Multidimensional Space: The Intersection of Architecture and Engineering in the Realm of the Senses

Barbara Erwine

University of Washington, Seattle, Washington

ABSTRACT: The historically lush and varied sensory environments we evolved in have paled to a relatively bland homogeneous palette. With ever-increasing technological accuracy, the environments we now design and build are controlled to narrowly acceptable ranges of temperature, light, smell, sound and color. To address the comparatively impoverished sensory environments prevalent in contemporary architectural/urban design practice, this paper explores the intersection of the design and engineering professions as they overlap in the realm of the senses. The paper presents a new framework for design of sensory spaces including light, color, temperature, smell, sound, touch and the personal and communal spaces brought to life through habitual use patterns. Each of these sensory dimensions is identified as an independently shaped space with attendant characteristics of location, boundary, intensity, duration, etc. which may coincide with or only partially overlap the architectural geometric space of solids and voids. The multidimensional design framework outlined in the paper explores how these sensory spaces may be either congruent, reinforcing each other for an intense nodal experience, or dissonant, diverging to create an illusion. To accomplish the paradigm shift required to implement the framework, the paper addresses the current silos of design and engineering professions and explores a collaborative relationship between them, where architects and urban planners move to embrace the traditional engineering realm of environmental controls and engineers claim their due place in the design arena.

KEYWORDS: Sensory Design, Architecture, Urban Design, Phenomenology

1.0 Attenuation of the Sensescape

The historically lush and varied sensory environments we evolved in have paled to a relatively bland homogeneous palette. Ocular-centric contemporary design practice prioritizes visual impact over engagement of the other senses. With ever-increasing technological accuracy, the environments we now design and build are controlled to narrowly acceptable ranges of temperature, light, smell, sound and color. This homogeneity of sensory experience arose from an egalitarian desire to provide a base level of comfort for all and to leverage the efficiency of flexible, universal design. As designers of the physical realm, architects and engineers were empowered to take this approach in the mid-twentieth century by engineering advancements that gave them precise control over a building's environment and by what appeared to be unlimited energy resources available to maintain this narrow band of sensory conditions. (Banham 1969) The resulting environments established a cultural "norm" with closely controlled ranges of temperature, light, smell, and sound. Experiments were conducted to understand comfort level preferences for the 80% peak of the population bell curve. Comfort charts were drawn; light levels were targeted; and elaborate electrical/mechanical systems were engineered to maintain these identified "comfort conditions" over every square foot of building space through every occupied hour of the day.

Historically, mankind has benefitted greatly from the elimination of environmental extremes that these systems guaranteed. Incorporated into generally accepted standards like ISO, ASHRAE, ANSI, etc., these environmental regulations saved workers from the poor air quality and dimly lit interior spaces of earlier times. But the rigid replication of this approach has resulted in spaces that are everywhere the same and nowhere special - environments that are acceptable but not inspiring, comfortable but not comforting, predictable but not memorable. The systems to maintain this consistency overdraw the earth's resources, returning in exchange environments with no sense of place, time or cultural identity.

At the urban scale, this attenuation of the sensescape may act to obscure or even obliterate the cultural identity of entire neighborhoods. The traditional activities of an area's occupants include associated sensory qualities that imbue that place with a familiar and recognizable sensory culture. Too often, urban rehabilitation projects attempting to recreate a pre-existing cultural identity mimic the visual symbols of culture while obliterating other more "problematic" sensory cues (smells, sounds, textures, etc.) that are essential to the cultural experience. Pardy calls this a de-politicizing of space (Pardy 2009) which makes these rehabilitated neighborhoods "sites of *display* rather than sites of *dwelling* where authentic engagement with diversity is avoided and a palatable non-confronting version of multiculturalism is promoted." (Palipane 2011, 3)

2.0 Sensory Design – An Intersection of Disciplines

The challenge of addressing the relatively impoverished sensory environments generated by these current architectural/urban design practices is exacerbated because the field of sensory design resides between traditional disciplines of study. In addition to the fields of architecture, engineering and urban planning, disciplines like psychology, physiology, sociology and anthropology provide vital information on how people actually perceive space and develop preferences (either individually or culturally). Thus the design of the sensory realm falls at the intersection of multiple responsibilities and frequently gets overlooked in the transfer from one to the other. This paper explores in particular the intersection of the design and engineering professions as they overlap in the realm of the senses, and touches on the other areas as needs for future work.

The built environment professions have evolved toward a separation between the architect or urban planner who designs the space and the engineering professions which regulate their sensory phenomena. The resulting silos of responsibility represent the right brain/left brain, heart/mind, emotion/logic dualism in our contemporary approach to problems. This duality sometimes plays out in stereotypes of the professions. Architects may characterize engineers as rigid and non-creative; engineers may portray architects/designers as emotional, unrealistic and impractical. To accomplish the paradigm shift required to implement full sensory design, the current silos of design and engineering must evolve to a new integrated/collaborative relationship. As the rewards of this new design paradigm unfold, architects and urban planners move to embrace the traditional engineering realms of environmental controls and engineers claim their due place in the design arena.

3.0 Sensory Design Reawakening

Numerous voices throughout recent decades have provided wake-up calls to remind us of the rich sensescape that is our heritage. Christian Norberg-Schulz, for example, reminds us that in Prague, "The illumination is not continuous and even; strongly lit and dark zones alternate, and make us remember the times when a street lamp created a place." (Norberg-Schulz 1980). Lisa Heschong's Thermal Delight in Architecture recalls the vitality of varied temperatures that drew people to cozy fireplaces in winter, cool courtyards in summer - spaces that invoked memories and a sense of place (Heschong 1982). Juhani Pallasmaa admires the capacity of the human ear to carve a volume into the void of darkness. (Pallasmaa 2005) And Victoria Henshaw invites us to take a walk with her through the urban "smellscape." (Henshaw 2013)

Benedikt examines the difference between vision-centric "exteriorist design," which places us as observers outside the space and sensory rich "interiorism," which places us within an enveloping spatial experience. In exploring this, he acknowledges that, "the lack of a way to describe and map sensory experience and to make it a part of design plagues the field to this day." (Benedikt, 2002, 4) Responding to this need, this paper develops a language and design framework to conceptualize the sensory dimensions and suggests changes to education curricula to ensure that future generations of designers are equipped to design within the multiple dimensions of sensory experience.

4.0 Multidimensional Sensory Approach

Multidimensional space is the term this paper uses to describe this framework of overlapping sensory spaces. Merging the poetry of design with the science of engineering, the multidimensional design framework moves designers beyond the myopia of a vision-centric experience to a full multisensory approach. This conceptual framework involves understanding sensory spaces as volumetric shaped spaces that can be inhabited - spaces of warmth, color, light, sound, smell, texture, and the personal and cultural spaces brought to life through habitual use patterns. These spaces are understood as existing independently from the geometric space of walls and openings. Each of these spatial dimensions has identifiable characteristics of location, shape, boundaries (rigid or porous), intensity, duration, etc., that can be designed and perceived just as we design the geometric space. The multidimensional framework lets us comprehend the experience of entering and leaving these sensory spaces. It lets us examine whether they are congruent with each other or dissonant - whether they build to intensify a cohesive experience or diverge to create an illusion (or just a bad design).

At the urban scale of sensory design, the multidimensional framework explores both the shape and rhythm of sensory spaces. Is the streetscape experienced as a series of human-scale spaces alive with sounds, smells and tactile enticements from sidewalk vendors and musicians or as a monotonous tunnel droning with vehicular traffic and exhaust?

To better appreciate the potential impacts of sensory space, the following sections explore individual sensory dimensions of light, temperature, and smell.

5.0 Light Space

The experience of light space is perhaps one of the easiest to understand as, like geometric space, it is experienced through sight, the predominant human sensory mode. It is an axiom of lighting design that we can't see light unless it is reflected off an object. Although scientifically accurate, this belies our kinetic experience that a volume of light exists between the light source (whether it is the sun or an electric light) and the surfaces it illuminates - a three dimensional volume of light nestled between three dimensional volumes of shadow. David Abram captures this whimsically as he explores the realm of shadow, noting that, "one of the countless signs that our thinking minds have grown estranged from the intelligence of our sensing bodies, is that today a great many people seem to believe that shadows are flat." (Abram 2010, 15) To the contrary, on exploring his own shadow, Abram experiences, "a precisely bounded zone of darkness that floats between my opaque flesh and that vaguely humanoid silhouette laid out upon the pavement … The actual shadow does not reside primarily on the ground; it is a voluminous being of thickness and depth, a mostly unseen presence that dwells in the air between my body and that ground." (Abram 2010, 16)

Light Space

The evening lamp on the family table is also the center of a world. In fact, the lamp-lighted table is a little world in itself, and a dreamer-philosopher may well fear lest our indirect lighting cause us to lose the center of the evening room.
(Bachelard 1969, 170)

Figure 1: The inviting cone of light space that envelops a dining room table

This experience of three dimensional volumes of light/shadow presages the rich possibilities of light space. Originating in the theater lighting profession, lighting design has long carried the power to create mini-environments within a larger setting. Just as the theater spotlight defines

a small cone of activity within the larger stage, so creative architectural lighting can generate light spaces that feel separated from the space around them (Fig. 1). Some light spaces occur naturally, such as the cozy glow of a window seat in direct sunlight or the shady recess beneath a willow tree. Others are more intentionally designed with carefully crafted window openings and custom electric light fixtures. Good lighting designers use these effects to advantage to create volumes of light (or darkness) not confined by physical walls. They create glowing spheres of light around restaurant tables to envelop intimate diners. They entice us with glimpses of bright volumes of light bulging out from behind walls or produce a dazzling pavilion of light to celebrate the intersection of two long hallways. In each of these, the occupant knows when he/she has entered and left the light space, senses how intense it is and how porous or abrupt its boundaries appear.

Thermal Space

Marcel Proust poetically describes a fireside space, as sensed by the skin: "It is like an immaterial alcove, a warm cave carved into the room itself, a zone of hot weather with floating boundaries." (Pallasmaa 2005, 50)

Figure 2: The inviting thermal space of an inglenook. Photograph courtesy Colleen Duffley Photography

Lighting designers may even intentionally camouflage a room's geometric shape by creating an illusion with a contradictory light volume. For example, the designer may intentionally lower the apparent height of a room by creating a light volume that stops short of the actual ceiling height. This can be done with dropped pendant lights or downlight fixtures in an open grid offset from the dark ceiling cavity.

However in most buildings today, especially work environments, this richness of lighting design is neglected in deference to the goals of flexibility and universality. In the vast majority of commercial buildings, the architect finishes the spatial design and then hands it off to an engineer who uses standardized spacing criteria to lay out a regular grid of electric lights in the dropped ceiling throughout the building. Even in break rooms and lobbies, where the range of activities doesn't require it, the uniformity of light levels persists. This is not because architects don't care how the space is experienced, nor that engineers can't creatively respond to higher design goals, but rather that sensory design has not been prioritized in the multitude of considerations required by the design process.

6.0 Thermal Space

This same uniformity is the default condition for other sensory modes. Some environmental designers have coined the term "thermal beige" to describe the monotone nature of contemporary thermal environments. How often any more do we experience moving in and out of warm cozy nodes like the inglenook fireplace set off from the main body of a living room (Fig. 2) or the warm abode of a window seat in sunshine? In Thermal Delight in Architecture Lisa Heschong jogs our collective memories of humankind's history of seasonal migration to these thermal spaces, the patterns of use marking the hours of the day or seasons of the year. (Heschong 1982) These thermal nodes of warmth or "coolth" can be designed and shaped in our current architectural landscape just as light spaces are designed. If we pay attention, we can sense their location, volume, intensity, and boundaries. Who has not experienced the sphere of warmth around a campfire and felt the edge of this warmth as it dissolves into the surrounding night air?

Figure 3: Pike Place Market in Seattle provides a sequence of smell and sound spaces

7.0 Olfactory Space

Olfactory spaces can represent the collective memory of a culture – the smell of a bread shop in Paris, spices in a Middle Eastern souk, fresh mown hay in the countryside. Often one smell evolves to another as a person moves through a neighborhood or space. The rhythm of smells may become a signature line for a particular city, neighborhood or season. Pike Place Market in Seattle, for example, is experienced as a modulation of smells and sounds (Fig. 3). Visitors move from the seaside smell and raucous sounds of the fish market to the delicate aroma and relative calm of the flower market. A blindfolded person could sense moving in and out of these distinct nodes as if they were separate rooms within the Market. Each of them would be diminished if their wares and sensory cues were intermixed.

8.0 Multi-Sensory Examples

Just as we can understand these sensory spaces of light, temperature and smell, so we can call to mind and design inhabitable volumes of sound, texture and touch, color and pattern – each of them independently located in space and time. Computer simulation programs can even render the shape of these spaces, noting how they overlap with a building's geometric space or the landscape of an urban neighborhood. As these rich sensory nodes take shape, they define sub-spaces that people are drawn to either alone or in a group. While the window seat might call out a private refuge for a solitary afternoon of reading; the inglenook draws a more social gathering.

The inglenook's strength as a social node is heightened by its intense overlap of multiple sensory zones. This small confined space adjacent to the larger space of the room is reinforced by the warm thermal space of the fire, the flickering orange light space of the flames, the crackling sound space and the smoky olfactory space. Over time, its habitual use on chilly winter evenings makes it also a cozy communal space shaped by the stories and laughter that have been shared within it. These perceived personal and cultural/spiritual shaped spaces are easily identified by the people who ritually use them, but they may be indiscernible to those who have not shared the experience and may not even recognize the spatial boundaries. A late night group of men gathered around an open charcoal fire in a metal drum may appear menacing to a visitor in unfamiliar territory but be experienced as a cozy neighborhood social node to those within the culture.

Crafting these multisensory spaces requires a truly integrated design approach that can no longer tolerate a handoff of responsibility from the designer, to the engineer, to the occupant, but rather requires all parties to work together at the design table and speak a shared language. The resulting multisensory designs may consist of intentional nodes of overlap among three or four sensory volumes that intensify the overall experience and ritualize its use as a cultural space. Alternately they may contrast individual sensory space experiences to create mystery and illusion. They can provide variety to allow occupants to choose their preference of warmth, light level, sound or quiet. These sensory designs can make spaces come alive with the rhythms and rituals of sensation and movement, privacy and community to enliven our homes, offices, public buildings and urban neighborhoods.

Two recent architectural examples illustrate the impact that multisensory design can have. In Seattle's Chapel of St Ignatius, Stephen Holl used the concept of seven bottles of light in a stone box to generate the form, clearly delineating light spaces separate from their geometric space container. Each of the seven bottles of light is a differently colored volume experienced sequentially in the building. (Holl) Perhaps the most compelling sensory space in the chapel is the Chapel of the Blessed Sacrament, whose walls are dripped with bee's wax. Stepping into this space, the visitor enters an olfactory volume of sweet smell that also radiates with the warmth and amber glow from a concealed skylight.

In his personal residence in Venice, California, artist Doug Aitken experiments with a variety of sensory dimensions. "The goal was to create a warm, organic modernism that's also perceptual and hallucinatory," he said of the design. (Yablonsky 2012) Aitken both combines sensory spaces to create intense sensory environments and contrasts them to create illusions. "The ground-floor walls and curtains have been silk-screened to simulate the hedges growing outside the windows, the sky-lighted staircase is lined with angled mirrors that turn the passage into a dazzling kaleidoscope … at certain times of day, the living room windows appear to melt away, dissolving the painted walls into the greenery beyond them." (Yablonsky 2012) Even the stairwell is an active sound space "played" by the rhythm of footsteps ascending and descending.

The attention to sensory design is not separate from, but in many ways arises from passive and sustainable design approaches. Daylighting design, for example, frequently results in distinct zones of light and dark. Although this modulation of light level can be evened out across a space where desired, the glow of direct sunlight is frequently used to call out significant nodes and gathering spaces. In addition, the basic premise behind task lighting or heating (well recognized sustainability practices) is the creation of subspaces of sensory intensity. Rather than conditioning an entire space, the design may provide a localized "tent" of light under which more demanding tasks can be performed or an alcove of warmth or "coolth" where people can gather to be refreshed. The passively designed cool-tower at Zion National Park's visitor center creates an alcove of cool air at its base for visitors to gather in and refresh themselves. This reduces the need to condition the entire space to a level that may be experienced as chilly to people entering the space from the overheated desert environment. Similarly, displacement ventilation systems provide fresh air (olfactory and thermal space) just in the first 8 feet above floor level, basically creating a truncated volume of sensory conditioned space where the occupants reside.

9.0 The Future of Full Sensory Design

To move contemporary design practice toward a full multisensory approach the following changes need to occur:

- The first crucial step is to recapture an understanding and appreciation of the sensescape and its impact on the emotional and physical health of occupants. Research into the mechanisms of human perception for individual sensory modes, the sensory responses of individuals and cultures, and the exploration of the ambiance of place is essential to a more complete understanding of this field. This work is gaining momentum with the research, projects and publications of many new advocates in this field and with seminal conferences like the International Congress on Ambiances under the aegis of the International Ambiances Network. Since much sensory design research focuses on an individual sense mode, this platform for cross-modal sharing of information is critical for integrating and reconciling the directions of this emerging work. In addition to architecture and engineering, this work engages the fields of psychology/physiology to understand the underlying mechanics of sensory perception, sociology/anthropology to explore the cultural implications, and art and creative writing to celebrate the depth of sensory experience. Development of a comprehensive list of contemporary and historic building/urban precedents is needed to further assist students and designers in experiencing multi-layered sensory impacts first-hand.

- Equally important is the development of a shared language and design framework to envision, and communicate sensory design. Sensory fluency is rapidly developing with the pioneering work noted above. Design frameworks like the one proposed in this paper are beginning to emerge to facilitate communication of the sensory design intent to the design team, client and stakeholders. Future work in these frameworks needs to also systematically characterize the physical attributes of each sensory mode. For example, how does one describe and control the boundary condition for the sense space or its intensity or the pleasant/unpleasant quality of its impact?

- Lasting change will require integrating this sensory design knowledge into traditional educational coursework to train tomorrow's designers in a multisensory approach. To achieve this, many parts of the design curriculum must evolve, including:

    - *History and Theory*: Introduction of the concepts of sensory design and the influence of the sensescape throughout history.

    - *Building Science/Engineering*: Reinforcement of the concepts of the experience of sensory space and the technical expertise to use passive and active design mechanisms to shape sensory space across multiple sensory modes. Integration of sensory principles with sustainable design curricula.

    - *Architecture Design Studio*: Use of sensory design criteria to envision and evaluate the ambiance of studio projects. Involvement of associated disciplines (building science, anthropology, physiology, etc.) in an integrated studio atmosphere to collaborate in envisioning and creating the sensory space.

    - *Design Computing*: Provision of programs/platforms to calculate and render shaped sensory spaces overlaid on three dimensional computer models.

    - *Urban Planning*: Exploration of the impact of the urban sensescape in identifying or creating urban ambiance and its attendant cultural implications. Involvement of associated disciplines (engineering, anthropology, physiology, etc.) in an integrated studio atmosphere to collaborate in envisioning and creating the sensory space.

    - *Landscape Design*: Exploration of the impact of the sensescape in identifying or creating a landscape ambiance and its attendant cultural implications. Involvement of associated disciplines (geography, civil engineering, etc.) in an integrated studio atmosphere to collaborate in envisioning and creating the sensory space.

- Sensory design will necessitate an evolution of professional practice into a fully integrated design process. This process must leverage the current sustainability emphasis on integrated project teams to involve all team members in the co-design of the full sensory experience.

- Tool Development: Although currently available design tools can render individual sensory spaces, a common platform is needed to visualize and juxtapose these diverse sensory environments. The expanding body of virtual reality research must also be leveraged to simulate the experiential impact of innovative new sensory designs.

By engaging a full sensory design process, we can make the places we spend time and move through in our daily lives more humane and interesting. These multi-sensory spaces will use

the earth's precious resources well to create magical, memorable experiences. No longer shuffling between anonymous universal spaces, we will savor our environments and dwell in the true sense of that word – to live or stay as a permanent resident, to linger over. And we'll imbue our man-made realm with the sensory variety and vitality that we are drawn to in the world of nature.

REFERENCES

Abram, D. 2010, *Becoming Animal: An Earthly Cosmology*, New York: Vintage Books

Bachelard, G. 1969, T*he Poetics of Space*, Boston: Beacon Press

Banham, R. 1969, *The Architecture of the Well-tempered Environment*, London: The Architectural Press

Benedikt, M. 2002, *Environmental Stoicism and Place Machismo*, Harvard Design Magazine, Winter/Spring

Heschong, L. 1982, *Thermal Delight in Architecture*, Cambridge, Massachusetts: The MIT Press

Holl, Chapel of St. Ignatius, Seattle University, Seattle, WA, http://www.stevenholl.com/project-detail.php?id=40 last accessed on 10-28-13

International Ambiances Network, http://www.ambiances.net/home.html last accessed on 10/29/13

Norberg-Schulz, C. 1980, *Genius Loci*: *Towards a Phenomenology of Architecture,* New York: Rizzoli

Palipane, K. 2011, *Towards a Sensory Production of Urban Space: Developing a Conceptual Framework of Inquiry Based on Socio-sensory Perception*, presented at the International RC21 conference, http://www.rc21.org/conferences/amsterdam2011/edocs/Session%201/RT1-1-Palipane.pdf, last accessed on 10/29/13

Pallasmaa, J. 2005, *The Eyes of the Skin*, West Sussex, England: John Wiley & Sons

Pardy M. 2009, *Multicultural Incarnations: Race, Class and Urban Renewal*, The Future of Sociology Annual Conference of the Australian Sociological Association, Canberra, Australia, the Australian Sociological Association, as noted in *Towards a Sensory Production of Urban Space: Developing a Conceptual Framework of Inquiry Based on Socio-sensory Perception*

Yablonsky, L 2012, *Sound Garden,* New York Times, March 30