemporary conceptions of architectural form is undeniable, the scope of topology's application in architecture is narrow. Since the late 1990s, topology has primarily served as a geometric reference for early theories of computer-generated architecture.

Greg Lynn, arguably the most influential theorist of this period, evoked topology in arguments challenging architecture's overreliance on idealized geometries, principles that had governed architectural composition for centuries (Lynn 1998). For Lynn, only geometry itself, not a specific type, was integral to architecture (Kipnis 2008: 198). Non-idealized geometries, such as the non-uniform rational basis splines of computer software, are as important to architectural composition as perfect cubes, cylinders, and domes. Through arguments such as Lynn's, topology's theoretical relevance was solidified in the domain of geometry, restricting its application to other areas of architectural speculation.

Veer expands topology's relevance in architecture by closely resembling the form of topological space known as a *manifold*. To explain this, we must first provide a brief description of manifolds as they relate to complexity theory, a scientific field studying, among other things, the emergent functional patterns generated from complex interchanges of components in a system (Protevi 2009). Such dynamical systems are studied through computer simulations that model its variables in a *phase space*, an imaginary space with as many dimensions as components in a system. A manifold is the mathematical equivalent of phase space, a multi-dimensional object that represents the range of behavior open to a system. All interrelated parts or dimensions of a system are represented in a manifold. Thus, at any one point, the global condition of a system can be represented by a point in the manifold. When one tracks a system across time, the points create a trajectory through the manifold/phase space, which represents the behavior of the system. Across multiple simulations, trajectories often appear in similar areas representing patterns of behavior, or what are called 'basins of attraction' in mathematical terms (Protevi 2009). These areas of the manifold represent *likely* behavior of the system even if no two trajectories ever match. Although dynamical systems are often too complex to predict in total, simulating their interactions allows scientists to observe patterns and predict probable effects.

Although brief and substantially limited, this description of manifolds provides an apt analogy for *Veer*. Conceptually, each material layer—from surface texture to sonic pitch, from lighting color to spatial configuration, as well as the particularities of each participant—is conceived as a dimension in *Veer's* phase space. Taken as a whole, these dimensions represent the range of possible behavior open to the system and, by extension, the experience of any single participant. This is not to say that precise experiences can be predicted, rather, the differential composition of *Veer's* variables (the way sound relates to space, color, and light) encourages people to engage the space in a particular way, which over time will likely produce repeatable patterns (Figure 5). In this way, *Veer* is best thought of as a manifold, wa differential space of variable intensities brought about by multiple, interrelated dimensions that encourage patterns of self-similar behavior.

More broadly speaking, this conceptual framing of *Veer* is a call to extend topological thinking beyond issues of geometry toward a deeper understanding of manifolds and the dynamic, interconnected variables at play

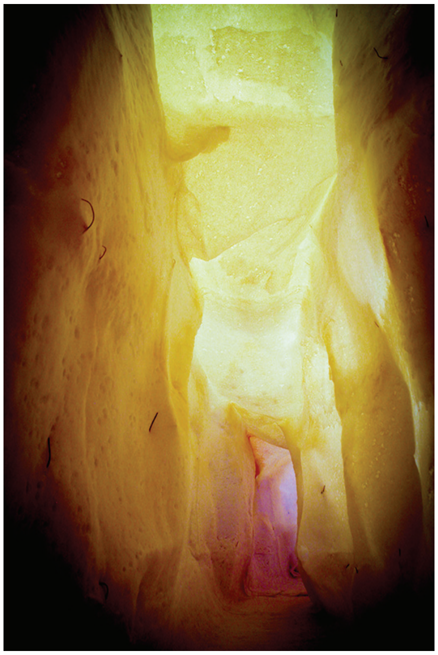

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Figure 5: Zone A with variegated light field

in spatial experiences. Specifically, this necessitates a shift in focus away from topological *surfaces* toward topological *spaces*. As stated above, topological spaces (manifolds) contain as many dimensions as there are components in a system. Although varied, topological surfaces (at least how they are thought of in architecture) are limited to a single dimension, that of surface continuity. A shift toward thinking topology spatially acknowledges the many variables of design while providing a conceptual framework to understand their interrelation.

CONCLUSION

In conclusion, our collaborative design process establishes relational logics between differing media. Supported by Brian Massumi's definition of design as the relation of sense data, *Veer* combines the sensory effects of sound, space, light, color, and matter into a series of memorable, emphatic moments. Further, the multiple temporalities produced by *Veer's* constituent mediums and the interactive technology that connects them, establishes a dynamic conception of aesthetic form that follows philosopher Henri Maldiney. This form is an experiential becoming guided by the rhythmic relationships of material, spatial, and sonic variation. Finally, *Veer* supports the development of an architectural topology based on notions of multi-dimensional spatiality. Its resemblance of a manifold, a multi-dimensional topological space, provides the conceptual framework to think of the multiple components of design as interrelated variables in an integrated whole.

Ultimately, these arguments are put forth to broaden the theoretical basis of research into responsive architectures. The opportunities afforded by interactive technologies challenge architecture's most established theories while opening new experiential potential. Designing space as a variably charged, responsive field produces novel relations between bodies, environments, and the differential energies that flow from and through them, while informing the theoretical lines that tie them together.◆

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