

SENSTHETICS: A CROSSMODAL APPROACH TO THE PERCEPTION, AND
CONCEPTION, OF OUR ENVIRONMENTS

A Dissertation

by

UPALI NANDA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2005

Major Subject: Architecture

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ABSTRACT

Senshetics: A Crossmodal Approach to the Perception, and Conception, of Our
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This dissertation counters the visual bias, and the simplistic approach to the senses, in architectural thought, by investigating the connections among different sense modalities (sight, sound, smell, taste and touch). Literature from the cognitive sciences shows that sensory modalities are connected perceptually; what we see affects what we hear, what we smell affects what we taste, and so on. This has a direct impact on the perceptual choices we make in our day-to-day lives.

A case study conducted in an urban plaza investigates the perceptual choices people make (or what they attend to) as they explore their physical environment. Results show that people construct subjective and embodied mental maps of their environments where sensory impressions are integrated with cognitive concepts such as emotions or object recognition. Furthermore, when one sense is muted (such as closing the eyes) other senses are prioritized. A theoretical framework termed as the “Senshetic Model” is developed illustrating the interdependence of sensory, kinesthetic and

cognitive factors, and the hierarchical and lateral relationship between sense-modalities. The latter is the focus of studies with architecture students in abstract thinking exercises:

a) *Hierarchical*: Students perceive a hierarchy of senses (sensory order) when they think about different places. Vision is primary, but not always. Touch, classically relegated to the bottom of the hierarchy, is often higher in the hierarchy and coupled with sound.

b) *Lateral*: Students associate colors with different sounds, smells, textures, temperatures, emotions and objects and cross over modalities conceptually, with a degree of consistency. There are more associations with emotions and objects (which are not constrained to a single sense-modality), than with purely sensory images.

Finally, the theoretical model is further developed as a tool to think “across” modalities (crossmodally) based on the identification of *sensory orders* and *sensory correspondences*. By focusing on the sensory modalities (nodes) and the relationships among them (connections), the model serves as a conceptual tool for professionals to create sensory environments. This dissertation is an initial step beyond the aesthetics of appearance, towards the *Sensthetics* of experience.

To Mama and Papa, my inspiration

To Anuna, Bijinani, Jiju, and Rimani, my support system

To Chiki, my joy

and

To Veera, my partner

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1. INTRODUCTION: A DYNAMIC APPROACH TO SENSORY AND KINESTHETIC CONCERNS IN ARCHITECTURAL THOUGHT

I woke up yesterday, confused. I saw Iraq on TV, heard Beatles on the radio, and smelt my mother's curry. It was warm inside, snowing outside, and I knew at least some of my senses were lying to me. I just didn't know which ones.

1.1. *Hegemony of Vision: An Overview of Architectural Theory*

According to Norberg-Schulz (1971), the following are different ways of approaching architectural theory: 1) indicating the various factors which determine architectural totality as well as their logical inter-relations, such as his previous work on *Intentions in Architecture* (Norberg-Schulz, 1966), 2) developing a coherent method of analyzing the building task, as undertaken in the *Pattern Language* (Alexander, Ishikawa, & Silverstein, 1977), and 3) aiming at a renewal of the theory of architectural form, as proposed in *Complexity and Contradiction* (Venturi, 1966). Each of these approaches is indicative of a distinct ideology, and each addresses a multitude of concerns: social, cultural, functional, formal and ethical, with an inherent aesthetic directive.

Even in its most historical exemplars architectural theory has been all encompassing. In his *Ten Books on Architecture* Vitruvius (c.40 B.C., tr. 1914) defines

This dissertation follows the style of *Journal of Experimental Psychology*.

the fundamental principles of architecture as dependent on order, arrangement, eurhythmy, symmetry, propriety, and economy (Vitruvius, 1960). While order, arrangement, eurhythmy and symmetry derive from aesthetic considerations for the form, propriety derives from prescription (style), usage (function) and natural causes (context), and economy derives from considerations of cost, and social context. In the *Seven Lamps of Architecture* Ruskin (1961) takes a more ethical view; his theory of architecture is personal, derived from informed opinions on architecture, art and society in the nineteenth century.

According to Johnson (1994) many writings or pronouncements in architecture that aspire to be theory are frequently a quest for some overreaching construct of the world that can both guide, and be reflected in, architecture. An argument can be made that such a quest is fuelled by the fundamentally multi-disciplinary nature of architecture, and its ability to touch (and be touched by) so many facets of life, making it a single cohesive theory of architecture difficult to identify. Typically scholars adopt different vantage points and argue their theories based on chosen theoretical frameworks and models.

Theoretical frameworks may spring from issues of composition (Meiss, 1990), space (Norberg-Schulz, 1971), human behavior (Canter & Lee, 1974; Lang, 1987), intentionality (Norberg-Schulz, 1966), ethics (Ruskin, 1871; Watkin, 1977), culture (Frampton, 1999), ecology (Porteous, 2001) etc. They are often used to create new knowledge from existing information. Many scholars such as Charles Jenks, Joseph Rykwert and Colin Rowe thematize historical or technical information into theoretical

frames in order to make contemporary arguments (Johnson, 1994). According to Lang (1987, p.12) “A (theoretical) model is a way of perceiving reality that imposes a structure on that reality”.

Because of diverse and seemingly fragmented approaches to architectural theory, architecture is seldom identified as a field in which theory governs practice. Agrest (1991) argues that the separation between theory and practice is the result of the critical and exploratory discourse of the former, versus the normative discourse of the latter. Aside from some specific milestones in history (post-modernism, modernism, and renaissance), during which theory has indeed governed practice for a brief while, most other theories of architecture have been formulated in hindsight.

Across the heterogeneous board of architectural theory, there is, arguably, a common language, and the eventual target of a theoretical discourse is often a visible manifest, with a spatial or formal translation. Even within works that address the subject of perception the focus on the visual over-rides concerns of any other sense. This bias towards the visual has philosophical roots and has had a lasting impact on the shape of architectural theory.

In western philosophy sight is equated to insight, light is knowledge, and the eye rules. Philosophers such as Plato and Descartes have valued insight over sight, and knowledge over perception. In the famous parable of the cave, Plato talks about men sitting in a dark cave with their backs to the light, chained in such a way that they cannot move their heads. They watch the shadows on the wall, thinking that the shadows are real, rather than a mere projection of their own bodies and an outside world. As human

beings, our senses often lie to us. For example, a spoon in water seems bent, although we know it is not. Perception and knowledge have always been at war with each other. Even so, the superiority of sight over the other senses, in western philosophy, has rarely been in question. The sense of sight, which has always been considered superior to the other senses, and become a metaphor for knowledge: Seeing is believing, and vision has philosophically deeper connotations than being purely “visual”.

In *Modernity and the Hegemony of Vision*, Levin (1993) addresses the historical connections between vision and knowledge, ontology, power and ethics. He traces the ocularcentric paradigm to the ancient Greeks, and argues that since modernity (the period beginning with the discovery of perspective and the rationalization of sight in the fifteenth century) there has been a change in this paradigm, which has been affected profoundly by the advances in technology. In this change, “vision is no longer synonymous to knowledge, and a new spectator theory of knowledge emerges” (Pallasmaa, 1996, p.10). In his essay on “Light as a Metaphor for Truth” Blumenberg (1993) argues that vision is no longer a path to wisdom or redemption, no longer even a method for acquiring knowledge and achieving freedom, but a technology complicit with domination.

In architecture and architectural theory the “discovery” of perspective and ocularcentricism is linked to issues of architectural representation, which has a possible effect on architectural conception. In *Architectural Representation and the Perspectival Hinge*, Perez-Gomez (1997) discusses the role of representation in architecture. He traces architectural drawings from before the Gothic age, when drawings were rare and

the whole building was seldom conceived at once, to the fifteenth century, when architecture became a liberal art with architectural ideas conceived increasingly as “ubiquitous, two-dimensional drawings” (Perez-Gomez, 1997, p.9). The power of the purely visual grew as the “drawing” superseded the “craft”. The architect was now no longer the master mason and representation became more important than the actual edifice. Within the theoretical discourse itself issues of composition, form and space were such that required representational resolution, before they could actually be constructed. This was unlike Gothic architecture in which occasionally different generations of masons, often using different styles, worked on the same building and practice was more constructive than theoretical. Now, the discourse itself has become dependent on representation, and therefore, by necessity, even more biased towards the visual. In the *Age of the World Picture* Martin Heidegger argues for a new epoch, in which the ocular subject becomes the reference point for all measurements and the value of being; where the very “being in this world is equated with our images and representations” (as cited in Levin, 1993, p.6).

1.2. *The Embodied Awakening in Philosophy and Mainstream Architectural Thought*

In his philosophy Merleau-Ponty (1964, p.164) argues for the embodied nature of the visual and claims “quality, light, color, depth, which are there before us, are there only because they awaken an echo in our body and our body welcomes them.” Once we lose a sense of this carnal echo, we dissociate the visual from what it means to be human. It is the same concern that consumes the writings of Heidegger, Sartre, Foucault and Derrida, although each of these writings has its own ideological agenda.

In *Philosophy and the Flesh* Lakoff & Johnson (1999) make an argument for an “Embodied Realism” which discounts the idea of a reality that is divided into categories independent of the “specific properties of human minds, brains, or bodies”. The core ontological assumption is that we are coupled to the world through our embodied interactions. The mind and the body are not separate entities, rather the mind is considered as embodied. In this sense our conceptual structures can be understood as arising from our sensorimotor (from sensation and movement) experience and the neural structures that give rise to it. Our mental structures become intrinsically meaningful by virtue of their connection to our bodies and our embodied experience, and reason is embodied because our fundamental forms of inference arise from sensorimotor and other body-based forms of inference (Lakoff & Johnson, 1999, p.77).

With the technological advancements in the last century issues of embodiment have become more critical than ever before. In “The Turning” Heidegger argues that “both our capacity for seeing and our capacity for hearing are perishing through radio and film under the rule of technology” (as cited in Levin, 1993, p.3). In the *Dawn and Decline*, Max Horkheimer blames technological advancements for human insensitivity, “as their telescopes and microscopes, their tapes and radios become more sensitive, individuals become blinder, harder of hearing and less responsive.” This lack of sensitivity has been a concern in architectural theory as well. Pallasmaa (1996) holds the ocularcentric bias and the consequent *sensory imbalance* responsible for the inhumanity of contemporary architecture and cities. He claims that the “art of the eye” has pushed us into isolation and detachment, creating imposing and thought-provoking structures that

are not rooted in humanity. In this tradition the human body itself is abstracted to be used as a *measure* (proportions, units of measurement, etc.) or a *metaphor* (symbols, forms etc). As a result, modernist design has “housed the intellect and the eye but left the body and the other senses, as well as our memories and dreams, homeless” (Pallasmaa, 1996, p.10). Books such as *Experiencing Architecture* by Rasmussen (1962), *Body, Memory and Architecture* by Bloomer (1977), and the *Image of the City* by Lynch (1960) have been some of the few significant efforts to address this lacuna. However, in the majority of mainstream literature, thought and design, the eye has continued to be “narcissistic, concerned only with self-expression and detached from essential mental and societal connections, and nihilistic, deliberately advancing sensory and mental detachment and alienation” (Pallasmaa, 1996, p.13).

To a large extent the era of electronic communication and simultaneity can be held responsible for this condition. The biggest irony of our times is that we live in a world that is connected to everything, without having any real sense of connection. A space-time collapse seems to occur because of this simultaneity of our worlds. According to Kripper & Aiken (2000) “as speed changes perception, our ability to know our senses and even our sensory organs adapts, and our understanding of time evolves accordingly”. It is a view supported by Pallasmaa (2001) who refers to the perpetual present that we live in, flattened by speed and simultaneity, and grasped by the instantaneous perceptions of the eye.

According to McLuhan (1967), the renaissance legacy of the vanishing point created a society of detached observers where art was placed outside the frame of

experience, and in the 20th century with an instantaneous world of electronic communication these frames collapsed, creating a “global village”. In this age of electronic communication all media can be considered extensions of some human faculty- psychic or physical (McLuhan & Fiore, 1967). The wheel is an extension of the foot, the book is an extension of the eye, clothing is an extension of the skin and so on. In this mediated world “visual space is no longer uniform, continuous and connected”, and thus “rationality and visuality are no longer interchangeable” (McLuhan & Fiore, 1967, p.45).

McLuhan’s “media as the extension of man” is an interesting theory, but it is a point where the distinction between a human and an android begins to get blurred. If we accept the analogy, and take it to the extreme, what happens when these “human” extensions pull us in different directions? Does the body then become fragmented? Our world is a myriad of images that do not always match. For example, in a restaurant with a tropical theme, while the décor is tropical, the air-conditioned and disinfected environment definitely isn’t, the food may or may not relate to the region, and the sounds are often muted in contrast to the décor. In short, the various human faculties, via our senses, give us discrete information about the environment that we carry in our heads as a credible, and even appreciable, potpourri. Incredibly, none of these, often-contradictory indicators seems incongruous to us.

With growing technological sophistication and the advent of Artificial Intelligence (AI) and Virtual Reality (VR), simulated environments become increasingly convincing. We now have interactive and programmable building skins, intelligent

buildings, and new data-driven architectural practices. In *Hyperbodies* Kas Oosterhuis (2003) proposes an “e-motive” architecture, in which buildings, like people, have senses, and are data-driven constructs surviving on the information flow. In times where people believe in the *Matrix* (Wachowski & Wachowski, 1999), nothing seems impossible. We are increasingly caught up in a storm of never-ending possibilities, all entertaining the human body, while remaining disembodied.

Although the assault on the senses has been growing at a steady rate, especially since the industrial revolution, the dissociation between the information from different senses is a relatively recent phenomenon. Leach (1999, p.33) notes the pressure on the metropolitan individual as predicted by the famous sociologist Georg Simmel in

Metropolis and Mental Life:

The metropolitan individual has to accommodate and register the rapid bombardment of stimuli within the city... the rapid telescoping of changing images in the city, and the 'pronounced differences within what is grasped at a single glance, and the unexpectedness of violent stimuli' call for greater expenditure of mental energy

Simmel’s prophecy seems to have come true today as we deal with more and more of these differences, reacting less and less to the anomalies in our perceived environment. One of the concerns with fragmented, but abundant, sensory stimulation is the effect it has on our collateral experience, which is the experience that we draw upon to make sense of new experiences. According to Smith-Shank (1995) “collateral experience” can be defined as the previous experience which makes a novel situation accessible, (i.e. use of our past experiences to make novel situations seem familiar). In

the following example the importance of collateral experience is illustrated by the author clearly (Smith-Shank, 1995):

When we enter rooms we have never before entered and come upon an object which has four legs, two arms, a back, and is upholstered, we can be pretty certain that it is a chair. We have experienced "chairness" before and have made a habit of using objects of this style as seats.

Suppose though, when we sat on this object (which due to habit, we assumed was a chair), it felt wet and cold, it starting melting, we heard what seemed to be the chirping of hundreds of birds, and smelled the odor of ammonia, then we would have to reassess the situation. Our reassessment is forced because of the incongruity of the signs we experienced. In this case, we revisit the contexts of past sensory experiences of hearing, smell, and touch so that the episode can be understood as a coherent whole within our bank of collateral experience. When these are not adequate clues to explain the event, we must hypothesize new cognitive models to make sense of the situation. It is only when our habits, are disrupted to the point that we are uncomfortable with the status quo, that we are motivated to reassess our previous beliefs and habits

In an information age of technological sophistication one of the biggest challenges in architecture is to address users' collateral experience, which is in a constant state of flux. Form no longer simply follows function, or even experience, simplistically. In fact technology allows experience, form, and function to be gloriously independent. A house in the mountains can have palm trees in an air-conditioned space, and be made of modified materials from the tropics; it may look like a house and be instead an unusual conference center. A sensate and experiential approach to architecture, mediated by technology, has infinite possibilities, by which old connections are being traded for new ones. It is within this context of changing connections, that this dissertation revisits the issue of the senses in architecture.

1.3. *Revisiting the Senses in Architectural Theory*

There has been a considerable debate in the social and physical sciences, as well as philosophy, about the number of senses attributed to a human being. Dating back to philosophers like Plato and Aristotle, the classical and conventional taxonomy of the senses, however, lists sight, sound, smell, taste and touch. What is curious in this discourse is the absence of *kinesthesia*; our sensory awareness of the position and movement of the body which derives its meaning literally from “movement” (kinetic) + “sensitivity” (aesthesia). It is the sense that provides information on the whole repertory of our motor actions (Farnell, 2003). At a purely physiological level, it is not possible for any sensation to occur without some degree of external or internal movement in the body. Within the scope of this dissertation, the emphasis will be on sensory modalities, which can be defined as “the different senses that provide ways of knowing about stimuli” (Westen, 1996, p.117). The sensory modalities include vision and audition, the two senses that allow sensation at a distance, and the more intimate senses of olfaction (smell), gustation (taste), touch, and finally proprioception (the sense of the body’s position and motion). Within this approach the term sense, and sense modality, will be used interchangeably. Kinesthesia, or more technically “proprioception”, will be an implicit and underlying concern, while the other five modalities, in accordance with the classical list of senses, will be emphasized.

In his work Schachtel (1959) makes a case for autocentric (people-oriented) senses and allocentric (object-oriented) senses. According to Porteous (1996) “autocentric senses” are people-oriented; they combine sensory quality and pleasure, and

the concern is how people feel. On the other hand “allocentric senses” are concerned with objectification and knowledge and involve attention and directionality. The author argues that vision, with the exception of color perception, is chiefly allocentric, or object-oriented. Speech sounds are allocentric, whereas most other sounds, such as music and the sounds of nature, which are concerned more with the sensory “quality”, are autocentric. Smell, taste and touch are all autocentric, because they are concerned more with sensory quality and pleasure than with objectification. Finally, the author discusses how children are basically autocentric, but in western cultures they learn to develop allocentric modes until these become dominant. In other cultures, the value of the autocentric may be higher, such as the importance of tactility in Japan, smell in Oceania, and kinesthesia in Africa.

In the 1960s “Environmental Psychology” emerged as a field that studied the outcome measures of human behavior in response to environmental factors. In a seminal collection *Environmental Psychology: Man and his Physical Setting* (Proshansky, Ittelson, & Rivlin, 1970) many such studies that addressed the social, cultural, and perceptual factors that impacted our interaction with the environment were published. Privacy (Sommer, 1969, 1970), territoriality (Esser, Chamberlain, & Kine, 1970; Sommer, 1970), and imageability (Lynch, 1960), are some of the issues of the day to day interaction with the environment that were studied, and experimental methods such as mapping, questionnaires, interviews, and cognitive maps, were developed in order to do study these issues. Although the emphasis on human behavior in some 1960 studies in environmental psychology has been critiqued as naïve realism, one that focuses on

what “appears” rather than what “is” (Norberg-Schulz, 1971), the nuanced attention to the factors effecting behavior has been valuable. During this period there was an increased sensitivity to the importance of the “other”, non-visual senses in the experience of place. Perhaps the most comprehensive approach to senses in the context of environments has been the *Hidden Dimension* by Hall (1969) in which he systematically addresses the significance of the different senses in determining the intimate, personal, social, and public distances that people maintain between each other. Other scholars such as Tuan (1976), Rasmussen (1984), Thiel (1997), Wilson (1984) and many others have addressed the different senses and movement in their works. In a recent study Malnar and Vadvarka (2004) revisit the role of the non-visual senses in design and architectural theory. However, in many cases the approach in which each sense-modality is addressed independently in terms of its impact on the environment to the senses has been simplistic.

Amos Rapoport (1967) was one of the first to address the complexity within the sensed perceptions in the context of built environments, by pointing out how some places were monotonous, because of sensory deprivation, while other places were chaotic, because of sensory satiation. He proposed the idea of *optimal perceptual rates* wherein the sensory environment was “just right”; however, he extended this theory to only the visual elements of the environment and proposed that ambiguity in the visual environment may be the solution. Rapoport’s work, like many others, is mostly *intra*-sensory, focusing on the visual, while acknowledging the other senses. An equally complex investigation is warranted in an *inter*-sensory context given that the

environment assaults a host of senses. Even though the role of the senses in architecture has been discussed in considerable detail by various authors, it has been in terms of isolated and independent systems that act together towards our perception of space. The use of terms such as soundscapes, and smellscapes mark an increased sensitivity to non-visual senses. However, this sensitivity remains intra-sensory rather than inter-sensory; focused on nodes, without enough emphasis on the connections between different modalities.

In the 21st century the term “sensory” is not only about experiencing with the senses, but also about using sensor technology, it is possible to create simulated and interactive environments that use multi-sensory and kinesthetic (movement-related) factors to “design” human interaction. Ironically, while main stream architecture remains detached, digital media, which is disembodied by nature, is now spearheading a new field of design called *Experience Design* (Shedroff, 2001) that includes web design, set design, theme-park design, and retail design. While it is an error of scale to put these fields together, they share the common concern of engaging people, in a multisensory way. It is a concern that used to belong to architecture, and must be re-claimed.

1.4. Summary and Mission Statement

Technology today allows us greater sophistication in designing for the senses but it does so within a disembodied and fragmented context, in which image often supersedes the experience. There is the potential of sensory disconnect when each of our senses can make us perceive different, and often semantically incongruent, environments. With film, radio, television, the internet, and now, virtual reality, it is

possible for each of our sense-modalities to be simultaneously “immersed” in a different space-time context. The cognitive and behavioral impact of this increasing distance between our sensed environments is yet to be investigated.

In this dissertation an initial step is taken towards this investigation by concentrating on the “connections” between different sense-modalities, instead of concentrating simply on the individual senses. The philosophical grounding of the work is in systemic thinking and embodied realism: we live in a connected world, where the mind, the body, and the environment cannot be separated, nor considered independently.

The aim of this dissertation is to introduce a new, *Sensthetic* approach to our inhabited environments, by thinking “across” sensory modalities.

The objectives of this dissertation are:

1. To understand the perception of our environments as a function of the connections between different sense-modalities.
2. To study the connections between different sense-modalities as perceived by architecture students
3. To develop a cohesive theoretical framework to address inter-modal and crossmodal concerns in the perception, and conception, of environments.

1.5. Scope and Methodology

1.5.1. Organizing and Interpreting Academic Knowledge

The literature on perception and the workings of our sensory and cognitive processes is not limited to psychology. Issues of perception are central in philosophy, anthropology and environment-behavior studies. In fact, according to Matlin (1989) all

of these fields come under the common umbrella of “cognitive sciences”; a contemporary field that seeks to answer questions about the nature of knowledge, its components, its development and its use. While the information from each of these fields is pertinent to the research, the nature of the information varies and provides different insights into the same academic issue.

According to the *Wordweb*, philosophy can be understood as the rational investigation of questions about existence, knowledge and ethics. It is from this understanding that the role and nature of information from the senses is considered within this dissertation. Philosophers such as Plato and Descartes, as discussed in Durant (1961) were skeptical of the senses because senses cloud pure reason. On the other hand, philosophers such as Merleau-Ponty (1962) and Lakoff & Johnson (1999) have embraced the senses and the role of perception, and have argued that reason emerges from our embodied interactions with the world. Although this dissertation is not a philosophical treatise, the rationale for some of these approaches, as pertinent to this dissertation, is used to develop the logical framework.

Anthropology studies the social relationships among human beings. Social relationships are often causative of, as well as the product of, particular “sensory orders”. Thus while the *hegemony of vision* is true for western philosophy, and even western culture, this is not the case for all cultures, especially for the more primitive cultures such as the Tzotzils of Mexico, descendents of the Maya, who understand their cosmology in terms of thermal dynamics, and the Ongees in Andaman, where smell is the fundamental cosmic principle (Classen, 1993). Although to undertake an extensive

literature survey of sensory priorities in different cultures is outside the scope of this dissertation, examples are used when pertinent to illustrate sensory connections as relevant to social and cultural factors.

Environment and behavior studies, discussed earlier in this section, are also included in the literature. Environment-Behavior, or Environmental psychology as its often referred to, is the “discipline that is concerned with the relationships between human behavior and man's physical environment” (Heimstra & Farling, 1978, p.5), where behavior is any form of activity observable either directly or with the aid of instruments. According to Dubin (1969) theories of social and human behavior address themselves to two distinct goals of science: prediction and understanding. Prediction refers to what we can forcefully tell about the value of one or more units making a particular system, or to what we can anticipate about the condition or state of a system as a whole. In both cases the focus is on outcome alone. Understanding, on the contrary, “is knowledge about the interaction of units in a system. Here attention is focused on processes of interaction between variables” (Dubin, 1969, p.9). The cognitive studies used as references are chosen on the basis of understanding, rather than outcome alone. Therefore, many studies that concentrate purely on outcome measures for particular sensory/behavioral qualities have been excluded. However, studies that focus on the “understanding” of human behavior with respect to the relationship between different sense-modalities, and the interaction with the environment, have been included.

Studies in perception from the field of psychology have also been included in the literature review. Psychology can be defined as the systematic study of mental processes

and behavior, the understanding of which requires constant movement between the micro-level of biology and the macro-level of culture (Westen, 1996). While psychology has many subfields such as developmental, social, clinical, industrial-organizational and health, these are not the focus of the study. Instead, the emphasis is on theoretical perspectives and paradigms that address the relation between different sense-modalities as pertinent to our interactions with our environments. According to Westen (1996, p.29) a paradigm is a “broad system of theoretical assumptions employed by a scientific community to try and make sense of a domain of experience”. For example Gibson’s (1966) paradigm of “senses as sensory systems within an ecological approach” is included because of the emphasis, from a perceptual stand-point, on the relationship between the different sense-modalities.

In order to investigate the relationship between the different modalities, a key source of literature is cognitive neuroscience, which addresses the neural basis of cognitive processes. The most important questions that cognitive neuroscience allows us to answer is the “where” and “when” of cognitive processing (Hunt & Ellis, 1999). The knowledge of the former is important because the human brain is more than a homogeneous mass of neurons; it is a collection of distinct information processing areas, each of which supports only a subset of the brain’s various cognitive functions. Thus the knowledge of “where” can predict what will happen if a particular area in the brain got damaged. It can also tell us if more than one area, which in this case could map to more than one information processing center, is involved in the cognitive process. Since each

of the sense-modalities is assigned to a particular area in the brain, this insight is valuable in understanding multi-sensory perception.

It is also important to understand “when” the neural processing occurs in relation to each other, and this understanding can provide insights about stages of information processing. The approach to cognition that deals with computational models and information processing falls under the category of cognitive psychology, and is as such distinct from social and behavioral psychology. In summary, Cognitive Neuroscience allows a physiological insight into the mechanisms of the brain and is valuable in that it can give us nuanced information, directly from recording brain activity, which is difficult to obtain by the recording of behavior alone. Works included address the processing of lower-level sensory information, rather than higher level cognitive functions such as memory and emotion.

1.5.2. Developing a Theoretical Model

Literature from environmentally based studies is layered upon literature from perception- based studies. Based on the information from the cognitive sciences, and environmental studies, a theoretical premise is formulated. The critical role of movement in sense perception, and our experience of our environments, is acknowledged. Movement involves three principle components: position of the body, motion of the body and the sensation the body receives (Goldstein, 2002). Position and motion can be observed externally, but the multi-sensory perception of the environment is internal. Because the premise is based on lab-based experiments from cognitive neuroscience it lacks ecological validity. Ecological validity requires that the results obtained in research

should also hold true in “real life” (Matlin, 1989). A case study is undertaken, in an environmental setting in order to test the ecological validity of the theoretical premise.

The case study investigates the multi-sensory experience of moving through a place. However, it is difficult in a natural setting to “measure” what users are sensing, and to record it. In order to address this issue, the case study focuses on only the sensations to which the users of an environment are consciously aware and are attending. Attention can be understood as the higher level cognitive process that organizes the sensory stimuli we receive at any point and forms them into a cohesive perception (Westen, 1996). Attention is therefore critical to the multi-sensory aspect of human experience in any given environment. Because it is a higher-level process users can give us information on what grabs their attention directly. In the case study this information from the user is collected at two stages: while moving through the environment (self-record), and immediately after experiencing the environment (interviews and mapping exercises). The nature of the data generated from the case study can be understood as the “mental maps” of the different respondents. The understanding of the term “mental map” ranges from the maps we carry in our heads of the environment around us, to the map of the brain and the manner in which it links concepts. Kevin Lynch’s seminal work in the *Image of the City* (1960) is one of the first cohesive attempts to determine the mental maps that govern the “imageability” of our cities. Lynch classifies the content of these images as determined by the following five types of elements: paths, edges, districts, nodes and landmarks. The identification of these categories argues for the tendency that we all have, in our own heads, to structure the world around us in order to

make it possible to function in a complex world. In turn, these categories can be considered mental models. To quote Senge (1990, p.174):

Mental models are the images, assumptions, and stories which we carry in our minds of ourselves, other people, institutions, and every aspect of the world. Like a pane of glass framing and subtly distorting our vision, mental models determine what we see. Human beings cannot navigate through the complex environments of our world without cognitive “mental maps”; and all of these mental maps, by definition, are flawed in some way.

The “flaw” in a mental map comes from the gap between subjective experience, and “objective” reality. Given that the external relations of the human body are internalized in its perception, the case study works within the naturalistic paradigm with the basic ontological premise is that “there are multiple, socially constructed realities...it is neither possible, nor necessarily desirable to establish value-free objectivity” (Groat, 2002). The interviews conducted are open-ended and follow the “naturalistic paradigm” (Lincoln & Guba, 1985) which involves looking for patterns of phenomena that lead to the explanation of connections between them, blurring the distinction of cause and effect by introducing simultaneous influence of factors over time.

Finally, the behavior of the users as they move through an environment (how they move, where they stop, how their position and motion changes) is observed and recorded. The information from the respondents themselves in self-reports and maps, and from interviews with the researcher, are triangulated with the observed movement patterns.

A strong conceptual framework based on the “identification of units, laws of interaction, boundaries, and systems states” (Lynham, 2002), as relevant to

environmental design, is then derived based on the literature, the premise, and the case study. This forms the basis of a theoretical model.

The development of a theoretical model is used as a method “which allows the mind at every step to lay hold of a clear physical conception, without being committed to any theory ... from which the conception is borrowed, so that it is neither drawn aside from the subject in its pursuit of analytical subtleties, nor carried beyond the truth by a favorite hypothesis” (Black, 1962, p.226). Essentially, the use of a theoretical model is in order to “introduce a new language or dialect, suggested by a familiar theory, but extended to a new domain of application” (Black, 1962, p.227). The familiar theory in question is primarily the field of cognitive neuroscience, and other cognitive sciences. The new domain of application is environment perception and design

The objective of this part of the study (Sections 2 and 3) is to understand the perception of our environments as a factor of the connections between different sense-modalities.

1.5.3. Exploring Relevance to Architectural Education

As an academic work this dissertation seeks to contribute to both the design and the education of architects, landscape architects, interior designers and planners; in short, it is for those who are involved in the design of environments, both in the profession, and the academic institution.

Based on the theoretical model developed in the first part of the study, the second part of the study (Sections 4 and 5) focuses on the relevance of this information and approach to architecture students. The pedagogical significance of studying senses other

than the visual, within a crossmodal paradigm, is discussed. Two independent studies (case study 2 and case study 3) are undertaken that explore the perception of the hierarchical and lateral interaction between senses, by the students.

Case study 1, in Section 3, is open-ended, and focused on the understanding of what users pay attention to in a particular environmental context, and how this understanding reflects the lab-based results of sensory and kinesthetic interaction that are included from the literature. While the case study supports the literary findings conducted by cognitive scholars in controlled conditions about the interdependence between different sense-modalities, it also illustrates that in an open-ended study, and in the absence of psycho-physical measures, it is difficult to separate the sensory information (what people see, hear, smell, taste, touch and how they move) from higher level cognitive information (what people think, feel, and conjecture).

In order to focus on the interdependence between different sense-modalities, and their pedagogical significance, case studies 2 and 3 are undertaken within a more constrained framework. The objective in these studies is to solicit output data solely on the perception of sensory interaction and inter-relationships. Based on the perceptual information from Section 2 and 3, and the theoretical framework developed, the studies explore the perception of hierarchical, and lateral, relationships.

Perception of a hierarchical relation between senses is based on a study that determines if students prioritize one sense over the other across sense modalities, while thinking about particular place-types. A simple survey study is undertaken asking students to rank the importance of different sense modalities in different kinds of the

places. The literature review for this section is derived from the notion of a hierarchy of senses prevalent in the cognitive sciences of philosophy, anthropology, and cognitive neuroscience. The student pool consists of nineteen beginning design. Because of the more simplistic and quantitative nature of the data statistical analyses could be undertaken, the *W* value of concordance in the rankings is calculated to determine whether the rankings are statistically significant (Siegel, 1956).

Perception of lateral relationships is based upon the study of the associations that ten beginning design students and nine graduate students make across sense modalities, when they conceive, or think about certain colors. The theoretical foundation for this section is based upon the neurological condition of synesthesia, caused by the involuntary joining of the senses such that the perception of one kind of sensory stimuli invokes a response in another sense modality (Cytowic, 1989) and other examples of the crossover among sensory modalities from philosophy, cognitive neuroscience and anthropology. In the case study the sounds, smells, textures/ temperatures and emotions/objects associated with the different colors by the different respondents are analyzed both qualitatively and quantitatively. The emphasis is not on developing color theory, defined as a set of principles used to create harmonious color combinations (Color Theory, 2002). Rather the emphasis is on the correspondence between different modalities, and consistency in these correspondences. Therefore literature from color theory is outside the scope of this work. However, it is definitely a possibility for follow-up studies.

Although the emphasis of the case studies is on seeking patterns, anomalies will also be acknowledged and discussed. The ability of students to think across modalities, within a controlled setting, will be evaluated in the context of present day architectural education. The objective of this part of the study (Sections 4 and 5) is to evaluate the connections between modalities *as perceived by architecture students*.

The emphasis is on the ease with which students can “think” about the different senses, in relation to each other, and the consistency with which this occurs within an environmental context. The studies (case study 2 and case study 3) rely on conjuring and communicating mental images, without the actual perceptual context available in the first case study. According to the *Dictionary* an image is a “mental picture of something not real or present”. Downing (2000, p.11) claims that “a mental image is a virtual object; its sensate character is its entire being”. An image is “sensate”, but not “sensed”, it is a construct of the mind, but it doesn’t enter through the gateway of the senses, and doesn’t imprint on the neuronal structure of the brain in the same way that contact with physical stimuli would.

In architecture, we use the experiences of a “real” world, in order to “realize” a world that can be experienced. The sensory connections that define human-environment interaction are important in how they are perceived via direct contact with stimuli as well as via mental imagery and abstraction. The latter falls into the category of *conception*, “the ability to form or understand mental concepts and abstractions” (*Dictionary*). The perception, and the conception, of sensory inter-connections, forms the content of this dissertation.

1.6. Dissertation Structure

This dissertation has a cloverleaf structure. The core of the dissertation is the literature review and the theoretical framework based in the perception of environments and the role of crossmodal processes. Feeding into the theoretical framework is the qualitative case study, and emerging from the theoretical framework are two smaller studies that address pedagogical questions. All three case studies are independent. Figure 1-1 shows the basic structure of the dissertation. Each section is color-coded.

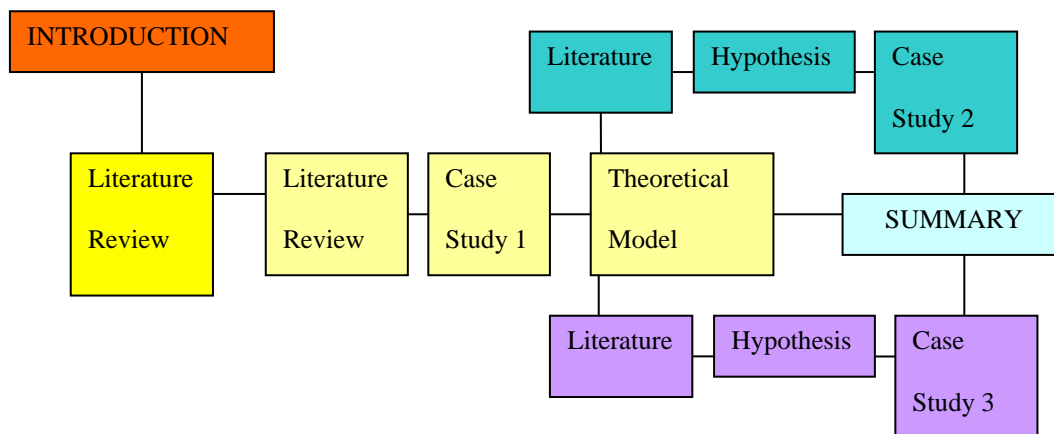


Figure 1-1 Dissertation-structure. Colors represent different sections

Section 2 introduces the literature from psychology and cognitive neuroscience, and focuses on the interconnections between sensory modalities. A crossmodal paradigm of thinking across senses is introduced. In Section 3 this paradigm is approached within the context of existing models for human-environment interaction. A case study is undertaken on what users pay attention to as they move through the Santa Fe plaza in

New Mexico, and the connections and associations that users make are noted. A theoretical framework (defined as the Sensthetic Model) about the connections between different modalities in our interaction with the external environments is developed based on the literature and the case study. Section 4 and 5 are based on the model for modal-interconnections and its pedagogical significance and are focused on student-perception of environmental concepts. Section 4 investigates the hierarchical relationship between the sense-modalities, as perceived by beginning design, and graduate level students. Section 5 investigates the lateral relationship between the sense-modalities as perceived by the same group of students. Section 6 forms the concluding section of the dissertation by summarizing the previous sections, bringing together the design and pedagogy implications of the study, fine-tuning the theoretical “Sensthetic” model, and introducing a crossmodal paradigm for design thought.

2. THINKING ACROSS MODALITIES IN THE PERCEPTION OF PLACE*

Sensory correspondence is not a domain of inquiry restricted to scientists, a matter solely for experimental scrutiny and empirically based theory.

The plain fact is that sensory analogies do exist; they are important to the ways that we sense, perceive and cognize; they are significant properties of the bodies and minds of people

– Lawrence Marks, 1978

Our world is connected. It is cohesive. It is coherent. What we see and what we hear, what we smell and what we taste, all comes together as we move through life, and we have stable images of what we know and think. There has been an ongoing debate among philosophers about whether we know our world through our senses, or whether we have preordained conceptual structures, what Plato would call “ideas”. It is true that the body is limited by the sensation it receives (or seeks), but what constrains the mind? According to Locke and Hume sensations of themselves, spontaneously and naturally, fall into an order, and become perception, while for Kant this process is determined by the inherent structure of the mind (Durant, 1953). Side-stepping this debate is the more contemporary ontological assumption that we are coupled to the world through our embodied interactions.

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Lakoff & Johnson (1999) in the *Philosophy of the Flesh* make the following arguments for an *embodied realism*:

1. Conceptual structure arises from our sensorimotor (from sensation and movement) experience and the neural structures that give rise to it.
2. Mental structures are intrinsically meaningful by virtue of their connection to our bodies and our embodied experience.
3. Reason is embodied in that our fundamental forms of inference arise from sensorimotor and other body-based forms of inference.

Within this context the distinction between the mind and the brain blurs, and the mind-body debate seems redundant. Perception is no longer a mere philosophical, or even behavioral, consideration, it is an intrinsically biological and psycho-physiological study.

2.1. *The Process of Perception*

According to Sekuler & Blake (2002) perception is the process that registers and interprets sensory information from the environment that guides behavior, which, in turn, shapes the nature of input to the senses. The environment offers a multitude of stimuli, and it is not possible to register and process each of these. Thus, in a crowded walkway we are not overwhelmed with the conversations that people are having among themselves, even though we can definitely hear the auditory stimulus. Similarly, in a cocktail party we can carry out a coherent conversation without being distracted by the sounds around us. The purpose of perception is not to know everything about the environment, but to allow us to engage in our environments in an efficient manner. In

essence, perception is not about gaining information about the environment, it is about using information, and acting on this information, in a complex world. The perceptual process is therefore, of necessity, dynamic and cyclic, where the environmental stimulus and our actions within the environment feed into each other and shape our perceptions. The entire process can be simplified into a cyclic process illustrated in Figure 2-1.

The distinction between environmental stimulus and attended stimulus, indicated in the figure, is critical since it is not possible to process every single aspect of the environment. Environmental stimulus refers to all the things in our environment that we

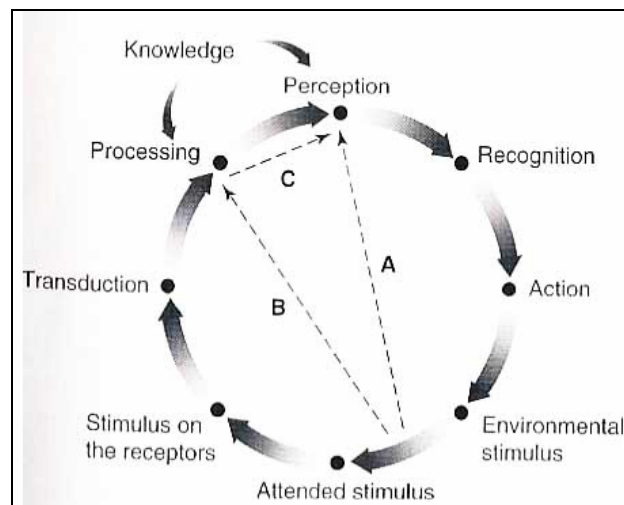


Figure 2-1. Perception process (Goldstein, 2002)

can potentially perceive, while attended stimulus refers to the aspects that we focus on. As a result of this focus the stimulus (from the environment) is mapped on our sensory receptors. For example, during the act of looking at a painting, an image of the painting is formed on the retina of the eye. The pattern of light on the retina is then transformed

into electrical signals in the receptors. This is the transduction step in the perceptual process where one form of energy is transformed into another to allow processing by the brain. The signals in the receptors generate new signals in the neurons in the brain. These neurons, in turn, create a series of interconnected pathways, along which the electrical signals travel. It is during this travel that “neural processing” occurs, which refers to the operations that change the electrical responses of neurons in various ways and perception occurs as a result of the flow of these electrical signals. According to Goldstein (2002, p.6) “perception is conscious sensory experience”. In the example of the painting, perception occurs when the electrical signals that represent the picture in the brain are transformed to the experience of seeing the picture. The next two steps, recognition and action, are the perceptual behavior outcomes of the perceptual process. Recognition refers to the ability to categorize an object that gives it meaning, and action refers to the outcome in terms of motor activities such as moving the head, or eyes, or speaking, or so on. For example seeing a painting in a gallery is different from recognizing it as, say, a ‘Monet’, and then moving on because you don’t like impressionists. This action changes the environmental stimuli we are subjected to, and the perceptual cycle begins all over again.

The distinction between these six steps is not as clear as one might suppose. For example perception and recognition are closely linked, and while we can intuitively appreciate the difference between sensing, perceiving, and understanding our environments, it is difficult to identify at exactly what point one gives way to the other. In the context of designing environments it is the interface between the environmental

stimuli and the perceptual process that becomes critical, and this is via the sensory systems that serve as the gateways to perception. It is a discussion on these systems that will be undertaken in the next section.

2.2. *Senses as Sensory Systems*

The inflow of information does not coincide with the inflow of sensation; they are at least semi-independent.

J.J. Gibson (1966)

Sight, Sound, Smell, Taste, and Touch: these are our five senses. The list of the five senses has been passed down to us through philosophers such as Plato and Aristotle. Historically, the five senses have been listed as independent and discrete entities, and approached within a certain hierarchy, with sight as the most prominent sense. This hierarchy is taken up in more detail in Section 4. Since kindergarten it is these five senses that we learn about. As we grow older we learn about how the different sense organs, and the corresponding nerves, make us perceive these senses; the eye and the optic nerve, the ear and the auditory nerve, the nose and the olfactory nerve, the mouth and the gustatory nerves, and the skin and a whole set of nerves which have never been completely identified. We learn the biology of these systems and the physics of their mechanisms.

In his seminal work on *Senses Considered as Perceptual Systems* Gibson (1966) critiques the naïveté of this approach. He places the study of the senses in the context of our interactions, as perceptual human beings, with our environment. His premise is simple: “in considering the problem of perception in man and animals the first question to ask should be, what is there to be perceived? And the preliminary answer would be

the environment that is common to man and animals” (Gibson, 1966, p.7). Here the term environment encompasses both the physical and socio-cultural factors. Gibson’s approach to environment is defined by ecology; a blend of physics, geology, biology, archeology, and anthropology, unified by the “principle of what can stimulate a sentient organism” (Gibson, 1966, p.29).

In his work Gibson makes a crucial distinction between “perception” and “proprioception”, and between “imposed stimulation” and “obtained stimulation”. Proprioception is defined as the unconscious perception of movement and spatial orientation arising from stimuli within the body itself (*Dictionary*). Traditionally it has been common to distinguish between the sensory (derived from the senses) and the motor (derived from muscle and joint movement). Yet, movement is intrinsic to the manner in which sense organs receive sensation and process it further. We squint our eyes to focus, we tilt our head to listen, we run our fingers across a surface to feel it and we sniff in the air to catch a pleasant aroma. For Gibson, this active, exploratory and orienting powers of the sensory organs makes them more than mere receptors, and make us, as human beings, sensation seeking organisms. Sensory stimulation may be obtained by us as a result of our actions in an environment, or imposed upon us by the environment without our active participation. Turning the door-knob and feeling the coolness is thus different from feeling the cool air when we step into an air-conditioned building. In fact, according to Heller (2000) touch is not a single sense. Shape perception by active touch depends crucially on combinations of inputs from the skin, movements

of the finger, hand, and arm in scanning, and body and limb postures which afford current anchor and location cues in the absence of vision.

In our interactions with the world, imposed and obtained stimulation go hand in hand, as do perception and proprioception. Table 2-1 tabulates the difference in perception and proprioception, and obtained stimulation and imposed stimulation.

Table 2-1
Perception and Proprioception Matrix. Interpreted from Gibson (1966)

	<i>Perception</i>	<i>Proprioception</i>
<i>Obtained</i>	Arises from the classical sense organs when they are oriented by way of body and are active, i.e. when they adjust and explore so as to obtain information.	Occurs when the individual behaves, or performs, with any of the motor systems of the body.
<i>Imposed</i>	Arises from the skin, nose, mouth, ears or eyes when these sense organs are passive and the stimulation impinges on them or is applied to them	Occurs when members of the body are moved and the joints are thereby stimulated.

Gibson (1966) also discards the notion of individual sense modalities that work independently and proposes the following perceptual systems:

1. *Basic orientation system* (responsible for body equilibrium and orientation – responding to the forces of gravity and acceleration);
2. *The Haptic system* (responsible for perception of passive and active touch, for temperature distinction, and for distinction of ones owns movements - responding to skin thermoreceptors and deformation of tissues, joints configuration, stretching of muscles);

3. *Visual system* (responsible for the instant and simultaneous perception of forms, depth and distance, variables of color, and transformations in light. Vision also controls movements of objects and individuals in space, conveying information about the environment spatial layout and its changes - responds to variables of structure in ambient light);
4. *Auditory system* (responsible for listening, orienting towards sounds and detecting the nature of sounds - responds to vibratory events)
5. *Taste/Smell system* (responsible for detecting the nature of volatile and nutritive sources - responds to composition of the medium and of ingested objects.

A more detailed description of these sensory systems is shown in Appendix A. The systematic approach to senses is distinct from the discrete classical categorization into sight, sound, smell, taste and touch. In essence Gibson (1966) introduced the idea that the senses work in correspondence and form a sensory system. He questioned the very polarity between senses and motor processes claiming that the “simple, neat, easily remembered contrast between receptors and effectors, between sensory and motor will have to be abandoned” (Gibson, 1966, p.45), and argued that sensory systems are active, defined by their interaction with the sensory environment.

According to Gibson (1979) different environments have different “affordances” in terms of what an environment can provide an animal, or what the animal perceives is provided by the environment, and this implies a “complementarity” between the animal and the environment. Here, the term “animal” refers to all living beings. For example “if

a terrestrial surface is nearly horizontal (instead of slanted), nearly flat (instead of convex or concave), and sufficiently extended (relative to the size of the animal), and if its substance is rigid (relative to the weight of the animal), then the surface affords support” Gibson (1979, p.129). When entering any given environment we perceive affordances (coffee, in a café, bread, in a bakery, and so on) and we act accordingly. But if the perceived affordance varies from the real affordance, (say the horizontal support in Gibson’s example is soft, and the café sells hardware), then this may be perceptually disconcerting.

Gibson’s work was seminal in its ecological approach, and the focus on human-environment interaction. By thinking in correspondences and affordances Gibson alluded to a nuanced relationship within different sense-modalities. However, because the emphasis of Gibson’s work was on visual perception, these relationships were not focused upon. In Appendix A, Gibson’s table for the sensory systems is shown where he maps the different sense-organs, their functions, and their organization into systems. However, the lateral relationship between the different systems is not addressed.

2.3. *Sensory Connections and the Role of Attention*

It is fair to say that Gibson’s sensory systems are situated within the physiological framework of sense organs, neural pathways, and processing centers in the human brain. With advancements in imaging technologies such as fMRI (Functional Magnetic Resonance Imaging), EEG (Electroencephalogram), ERP (Event Related Potential) and NIRS (Near Infrared Spectroscopy), and the emergent fields of cognitive neuroscience and neurobiology it is now possible to seek physiological collaborations

(and refutes) of the psychological phenomena and measure the interaction between different sense modalities that was alluded to by Gibson and his followers. Figure 2-2 shows an image of the human brain representing the different cognitive centers as they are understood today. Such a detailed insight into the neural mechanisms also enables the experimental study of the nuances of the perceptual mechanisms, hitherto just a theoretical possibility.

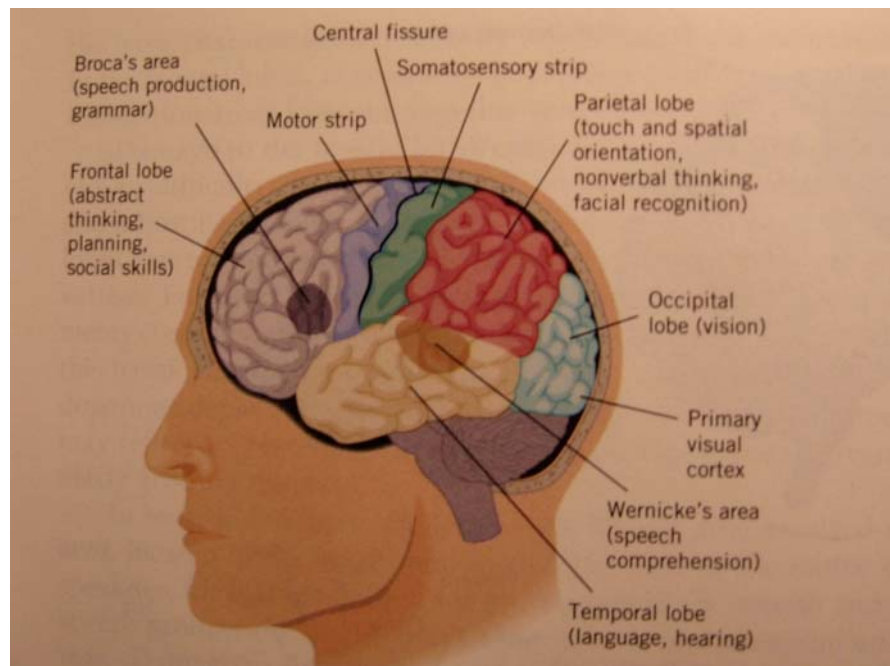


Figure 2-2. Cognitive centers in the human brain (Westen, 1996)

Once the approach to the sense modalities was taken out of its discrete pockets of investigation, the interest in the correspondence between the different sensory systems gained popularity. In the *Unity of the senses* (Marks, 1978) five doctrines of sensory correspondence are postulated. In the first *doctrine of equivalent information* Marks

postulates that different senses can inform us about the same features of the external world. For example, movement can be perceived by sight, sound and touch, size can be perceived by sight and touch, volume can be perceived by sight, touch and sound. However, the information from different senses, about the same features, may vary perceptually. Thus equivalence is not always proportional. For example, Linear extent (or length of an object) is perceived as longer by sight than by touch. Similarly, roughness or smoothness perceived by touch is not the same as perceived by sight. Despite the salience of the phenomenal differences among the qualities of various sense modalities, there are a few properties of sensation held in common. Galileo, an astronomer and natural philosopher in the seventeenth century, identified these “primary” qualities as solidity, size, shape and motion, while Locke, later in the century, included “number” in this list. Primary qualities are different from secondary qualities such as color, pitch, warmth, cold, and so on which are limited to a single sense. Primary attributes are supra sensory; i.e. categories or dimensions of experience that are not limited to a single modality, but that apply to most or all modalities. For example, according to Kant, space, time, number and quantity are “suprasensory”; logical forms of perception which are prior and common to all sensation. Suprasensory qualities can also be considered “amodal”; qualities which are not unique to a single-modality. Intensity, rate, duration, spatial location, spatial extent, rhythm, and shape all represent amodal features of the world that can be specified in more than one modality (Lewkowicz & Turkewitz, 1980). According to Marks (1978), to the extent that primary qualities are attributes of objects, they play a central role in the doctrine of equivalent information. To

the extent that they are only attributes of sensations they pertain to the doctrine of analogous attributes and qualities.

In the *doctrine of analogous attributes and qualities*, Marks postulates that certain dimensions of sensory experience are similar, even identical, across sensory modalities. Resemblances among color, sound, taste, smell and touch can be solely phenomenological, which is to say that similar qualities need not refer back to common objects or events in the physical world, need not provide equivalent information. An example quoted by Marks (1978, p.50) is about the description of the colors of flowers in a garden by a woman who had sight (but subsequently lost it), to another blind woman who was blind from birth:

Red or yellow, like the warmth of the sun. Blue like the coolness of the water that splashes in the mountain out there, green like the freshness of the grass under your feet or the taste of mint. I can remember these colors because I was not always blind.

In this example the quality in one modality (touch) is analogous to a quality in another (sight). This phenomena will be discussed later in this section in the context of the neurological condition of “Synesthesia”, which is characterized by an involuntary joining of senses

According to Marks different senses have *corresponding psychophysical properties*. Psychophysical refers to the functional relationship between properties of sense perceptions and the properties of the physical stimuli that produce them. This suggests that at least some of the ways the senses behave and operate on impinging stimuli are general characteristics of sensory systems, similar in vision and hearing, as well as touch and olfaction. Also, similar or *identical neurophysiological mechanisms*

parallel the aforementioned examples of sensory correspondence. Finally, in the *doctrine of sensory correspondence* Marks incorporates the first four theories in which multiple senses are interpreted as modalities of a general, perhaps more primitive sensitivity.

Mark's (1978) doctrines also address the principle of sensory interaction i.e. "the modification of responses to stimulation in one modality by concurrent or juxtaposed stimulation in another" (Marks, 1978, p.7). For example in a dark room it is possible to judge the orientation of an illuminated line quite accurately even though there is no visible background. However, if the same judgment is made during or after a centrifugal rotation the line appears tilted (Stein and Meredith, 1993). The possibility of such interaction allows us to take an approach beyond the multisensory and multimodal, to the cross-sensory or crossmodal. The term "crossmodal" refers to different modalities not just acting together, but *simultaneously affecting one another*.

A certain correspondence between senses is evident in how the different senses come together in how we function in the world around us. For example, space can be perceived aurally as well as visually. The auditory space extends around the space in all directions, and visual space is frontal within the cone of vision. While visual space is binocular, auditory space is binaural: for vision the depth cue depends on differences in the image in the left eye and the right eye, while for hearing the cues depend on the differences in intensity and timing of sounds arriving at the left and right ear (Goldstein, 2002, p.264). Another example is the manner in which colors can affect odor identification and taste. Extraneous colors can hamper taste identification, while colors consistent with the odor aid odor identification (Cytowic, 1989, p. 219). What is not

clear is to what extent this correspondence is a bottom-up process (e.g., processing that begins with the information received by the receptors) or a top-down process (e.g. processing that is influenced by the knowledge that a person brings to the perceptual situation), and this has been an ongoing debate between cognitive scientists.

Another significant aspect of the interdependence between the sensory systems can be seen in the manner in which one sense often compensates for the other. This happens at a functional level when the visually impaired use audio and tactile cues to recognize objects. Experiments show that there are distinct neurological changes that occur when one sense is dormant and the other senses take over, for example, depriving kittens of vision causes an increase in the area of the *ectosylvan sulcus*, which is an area devoted to auditory localization (Goldstein, p. 265).

In our day to day use of language we often cross over sensory modalities, talking about “warm” or “cool” colors, although we sense colors visually. Our ability to pair a tactile sensation with a visual one reflects an inherent capacity to integrate or translate between modalities. This ability is not merely because of the nature of the words alone; according to Cytowic (1989) the development of speech itself depends on the ability to form stable inter-modal associations readily. In its most evident and intense manifestation, crossmodality can be appreciated if we consider the phenomena of Synesthesia.

2.3.1. *Modal Cross-Connections and Synesthesia*

Synesthesia derives from the Greek *syn* (union) and *aesthesia* (sensation), literally interpreted as a joining of the senses. It is a neurological condition causing an

involuntary joining in which the real information from one sense joins or parallels a perception from another (Cytowic, 1989). For example while hearing/ reading music a person might see colors or shapes, or while tasting something with intense flavor perceive objects with weight, shape, temperature and texture, or see shapes while listening to words or music. This is not “metaphorically’ speaking, it is more basic in that it is a “real” percept of joined senses. According to Lakoff and Johnson (1999, p.543) metaphors are means by which we “understand abstract domains and extend our knowledge into new areas....metaphor is a tool for understanding things in a way that is tied to our lived, embodied experience”. Metaphors are thus more in the domain of thought, while synesthetic perceptions are in the domain of “sensory fact” (Cytowic, 1989). Cytowic claims that this distinction between “sensory fact” and “thought” is not so apparent, but crucial. The synesthetic sense must be considered more of a parallel sense than an associative one.

Although Synesthesia is known to be a rare condition (approximately 1 in 300,000 people) it is a powerful perceptual phenomenon, an extreme form of the perceptual experiences of our day to day life. It is significant as an illustration of the connections between different sense-modalities, and the perceptual consequences of the involuntary cross-wiring between them. Synesthesia, and its relevance to how we conceive our environments, is taken up in more detail in Section 5.

2.3.2. Modal Interconnections and the Role of Attention

It is a well-known fact that the sensation received by the body is processed by the neurons in the brain. A myth prevalent in psychology for a long time was that there are

specific neurons in the brain for specific senses i.e. neurons in the primary visual cortex, for example, receive and process signals from the eyes; those in the auditory cortex react from the ears, and so on. This has been proved to be a limited view in the last two decades. While there are neurons that respond to particular sensations, and one particular sense-modality, studies have also shown the prevalence of bimodal neurons and multimodal neurons, neurons that respond to sensory stimulation in more than one modality (Goldstein, 2000). An example of bimodal neurons are neurons that respond to both visual and tactile stimuli, which are relevant to the perception of extrapersonal space (Graziano & Gross, 1995). Extrapersonal space is the space beyond arm's reach. While the bimodal neurons were observed initially in monkeys, there has been a case in humans wherein, a man blind in part of his visual field could get partial sight there--as long as his hand was in the blind area (Schendel & Robertson, 2004).

The study of which neurons are activated by particular actions falls under the category of "attention". The introduction of attention is the key to addressing the multi-sensory and the kinesthetic in the human performance through environments. The value of attention is that it is a higher-level process that organizes the sensory information that we receive. Attention can be defined as the higher level cognitive process of focusing on relevant stimuli (Westen, 1996). Its role in the perceptual process is illustrated in Figure 2-1. In essence, attention acts as the organizing phenomenon in a simultaneous world and can be measured by the neuron movement in the cortex; the modality that is 'attended' to is determined by the areas in the brain that are affected in terms of a physiological response. Advanced imaging techniques such as fMRI (functional

Magnetic Resonance Imaging), CT-Scan (Computer Tomography), NIRS (Near-Infrared Spectroscopy) etc. allow scientists to measure activity in the brain with increasing accuracy.

Spencer and David (1998) identify the most basic issue concerning attention to be whether people can attend to one modality at the expense of others, or whether the modalities are so independent that concentrating on one has no impact on the others. In a crowded party we hear what people are saying by looking at their lip movement, we tune out everything else but what is being said to us, and while we may be hearing many sounds at the same decibel levels, by the act of focusing on what is relevant, and by combining our audio and visual inputs, we ‘obtain’ the information from the environment that is needed. If we revisit Gibson’s theories, and look at the diagram for the process of perception shown in the previous Section, we can gauge the importance of selecting important information from our surroundings by what we decide to pay attention to.

2.3.3. Attention, Location and Crossmodal Considerations

A central issue in attention studies is location. Studies have shown that different senses have different mapping systems. Each of the cortical receiving areas in the brain for hearing, vision and touch, contain maps—neurons arranged in an orderly way to represent the sound frequency (tonotopic map), location on the retina (retinotopic map) and places on the body (somatotopic map). The maps for vision and touch are distorted; there is a magnification factor in vision in which the fovea is represented by a large area in the cortex, there is also a magnification factor in touch, so that parts of the body, such

as finger-tips, that are very sensitive to tactile details of the environment, are allotted an area in the cortex that is far out of proportion to their area on the skin (Goldstein, 2002). This is illustrated in Figure 2-3. A similar ‘space-allocation’ happens in the motor-cortex. The motor cortex and the somatosensory cortex are on two sides of the central fissure in the human brain (Figure 2-2). The motor cortex directly initiates movement through its projections to the spinal cord, and the somatosensory cortex receives sensory information from the spinal cord; they thus work in complementary ways.

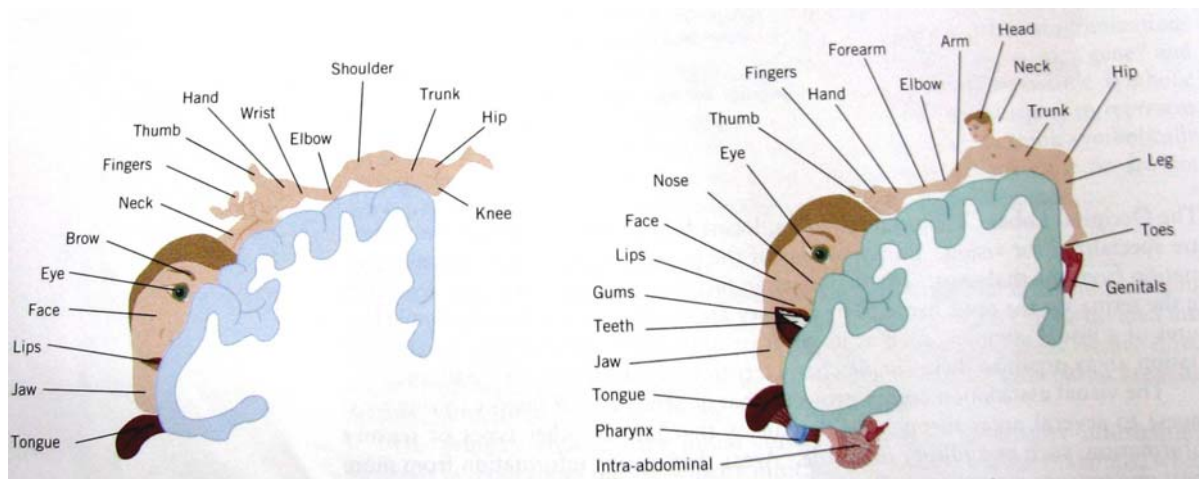


Figure 2-3. Space allocation in the motor and somatosensory cortex. Left: cross-section of the motor cortex. Right: cross-section of the somatosensory cortex. Both motor and somatosensory cortex devote space according to the importance, neuronal density (number of neurons), and complexity of the anatomical regions to which they are connected (Westen, 1996)

It is evident that the “spatial organization at the input levels varies for different senses” (Driver & Spence, 1998b) . Furthermore, the mapping in each modality changes with body posture. Yet the brain derives useful representation of these stimuli that is a cohesive, non-fragmented, image. The issue of localization in attention processes is

critical to the continuity perceived in the lived world, and therefore in the designed world.

The evidence of a certain overlap between auditory and visual space is illustrated in two well-known perceptual illusions: *The Ventriloquist Effect* and the *McGurk Effect*. The ventriloquist speaks without moving his lips but it is his puppet that seems to be talking. Similarly, in a movie hall, though the speakers are at the back, we perceive the sounds to come from the screen upfront, attributing the voices to the actors we see on screen. Calvert et al (1998) interpret this phenomenon of “localizing” different sense-data as proof of how perceptions fuse across different modalities, as also the superiority of vision in these crossmodal processes. They argue that typically the modality with the greatest resolution has the greatest influence on the location of the fused percept. Along the lines of the Ventriloquist’s illusion, is another illusion dealing with crossmodal interaction: the McGurk effect. In this illusion when an audible syllable ‘ba’ is dubbed onto videotape of a speaker mouthing a different syllable ‘ga’ subjects report “hearing” a third syllable ‘da’. In this case vision does not completely over-ride the sensed percept, but the final percept is a fusion of the information given by the individual senses. One can almost think as if the two sense-modalities negotiated to form a stable image of their dynamic world. Another key factor that this illusion deals with is identification. However, localization and identification cannot be seen as mutually exclusive, since it is obvious that it is the tendency to localize in the first place that causes the McGurk illusion. Localization of audio and visual percepts has also been observed in the context of visual motion. In an investigation of how the human perceptual system coordinates

complementary inputs from auditory and visual senses it was seen that an auditory aftereffect occurs from adaptation to visual motion in depth. After a few minutes of viewing a square moving in depth, a steady sound is perceived as changing loudness in the opposite direction. The results provide psychophysical evidence that, for processing of motion in depth, the auditory system responds to both auditory changing intensity and visual motion in depth (Kitagawa & Ichihara, 2002).

Experiments carried out by Driver and Spence (1998b) address the issue of localization within the context of spatial expectancy (i.e. where, in space, an object is expected to be located by our perceptual mechanisms) by studying neuronal activity. The studies show that stimulus localization improves within endogenously (voluntarily) attended regions. They show that when a target is strongly expected from one side in just one modality (e.g. audition) up/down discriminations also improve on that side in other modalities (e.g. vision), suggesting a tendency for common shifts in other modalities. However, the spatial effect for secondary modalities is smaller than in the primary modality (which is task relevant), for which the spatial expectancy applies. In simple terms, this means that if one is expecting to 'see' something, more of the attention is focused on vision, and less on audition. However, the attention in each modality is focused towards the same location. So if I am expecting to see a bus, then I am focusing on sight, more than sound. However, at the same time I expect the sound to come from the same location that I see the bus. The expected visual location is mapped with the sensed auditory location. The brain localizes in a cross-sensory manner. And it strives to localize. This is further substantiated by the observation by Driver (1998) that though

endogenous (voluntary) attention can be split spatially (directed in opposite directions for say audio and visual), this is less efficient than directing attention to a common stimulus crossmodally. This phenomenon can also be seen between vision, touch, and proprioceptive information (Driver et al, 1998). It is particularly difficult to direct endogenous attention to one side in vision, and another side in touch. In fact, the tendency to localize is so strong that it causes perceptual illusions, such as the Ventriloquist illusion and McGurk effect discussed earlier in the section.

2.3.4. Crossmodal Processing of Attention: Different Viewpoints

Technically, attention has been studied at two levels: exogenous (reflexive) and endogenous (voluntary). The difference between exogenous and endogenous attention processes has been established in various unimodal (single sense: such as sight, hearing, smell, taste and touch) studies and thus exogenous and endogenous attention have been dealt with separately by most scientists. Multimodal studies in attention are aimed at studying brain behavior in response to particular stimuli. These studies have shown that areas of the brain hitherto attributed to particular sense modalities are not so clearly demarcated. Furthermore, stimuli associated with one modality (such as picture to vision) are not responded to by neural mechanisms attributed to that modality alone.

Traditionally, attention studies in cognition have concentrated on the spatial aspects of the human response to stimuli, distinguishing between overt shifts (visible shifts like moving the head etc. towards the region of interest) and covert shifts (internal changes shown only by the behavior of the neurons). Also, the modalities primarily addressed in crossmodal studies where scientists have concentrated on the impact on one

modality due to a change in the other, thus far, are vision, audition and touch. Smell and touch have not yet been addressed extensively in terms of how they are linked to other modalities. The link between smell and taste however, is very well established. For example, it is a known fact that flavor is a function of smell and taste together. We have only 4 basic tastes; bitter, sweet, sour and salty. All the other more subtle flavors, such as strawberries, oranges, chocolates, come from a combination of taste and smell (Goldstein, 2002). Unlike taste and smell, the interdependence between vision, audition and touch is subject to various debates.

Driver & Spence (1998a) argue for simultaneous crossmodal interactions between audition, vision, and touch in terms of links between different modalities. They advocate that there is a certain hierarchy to this approach: the 'task relevant' modality affects other secondary modalities, which attenuate to the spatial location in terms of the relevant modality, but are less significant. Furthermore, there seems to be a competition for the status of relevant modality. An illusion that might illustrate this is how the ambient sound in a room always seems louder when the lights are switched off. Thus, once vision is not relevant, audition, that was secondary until that point, becomes more significant, and is thus perceived as louder. Also, at no point is the brain considering that the room has changed in any manner due to the fact that you can no longer see the objects. One sense has over-ridden the other, but the image of stability continues, and no gap in this image is perceived.

In response to the theory of crossmodal links discussed above, Eimer, Van Velzen, & Driver (2002) investigated the question whether crossmodal interactions

representing a certain spatial synergy in attention between different modalities reflect a certain supramodal control system for spatial attention. The study addressed the debate between this supramodal system advocated by Farah et al. (1989), and the horizontal links between separate systems advocated by Driver and Spence (1998).

Shimojo & Shams (2001) discard both the theory of crossmodal links, and supramodal systems, by arguing that sensory modalities are not separate modalities at all, and that not only is there integration, but there is plasticity across modalities. They argue for this plasticity by observing how modalities are not distinct at infancy, and how by the removal of some brain parts (in this case the superior colliculus) visual responses were solicited from the neurons in the auditory or somatosensory cortex. Crossmodal plasticity is shown by the fact that the deprivation of one modality early in life causes the cortical area typically devoted to it to be used by another modality. The argument for the vigorous interactions between modalities that is witnessed in the smoothness of day to day life is attributed to this plasticity, in contrast to what they call the “naïve modality” point of view where each modality develops independently. In other words, since modalities are plastic, their interaction is intrinsically fluid. While acknowledging the merit to this approach, it is important to remember that different senses operate differently with distinct processing and mapping systems.

According to Ernst and Bulthoff (2004) humans combine information following two general strategies: the first is to maximize information delivered from the different sensory modalities (“sensory combination”). The second strategy is to reduce the variance in the sensory estimate to increase its reliability (“sensory integration”). In the

creation of environments, sensory combination and integration must be towards a coherent, meaningful environment, and the knowledge of perceptual mechanisms is important in order to achieve this.

2.4. *Summary: Crossmodal Considerations in the Perception of Our Environment*

In a biological sense attention is measurable by the neuron movement in the cortex. Thus it is possible to know that when subjected to particular stimuli, which areas in the brain show activity. This is understood to be an indicator of what the brain is paying attention to: the modality that is attended to is determined by the area that shows more activity. Now, recent research has focused on how audition, vision and touch are coupled in ways where each affects the other. Not much work has been done experimentally on taste and olfaction, but position and motion (kinesthetic considerations) are taken as implicit in all the experiments. The turn of the head, the movement of the eye, the tightening of muscles, the perked ears, these are all indicators of paying attention at a micro scale. Within audition, vision and touch, however, a certain hierarchy is seen to emerge. For example, behavioral responses to tactile stimuli in a tactile relevant condition (such as a hot bath) are faster than the responses to auditory stimuli in an auditory relevant condition (such as listening to music). In fact, in the majority of the literature on crossmodal experiments (mapping the physiological and neural activity for two or more senses simultaneously), touch seems to warrant the quickest response, though it does not necessarily solicit the most activity in the brain. It is important to keep in mind that most neuro-imaging studies conducted on humans are

at a micro level in controlled laboratory settings. Movement, an intrinsic part of our real-life interactions is kept to a minimum to reduce confounds in the study.

The literature from these lab-based studies indicates that at a basic level certain hierarchies can be considered fundamental, (such as the immediacy of touch). However, in environments where many stimuli occur together, this hierarchy is constantly emerging and reforming itself. In such situations the task relevant modality affects other secondary modalities, which attenuate to the spatial location in terms of the relevant modality. In fact, there seems to be a competition for the status of relevant modality, and when the relevant modality changes, the hierarchy is reformed, creating a context for an emerging and dynamic hierarchy. Imagine a theater: when we enter all our modalities are equally assaulted, with perhaps an emphasis on vision. When the show starts, the lights are dimmed and everyone is quiet, allowing us to focus our attention on the stage and ‘tune-out’ the irrelevant stimuli. If it is a music concert we deliberately close our eyes, allowing audition to become the relevant modality. The concert then has our complete attention, with audition as the most relevant. If the next item is a mime then we refocus on the visual, and the hierarchy has changed again.

The most critical issue in attention is that of change. We automatically respond to a change in our sensory environment, whether this is because of a change in our own position or movement, or in the sensory stimulation we are receiving from the external environment. This re-orientation ties into the hierarchy of senses, and the effort to localize, as discussed above. Thus changes act as triggers towards the organization of attention. Once triggered the dynamic process where the different modalities compete

and reorganize into one fused perception can almost be thought of as negotiations aimed towards integrating sensory stimuli, and cohering it.

If we design a place where the sensory input is fragmented then the user will be unable to form a cohesive image and this might reduce the impact. There are many examples of places today where there is almost a conscious effort towards de-localization. In some bars, for example, one is accustomed to watching images on a screen that are dissociated from the music that is playing, which in turn is dissociated from the staged lights and the shows up front; there is almost an effort to create “fleeting” impressions rather than lasting memories. Our tendency is to localize all the sensory input we get into a cohesive image than can be attended to; it is up to the designer to use this insight for desired impact. In order to do so it is important to realize that senses don't just add together from a checklist, rather they interact with each other and act as “negotiated additives”, where each modality negotiates with the other, towards a stable perception, while incorporating the shifts in attention which are intrinsic to the dynamics of human-environment interactions.

3. SENSTHETICS: DEVELOPMENT OF A THEORETICAL FRAMEWORK*

3.1. *The Dynamic Nature of the Human-environment Interface*

In Section 2 a detailed overview of the perceptual processes was undertaken, with an emphasis on the relationship between different sense modalities. The dynamism of the perceptual process was acknowledged. In order to incorporate the dynamism of the perceptual process in the approach to environments, it becomes important to shift the focus from human and environment as two separate entities, to the interface and interconnection between the two. In fact, if the purpose of perception is to allow us to interact with our environments efficiently (Gibson, 1966), then the environment must also be considered via the perceptual filter. Two distinct approaches to the interface between humans and their environments are 1) The notion of flowfields expostulated by Gibson (1966), and 2) The notion of invisible bubbled expostulated by Hall (1966).

A flowfield refers to the continuous change of position (observer movement) generating characteristic patterns of image motion that directly indicate observer motion (Figure 3-1) (Gibson, 1966). In this theory, perception is anchored on movement in the human body, and the environment is something that flows by it. While flowfields are

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more temporally oriented, a much more basic way of reading the man-environment interface, the very stage of this ballet, has been to see man as surrounded by a series of invisible bubbles (Hall, 1969, p.129).

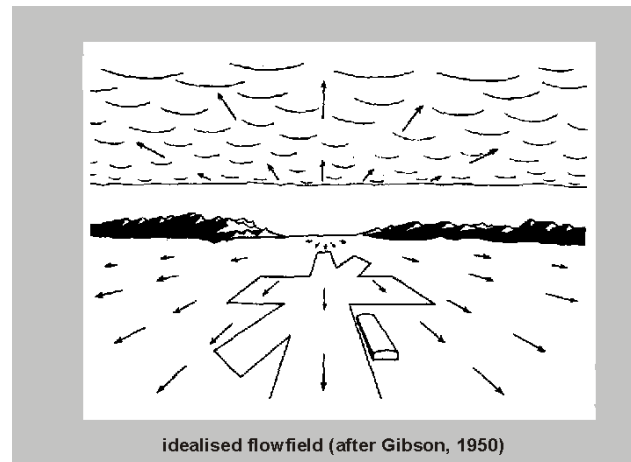


Figure 3-1. Flowfields (Gibson, 1966)

3.2. Crossmodal Considerations in Proxemics

The notion of invisible bubbles falls within the field of study known as “proxemics”. Personal distance (i.e. distance between two people) and personal space proxemics both describe the relation between organisms and their spacing (Wilson, 1984). Originally conceived by Heidegger the concept of “Life Space” and the “Invisible Bubble” was later taken up by Hall (1969). These two concepts serve as “theoretical models developed to describe requirements of individual privacy, and/or the need for freedom of the person, or group, from unwanted intrusion by others” (Wilson, 1984, p.253). Sommer took the concept further in his thesis on “personal space” and “territory”, which was defined as an area which “should be a volume of individual

“territory”, which was defined as an area which “should be a volume of individual boundaries, into which intruders may not come” (Sommer, 1969, p.254). This boundary is flexible, depending on the context, as illustrated by Untermann (1984) in Figure 3-2. If we think about the typical pedestrian, and the notion of place-ballet discussed above, it is almost as if we walk through our environments gently choreographing our invisible bubbles.

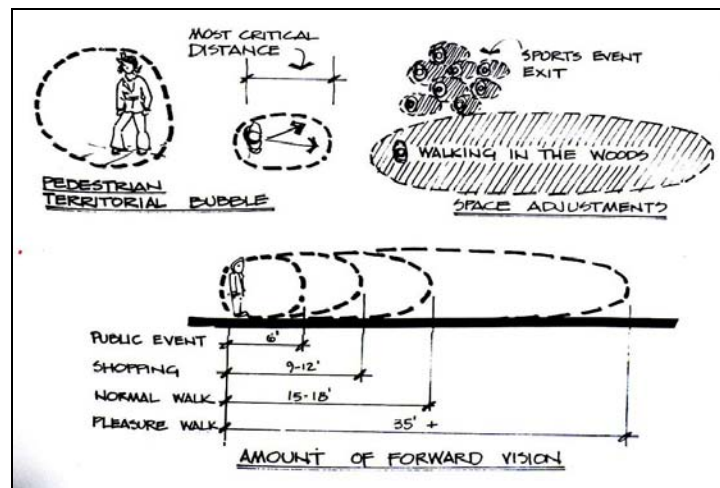


Figure 3-2. Shifting territorial bubbles (Untermann, 1984)

3.2.1. Invisible Bubbles and Space Zones

In *The Hidden Dimension* Hall (1969) observes that there are basically four kinds of distances that humans maintain between each other: intimate, personal, social, and public and gives concrete spatial dimensions for all of these distances: intimate (close phase: 0", far phase 8"-16"), personal (close phase: 1 ½ - 2 ½'), social (close phase: 4' - 7', far phase: 7' - 12') and public (close phase: 12' - 25', far phase >25'). While Hall is sensitive to the different senses, and the kinesthetic aspect, in how people mark their

territory and claim space, the senses have been considered as isolated systems that “influence” each other. They have not been considered as biologically, and intrinsically, interdependent systems, which our perceptual systems are (as discussed in Section 2). We will come back to this point later in the text.

Fruin (1971, p.25) takes Hall’s work further by identifying two kinds of “space zones in locomotion”: the sensory zone, and the pacing zone, which he defines as follows:

The space required for locomotion may be divided into a pacing zone, the area required for foot placement, and the sensory zone, the area required by the pedestrian for perception, evaluation and reaction

In this categorization the author recognizes that the length of the pacing zone depends on the age, gender and physical condition of the pedestrian, and has a direct linear relationship with speed. Both the pacing and sensory zone can be affected by external influences such as terrain and traffic conditions. Pedestrian pacing lengths may be physically measured (Figure 3-3), but sensory zone requirements are comprised of many human perceptual and social factors.

According to Unterman (1984) the sensory zone is critical for safety since it determines the reaction times to stimulation. Pacing zones are often determined via the sensory zones. For example, visually impaired people walk slower since they take longer to process the visual cues. There are two questions that emerge out of this discussion: 1) would the presence of other sensory cues (non-visual) have an equal impact on pacing zones, and 2) Does the pacing zone, in fact, determine the sensory zone, and are the two, in fact, interdependent?

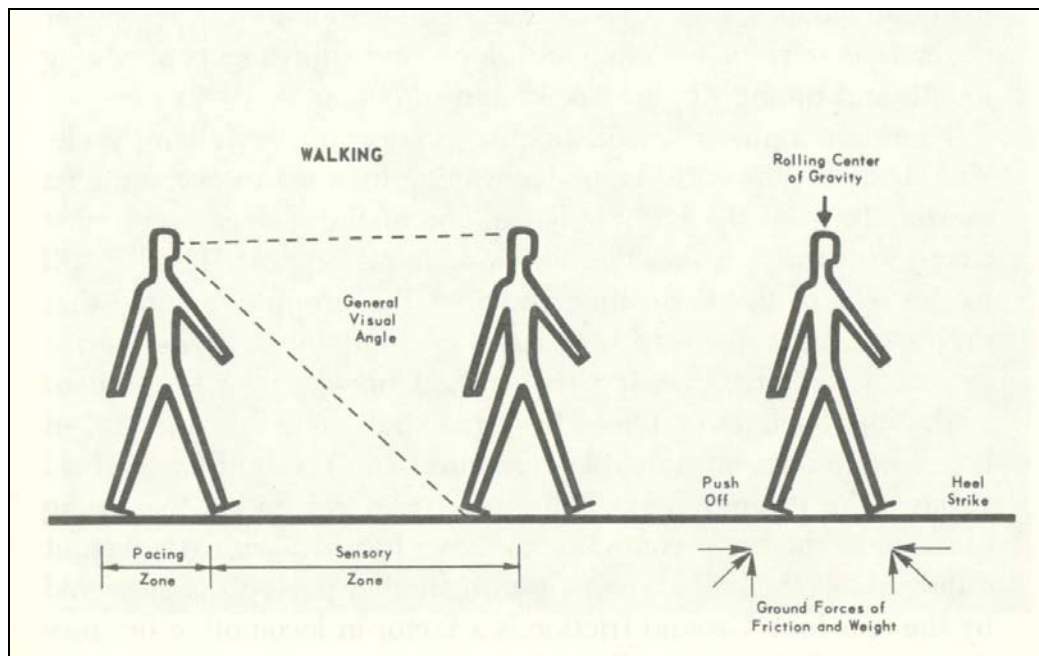


Figure 3-3: Pacing zone and sensory zone (Fruin, 1971)

According to Jan Gehl (1987) the human body is by nature limited to predominantly horizontal motion at a speed of approximately 5 km. per hour, and it's sensory apparatus is finely attuned to this condition. The senses are frontally oriented with the sense of sight distinctly horizontal, i.e. the horizontal visual field is considerably wider than the vertical; if one looks ahead, it is possible to glimpse what is happening, within a horizontal circle of almost 90 degrees to both sides, the downward field of vision is much narrower, and the upward is narrower still. In fact a person walking down the street sees practically nothing but the ground floor of buildings, the pavement, and what is going on in the street space itself; pedestrians' trousers and shoes, peddlers, beggars, etc. Though the sense of sight has the widest functional area however

while it is possible to “see” airplanes and stars, in connection with “experiencing” other people this sense too has limitations:

In the social field of vision one can see others and recognize them as people at a distance from 0.5 to 1.0 km (depending on factors like lighting, background, and movement). At approximately 100 meters figures that can be “seen” at greater distances become 'human individuals'. At a distance of 70 to 100 meters it becomes possible to determine the sex, approximate age and probable occupation, also to recognize the people one knows well on the basis of characteristics such as clothing, walk, and other idiosyncrasies. At a distance of 30 meters facial features, hairstyle, age, and people met infrequently can be recognized. When the distance is reduced to 20- 25 most people can perceive clearly the moods, and feelings of others. At even shorter distances the amount and intensity of information is increased because other senses now begin to supplement the sense of sight.

The sense of hearing has a smaller functional range than the sense of vision. Within distances up to 7 meters the ear is quite effective, making it possible to hold conversations easily. At distances up to approximately 35 meters it is possible to hear a lecture or establish a question-answer session. Beyond 35 meters the ability to hear others is reduced and while one can hear a person shouting it is difficult to comprehend what is being said. At distances of one kilometer or more it is possible to hear loud noises such as a cannon roar, bomb blast etc.

The sense of smell registers variations in odor within a limited range. At distances of approximately 1 meter it is possible to get intimate, and relatively weak

odors such as those emanating from hair, skin, and clothing of other people. Perfumes and other stronger odors can be perceived at 2-3 meters. Only much stronger smells such as died fish etc. can be perceived at larger distances.

Touch has the minimum “range” and the most intimate implication. The comfort range of temperature for the body is between 22 degrees and 27 degrees. The internal body temperature remains at 37 degrees, while the external can range (in habitable conditions) from -1 degree to 46 degrees. All climatic conditions (such as sun, wind, humidity etc) effect the human body directly through touch. It is evident from the above description that the zones of influence for the different senses, or the sensory zones, vary significantly across the five sense modalities, and are effected by the user’s movement. Thus a simple distinction between sensory and pacing zones cannot suffice.

Malnar and Vodvarka (2004) illustrate the different sensory zones, within the context of our environments, in a diagram shown in Figure 3-4. Within this context we can now revisit Gibson’s claim in the previous section, i.e., the human body and sensory systems cannot be considered in exclusion of the motor processes and proprioceptive factors (such as the position and movement of the body). In the following sub-section the significance of the interdependence within the individual sensory systems is discussed within the context of the invisible bubbles and sensory zones.

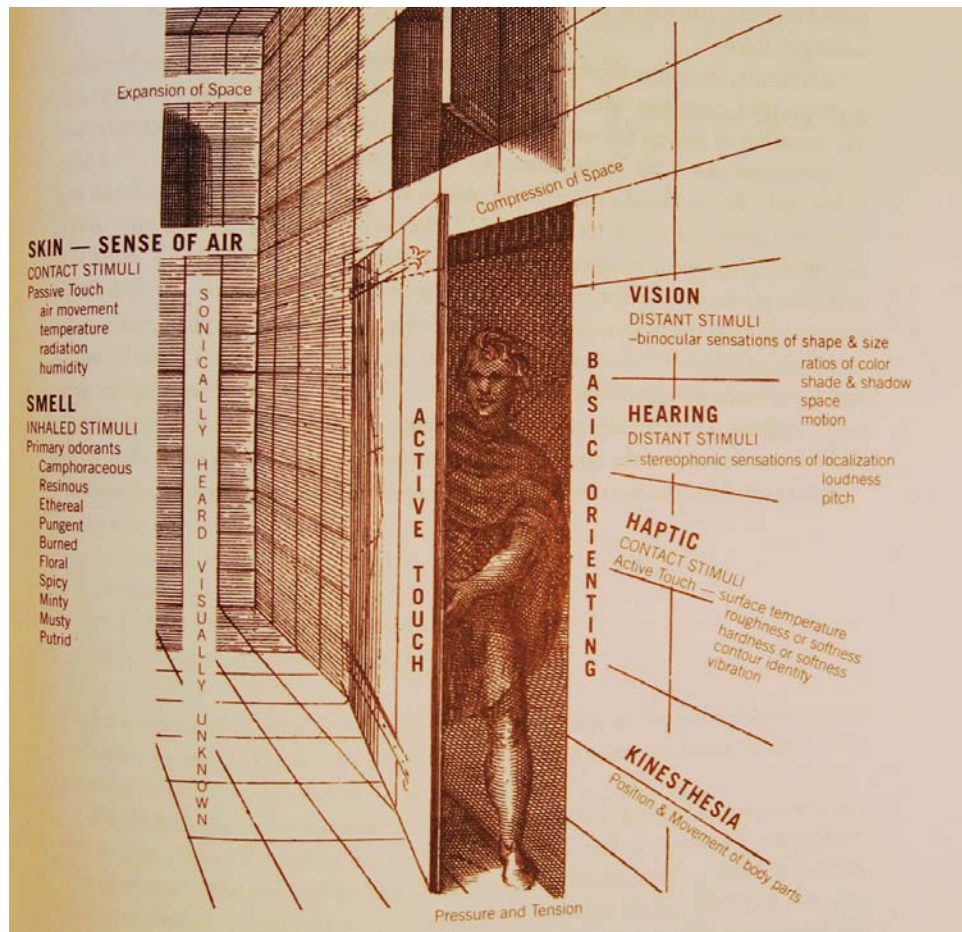


Figure 3-4. Ranges of the senses (Malnar and Vodvarka, 2004)

3.2.2. Overlapping Sense Domains and the Significance of Attention

In environment-behavior studies there have been various mentions of tactile space, auditory space, olfactory space and so on (Fruin, 1971; Gehl, 1987; Hall, 1966; Wilson, 1984). Appendix B is a thorough depiction of how these different spaces affect our personal space. What there has been less emphasis on is the overlap between these different bubbles, and their interdependence. For example, if we suddenly start running, then we may become suddenly more aware of our body, and of different elements in the

visual environment, and “attend” less to the smells and the sounds. That is, in a sense, our sensory bubbles can get distorted based on changes in our interactions with the environment.

The general failure to grasp the significance of the many elements that contribute to man’s sense of space has been identified by Hall (1966, p.11) as being due to two mistaken notions 1) that for every effect there is a single identifiable cause, and 2) that man’s boundary begins and ends with his skin. To this we can add the third mistaken notion: that man’s boundaries are static and space-bound alone. In fact, according to Hall (ibid), if we can rid ourselves of the need for a single explanation, and if we can think of man as surrounded by a series of expanding and contracting fields that provide information of many kinds, we shall begin to see him in an entirely different light. This is in keeping with the philosophical tradition of dialectics, which goes back at least to Socrates, which claims that in order to understand any active, changing processes it is necessary to consider at least two interacting systems (Canter, Krampen, & Stea, 1988).

Based on the understanding of the perceptual process, one can argue that it is the process of attention, which to a large extent, expands and contracts these invisible bubbles that define our sense of place, and provides the framework for interaction. The term space here has been replaced by place, following Tuan’s (1977) definition that ‘Place is whatever stable object that catches our attention’. At any point in time ‘t’ we are being bombarded by a myriad of stimuli, yet we find a way to focus on what is relevant to us, and to disregard the rest. Our sense-perceptions seem to work within certain dynamic hierarchies, which are determined by our biological, situational and

cultural context. The biological context refers to purely physiological changes within the body as a factor of external, or internal, changes. The situational context refers to the particular time/space/event framework within which the change occurs. The cultural context refers to the factors as a socio-cultural framework within which the situational change occurs. The three are dynamically nested, but influence one another.

In the act of focusing on “relevant” stimuli it is almost as if our “space zones” and “bubbles” contract and expand. They can be thought of as cross-sensory fluid zones, or permeable bubbles; phenomena that are interdependent and dynamic in nature, structured by the higher level cognitive process of attention. This is the underlying premise of an interdependent approach to understanding our invisible boundaries. To investigate the role of attention in people’s perception of their environments, and the ecological validity of the premise, the following case study was undertaken.

3.3. *Case Study*

A three day study was conducted in the plaza in Santa Fe in the month of July in 2003. The project involved the study of how people interacted with this public place, and investigated the relationship between their movement patterns, what they paid attention to, and what they remembered. Figure 3-5 shows images of different types of people who frequented the plaza. More than a dozen people were approached randomly in the plaza itself, at different times of the day, and asked if they were willing to take part in the study. A total of ten people agreed (Table 3-1). These respondents were given an audio recording device to talk into as they moved around the plaza. Those respondents who were comfortable with it were also recorded on videotape. After exploring the

plaza, without any priming as to where they should go, the respondents were asked to return to the park in the centre. They were then asked to map the route that they took as they remembered it. Respondents were given tracing paper to layer on their initial maps as they remembered more details and their recollections got denser. They were simultaneously encouraged to talk about their experience while they mapped their routes. The respondents were then engaged in an open-ended interview about their experience and what they recalled. In particular they were asked to concentrate on the sensory impressions. Finally, the respondents were asked to close their eyes and talk about what they noticed about their environment. The objective of the study was to understand what people paid attention to in a particular environment based on their mental maps.



Figure 3-5. Santa Fe Plaza. Left: A homeless person leans against the lamp-post and gets some rest. Right: A woman walks briskly during a shopping trip.

There were a few basic concerns in the research design, for example the audio recording device was unnatural and probably affected the behavior of the users. If video

recording was done walking alongside the respondent they became conscious, which could have invoked an unnatural usage pattern. Table 3-1 illustrates the different modes of recording that the respondents agreed to. Figure 3-6 shows images from the plaza.

Table 3-1

Respondent profiles. M: morning: 8:30 A.M.- 10:30 A.M., D: Day-time: 11:30 A.M.-6:30 P.M., N: Night-time: 6:30 P.M. onwards, (t): tourist (r): resident (r-t): ex-residents who are back for a visit

<i>Time of day</i>	<i>Gender</i>	<i>Profile</i>	<i>Video</i>	<i>Audio</i>	<i>Mapping</i>	<i>Interview</i>	<i>Closed-eyes Exercise</i>
M	M	Lawyer (t)		•	•	•	•
M	F	Retired real-estate person (r)	•	•	•	•	•
D	F	Teacher (t)			•	•	•
N	M	Architect (r-t)			•	•	•
D	F	Student (t)	•	•	•	•	•
N		Student (t)		•	•	•	•
D	M	Jeweler (r)		•	•	•	•
D	M	Student (r-t)		•	•	•	•
D		Accountant (t)		•	•	•	
M	M	N.A. (t)			•	•	•

It was noticed that even when they were observed from a distance the respondents became conscious. However, overall, observing from a distance was preferable to the subjects. The basic problem with observation was that there were too many co-incident complex patterns that were difficult to map. That is to say changes in the user movement/ behavior and changes in the environmental context they occurred in, were difficult to note simultaneously. Furthermore, there were very few significant sensory nodes or impact places: in general the surroundings were pleasant but not

particularly definitive. However, during the observation and documentation it was possible to identify particular movement patterns, and pace variations. The mapping exercise was the most forthright, and most respondents had little trouble with it. It is possible that the observation of the respondents could have affected their movement patterns. However, the concern of this study is not with the quality of the environment itself, but the manner in which people experiencing it, mapped the environment mentally. Two categories of the mental maps have been analyzed: 1) those emergent from verbal description (whether in a self-report as they spoke into a recording device (SR), or as a conversation with the interviewer (I)), and 2) those sketched on paper by the respondents themselves.



Figure 3-6. Plaza square. Left: People in the park sitting along the radial paths leading up to the central monument. Right: The governor's palace along the park where Indian hawkers sell merchandise in the verandah.

3.3.1. Mental Maps Emergent from Self-report and Conversations

There was a distinct difference between the mental maps emergent from self-reports (SR), and those emergent from conversations (I). In the former the format was

much more fragmented, almost like a random access of images and thoughts. The

following is an excerpt from one of the self-reports (SR-5):

Ok. I am walking along the Lincoln street and I can hear music from somewhere along the back of the street and smell pastry from the café. See the boy's car... it was there last night and it's still here. That's weird. Plaza restaurant has big red sign at the bottom. And the smell is totally off. Very American food. And the people who are sitting there and staring at us. Hmm. Another boy's car. I wonder what's going on. They might have an event this May. Tourist information stands on the left. Impresses me how empty it is. There's not a single person, there's no light. There's no nothing. Just big empty space. And of course the wonderful clock in front of the art museum and the big purple poster.

The report made by the respondent, as she was walking through the plaza, can be classified as mental meanderings, weaving through observation [O], conjecture [C], reflection [R], and projection, or placing one-self in a different time-frame [P]. If we analyze the above passage again it can look as follows:

Ok. I am walking along the Lincoln street and I can hear music from somewhere along the back of the street and smell pastry from the café. See the boy's car...[O]
 it was there last night and it's still here. That's weird. [R]
 Plaza restaurant has big red sign at the bottom. [O]
 And the smell is totally off.]C]
 Very American food. [O]
 And the people who are sitting there and staring at us.[O,C]
 Hmm. Another boy's car [O].
 I wonder what's going on. [C]
 They might have an event this May [C, P]
 Tourist information stands on the left [O]
 Impresses me how empty it is [R]
 There's not a single person, there's no light. There's no nothing. Just big empty space. And of course the wonderful clock in front of the art museum and the big purple poster [O]

In Appendix C the above mental meanderings are mapped within the physical context as graphical field-notes created immediately after the respondent completed her

report. It is interesting to see that the associations made by the respondent form a network; this is consistent with the literature on mnemonic devices and the use of a “network of associations” to aid memory (Westen, 1996). The report was made at night when the lights were particularly conspicuous. The respondent wandered around for 15 minutes in and around the plaza before returning with a report. After she came back she mapped her route and discussed her walk. It was interesting that the mental meanderings during the self-report were not mentioned in conversation. It seems that the focus was on structuring the experience as evident from the following example (I-5):

I think it's kind of circular, I am not sure there is a monument in the middle of it. There is a fence around here then. A little garden or something around it. There are benches all along the pathways. People can sit down and you can sit here. And a statue or something. And I am not really sure beyond that.

The whole area. Ehm. I don't know. There are like 4 sides to it I know. I remember over there all those people have those shops and it's kind of squeezed to get to there. I notice there is a lot of construction going on. And along some of them there are little areas that you can go in and shop. Mall like, I went to a few of them. I know there is one that is really big.

It was evident from this example, and the others, that events took precedence over environments in most cases. Also people attended to more than they reported, which was evident in the difference in content between the self-reports and the interviews. Due to lack of psycho-physical measures it was not possible to measure the behavior in the brain, and which modality was being attended to, therefore the reliance was on the reports from the respondents, in which the perceptual and the cognitive contexts were intertwined. In the interviews respondents projected themselves back to the actual path they took, and recounted what they remembered, as if walking the path in their minds all over again. The spatial context could not be separated from the temporal

context, and the movement had to be retraced to facilitate recall. An example that illustrates this is as follows:

And then I walked this way.. and then I walked this way...Sorry sorry.. I went this way first...because I was looking for that restaurant... then I walked this way... then I came back here.. and then this way... and then back. And then I left the plaza and took a little detour. And then I came back in here. And then there I didn't walk past *Indians*. I think it was kind of crowded, and then I walked back diagonal here, and then sat.

Not surprisingly, in most cases route was recalled more accurately than the spatial context. The use of the language itself was inherently embodied. In the above example there is an extensive use of what Lakoff and Johnson (1999) term as “bodily projections”. Bodily projections can be defined as “clear instances of the way in which our bodies shape conceptual structure... our bodies define a set of fundamental spatial orientations that we use not only in orienting ourselves, but in perceiving the relationship of one object to another’ (Lakoff & Johnson, 1999, p.34). The examples stated by the authors are our most basic propositions: “in front of”, “behind”, “above”, “below”, “right of”, “left of”, and so on. The authors argue that our spatial relations are anchored in our bodies. This argument is substantiated both in the self-reports and the interviews. The respondents seem to ‘project’ their bodies into the environment, and experience everything ‘relationally’. For example ‘I am walking along the Lincoln street and I can hear music from somewhere along the back of the street’. ‘Walking along’ is a reference that the street continues along with the body. The ‘back’ of the street is when it is ‘behind’ the respondent. Each of the interviews and the self-reports used such projections constantly. That is, after all, the way we speak about our environments; front/back, up/down, in/out, side to side. Each of these is intensely metaphoric in body

references; front is good, back is not so good, up is good, down is not so good, and so on. In most of the self-reports and interviews:

1. Event took precedence over environment, i.e. respondents referred more to the events occurring in an environment, rather than describing the environments itself
2. Route took precedence over area, i.e. responses were rooted in the individual's route through the environment, rather than objective descriptions of the environment, and
3. There was an extensive use of bodily projections in the language to describe experiences

3.3.2. *Mental Maps Depicted through Drawings*

In the drawing exercise, a comparison of the route mapped by the respondents, and the route mapped by me (the researcher) during observation showed a remarkable degree of correlation. While there was a difference in scale, and detail, respondents tended to remember the route their body took. That is to say that while the correlation of the route of the body, and the space it was moving through was not always accurate, the movement of the body (where it turned, where it went straight and so on) was accurate (ref Figure 3-7).

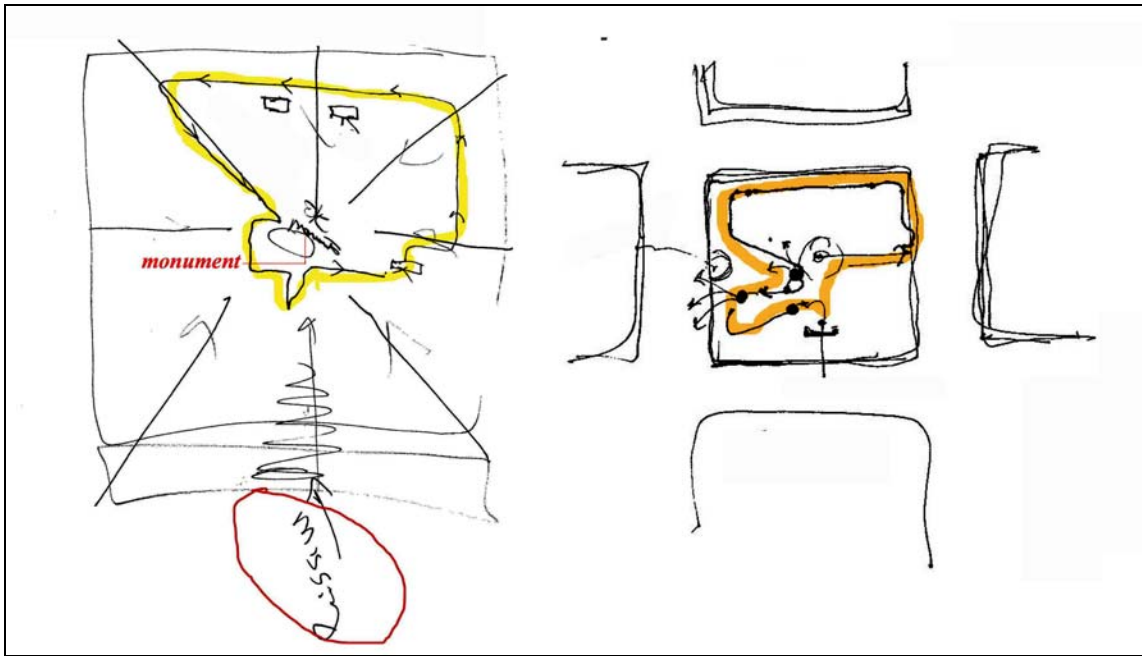


Figure 3-7. Comparison of mapped routes. Left: Mapping by memory (respondent). Right: Mapping by observation (researcher). Colors have been used for additions on the original documents.

Also, maps were drawn with spatial exaggerations; one can hypothesize that this was in accordance with the relevance of each of the areas in question.

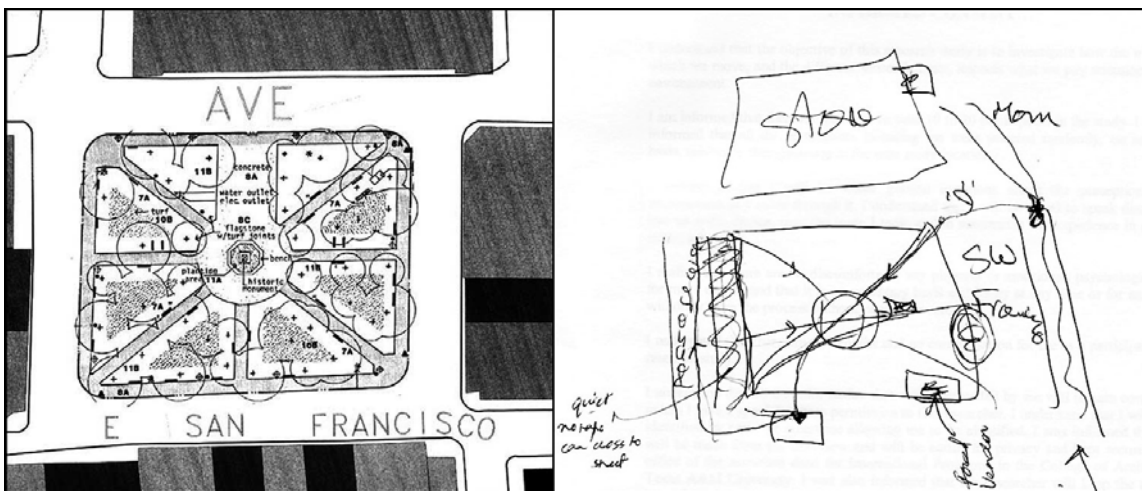


Figure 3-8. Actual plan vs. mnemonic plan. Left: to-scale plan of plaza. Right: plan drawn by respondent with spatial exaggerations

On the left of Figure 3-8 is a to-scale plan of the plaza area that was obtained from the city of Santa Fe and on the right is a plan mapped by one of the respondents. In the respondent's plan the store area is exaggerated. The areas recollected are the store, the food vendor, the Indian Open market. The pedestrian street is recalled vividly, as well as the 'target/goal' for that particular respondent, i.e. she was meeting her mother. Again, the embodied accuracy, or accuracy of subjective experience, seems to be greater than environmental accuracy, or accuracy regarding the environmental setting for the experiences. In fact in Figure 3-9 one can see a blatant disregard of the actual environmental settings by two of the respondents. The respondent in the left is one of the few who had a sensitivity to the fact that the platform at the centre of the plaza with an obelisk had edges (instead of a circle), even if he represented it as a pentagon instead of the octagon that it is. However he disregarded any of the other elements in the plaza. The respondent on the right went a step further. While he seemed to acknowledge the edges of the platform he simply extended that edge in the most symmetrical manner: a square. And then represented the plaza as a circle! This was the most blatant deviation from the actual form of the plaza. This particular respondent had, however, come straight to the platform in the centre and had been sitting there reading a book, his mental map of his surroundings was therefore, severely impaired. However, he still seemed to adhere to the basic formal principles of symmetry and balance, which will be discussed in the following section.

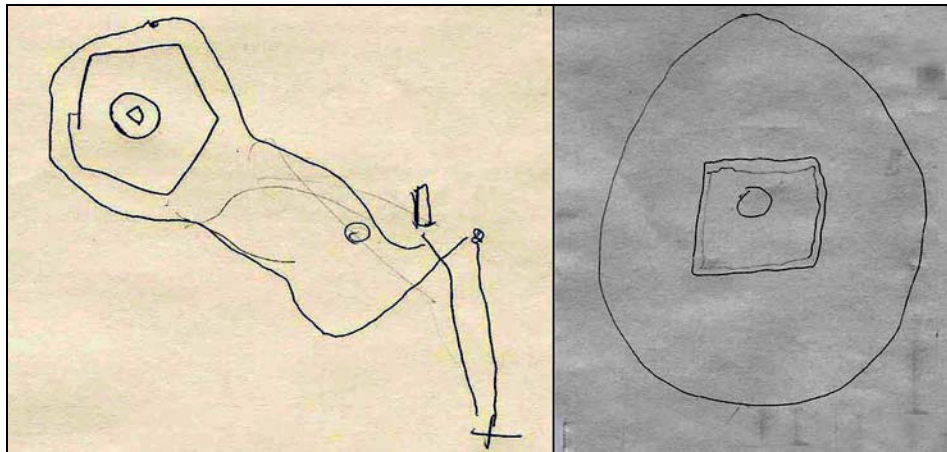


Figure 3-9. Environments 'seen' differently

In fact, there seems to be a tacit memory of the body's movement, and the choices made according to what is relevant to a user in an environment, which is reflected in the way they represent their mental maps. This tacit memory of the body's movement, as emergent both in the verbal and graphic representations of the respondents can be understood as the domain of the embodied kinesthetic, dependent on what respondents pay attention to in their movement through the environment.

3.3.3. Formal Bias and the Argument of Embodiment

In the analysis of the self-reports and the conversations there was a certain structure that was emergent. In the interviews the route was usually communicated as a function of the target, the path taken and the goal. Lakoff & Johnson (1999, p.32) identify such a schema as a source-path-goal schema, which has the following schema:

1. A trajectory that moves
2. A source location (the starting point) (S)

3. A goal, that is an intended destination of the trajectory (G1)
4. A route from the source to the goal (R1)
5. The actual trajectory of motion (R2)
6. The position of the trajectory at a given time
7. The direction of the trajectory at that time
8. The actual final location of the trajectory, which may or may not be the intended destination (G2)

In the interviews the respondents are analogous to the trajectories. The following excerpt is an example of how the source-path-goal schema is embodied in most mental maps:

Now what... I came down here (S)
and around (R1)
for my usual morning jog (G).
Here's the cemetery. And I came almost directly to the bench where we are right now (G2).
Which is actually on the other side. oh the building right here. ... and then walking down towards the trees... and coolness... but that's because its been so hot (R2).

The respondent intended to take a particular route to get to her goal. In the meantime she experienced the heat of the morning and changed her route. Her recollections were based on her position and direction at that particular time. While the self-reports were, as mentioned before, fragmented and a collection of random thoughts, emotions and feelings, the interviews structured their experiences according the schema discussed above.

It seemed that respondents created their mental maps by projecting themselves back and forth in time, recreating the position and direction at particular points in time, and structuring their experience in terms of the source (where they were), the goal (where they were going), and the path (the path they took and what they noticed along the way).

In the mapping exercise, when respondents were required to draw out the map of their movement and what they attended to, a tendency to structure the experience spatially was observed. That is, in the process of mapping they would a) map the spatial context, even when they did not necessarily have the opportunity to ‘observe’ it to be so, i.e. map their tacit knowledge of the spatial context, and b) use rules of symmetry, and geometry to fill the gaps in their knowledge, and c) use certain spatial elements as anchors to formulate the spatial context.

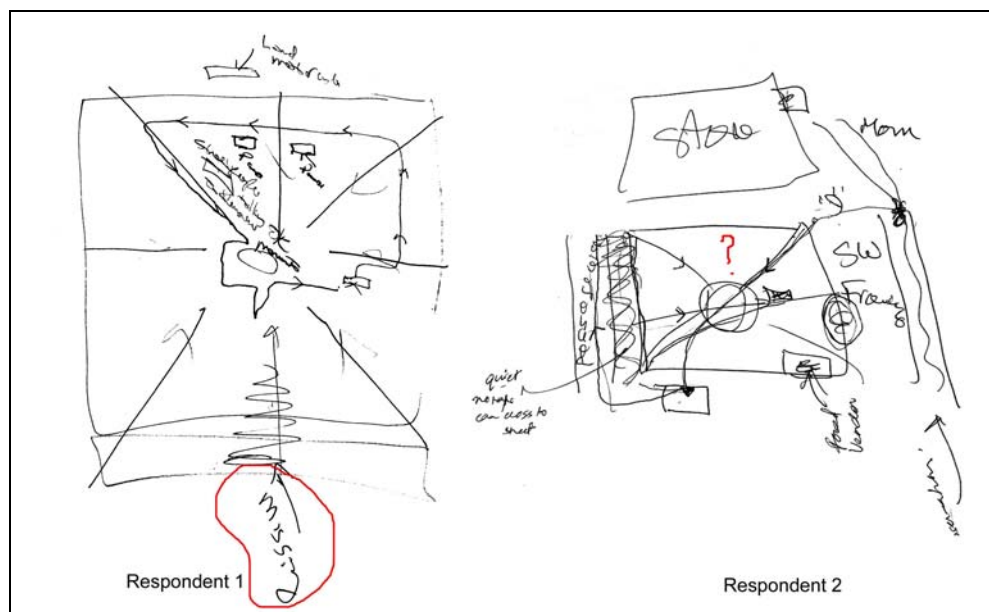


Figure 3-10. Spatial context as recalled by different respondents

In Figure 3-10 we can see how two respondents sought the same structure in the radial paths cutting through the plaza. While Respondent 1 noticed that a path was “missing” (assumption: it ‘should’ have been there to complete the symmetry), Respondent 2 did not recall the asymmetrical path to begin with. A third respondent went to the extent of representing the path in any case (Figure 3-11). All three respondents made the assumption of symmetry, and can be categorized under the domain of spatial balance. This is consistent with Lakoff & Johnson (1999, p.35) identification of “balance” as one of the “body-based image schemas” that determine the form of logic used in abstract reason.

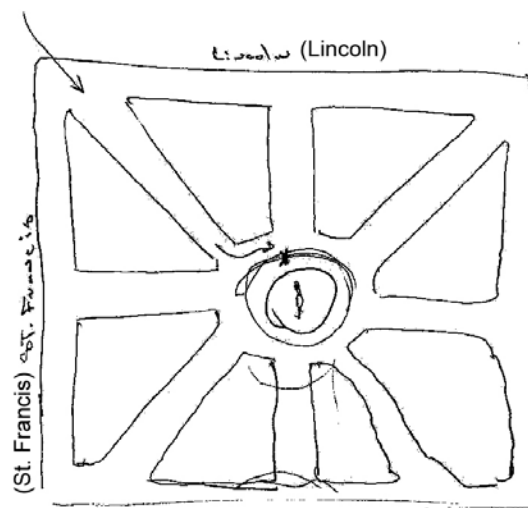


Figure 3-11: Assumption based on spatial balance

The mapping of the spatial context of the experience, as recalled, also depended on certain anchors. The preliminary analyses shows that people tended to definitively mark edges, paths, nodes, and landmarks. This is in keeping with Lynch’s thesis (1960). No doubt these themes fall under the broad domain of structure when considering the

“image” of the route taken, but in the “act” of mapping a route, these can be classified under the domain of anchor.

Thus, spatial elements that could serve as anchors, and the quality of balance and symmetry, were tools in formulating the spatial structure of the experience, as recalled. When asked to annotate their maps, most respondents recalled fragmented sensory images, in no chronological or spatial order. In the verbal recollection respondents took a time-bound approach. This was in keeping with the embodied kinesthetic, where they seemed to project their bodies and walk through that time again.

Even so, in the annotation of the maps, and the recall of just impressions, there was no time-bound structure. Furthermore, most of the features that were recalled integrated a sensate impression with either recognition of an object, an emotion, a person, a situation and so on. In Figure 3-12 one can see how the sensory domains are integrated with the domains of object, emotion and style. The essence of such a map is not the individual schemata of fragmented information, but their integration into strong impressions. For example ‘dangerous, bad, blue, crane’ integrates emotion, color (vision) and object recognition into one impression. Similarly, the plaza is remembered in terms of coolness, quiet and trees, here again there is an integration across senses (tactile and audio), and with object (tree).

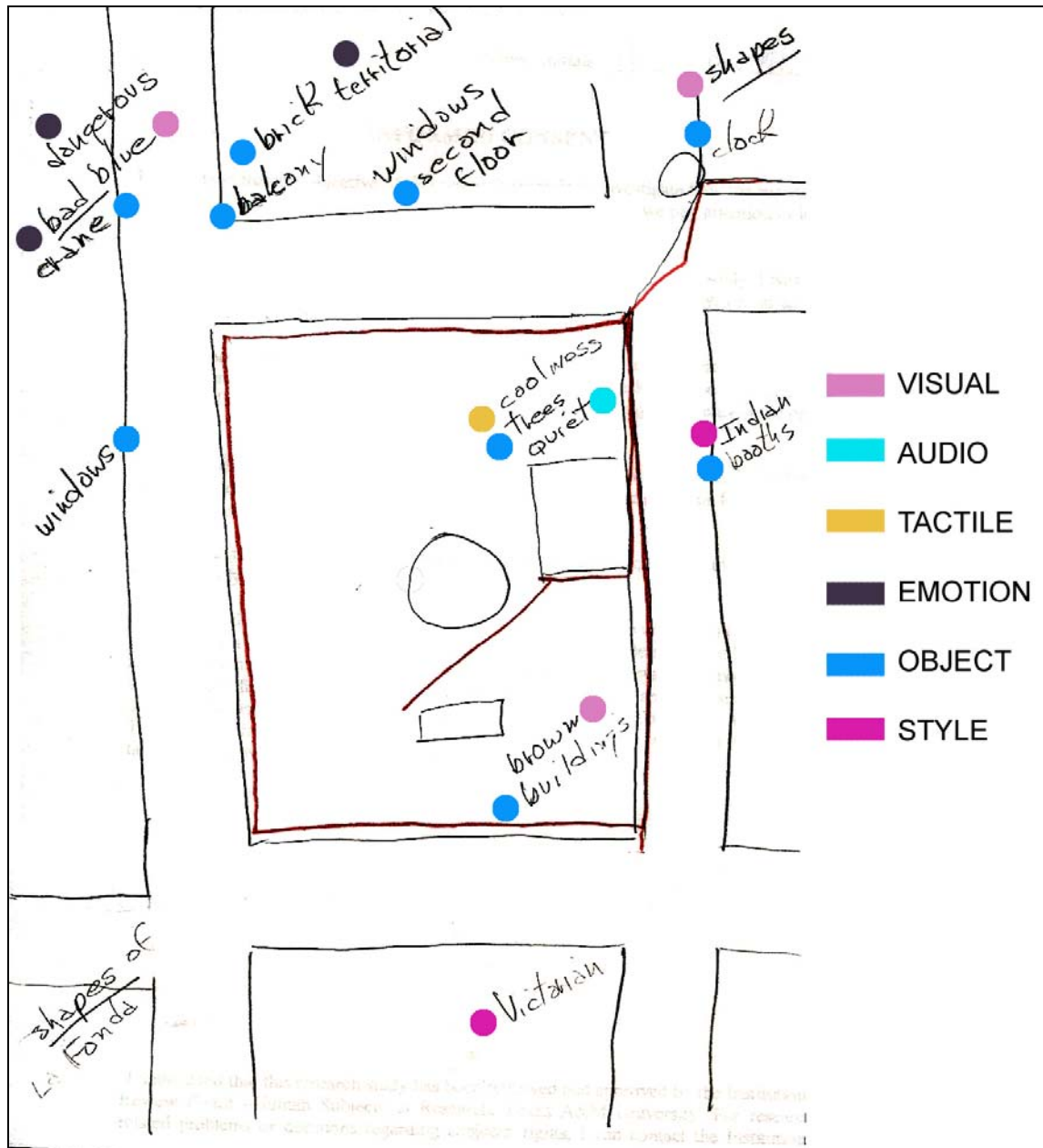


Figure 3-12. Sensory impressions of the plaza. Colors are added by the researcher to emphasize the different sensory and cognitive qualities

An interesting aspect of sensory integration also emerged when the respondents were asked to recall their experience with their eyes closed. There are two interesting,

preliminary, observations. Respondents noticed/remembered certain sensory impressions that they hadn't noticed before, for example:

Well NOW I hear the cars. Ya. I am hearing the cars and the noise and I didn't hear them before...hmm. (I2)

The integration across domains changed and became more abstract, and more sensual, rather than object oriented. Subtleties in the environment were noticed. For example:

The traffic. The smell of the food and the restaurants (I3: Eyes open)

The birds, the sun, and a slightly cool breeze. (I3: Eyes closed)

Visual identification helped respondents structure their sensory impressions. There was an effort to relate the impressions to objects, or in other words to map stimuli to concept. The structuring of fragmented impression was done in terms of forging relationships. If we concentrate on the relationship, instead of concentrating on the parts themselves, then this can be understood as the domain of integration. Also, by the act of closing their eyes, or removing one sense, the observation of other senses came into the forefront, which can be understood as the domain of sensory-compensation, where the lack in one sense was compensated by increased sensitivity to others. The domain of compensation is in fact evident in all the observations in the manner in which perceptual choices seemed to affect later recall. That is to say that due to perceptual choices some perceptions of the environment took precedence over others for different respondents at different times, and so the lack of sensitivity to certain aspects of the environment was compensated by increased sensitivity to others.

3.4. *The Sensthetic Premise and Theoretical Framework*

The process of creating mental maps is a function of our attempt to structure impressions into “concepts” or “domains”, which is obviously a higher-level function of our minds. When people reported into their audio-devices, or when they were asked to recall different sensory impressions at the end of the interview, there was no seeming order. The reports usually alluded to what they could “see”, or what they were thinking about. References to the other senses were few and far between.

Unlike the seemingly fragmented quality of the self-reports in the interview, and the mapping exercises, when respondents were asked to recall the entire experience, a particular structure seemed to evolve. This structuring seemed to be a function of some basic schema (source-path-goal), spatial rules (symmetry, balance, axes and so on), perceptual choices (relevance of elements perceived as vs. those that were irrelevant or not noticeable), and finally identification (ability to tell what an element was). The domains that were emergent from the data collected that reflected the basic schema used in the structuring process were:

1. *The Domain of Embodied Kinesthetic*: Recollection of the route the body took by projecting it through space and time accurately, although the spatial context may well be inaccurate
2. *The Domain of Spatial Balance*: Biased recollection of the spatial context on the basis of Formal principles such as symmetry, balance, axes etc.
3. *The Domain of Anchor*: Recollection based on Landmarks

4. *The Domain of Integration*: Recollection joins sensory observations with event/object/emotion. Integrating fragmented observations
5. *The Domain of Compensation*: Recollection of different nuances based on perceptual choices

The structuring process seemed to be, in turn, iterative. With each layer of interaction the memories were structured differently. Sensory images were recalled, when specifically solicited, thus purely sensory sensibilities were difficult to evaluate. However, when one sense was suppressed (such as with the closed eyes exercise), other senses were prioritized, and attention shifted to different, and more sensorial aspects of the environment.

Given the degree of variability in the recall of the environment it seems that our mental maps are not constant or etched in stone, but constantly changing and re ‘forming’, within an embodied directive. Finally, in keeping with how dynamic the mental mapping process seemed to be, and how subjective the domains that emerged were, it seems as if in the attempt to make a stable image of the world, we all make our own unique worlds; worlds that co-exist, and are credible because they co-relate. Stability in our image of the world comes from our ability to constantly match our internal and external worlds, while maintaining our exclusive and embodied interactions within them.

The case study re-iterates that in any experience it is difficult to pick a certain point (in time of place) to explain a process that is only part of a larger system, and perception of which is effected by prior experiences. The (theoretical) distribution of

attention at a basic physiological level cannot be dissociated from the layers of top-down processing that include memory, emotion, etc. that lead to the final perception. It is evident that there are complex, interwoven, iterations involved in the simplest human perception, which are difficult to explain in terms of a linear process. However, understanding the tendency of the brain to tend to fuse different sensory inputs into one cohesive image (localize), and to process some sensations more actively than others (work in hierarchies), depending on the task at hand, can be the starting point of a dynamic approach to the design of experiential places, one that is based on the connections between the different modalities to design external stimuli in the physical environment (space, volume, textures, acoustics, air-conditioning, colors, smells and so on) in terms of their concurrence (simultaneous occurrence of stimuli), correspondence (between the concurring stimuli) and coherence (meaningful correspondence) . This forms the theoretical framework of the Sensthetic approach, one that is based on a symbiotic interdependence between sensory and kinesthetic factors in the human interaction with the environment.

Based on this understanding let us re-visit some of the key perceptual phenomena discussed in Section 2.3: 1) Senses can get cross-wired, 2) Senses compensate for each other, and 3) Senses tend to fuse towards localization in external space. From the case study we learn that there is a constant association between the sensed world, and the cognitive world of memory, emotion and other higher-level thinking processes, and that in a real-life setting it is impossible to de-link the two. Based on the framework, the literature, and the case study, a model for the interaction between the different sense

modalities is developed which addresses the complexity of the interactions between different modalities, and the dependence of these interactions on the changes in the external and internal environment. Figure 3-13 illustrates this model in terms of the organization across the senses in a dynamic, constantly re-forming pie-chart.

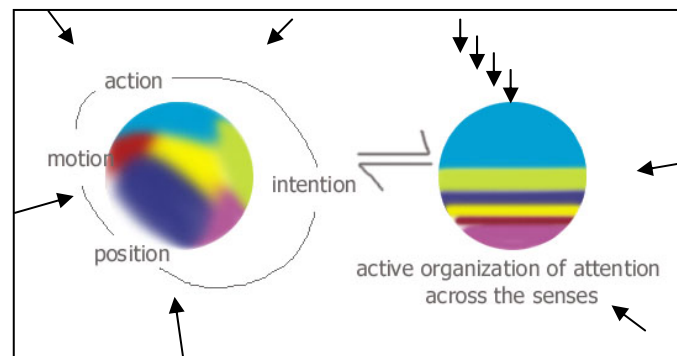


Figure 3-13. Sensesthetic model of sensory and kinesthetic interaction. The colors represent the different sense modalities and the arrows indicate 'triggers' which could be a change in the physical or emotional environment.

The above illustration represents only a moment in time in a highly dynamic interaction. For the sake of analysis the intention (which is understood as a sum total of cognitive factors in this case) can be separated from action (which is a consequence) and motion and position (which are kinesthetic factors that are coupled with a change in sensory modalities). Very simply put, our different modalities talk to each other to form a stable perception that makes sense, sometimes in common, and sometimes in highly uncommon ways.

4. SENSORY ORDERS PERCEIVED BY ARCHITECTURE STUDENTS

4.1. *The Implicit Hierarchy of Senses in Architectural Education*

Senses are the gateways to our perception. We perceive the external world through our eyes, our ears, our skin, our nose and our taste-buds. And though emotions, thoughts, intentions, and other higher-level cognitive phenomena are beyond the merely sensory, the senses remain as the communication channels through which we interact with our worlds.

In the design of place the sense of sight has often taken precedence (Pallasmaa, 1996; Pérez Gómez & Pelletier, 1997). While the experience of place is multi-sensory, it is common to consider the sense of sight before the sense of hearing, touch, smell and taste. Considerations such as acoustics, HVAC, textures of materials and so on, have not been overlooked in the practice, and the teaching, of architecture. Even so, these considerations take a backseat to the more primary concerns of function, mass, form and space. As discussed in Section 3, a comprehensive approach to senses in the context of environments has been undertaken in the *Hidden Dimension* (Hall, 1966; Hall, 1969) where the author systematically addresses the significance of the different senses in determining the intimate, personal, social, and public distances that people maintain between each other. The field that has contributed most significantly to the understanding of human needs in an environment is Environmental Psychology or Environment Behavior, however, this discussion has also been within a narrow scope,

and biased towards the visual criteria for aesthetic preferences. The inclusion of the non-visual senses has been from the point of view of comfort or unique functional needs.

While scholars such as Tuan (1976), Rasmussen (1984), Thiel (1997), Pallasmaa (2002), and many others have addressed the different senses and movement in their work, this has been a theoretical discourse without any particular emphasis on the means to incorporate this theory in mainstream architectural discourse. Furthermore, there has been little or no emphasis on the importance of each of the senses in relation to the other. The interest in the senses has been theoretical at best, and has not made it into the core curriculum of architectural education.

The typical bachelors degree in architecture is based upon a studio-format, derived from the Bauhaus tradition. Over the years the architectural curriculum has gone through a myriad of transformations. The Ecole de Beaux Arts and the Bauhaus School have given way to more amorphous pedagogical initiatives. The length of the course itself varies from the 5 year integrated curriculum to the 4+2 Environmental Design + Architecture format. In fact, around 1940, Joseph Hudnut from Harvard compiled a list of all the subjects that he deemed essential for a sound and complete architectural education and calculated that it would take twenty-two years to learn everything on this list (ACSA, 1998). Obviously, this is an impossible objective for even the most extensive curriculum to achieve. A brief overview of the courses that are offered in the prominent schools tell us that considerations of the sensory complexities in the perception of, and movement and action within, environments, have not made it to the

edited and revised list of what must be taught under the aegis of an academic institution for architecture.

The emphasis on formal principles, building technology and cultural and social concerns is common to most academic institutions. However, the fact very few schools offer a course on basic human perception is significant. The human body, and the senses which act as the gateways to human perception, are the final line of defense between the human being and his or her environment. That this very critical piece of the puzzle that defines human-environment interface has been overlooked warrants further investigation. What makes this lacuna particularly ironic is that perception is one of the most over-used words in architectural discourse. Within this discourse, there is a certain implicit order of importance accorded to the different senses when we teach design. Visual considerations are paramount, followed by considerations of aural and tactile factors (such as acoustics, HVAC, textures, etc.). Olfactory considerations are rare, often limited to limiting possible bad odors, rather than incorporating pleasant odors. Gustatory considerations are almost never considered; understandable considering that they are rarely within the scope of environmental interventions.

While this hierarchy is implied in the current education system there has been no systematic investigation of how prevalent it really is. There has also been little discussion on the history of this hierarchy, and the validity of a hierarchical approach to addressing the senses. This discussion forms the theoretical foundation for this section. Because the beginning design years are the most formative, the question addressed in this section is whether beginning design students follow the implicit order of visual,

audio-tactile, olfactory and gustatory in terms of the importance of the senses, and whether this order remains the same across different place-types.

4.2. *A Background of Sensory Orders*

4.2.1. *A Philosophical Insight*

The notion of attributing different levels of importance to different senses is an age-old debate. In his philosophy Plato pits the senses vs. reason and proclaims reason as the more superior of the two. At the same time he acknowledges the sense of sight as the foundation of philosophy (Synott, 1991). Aristotle followed Plato's lead in believing sight to be the most developed of all the senses. Unlike Plato who ignored some of the senses such as touch in his writings, Aristotle not only acknowledged the senses but ranked them based on the criteria such as clarity, purity, degree of development, desirability, honor, enlightenment and "animality" as follows:

1. The Human Senses

- 1) sight
- 2) hearing
- 3) smell

2. The Animal Senses

- 1) taste
- 2) touch

While Plato pitched our senses and our reason against each other, the early Christian scholars believed the bodily senses to be at war with the spirit. Senses were considered the means to commit sin and acts of excess. Sensory gratification was good

only as long as it was directed towards the glory of God (Synott, 1991, p.66). Saint Thomas Aquinas had his own rank order of senses in keeping with this view: vision was at the top and ‘food and sex (taste and touch) were at the bottom. In fact, vision was accorded “the pride of place as the noblest of senses” (Farnell, 2003).

In the early modern era, after the Renaissance, the debate between the senses and the “higher” human faculties continued. Descartes discarded all senses because of sense deception, promoting his famous dictum of “*cogito ergo sum*”; I think therefore I am. He consciously rejected the information from his senses to develop his philosophy. By contrast Locke identified the senses as the source of most ideas we have, claiming that nothing was in the intellect that was not in the senses before. While the debate ranged from suppressing the senses to celebrating them, there remained a bias towards which senses were more important. In the 19th century Hegel came up with his own hierarchy of senses where he distinguished the spiritual sphere and the animal and vegetable sphere (Synott, 1991). This hierarchy, in terms of the sense organs and the spheres he attributed them to, is shown in Table 4-1:

Table 4-1
Hegel’s hierarchy of senses

<i>Primary Senses</i>	Forehead, Eyes, Ears	Spiritual Sphere
<i>Secondary Senses</i>	Mouth, Nose, Chin	Animal Sphere
	Hair	Vegetable Sphere

Once again the sense of sight took precedence, and the sense of touch, was overlooked. With the advent of phenomenology placing the body as the locus of reason became a more accepted view, making perception primary. Phenomenology can be considered a philosophical movement founded by Edmund Husserl, which limits itself to “re-confirmable descriptions of experience” (Solomon, 1991). It is important to distinguish the early phenomenologists such as Husserl, from the later phenomenologists such as Heidegger and Merleau-Ponty. While Husserl concentrated on the “thing” that one was conscious of, Heidegger and his other successors concentrated on the “person” who was conscious. In a sense this was the distinction between the *Ontic* (a statement about some entity or the other) and the *Ontologic* (a statement concerning the being of such entities) (Collins & Selina, 1998). Although, sight and sound continued to get more emphasis, while touch, smell and taste were relegated to the lower senses, nuances within these senses, and the role of the individual senses began to be appreciated.

According to Merleau-Ponty (1964) the manifest visibility must be repeated in the body by a secret visibility. That is to say that quality, light, color, depth, which are there before us, are there only because they awaken an echo in our body and our body welcomes them and the visible is a manifest of the invisible. In that sense, philosophically speaking, while vision is the primary sense because of all it connotes, it is also the most basic because it is necessarily connotative...of what we touch, smell, hear, feel and so on. In fact, some theorists today place touch as the primary sense because all other senses require contact, or some form of touch, with the stimuli (food must have contact with the tongue for taste, sound waves must touch the ear, and light

waves touch the eye, for hearing and sight respectively) to finally perceive. One such model is seen in Figure 4-1. Palmquist (1998)The author makes a secondary distinction (between senses that are voluntary (+) and involuntary (-). A sense is voluntary if the organ is equipped with the ability to close itself off from the outside world and involuntary if it cannot do so on its own. As such, seeing and tasting are both voluntary, because we can shut our eyelids and keep our mouths closed, whereas hearing and smelling are involuntary, because our ears and nose cannot plug themselves but require external intervention (such as the fingers) in order to block out unwanted sensory input.

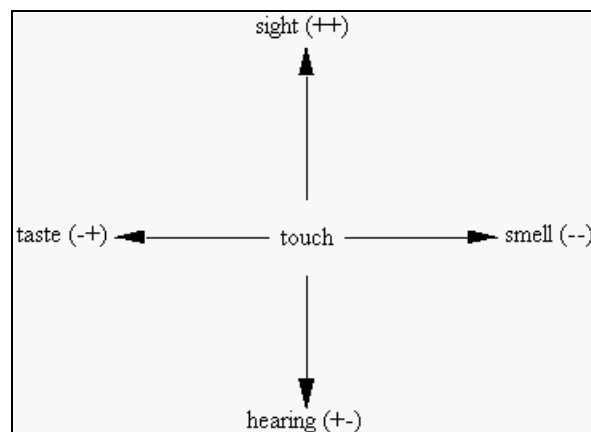


Figure 4-1. Map of touch as the core of all sensations. '+' denotes voluntary sensation, '-' denotes involuntary sensation (Palmquist 1998)

Frederich Hayek, a Nobel prize winner for his theory on money and economic fluctuations, was yet another theorist who discussed the concept of sensory orders in his *Theory of Mind* (Dempsey, 1996). Similar to Hume, Hayek contends that knowledge does not begin with the sensory event at hand. Knowledge, rather, is forged by the

connection, or "linkage," of new sensory information—optical, acoustical, and otherwise—to previous sensory experiences. Hayek contends that the mind is “a weave of old and new sensory data in a network of connections or "links" called the "sensory order”, that involves past sensory information to which new sensory information is connected. Thus sensory data have significance insofar as they show certain regularity in appearance to things we have experienced in the past. Interestingly, Hayek links the notion of sensory orders to market economy. To quote (Dempsey, 1996):

They (market economies) result from the complex interaction of preferences and motivations as they manifest in millions of emerging "sensory orders." Economies, in other words, are the composites of supporting and counteracting actions and reactions of individual "sensory orders," amalgams of multiple relations in motion. Accordingly, all economic phenomena, from local economies to international trade, are the byproducts of the interplay of motivations of individual human beings.

The subjective connotation in Hayek’s sensory order, which makes for a constructed rather than pre-ordained order to the senses, compels us to understand sensory orders in a more dynamic framework than that imposed by the classical philosophers.

At a philosophical level the bias towards the visual in architectural education can be appreciated because the visual sense is the one most given to abstraction. The primacy of vision as the human ‘thinking’ sense remains uncontested. The *Hegemony of Vision* (Levin, 1993) in western thought is the evidence of a hierarchy of senses with this strong sensory bias.

4.2.2. *A Cultural Perspective*

The notion of prioritizing one sense over the other has a strong cultural basis as well, one that was hinted upon in Hayek's philosophy discussed in the previous Section. In fact, a sensory order was often a reflection of a social order within a particular society. According to Farnell (2003) in the early 19th century, pre-Darwinian natural historian and embryologist Lorenz Oken mapped the prevalent sensory hierarchy onto the conventional racist ordering of human groups in a 'taxonomy by fives', starting from the lowest to the highest, as follows:

1. The skin-man is the black, African
2. The tongue-man is the brown, Australian-Malaysian
3. The nose-man is the red, American
4. The ear-man is the yellow, Asiatic-Mongolian
5. The eye-man is the white, European

The bias in a society is often reflected in the bias of a particular period in the history. In *Worlds of Sense* (Classen, 1993) discusses how through different times societies have had different sensory priorities. The sense of smell, and its domination by sight, is considered parallel to a similar domination of the other non-visual senses; however smell is the chosen protagonist. The analogy of the rose is used by the author to communicate the change in the potent sensual imagery of the rose from its smell ('the rose by any other name would smell as sweet') to its color and form ('a rose by any other name would still be a rose'). The olfactory design of the garden, the odor of

sanctity in Christian thought, the exposure to the spices and perfumes of the east during the crusades, the use of perfumes in regular living-room culture, and the medicinal or healing powers associated to smell are put together in an interesting socio-political potpourri of information about the western world's olfactory roots. The author identifies a shift towards the visual at around the 17th century, reinforced by prominent philosophers such as Descartes. However at the same time evidences of more sensual leanings are discussed as demonstrated in much of Victorian literature. The triumph of a visual world as a mascot for science, and modernity, over the Victorian "love-affair with fragrance" demonstrates the shift in the "sensory priorities" of an age.

Furthermore, different cultures may have their own sensory orders that do not adhere to the western philosophical bias. In her work Classen (1993) gives three detailed examples of how these orders can vary. The Tzotzils of Mexico (descendents of the Maya) understand their cosmology in terms of thermal dynamics, wherein everything in the world is identified by its heat content, including medical treatment and man-woman relationships. In contrast to the thermal order of the Tzotzils, the Ongees in Andaman, consider smell the fundamental cosmic principle. Thus, during illness the body would be heated or cooled by the Tzotzils; the Ongees on the other hand would focus on controlling the flow of odors. The social order of the Ongees is defined by smell, which defines both the social and belief structure. The different sensory models in the two cultures show different interdependence levels between the senses. For example, for the Ongees lightness is associated with the emission of odor, and heaviness by its

retention. In both cases, a sensory order is in place which is distinct, and unique to the cultural context.

4.2.3. A Developmental Perspective

The prioritization of the different senses into particular hierarchies is also effected by our own unique developmental contexts. According to Piaget children in their early years (0-2) depend on their sensorimotor processes and use their bodies to develop cognitive structures through which they understand their world (Flavell, 1968). While there is a considerable debate about whether prior to the development of the cognitive structures the sensory modalities work independently (a view supported by Piaget), or are fused together (check section 5 for further discussion), the fact remains that cognitive structures do develop and are instrumental in how we prioritize the different senses. This is particularly evident in certain documented cases of children who have grown up in unique developmental conditions.

Classen (1993) discusses three such unique cases in her work; Victor, the wild boy of Aveyron (lived in the woods for six years and reintroduced to human society at the age of twelve), Kamala, one of the wolf children of India (brought up by wolves and discovered at age of eight), and Kaspar, discovered at the age of sixteen in Nuremberg brought up in a small dark room without any human interaction. The three case studies referred to by the author cover an interesting range; a boy with no interaction with the human or the natural world, a boy with interaction with the natural world alone, and a girl with interaction with the animal 'instead' of the human world. The difference in the prioritization of the senses by these children is interesting. Victor's hierarchy placed

smell first, followed by taste, sight, hearing and finally touch. For the other cases the hierarchy is not so well documented by the scientists overseeing the children, however both Kaspar and Kamala had great acuity in terms of sensing sounds and smells. Kaspar, after being in a sensory deprived condition for so many years, would often find some sounds and smells repugnant. Victor had immense acuity when a sound relating to his needs (e.g. the sound of a walnut breaking) while being indifferent to something as loud as a gunshot. Because each of these cases had such a unique developmental context, and none of the children survived in the modern day city long enough to be subjected to more thorough scientific experiments, the study of these individuals can not support an empirical theory. The evidence is more anecdotal, but significant in the insight they offer into the subject of sensory orders.

Thus, one can argue that cognitive structures may derive from the developmental contexts which, in turn, affect the prioritization of senses. It seems that the ordering of senses may be more dynamic than previously perceived, and one that is dependent on relevance and context, and directly effects our perceptions

4.2.4. *A Cognitive-Neuroscience Perspective*

In *A Natural History of the Senses* Ackerman (1990) discusses the five senses, but she starts from the most mysterious (smell), and ends with the most evident (vision). Each of the sense-modalities is discussed within their role (or prioritization) in daily life and this is reflected in the following quote (Ackerman, 1990, p. xv):

We may neutralize one or more of our sense temporarily—by floating in body-temperature water, for instance—but that only heightens the others. There is no

way in which to understand the world without first detecting it through the radar of senses...Our senses define the edge of consciousness

Ackerman's description is consistent with the discussion in Section 2, about the importance of senses, and the dynamic hierarchy emergent from context. At any given point in time 't' in our day to day lives, we are being bombarded by a myriad of stimuli, yet we find a way to focus on what is relevant to us, and to disregard the rest. The higher level cognitive process of focusing on relevant sensory stimuli is known as Attention (Westen, 1996); a higher-level process that organizes the sensory information that we receive.

In a biological sense attention is measurable by the amount of neural activity in the cortex. Advanced imaging technologies make it possible for us to observe the modality that is 'attended' to by the area that shows more activity. Position and motion of the body are important in such experiments. The turn of the head, the movement of the eye, the tightening of muscles, the perked ears, are all indicators of paying attention at a micro scale. In the past decade research has focused on how audition, vision and touch are coupled in ways where each attending to one modality affects the other. For example, behavioral responses to tactile stimuli in a tactile relevant condition (such as a hot bath) are faster than the responses to auditory stimuli in an auditory relevant condition (such as listening to music). In fact, in the majority of the literature on cross-modal experiments (mapping the physiological and neural activity for two or more senses simultaneously), touch seems to warrant the quickest response, though it does not necessarily solicit the most activity in the brain.

Furthermore, a certain level of “spatial expectancy” applies to our perceptions, as discussed in Section 2. Experiments carried out by Driver and Spencer (1998) show that when a target is strongly expected from one side in just one modality (e.g. audition) up/down discriminations also improve on that side in other modalities (e.g. vision), suggesting a tendency for common shifts in other modalities. However, the spatial effect (or amount of neuronal activity) for secondary modalities is smaller than in the primary modality (which is task relevant), for which the spatial expectancy applies. In simple terms, this means that if I am expecting to ‘see’ something, more of my attention is focused on vision, and less on audition, i.e. there is a prioritization of the senses that is dependent on the perceptual task at hand. It can be argued that the manner in which we order our fragmented stimuli from the external world into a cohesive perception comes from prioritizing the senses contextually. This approach is consistent with Hayek’s “linkage” approach discussed in the previous section 4.2.1.

The hierarchy of senses seems to emerge from a combination of factors. What is evident is that the senses have never been perceived as equal, nor is our interaction with the environment possible if we accord equal importance to all the senses at all times. The perception “of” the senses (philosophically and culturally), and the perception “from” the senses (physiologically and perceptually), is intrinsically ordered. However some orders (such as perceptual orders) are more dynamic than others. Before accepting a particular order for our pedagogical initiatives, the order of senses that design students perceive, if at all there is such an order, must be appreciated, and addressed.

4.3. *Case Study: Sensory Orders for Different Place-types*

As an initial, exploratory step to investigate the perception of sensory orders a simple survey was developed for design students. Seventeen students in first year design studio were given a list of fifteen places, and asked to rank the different senses as per their perceived importance. Rank 1 was the most important while rank 5 was the least important. The choice of the places listed in the survey ranged from places with distinct sensory needs (e.g. painting gallery, music concert) to places which were more generic (living room, bedroom etc.). The list consisted of generic place-types that the students would be familiar with. The survey is shown in Table 4-2.

The study was based upon the following null hypotheses:

1. There is no significant hierarchy of senses perceived across different places
2. There is no significant hierarchy of senses perceived across different subjects for a particular place

The average ranks for each place were calculated across the seventeen subjects. For computation purposes the weight was reversed (making 5 the most important and 1 the least important). These are shown in Table 4-3. W test for concordance was conducted on the ranked data to determine the level of agreement in the ranks across the 19 respondents (Siegel, 1956). Apart from the swimming pool, all other places had a significant concordance. So the null hypothesis that there is no significant hierarchy of senses perceived across different subjects for a particular place was rejected. A value above between 0.3 to 0.6 or more is considered significant. The most significant concordances in the ranking have been marked out in bold typeface in the Table 4-3.

A total of twelve different combinations were observed in the ranking of the senses. While the most common hierarchy was sight> sound> touch> smell> taste, this hierarchy only occurred four times. In two cases, sound and touch were given equal importance. Therefore, the null hypothesis that there was one hierarchy of senses across the different places was also rejected. The findings were as follows:

1. There was a certain sensory order, in terms of the prominence of different senses, perceived in different places.
2. The hierarchy of senses was unique for different place-types: it was place-specific, but consistent across subjects.

Figure 4-2 shows the hierarchy of senses across the different place-types depicted as a pie chart. It was noticed that in most cases, the ranks of sight-sound-and touch was coupled together, and so was the rank of smell and taste. This is consistent with data from psychology and neuroscience (Figure 4-3 depicts these in terms of histograms) but questions the philosophical bias that puts touch at the very bottom of the sense-hierarchy.

4.4. *Summary: Conceiving Hierarchical Relationships Across Modalities*

Across the cognitive sciences no consistent hierarchy of senses is perceived. At the same time, there is a distinct tendency towards a sensory order, be it in terms of an abstract philosophical bias or physiological neuronal activity. While it seems evident that vision is a prominent part of the sense-orders across different philosophies, cultures, and physiologies, the role of the other senses, for example touch, seems to be shifting in priority.

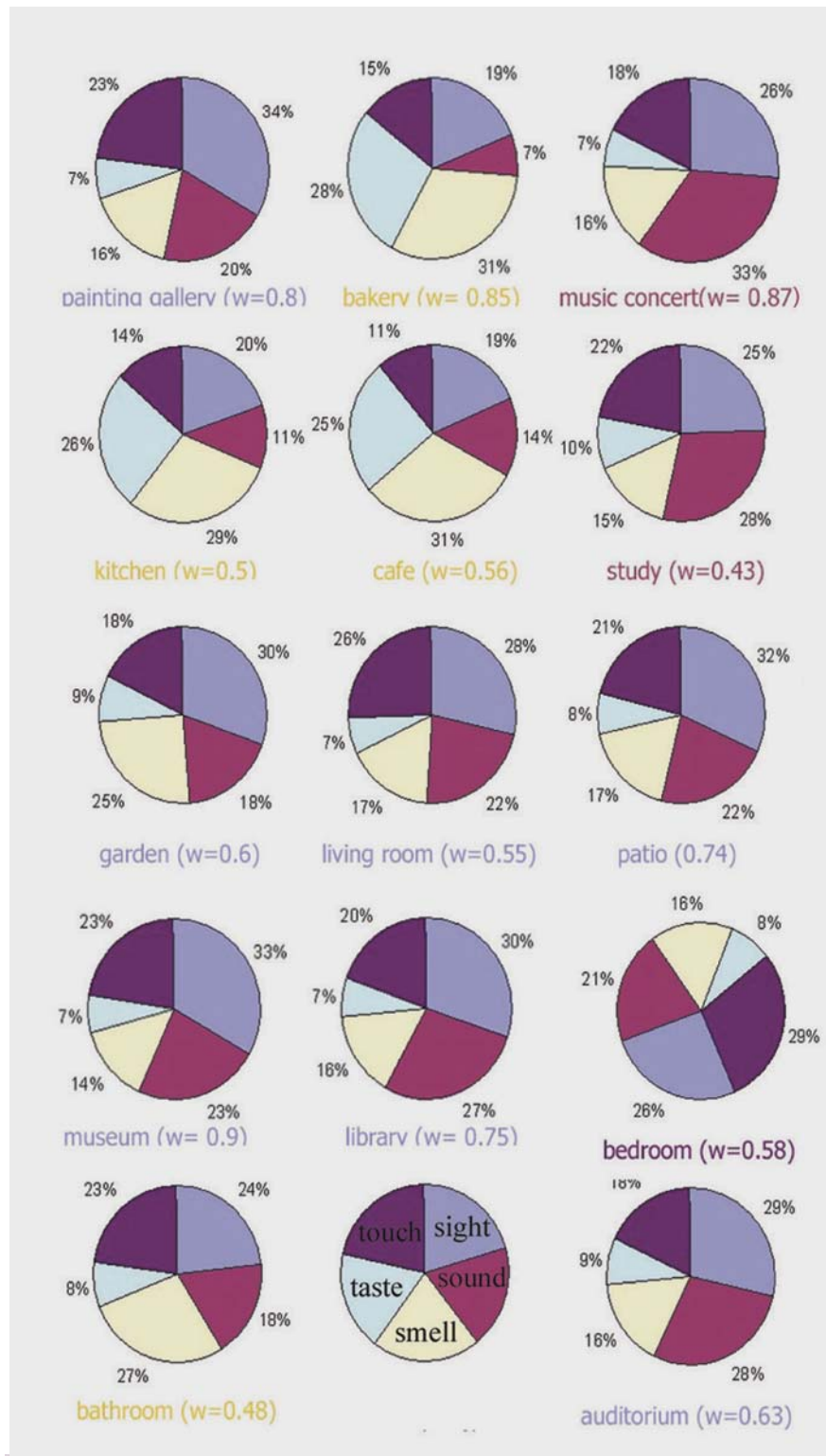


Figure 4-2. Pie-chart of senses

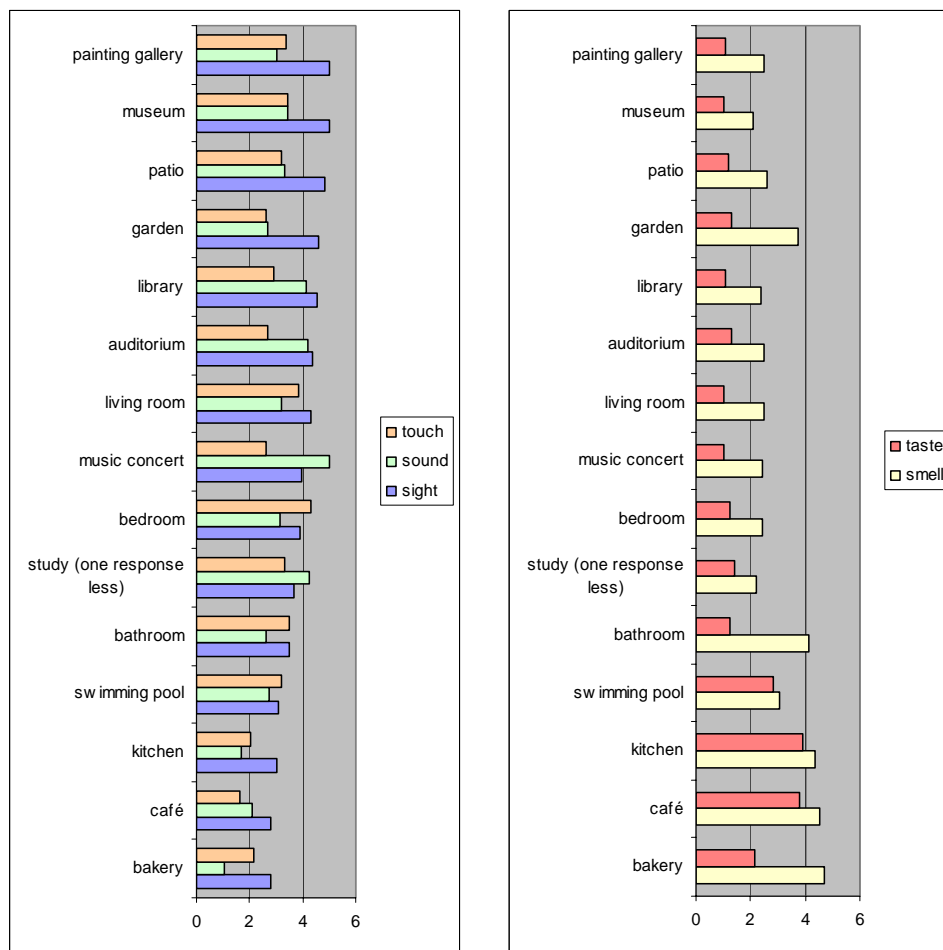


Figure 4-3. Histogram for the ranking of senses. Left: Touch, sound and sight. Right: Taste and smell

While many of the philosophers had relegated touch to the bottom of the sensory order, considering it an animal sense, it is seen that touch is actually quite prominent in the sensory orders perceived in different kinds of places. Furthermore, touch, the most “basic” of the animal senses, seems coupled with the ranking of the higher senses of sound and sight. Furthermore, these higher senses are not quite as sacrosanct as we may suspect; the sense of sound, for example, is often relegated to the bottom of the order.

Thus, the ranks are not as clearly delineated as one might expect. Similarly sight does not get the clear prominence that our educational bias would lead us to believe.

There seems to be a valid basis for the implicit hierarchy that is followed in architectural education today: Sight > Sound-Touch > Smell > Taste. It is significant however that this hierarchy of senses is not etched in stone; different sensory orders are associated with different places. While the association maybe because of a variety of factors, both higher-level cognitive factors, as well as lower-level stimuli related factors, and the hierarchy may be subject to constant iterations and reformations, it seems incumbent that we, as architects have a sensitivity towards this dynamic hierarchy of senses. Students must be made aware of the relationship between the senses, and the particular context of the place they are designing, in order to address the unique sensory requirements of different place-types. It is evident that students already possess a certain sensory order when they think of different places. It becomes important to allow students to draw from this sensory understanding of different kind of places in their design endeavors.

The case study, with only 17 respondents, showed evidence of a certain level of consistency across the perceived sensory orders. It seems fair to say that the ordering of senses is significantly uniform in this particular set of students with this particular set of places. A more detailed study now needs to be conducted that is more flexible in its approach, and can allow greater depth and reliability. Conducting a more in-depth study, with a larger respondent pool, could allow for the development of this initial work into a sense-syntax for place, similar to the space-syntax established by Christopher Alexander

(Alexander, Ishikawa, & Silverstein, 1977). This section is one small step in that direction.

5. BLACK SMELLS, BLUE SOUNDS

5.1. *A Background of Synesthesia and Cross-modal Imagery*

Synesthesia, as discussed in Section 2, refers to the neurological condition where “stimulation in one modality leads to perceptual experience in another” (Goldstein, 2002, p.368). Thus a person suffering from this condition, known as a ‘synesthete’ may “see” sounds, “taste” shapes, “smell” colors and so on. As a condition synesthesia has been known to the scientific community for over 200 years. The first reference to it was around 1970 by Thomas Woolhouse, an English ophthalmologist, who described the case of a blind man who perceived sound-induced visions (Cytowic, 1989). Marks (1978) discusses various records of synesthetic associations between colors and sounds of musical instruments during the 19th and early 20th century. These include composer Joachim Raff’s perception of the trumpet’s sound as scarlet in 1892, and subsequent studies with other synesthetes who saw the same sound as yellow-red, yellow and blue-green. Such “colored hearing” is probably the most common documented form of synesthesia, and the variability within perceptions, such as the colors associated with a particular sound across different synesthetes, is considerable. It is this subjectivity that has kept synesthesia on the sidelines of scientific inquiry. A few typical examples of synesthesia are shown in Table 5-1.

Table 5-1

Impact and Examples of Different Types of Synesthesia (Cytowic, 1989, p.32-39)

<i>Type of Synesthesia</i>	<i>Impact</i>	<i>Example</i>
Simple Synesthesia	Colored Auras Around Objects triggered usually, but not always, by strong emotion. Colored auras or blobs arise spontaneously, and are not related to specific objects	A woman sees a purple aura around her children when she is angry with them
Polymodal Synesthesia	Letters, numbers and music have color. Specific words or sounds may evoke flavor, visual shape and color.	A man perceives involuntary tastes and smells when he plays the piano
Colored Music	Seeing colored shapes on hearing music	A person sees shiny, white isosceles triangles when listening to a particular piece of music
Visual Pain and Geometric Hearing	Feeling pain or hearing voices on seeing shapes	A person feels a round shape when he hears a baritone voice
Colored Orthography	Graphic representation of numbers and letters stimulates color	A person who sees 'a' as strong blue, dark, 'p' as gray, 'z' as orange red, '6' as black, and so on

The examples in the table are from documented cases. Synesthetes, as the individuals experiencing this condition are called, vary in their perceptions. Not all synesthetes who experience colored orthography, for example, see the letter 'a' as dark blue. It is possible within these differences, however, that there are certain correspondences in terms of tones, spectrums, regular-irregular shapes and so forth that extend to the normal populace as well.

Synesthesia has been of interest to both the scientific community investigating perceptual mechanisms, and the artistic community fascinated by the synesthetes' unique insight into the world of senses. However, this interest has been sporadic. Apart from a few spurts of interest in the 18th century, and later between the late nineteenth and early twentieth century, the interest in synesthesia within the scientific community dwindled due to its subjective nature until its recent revival in the 1980s. According to the American Synesthesia Association, a not-for-profit organization created in 1995, two developments have contributed to the greater awareness and attention to synesthesia: the use of neuro-imaging techniques such as fMRI (Functional Magnetic Resonance Imaging), PET-scan (positron emission tomography), CT-SCAN (Computer Tomography) and so on, has prompted numerous scientific studies worldwide on synesthesia, and the internet that has enabled synesthetes to learn more about their abilities and contact other synesthetes (American Synesthesia Association, 1995).

Neuro-imaging studies become particularly pertinent in the study of synesthesia, since they allow measurable proof of the disorder which had never been taken seriously scientifically given its subjectivity, variability, and rare occurrence. It was almost impossible to determine in any empirical manner, whether a person was truly synesthetic or not. This has changed with the advanced imaging techniques. For example, in a PET-scan conducted in London it was found that there were significant differences in cortical responses between synesthetes and non-synesthetes as they listened to a list of words. In the non-synesthete subjects there was an increase in blood flow to the parts of the brain involved in language processing. However, in the synesthete subjects there was also an

increased blood flow to parts of the brain involved in processing color (Duffy, 2001). While the colors induced may not be consistent across the different subjects, this study establishes the physiological reality of synesthesia over the more poetic allegory, which will be discussed in the next section.

Fundamentally a change has occurred in the approach to synesthesia; scientists have begun to appreciate the value of understanding synesthetic mechanisms to solve cognitive problems of sensory integration in *non*-synesthetic populations. Patricia Lynne Duffy (2001, p.xiii) proposes that it is possible that connections existent in the brains of the synesthetes also exist, un-used, in the brains of the non-synesthetes, and knowledge of these connections can aid in devising new methods of rehabilitation of people suffering from stroke and other brain disorders.

The phenomenon of synesthesia, or modal cross-wiring, has a developmental significance as well. In a study with three-week old infants (Lewkowicz & Turkewitz, 1980) it was observed that the infants made no distinction between visual and auditory stimuli, but reacted to the intensity of the stimuli, regardless of the modality. Thus a bright light and a loud sound may receive a similar response, whereas a bright light and a dim light may receive dissimilar responses. In a sense then, the infants are reacting to the quantitative aspect and amodal aspects of the stimuli, rather than the qualitative and modality-specific aspect of the stimuli. This is quite different from the way older children and adults would respond, but the possibility remains that as young babies life is experienced as a sensory blend, an “integrated pattern that they do not seek to question, simply to live” (Duffy, 2001, p.13). In time, however, the brain develops and

compartmentalizes its functions and the “synesthetic fusion of infancy makes way for the discrete sensory experiences of later years” (Duffy, 2001, p.12). There are two different hypothesis for the “fused” perception in infants as described by Baron-Cohen (1996) as follows:

1) *The Neonatal Synesthesia* (NS) hypothesis argues that early in infancy, probably up to about 4 months of age, all babies experience sensory input in an undifferentiated way. Sounds, for example, can trigger auditory, visual and tactile experiences and

2) *The Cross-Modal Transfer* (CMT) hypothesis argues that objects can be recognized in more than one modality, as a result of infants being able to represent objects in an abstract form. For example, babies can “visually” identify an object they have only “touched” (but never seen) before. This implies an abstraction of their sensory impressions which works across sense-modalities.

In our day to day use of language it is not uncommon to cross over modalities, with references to “warm colors”, “soothing sounds” and so on, and while this occurs metaphorically, rather than physiologically, it is derived from the fundamental ability to link different sense modalities. In fact, many scholars argue that the development of Speech itself depends on the ability to form stable inter-modal associations readily (Cytowic, 1989). Eventually, the cognitive ability to convert sensory perceptions to verbal concepts supersedes the more fundamental ability to convert a sensory perception in one modality to a sensory perception in another. And thus, while we may all be synesthetic at birth, and even through some years of our childhood, with the

development of individual modalities (sight, sound, smell, taste, touch) and the development of higher level cognitive processes such as language, the ability to transfer across modalities reduces. As the brain develops, it compartmentalizes it's functions, and synesthetic fusion of infancy gives way to discrete sensory experiences of later years (Duffy, 2001). Such an argument is in direct contrast to the argument made by Jean Piaget that senses are separate from each other at birth, and post-natal experience is required before the senses can be interrelated (as discussed in (Stein & Meredith, 1993).

According to Duffy (2001) there are two types of synesthesia acknowledged by the scientific community which can be listed as follows:

1) *Developmental* synesthesia, which has a childhood onset (before the age of four), which is vivid, automatic or involuntary and unlearned. This kind of synesthesia is different from imagery rising from imagination, or from hallucination, delusion, and other psychotic phenomena, and is not induced by drug use.

2) *Acquired* synesthesia, which is caused by neurological dysfunction or other dramatic physical change. This may be the result of a head injury or tumor producing blended sensations in previously non-synesthetic individuals. This form however does not take the systematic form of colored alphabets, numbers, music etc which is common to developmental synesthesia, but rather unorganized forms such as colored loud noises. Acquired synesthesia may also result from blindness.

Grossenbacher & Lovelace (2001) add a third type of synesthesia; "pharmacological synesthesia", which is induced in a drugged state by people who ingest hallucinogenic drugs (e.g. LSD or Mescaline). This kind of synesthesia is induced

by sensory stimuli, but the authors have not found evidence about whether it is induced by *thinking* about particular concepts, which is often the case in the other two types.

In addition to these conditions which have a distinct neurological and physiological component is the condition of metaphorical synesthesia which is “the artistic or linguistic device of expressing one sensory experience in terms of another” (Duffy, 2001, p.42). The common transfer between modalities in the use of metaphors in language is a typical example. According to Martino & Marks (2001) synesthesia can be classified as strong or weak. Strong synesthesia is characterized by a vivid image in one sensory modality in response to stimulation in a different sensory modality. Weak synesthesia is characterized by cross-sensory correspondences expressed through language, perceptual similarity, and perceptual interactions through information. Developmental and acquired synesthesia discussed above would be an example of the former, which metaphorical synesthesia is an example of the latter.

5.2. *Crossing over Sense Modalities in Architectural Education*

According to Downing (2000, p.83) “analogical thinking and metaphoric thinking are the catalysts, and form the framework, for the human ability to understand”. In her work on *Remembrance and the Design of Place* Downing (2000) discusses how architects, during the design process, tap into their highly sensate image banks, and cross over different domains, relying highly on analogy, and metaphor, to order the unknown in reference to the known.

In the field of art and architecture, or any form of creative endeavor, one can argue that synesthetic fusion, “weak” as it may be (i.e. characterized by cross-sensory

correspondences expressed through language, perceptual similarity and perceptual interactions through information) never ceases. It is not surprising that ever since the discovery of synesthesia artists have been fascinated by the condition, and its ability to provide new insights into old themes. In architectural education the translation of information about many different modalities has traditionally been into a visual artifact. It is in the *representation* of space, volumes and planes that we read the experiential quality that a design will take on once it is built and inhabited. Architects and designers are in the habit of translating very complex concepts: emotional, cultural, and functional, into a formal, and visual, artifact, with occasional verbal annotations. One can argue here that the process of translating from one modality to another is inherently synesthetic. In fact “joining of the information received by one sense to a perception in another sense is the essence of the architectural thinking that ought to take place during the drafting, preceding the constructing a building. Architectural concerns in matter(s), material substances or material beings and their transformations and transubstantiations in the built world can be recognized through a synesthetic view of the drawing procedures” (Fracari, 2004). In his work Fracari discusses the synesthetic nature of Carlos Scarpa’s drawings, and argues that Scarpa’s drawings are different from the traditional “analytical” sectional drawings in that “Scarpa used drawings to figure out human dwelling and construct edifices that are bundles of intertwined sensory perceptions, which intermingle and determine human thinking”. The following passage illustrates how this aspect of his drawing impacted the design studio (Fracari, 2004):

The implicit requirement of Scarpa's studio was that non-duplicable drawings were to be traced on Bristol board or similar material using a range of colored

pencils and pens. The first attempts were too often drawings with blue skies, red bricks, green grass and gray concrete, black poché and terracotta parterre. Unfailingly, these drawings dissatisfied and frustrated Scarpa, who after examining and carefully touching them, urged his assistants to explain to students that the colors used in the drawings were not to suit a process of material identification or to give pseudo-effects of tri-dimensionality, but, to make architectural ideas visible, tainted with non-visible phenomena and tinted with meanings.

Figure 5-1 shows an example of Scarpa's drawings. It is evident that the drawing is not a mere "presentation" of a visible object, but a complex artifact that is layered in meaning.

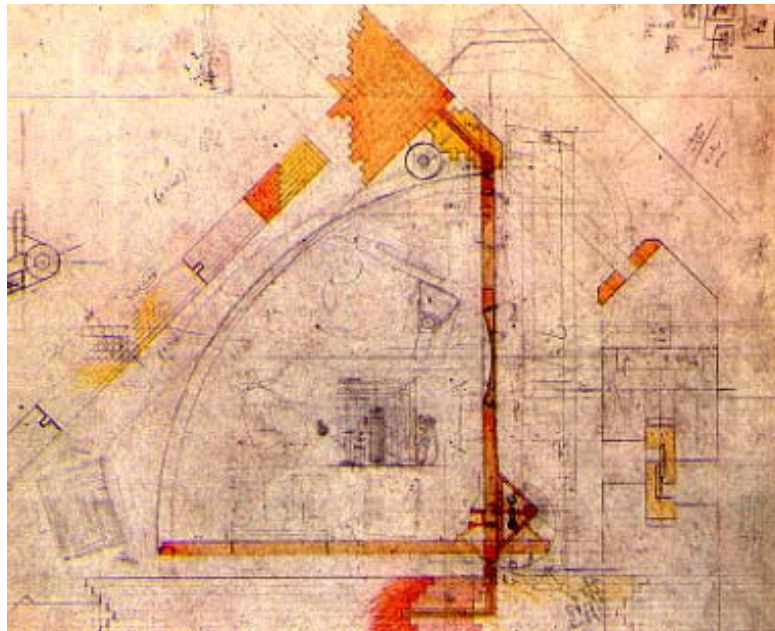


Figure 5-1. Carlos Scarpa's sketch for the Brion-Vega cemetery.
(<http://falcon.jmu.edu/~tatewl/SCARPA/04.scarpa.brion.sketch.jpg>)

Also significant to architectural thought is the crossing over modalities in the *conception* of space. In an interview with artist David Hockney, Cytowic (1989) pursued the question of how color was used to control sense of space. For an architect this may not be surprising, but the strongly sensorial connection is definitely intriguing. Hockney

is one of the rare synesthetes who have channeled their perceptual depth into art. The reference to gold is the gold light that Hockney projected in the lighting for the opera *Oedipus Rex* (Cytowic, 1989, p.278):

It's a special characteristic of color, that the more you see of it the more there is....to make blue bluer you simply add more space to it. Light and dark is a factor too. If it's bigger, then you know it's not dark. It becomes something else. Look at this color, which is much darker in tone than the one here. But if it was bigger, it wouldn't be dark because there would be more of it and it expands it a bit and it's not the same thing. Blue has the quality of being spatial, which other colors do not. The more of it there is, the more you feel of it. The music is like this --horizontal and vertical, very geometric. I projected gold into the side of the proscenium to give it weight and to make it big.

Since the revival of interest in synesthesia, the internet has become a source of knowing about synesthetes who experience this condition, and others who claim it, or seek to induce it. On his website Sean Day (2005) lists various artists who are synesthetes and differentiates between true synesthetes such as Carol Steene, David Hockney, Michael Frantangelo and pseudo-synesthete artists such as Georgia O'Keefe, Max Ackerman and Wassily Kandinsky. Artists in the second category adopt synesthetic principles for their work, but do not experience the neurological condition. Kandinsky for example used an established system of correspondences between colors and the timbres of specific musical instruments for his sets and paintings. These correspondences (shown in Table 5-2) between colors and musical timbres has no "scientific" basis, but was founded upon a combination of his own personal feelings, current prevailing cultural biases, and mysticism (Day).

Table 5-2

Kandinsky's table of color-sound correspondence (Day, 2005)

<i>Colors</i>	<i>Musical Timbers</i>
Yellow	Trumpet, sound of the fanfare
Azure	Flute
Blue	Deep sounds from the organ
Dark blue	Cello
Very dark blue	Bass
Green	Middle tones of the violin
White	Temporary pause
Black	Conclusive pause
Grey	Lack of sound
Bright-red	Fanfare; Tuba/Horn
Crimson red	Drum-roll; Tuba/horn
Cool red	Medium and deep tones of the Cello
Bright cool red	Other tones of the violin
Orange	Middle bells of the church; strong cantrallo voice; viola
Violet	English horn; bagpipe
Deep purple	Deep tones of the woodwinds; Bassoon

An interesting parallel to Kandinsky's work is the fictional character of "Chroma" in the famous *Phantom Tollbooth* (Juster & Feiffer, 1961). Chroma is a character who conducts symphonies in color. The musicians play different musical instruments, but the sound appears in colors across the sky for various seasons and times of the day. In fact, the musicians are playing not tones, but chromes. To quote: "the last

colors slowly faded from the western sky, and as they did, one by one the instruments stopped, until only the bass fiddles, in their somber slow movement, were left to play the night, and a single set of silver bells brightened the constellations” (Juster & Feiffer, 1961, p.124).

The color-sound correspondences used by Kandinsky, and conceived by Juster & Feiffer, serve as an opportunity for architectural conception and representation, one that can address the challenge of the visual bias that prevails in the educational system today. Unfortunately there are few research-studies focused on such crossmodal mappings as relevant to the design of places (as in what colors and shapes and textures and sounds are paired together). One study that did examine this issue (Simpson, Quinn and Asabel (1956) as cited in Marks (1978, p.67) interviewed more than a thousand school children asking them to match visual hue and auditory pitch. Based on these interviews certain relations of color and pitch were found: Violet and blue were predominantly associated with the lowest frequencies, while orange and red were associated with mid-range frequencies, and green and yellow were associated with high frequencies.

As discussed in previous sections colored hearing is the most common form of synesthesia. Also color is a significant aspect of architectural endeavors. Fundamentally, the process of synesthesia, weak or strong as the case may be, such as sound inducing color, involves a set of triggering *inducers* (e.g. sounds) mapped to a corresponding set of synesthetic *concurrents* (e.g. colors). Inducers may be sensory, or conceptual. In synesthetic perception, concurrents are induced by perceiving particular sensory stimuli. In synesthetic conception, concurrents are induced by thinking about particular concepts

(Grossenbacher & Lovelace, 2001). Based on the significance of synesthesia to architectural representation as well as the conception of space and color, the following section explores the prevalence of weak synesthesia, in the context of synesthetic conception, among architecture students.

5.3. *Case Study in Educational Setting: The Sound of Blue, and the Smell of Black*

A case study was conducted with 10 beginning design students and 9 graduate students to gauge the level of synesthetic conception induced by thinking about different colors. In case study 1 it was seen that sensory impressions were usually integrated with the recognition of objects, or certain emotions and qualities. Based on this insight, a survey was prepared.

All students were given a simple list of eight colors: Blue, Red, Green, Yellow, Orange, Violet, White and Black in a table with 5 columns. Students were asked to think of corresponding sensory images (sounds, smells, textures, temperatures) and the objects and emotions they associated with the colors. The colors were listed across the rows and the columns were blank under the headings of sounds, smells, textures/ temperatures and emotions/objects. Textures and temperatures were clubbed together because of their tactile quality, and emotions and objects were clubbed together because they represented the multimodal/amodal associations, i.e. associations which could not be attributed to a single modality.

There was no requirement to respond to all the colors, or all the columns (smell, sound, texture/ temperature, emotion/object). There was also no restriction on the

number of images; however the size of the table restricted this number. A sample response from one of the students is shown in Appendix D.

The hypothesis was that the sensory correspondences for a particular modality in a particular color will be consistent across subjects. To test this hypothesis a content analysis was undertaken by using a sorting task per-correspondence/ association to determine the consistency across the various images conjured among the different respondents. There were a total of 32 correspondences as shown in the matrix (Table 5-3).

Table 5-3
Survey matrix

	<i>Sound</i>	<i>Smell</i>	<i>Textures/ Temperatures</i>	<i>Emotions/ Objects</i>
Blue	X			
Red				X
Green				
Yellow			X	
Black				
Violet				
Orange		X		
White				

Star-plots for the thematic content analysis of the words, or “sense-images” associated with each color, across the four modalities, are shown in Appendix E. Reference to particular respondents is connoted by U (undergraduates) and G (graduates). It is important to remember that respondents were only ‘reading’ the words; the ‘visual’ image of the color was conjured in their own minds.

5.3.1. Color-Sound Correspondence

Across the undergraduate and graduate students it was found that the color-sound correspondence varied across different colors. It was found that the largest number of associations, purely quantitatively, was for the color blue, followed by red, black and white, green, yellow, orange and finally violet (Figure 5-2)

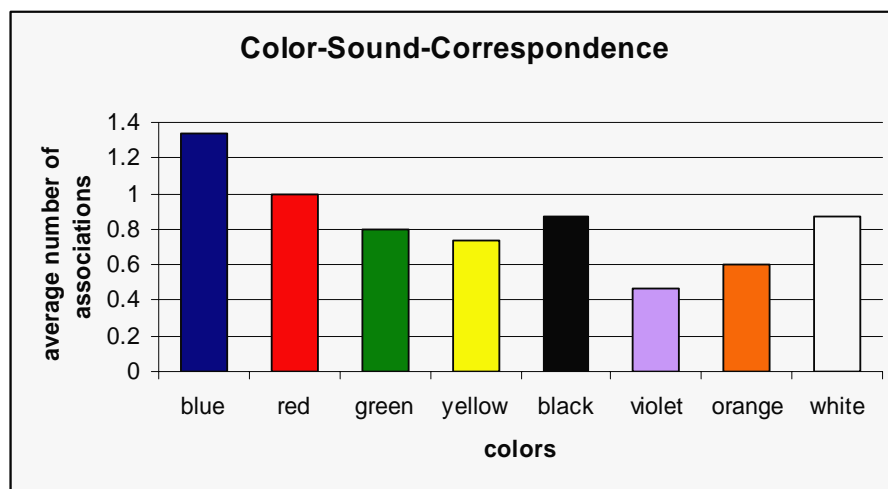


Figure 5-2. Color-sound correspondence

Overall, it was observed that the sound-association with color was more evident in the graduate students as compared to the undergraduate students (Figure 5-3). It is interesting to deliberate whether this difference derives from difference in the vocabulary of the two groups of students, or difference in the ability to think, and articulate, abstract thought. This warrants further investigation, but is outside the scope of this study. It was also interesting to note that despite the differences, ‘violet’ invoked the least sound associations by both group of students.

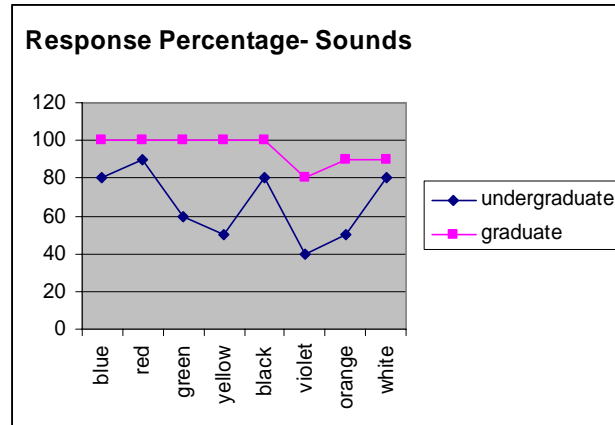


Figure 5-3. Percentage response for color-sound correspondence

The content analysis of the words revealed that although the correspondences varied for different colors, there were certain underlying themes. For example, ‘blue’ is associated with water sounds (10 respondents) more than any other sound, ‘green’ with the sound of wind through leaves (6 respondents), ‘red’ is associated with fire sounds (5 respondents), and ‘black’ with no sound or quiet (4 respondents). In yellow, orange and white the response was more varied, and not biased towards any particular sounds. For example ‘yellow’ is associated with soft sounds, and the sounds of kids playing (2 respondents), but most of the other sound images are unique, if similar (for example the sound of dry leaves crackling, and wind in tall grass are both sounds of nature, but distinct in their quality).

Also, interestingly, certain sound images are associated consistently with one color (for example water sounds are always associated with blue); however in other cases the same type of sound may be associated with different colors (nature sounds are associated with green, blue as well as yellow). Of course, since one cannot be sure about

what particular sound stimuli the respondents are conjuring there is a certain latitude in this statement, however it is significant that nature sounds are never associated with black or red, and similarly water sounds are never associated with red or orange.

Finally, it is interesting that silence, or no sound, is associated with black and white, hues devoid of color. ‘Quiet’ is different from ‘silent’, and is associated with yellow and violet, in addition to black and white.

5.3.2. Color-Smell Correspondence

Similar to the color-sound correspondence, color-smell correspondence also varied across different colors in all the students. It was found that the largest number of associations, purely quantitatively, was for the color red, followed by green, blue, black, yellow and orange and white, and finally violet (Figure 5-4).

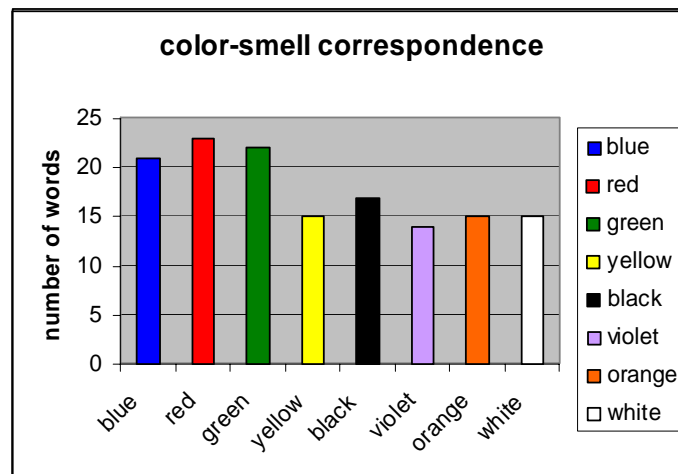


Figure 5-4. Color-smell correspondence

Again, similar to the sound-associations with color, smell-associations were more evident in the graduate students as compared to the undergraduate students (Fig 5-5). Violet has the least association with smell for the graduate students, but for the undergraduate black has even lesser smells associated with it than violet. Red had the maximum number of associations for the undergraduates.

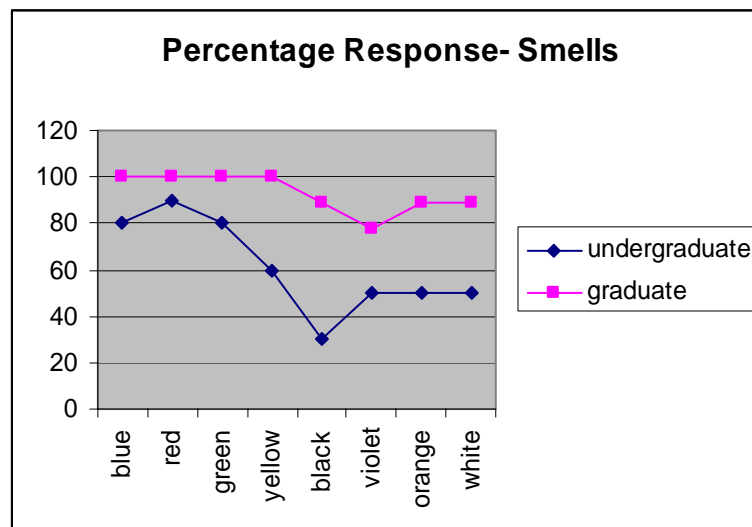


Figure 5-5. Percentage response for color-smell

In the analysis of words for the color-smell correspondence, it was noticed that similar to sounds; corresponding smells also varied across colors. Some of these associations were more varied than the others: 'blue' is primarily associated with the smell of nature, air or water (5 respondents each), 'red' is associated with the smell of fire (8 respondents), 'green' is associated with the smell of trees or plants (9 respondents), and a fresh smell (5 respondents), 'yellow' is associated with the smell of

lemon (4 respondents), 'black' with the smell of burning smoke (5 respondents) and carbon (4 respondents), 'violet' with the smell of flowers (9 respondents), 'orange' with the smell of citrus or orange (7 respondents), and 'white' with the smell of clean (3 respondents) and fresh (3 respondents). The strongest correspondence is the smell of trees or plants for green, smell of flowers for violet, and the smell of fire for red.

Again, certain smells are associated consistently with one color (for example the smell of water-bodies like oceans, lakes etc are exclusive to blue), however in other cases the same type of smell may be associated with different colors (fresh smells are associated with green, blue, red, yellow and orange). A particularly interesting example is how the smell of a rose is associated not just with the color red, but also with the color violet (G7) rather than the smell of violets; this is a synesthetic illustration.

5.3.3. Color-Textures/Temperatures Correspondence

It was found that the largest number of texture/temperature correspondences, quantitatively, were for the black, followed by blue, green, red, white, yellow, and violet and orange (Figure 5-6). There was a remarkable degree of co-relation between the responses of the undergraduates and the graduates (Figure 5-7). Respondents in both categories found maximum texture/temperature correspondences for violet, and minimum texture/temp correspondences for violet. In both cases, yellow and orange had fewer responses.

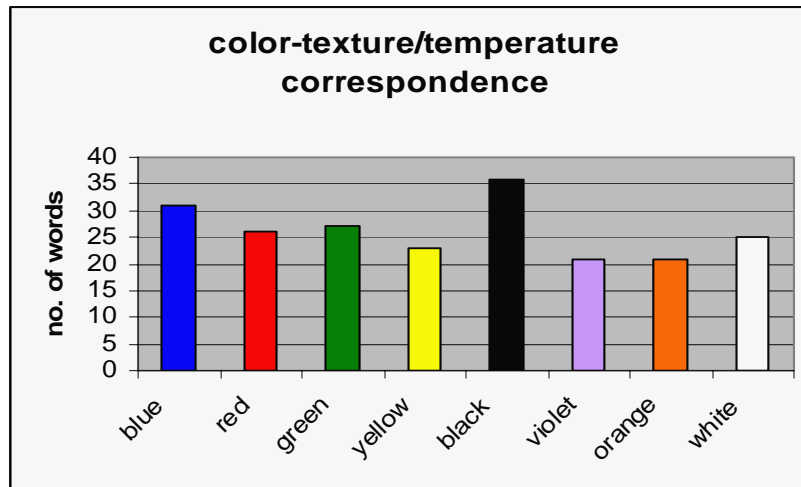


Figure 5-6. Color- Touch correspondence

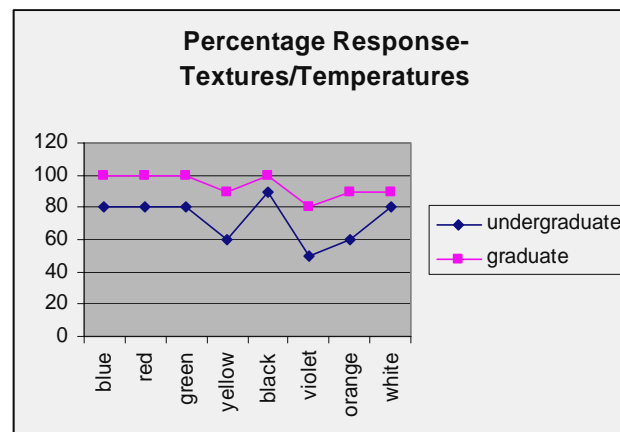


Figure 5-7. Percentage response for color- touch

In Appendix E the star-plots for each of the color-touch correspondence is shown. Similar to what was noticed in sounds and smells, texture and temperature associations varied across colors. However, in spite of numerous textures and temperatures conceived by the students, there was homogeneity in the most prominent, or commonly used, which were “warm”, “cool”, and “smooth”. In Table 5-4 these

images are shown with the corresponding colors and the number of respondents is represented within parentheses.

Table 5-4
Color-touch correspondence

<i>Warm</i>	<i>Cool</i>	<i>Smooth</i>
Yellow (7), Orange (8) Hot: Red (12)	Blue (11), Green (6), Violet (3)	Black (8), White (6)

The table shows that the strongest associations were for red (hot) and blue (cold). Black and white, were once again distinct from the other colors; while other colors were associated more strongly with temperatures, black and white were associated more strongly with texture, in particular a smooth texture. Red and Orange had more homogeneous associations than the other colors. Green, blue and violet were the most diverse.

5.3.4. *Color-Emotions/Objects Correspondence*

It was found that the largest number of emotion or object correspondences, in terms of the number of responses, were for the colors black and red, followed by blue, green, white, orange, violet and finally yellow (Figure 5-8). A certain level of co-relation was observed between the responses of the undergraduates and the graduates; however this was not as congruent as the response to textures/temperatures (Figure 5-9). The lowest response in both groups was for violet. The highest response for the undergraduates was for black and red, however, none of the colors had a cent percent

response. For the graduate students there was a 100% response to the colors blue, red, green, black and orange.

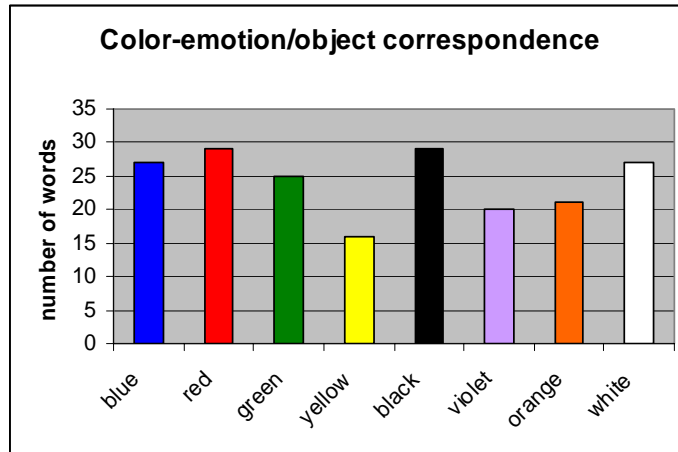


Figure 5-8. Color-emotion/object correspondence

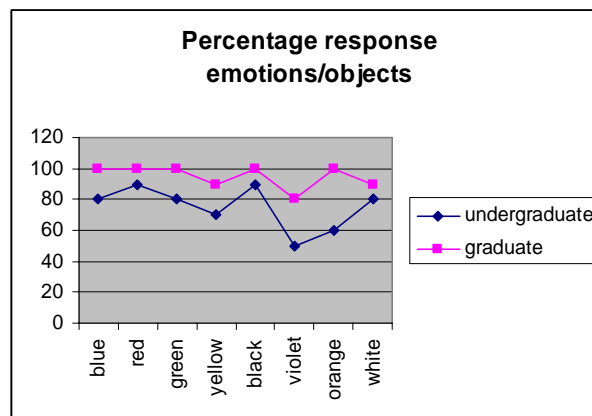


Figure 5-9. Percentage response for color- emotions/objects

Star-plots for the complete range of images generated are shown in Appendix E. Similar to what was noticed in the previous sections, emotions or objects associated with *particular* colors varied across the respondents. Associations for the *different* colors

varied considerably. The clear biases evident in the tactile associations were not seen for emotions and objects. However, certain repetitions/biases were obvious: 'blue' was associated with relaxation (4 respondents) and peacefulness (4 respondents), 'red' was associated with anger (7 respondents), 'green' with trees and plants (9 respondents), 'yellow' with happiness (6 respondents), 'black' with sadness (5 respondents), 'violet' with flowers (4 respondents), 'orange' with happiness (4 respondents) and oranges (4 respondents) and 'white' with calmness (4 respondents). If we reword these findings we can argue that anger is red, sadness is black, and happiness is orange. This is a synesthetic statement.

5.4. *Summary: Hearing Textures and Feeling Sounds*

The analysis of the data from the undergraduate and graduate students showed that graduate students were more homogenous in their synesthetic conception. Their response was more or less uniform across the nine graduate students, although there was a variance in the actual sensory images that students conjured for a particular color. Undergraduate students, on the other hand, showed a more preferential response to the different colors. Few students responded to all the colors, and all the modalities. The average trend of response to different colors for the different modalities was consistent for textures/temperatures and emotions/objects. In both cases, the color black generated the most number of associated responses, and violet generated the least number of associative responses. For emotions and objects *red* generated as many associations as *black*, quantitatively. For textures and temperatures *orange* generated as many responses as *violet*. The trend for graduate and undergraduate students was more different for

smell-correspondences, and very different for sound-correspondences. For smell correspondences black generated the least response, and red generated the most. For sound correspondences blue had the most responses, and violet had the least responses.

Consistently, across the different modalities, for both groups of students, violet generated the least response. Response to black was either extremely high, or extremely low. Responses to the primary colors of blue, green and red were consistently high. Thus, it seems that not all colors lend themselves to the same level of synesthetic conception. This is significant while making a decision about using colors that are *neutral* versus those that are *connotative*.

On analyzing the specific associations that students made with the different colors to understand the *quality* of cross-sensory correspondence, a complex pattern emerged which showed consistency and homogeneity for certain images and variability across others. For example, blue was overwhelmingly associated with water sounds, and green with the smell of trees/plants and grass. Both blue and green had a “nature” connotation. On the other hand, violet had a large variability in the sounds, and not more than one respondent associated the same sound with violet. While a level of homogeneity existed across certain *color-sense* (color-sound, or color-smell, or color texture/temperature) correspondences, and *color-emotion/object* correspondences, the correspondences were not uniform across all respondents.

While certain associations, such as the association of the color blue with water sounds, and green with nature smells, is not particularly surprising, other associations were proof of the very subjective and personal nature of the responses. In the following

examples some of the cross-modal images conjured are put into a meaningful sentence, and paraphrased, (respondents are identified in parentheses):

Yellow is less sweet than red (G9).

Yellow feels warm or cold like a glass of water (U5)

Violet smells of roses (G7)

Orange sounds like kids playing (G2)

These correspondences are surprising, unexpected, and bring a depth to the approach to color that goes beyond simplistic color-theory. One of the questions that this study can not answer, conclusively, is the *directionality* of the images conjured. For example, if thinking about the color blue, conjures a mental image of water sounds, then does thinking about the sound of water, conjure the mental image of blue? Water is transparent, it doesn't have a color. Water is associated with many facets of our life. Finally, water sounds, depending on the nature of the sound, can have a myriad of connotations, thus there is no proof that 'hearing' the sound of water (trickling from a tap or splashing in the ocean) would be associated with the same color.

This leads to the larger question of how lateral correspondences occur between different sense modalities, and if a purely sensory image can be conjured devoid of an emotion or object. That is to say, do respondents conceive an object, and *then* a sensory correspondence, or does the sensory correspondence *precede* the object conceived. Again, in the case of blue, would a respondent think of water first, and then the *sound* of water, or does the sound of water come to mind before the actual object. Unlike

neurological synesthesia, synesthetic conception must address the question of whether sensory correspondence can be teased apart from cognitive connotations.

In the Table 5-5 the correspondences for the color *red* and *orange* for one student (G3) are shown. For the color orange we can see an underlying theme of energy. The sounds, smells, and textures can be associated with one cohesive scenario. For red, on the other hand, the student seems to have conceived discrete images. An object “flower” and the smell of a rose are thematically consistent. But the sound of “bustle”, and a “hot” temperature could be thematically independent. Thus, it is possible that students conjure a particular mental image and derive sensory images from that image across all modalities. It is also possible that they derive separate mental images for each modality, and that these correspondences could be sensory, or abstract and semantic.

Table 5-5
Sensory correspondence for red and orange

<i>Color</i>	<i>Sound</i>	<i>Smell</i>	<i>Texture/ temperature</i>	<i>Emotion/object</i>
Red	Bustling	Rose smell	Hot	Flower
Orange	Festive sounds	Fruity smell	Simmering heat	Energizing

Another question that emerges from this study is whether associations are possible across single sense modalities, devoid of other senses, i.e. are unimodal mental images possible, or are images intrinsically multimodal. Can the mental image of the sound of water in a swimming pool, associated with blue, be separated from the smell of chlorine? If not, then how is it that all the respondents who associated water sounds with

blue, did not associate water smells with blue as well. In using words, instead of actual color cards, respondents could project their mind into particular hues within particular contexts. It would be interesting to compare results from this study to a study using actual color cards.

The complexity of synesthetic conception begins to emerge in the ability of the mind to both separate, and join, sensory images. Irrespective of how the correspondence across sensory modalities actually occurs, it seems evident that crossing over sense-domains is natural to us, and this can become a significant pedagogical tool.

6. SUMMARY: A CROSSMODAL APPROACH TO SENSORY ENVIRONMENTS*

6.1. *Summary of Literature*

There has been a bias in architectural theory towards the purely visual and aesthetic, often overlooking more experiential and holistic concerns. The visual bias, which can be traced to the change in media and representation beginning with the Renaissance, is heightened today with the use of new media and virtual reality. While the ability to see (and show) what the eye perceives has become sophisticated, the understanding of the process of perception itself is lacking, and the link between the perception of the eyes, to the overall cognitive processes, is seldom understood. The senses that serve as the gateways to our perception have not been given their deserved emphasis in the architectural curriculum, even though as architects we design a significant part of the sensory environment perceived. In fact, the approach to the senses has been limited to the classical approach of categorizing sight, sound, smell, taste, and touch, as independent senses and, but in the rare cases in which the role of different senses has been studied, each sensory modality has been addressed separately resulting in specializations such as lighting, acoustics and HVAC.

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In psychology and the cognitive sciences, the classical approach has been obsolete for a long time. Many scholars agree with the Gibsonian way of thinking about the senses as sensory systems, that can be listed as: 1) Basic orientation system (responsible for body equilibrium and orientation – responding to the forces of gravity and acceleration); 2) The Haptic system (responsible for perception of passive and active touch, for temperature distinction, and for distinction of personal movements); 3) Visual system (responsible for the instant and simultaneous perception of forms, depth and distance, variables of color, and transformations in light); 4) Auditory system (responsible for listening, orienting towards sounds and detecting the nature of sounds - responds to vibratory events), and 5) Taste/Smell system (responsible for detecting the nature of volatile and nutritive sources - responds to composition of the medium and of ingested objects). Color, texture, temperature, light, air, sound, and smell are some of the sensory properties of our environment that pertain to the five systems. The sensory properties help us to identify objects, areas, and activities in a given environment. They can also enhance the experience of a given space without relying on purely visual appeal.

Scholars such as Marks (1978) go a step beyond Gibson's systemic theory and argue for an interdependent process in which different sensory systems cannot be grouped into discrete compartments. In the theory of the *Unity of Senses* (Marks, 1978) doctrines of sensory correspondence are postulated arguing that different senses can give us equivalent information, or analogous information about the external world, and may have similar psychophysical and neuro-physiological properties

The interdependence, and correspondence, among different sense-modalities has become increasingly apparent in the crossmodal investigations in cognitive neuroscience wherein the physiological and neural activity for two or more senses is mapped simultaneously. Sensory integration and compensation across different sense-modalities is integral to the process of paying attention and functioning in our environments. The analysis of the connections between different sensory modalities has been undertaken by the study of “attention,” a higher level cognitive process that organizes the sensory stimuli we receive at any point and forms them into a cohesive perception (Westen, 1996). Due to the process of attention we are not overwhelmed by the myriad of stimuli that we are subjected to at any given point in time; instead we focus on what is relevant to us for a specific function in a specific context.

In a biological sense attention is measurable by the neuron movement in the cortex; the modality that is ‘attended’ to is determined by the area that shows most activity. By mapping the behavior in more than one area of the brain at a time, and knowing the cognitive processes attributed to different areas, analyzing the extent to which different processing centers in the brain are interdependent is now possible.

Crossmodal experiments undertaken in the last decade have focused more on the links among audition, vision and touch, than on taste and olfaction, both of which have a proven interdependence. For example, smell is critical to the perception of flavor. Position and motion of the body are taken into consideration during these experiments because the turn of the head, the movement of the eye, the tightening of muscles, and perked ears, are all indicators of paying attention at a macro scale. These experiments

have shown that contrary to the classical view point, sensory processing centers cannot be considered in isolation, and they have a direct and measurable impact on each other.

The following findings have been made:

1) Senses can get *cross-wired*, i.e., a stimuli to one sense-modality may trigger a response in another. For example, visual stimuli might evoke a response in the auditory cortex. In the neurological disorder “Synesthesia”; people have been known to ‘taste’ shapes and ‘feel’ colors

2) Senses *compensate* for each other, such as, in the attempt to maintain a coherent percept of the external world one sense might compensate for the other when required. For example, sounds seem louder in a dark room, or the auditory cortex may be more well-developed in a blind person and

3) Senses tend to fuse towards *localization* in external space. In receiving simultaneous stimuli to different sense-modalities, the brain assumes that the different inputs correspond with each other and can be localized in external space. This explains why we get the illusion in a movie theater that the sound is coming from the screen up front, because we see the actor’s lips move. Actually the sound is coming from a digital speaker in the back.

Correspondence and *Coherence* are critical to the perception process. In order to achieve coherent perceptions the corresponding sensory information we receive from our environments are often prioritized, and dependent on physiological and situational factors. For example, in many cross-modal experiments touch seems to warrant the

quickest response to stimuli, though it does not necessarily solicit the most activity in the brain.

While the immediacy of touch can be considered an indicator of a basic hierarchy in our sensory processing, in complex environments where many stimuli occur together, this hierarchy is constantly changing. Thus both *hierarchical relationships* (the prioritization of different sense-modalities), and *lateral relationships* (the exchange of information between different sense-modalities) are relevant to how we approach the *crossmodal* (thinking across sense-modalities) in our perception of space, and are closely linked to what we “attend” to while we are experiencing a particular environment.

Change is one of the most critical factors in determining to what we pay attention. We respond to a change in our environment, because of changes in our own position or movement, or in the sensory stimulation that we are receiving from the external environment. In order to re-orient to the changed circumstance the stimuli are prioritized as discussed above. Thus changes in the environment act as triggers towards the organization of attention. The dynamic process by which the different modalities compete and reorganize into one fused perception is *negotiative*, and aimed towards integrating and cohering sensory stimuli.

While many scholars have appreciated the role of the different senses in architectural theory (Fruin, 1971; Hall, 1966; Lynch, 1960; Pallasmaa, 1996; Proshansky et al., 1970; Rapoport, 1977) the approach has been classical with each sense addressed independently, and as distinctly inferior to vision. The primacy of vision as a sense that orients us in a complex world cannot be challenged, but at the same time vision is a

distant sense, more prone to illusions than a more proximal sense like touch, or smell. Physiologically, touch has its own “intra-modal” hierarchy; parts of the human body which are anatomically more complex have a greater area devoted to them in the somatosensory cortex, resulting in a *somatosensory mapping* of the external world which is out of proportion to the physical external world we “see”. The tactile sensitivity of the fingers, for example, makes its role in the active exploration of environments critical.

In many cultures the “sensory order” relegates vision as secondary to smell or touch (Classen, 1993). Within this varying prioritization of the senses, the correspondence between different sensory stimuli still gives stability and credibility to our perceptions; a rose that smells like a tulip is as disconcerting as a dog that meows. Synesthetes, who experience the involuntary joining of senses, have a unique understanding of the world, because their sensory stimuli correspond differently from other people. Many of them, for example, attribute colors to words, a concept that we can comprehend only if we are using colored pens. At the same time, the common use of metaphor in daily life, “warm” colors, the “sweet” revenge, “prickly” disposition, are examples of how we cross over sensory modalities in abstract thought.

The literature shows that the crossover among sensory modalities happens both *hierarchically*, when one sense is prioritized over the other, or one compensates for the other, and *laterally*, when one sense-modality crosses over to the domain of the other or becomes analogous to the other), and affects the perceptual choices we make in the functioning of our day-to-day lives. The question however remains whether these crossovers can be analyzed and observed in a non-laboratory and real-life setting.

6.2. *Summary of Findings*

6.2.1. *Mappings*

In order to understand how the mind crosses over different domains, and exchanges information among different sense-modalities, within an environmental context, a case study was conducted in the plaza in Santa-Fe, New Mexico. Ten people were approached randomly in or around the park that forms the square in the center of the Santa Fe plaza, and asked to take a walk around the plaza, while speaking into an audio-recording device about what caught their attention. While the respondents were on their particular journey, their route was observed by the researcher and mapped on a to-scale plan. Upon return to where the researcher sat near the center of the square the respondents mapped their own routes, by memory, on a blank sheet of paper, without a to-scale plan view to which the researcher was privy. The respondents then annotated this map with the sensory impressions and other information they recalled, and then recanted their experience in an interview. The self-reports, interviews and maps were triangulated in order to analyze what users paid attention to in a complex and real-life environment, and determine the ecological validity of thinking across modalities.

Because the study was open-ended, and allowed the ten respondents to choose where they moved, how long they walked, and what they reported, the data derived was rich and complex. Information about what users attended to, i.e. what they saw, heard, smelt, tasted, touched and felt was interwoven with their emotions, and their thoughts.

The self-reports in which people spoke into an audio-recording device of their own volition were in the nature of mental meanderings. There was a constant switch

between *observation*, *conjecture*, *projection* and *reflection*. People noticed certain aspects of their environment (observation), they wondered about it (reflection), derived meaning from it (conjecture), and projected themselves in time, both forward and backwards, in what could have been and what will possibly occur (projection). This process was in no way linear or consistently identifiable across different users. Some respondents noticed a particular detail about the environment, and then went on to reminiscence about the history and politics of Santa Fe, often with seemingly complete disregard for the actual stimuli they were receiving. This is consistent with the formation of a *network of associations* as a mnemonic device (Westen, 1996). The process of what users paid attention to was obviously layered, iterative, and complex. Consequently, when people reported into their audio-devices, or when they were asked to recall different sensory impressions at the end of the interview, there seemed to be no order. The reports usually alluded to what they could ‘see’, or what they were thinking about, with very few references to the other senses or conscious acknowledgment of how one sense influenced the other.

However, in the consequent mapping and interview process, they depicted details about the environments that they did not verbally acknowledge during the self-report process. Unlike the meanderings of the self-reports there was an attempt to structure the experience in the mappings and interviews. This structuring seemed to be a function of basic schema (source-path-goal), spatial rules (symmetry, balance and axes), perceptual choices (relevance of elements perceived as vs. those that were irrelevant or not noticeable), and finally identification (ability to recognize an element was give its

significance). The following domains emerged from the data collected and reflected the basic schema used in the structuring process were:

1. *The Domain of Embodied Kinesthetic*: Recollection of the route the body took by projecting it through space and time accurately, although the spatial context was often inaccurate.
2. *The Domain of Spatial Balance*: Biased recollection of the spatial context on the basis of formal principles such as symmetry, balance, axes etc.
3. *The Domain of Anchor*: Recollection anchored upon particular Landmarks, and specific Events.
4. *The Domain of Integration*: Recollections joining sensory observations with event/object/emotion. Fragmented observations are integrated across modalities (e.g. bad-blue-crane, trees-coolness-quiet/peace). The domain of integration alludes to a lateral relationship between different modalities with an exchange of sensory information in order to form a coherent thought.
5. *The Domain of Compensation*: Recollection focusing on different sensory nuances of the environment based on perceptual choices. For example, sounds are noticed more vividly when the eyes are shut. A hierarchical relationship between modalities is evident in the manner in which one sense is prioritized over the others in different contexts.

The iterative nature of the structuring process was evidenced by how the memories were structured differently during each level of interaction (self-reports, maps and interviews). When specifically solicited, sensory images were recalled, but purely

sensory sensibilities were difficult to evaluate. However, when one sense was suppressed (such as with the closed eyes exercise), other senses were prioritized, and attention shifted to different and more sensorial aspects of the environment. Although the case study provided rich information about the human interaction with the environment, it did not allow the focus on sensory interdependencies that are possible in lab-based crossmodal studies. This is understandable given the complex nature of real-life environments and human interaction in them. Follow-up studies were warranted to focus on the hierarchical and lateral relationships which were emergent from the data within a more constrained framework.

6.2.2. Hierarchical Relationships between Modalities

In order to investigate if the prioritization between different sense-modalities takes place within an educational context, a case study was conducted on a group of nineteen beginning design students at the Department of Architecture at Texas A&M University. Students were given a list of places ranging from places with distinct sensory needs (e.g. painting gallery, music concert) to places that were more generic (living room, bedroom etc.). Students were asked to rank the importance of the different senses in each of the places given in the survey. The study was based upon the following null hypotheses:

1. There is no significant hierarchy of senses perceived by architecture students across different places
2. There is no significant hierarchy of senses perceived across different architecture students for a particular place

A Kendall's W test for concordance of ranked values was conducted on the ranked data to determine the level of agreement in the ranks across the respondents. A value between 0.3 and 0.6 is considered significant, and rankings for all the places, except the swimming pool were significant. Twelve ranking sequences were observed, with the most common one being Sight> Sound> Touch> Smell> Taste. However, this combination occurred in only four places: painting gallery, patio, library and auditorium. In the case of museums, and gardens, sound and touch were perceived as equally important. Particularly significant was how taste and smell were ranked together, each time, with the exception of bathrooms, a pairing that is consistent with the cognitive connection between smell and taste (flavors are perceived by a combination of smell and taste). Sight, sound and touch, were ranked interchangeably, usually above smell and taste, proving that these three senses are critical to any architectural endeavor. However, in places like a bakery, kitchen, café, or other food-oriented places, smell becomes equally, if not more, critical. This is also true of a bath-room, where an unpleasant odor makes for an unwanted experience. In Figure 6-1 the various ranks are represented graphically, and in Table 6-1 the most prominent senses (those ranked No.1) for the different places are shown.

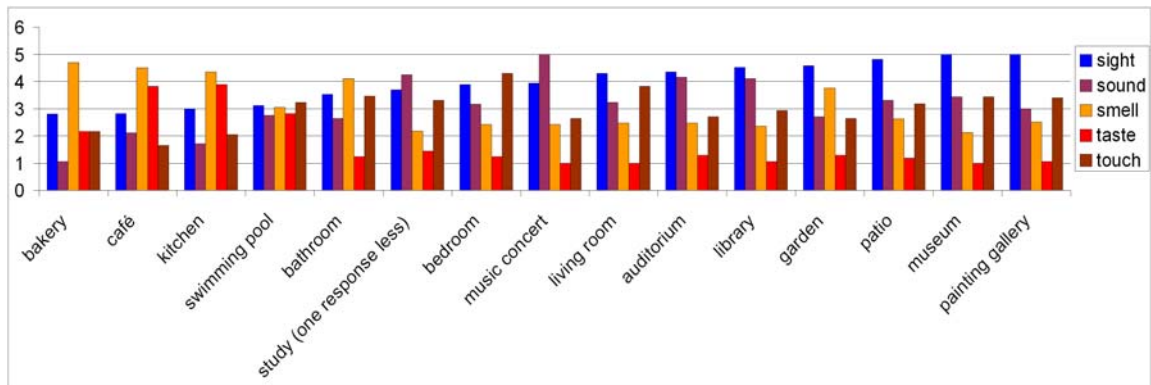


Figure 6-1. Bar-graph of sensory rankings in different place types.

Table 6-1

W value of concordance and most prominent sense

<i>Place</i>	<i>W value of Concordance</i>	<i>Most prominent sense</i>
Bakery	0.85	Smell
Café	0.56	Smell
Kitchen	0.5	Smell
Swimming Pool	0	None
Bathroom	0.48	Smell
Study	0.43	Sound
Music Concert	0.87	Sound
Living-Room	0.55	Sight
Auditorium	0.63	Sight
Library	0.75	Sight
Garden	0.6	Sight
Patio	0.74	Sight
Museum	0.9	Sight
Living room	0.55	Sight
Bedroom	0.58	Touch

In architectural education there is an implicit prioritization of the senses; visual considerations are primary, followed by considerations of acoustics, and thermal comfort. Olfactory (smell) and gustatory (taste) factors are rarely taken into consideration. The ranking study shows that the order in which sensory factors are prioritized is not uniform across different kinds of places. In fact, touch, classically relegated to the bottom of the sense-hierarchy by philosophers is consistently ranked second or third, making it central to the sensory order. On the basis of the findings both the null hypothesis formulated were rejected, and the following conclusions reached:

1. A particular sensory order in which different senses are prioritized is perceived in different places
2. The sensory order is unique for different place-types, but it is consistent across subjects with a significant level of agreement

It is apparent that when students thought about different places, each place had its own, unique, interplay between senses. In being asked to think about certain place-types, students essentially had to conjure a mental image, and whether this image was of a particular example of the generic place-type, or simply an idealized notion, cannot be determined. A follow-up study is warranted to investigate the relevance of the source of the mental image.

While a simple ranking exercise cannot tell us how much more important sight is than sound, or how marginally more important sound is than touch, in a particular place, it is evident that not all the senses are equally important, and nor is sight

uniformly, and independently, the most important sense. This insight, and a conscious effort towards incorporating the unique sensory orders in different place types, can help to enrich architectural education and the design process.

6.2.3. Lateral Relationships across Modalities

The interplay between the senses takes on a different level of complexity when we think of them not only hierarchically, in how we prioritize one sense over the other, but laterally, in how our sense-modalities can inform each other, and occasionally cross over. Evidence of sensory cross-overs is emergent from the literature on Synesthesia, a neurological disorder which causes involuntary cross-wiring between different sense-modalities, and in our common use of metaphor. Color, in particular, lends itself to crossmodal connections in both a metaphorical sense (e.g. We refer to warm and cool colors), and a neurological sense (e.g. Color-induced synesthesia is one of the more common forms of synesthesia, where seeing a particular color invokes imagery in different senses). Based on this foundation a study was conducted with ten beginning design and nine graduate students to gauge the level of synesthetic conception induced by thinking about different colors, namely, blue, red, green, yellow, orange, and violet. White (perceived by the absence of all colors) and black (perceived by the addition of all colors) were also included in the list. Students were asked to think about the particular colors and the mental images they conjured in terms of purely sensory images (sounds, textures, temperatures, and smells) and more cognitive images pertaining to particular emotions, or object recognition.

The colors were listed across the rows of a table with the following columns: Sounds, Smells, Textures/ Temperatures, and Emotions/Objects. Students were asked to list words in the appropriate columns describing the sounds, smells, textures, temperatures, emotions and objects that corresponded to the colors. There was no requirement to respond to all colors, and all the modalities (listed in the columns), nor was there a restriction on the number of words they could list, although they were constrained by the size of the cells in the table (Appendix D). The hypothesis was that the *sensory correspondences* for a particular modality in a particular color (for example blue-sounds) would be consistent across all respondents. The hypothesis was tested by undertaking a content analysis of the words generated in the survey in the following crossmodal correspondences: color-sound, color-smell, color-texture/temperatures, and color-emotions/objects. There were nineteen sets of data (10 undergraduate respondents and 9 graduate respondents) across the eight colors in each of the four correspondences resulting in a total of thirty-two correspondences. The findings will be discussed as per the associations that respondents made in each of the four categories of crossmodal correspondences:

6.2.3.1. Color-Sound Correspondence

The number of sounds associated with color varied across the different colors. The largest number of associations was for the color blue, followed by red, black and white, green, yellow, orange and finally violet.

Different colors were associated with different sounds, and each color was often associated with more than one sound by different respondents. Some associations were more common than others, as shown in Table 6-2.

The response was more varied for the colors yellow, orange, and white, all of which covered a larger spectrum. There was also a certain level of overlap among the images. For example, nature sounds were associated with green and blue as well as yellow. On the other hand, water sounds were always associated with blue. Silence, or no sound, was always associated with black or white.

Table 6-2
Common color-sound associations

<i>Colors</i>	<i>Sound Associations</i>	<i>Number of Respondents</i>
Blue	water sounds	10 respondents (52%)
Green	wind through the leaves	6 respondents (31%)
Red	fire sounds	5 respondents (26%)
Black	no sound	4 respondents (21%)

While it is tempting to look for consistencies and similarities in the associations that the respondents made, it is evident that associations varied across different respondents and different colors. For example, while most respondents associated the color blue with the sound of water, one respondent associated it with the sound of a quarrel and another one with the sound of breaking glass. It is significant that conceiving

a sensory image in a different modality was easy for most respondents, although it was demonstrated with more ease by the graduate students. While colors such as violet generated a poor response, respondents conceived sound images vividly for the primary colors blue, red, and green.

6.2.3.2. Color-Smell Correspondence

Respondents associated with different smells with different colors. The maximum associations were for the color red, followed by green, blue, black, yellow, orange and finally white. Similar to the sound associations, respondents often associated more than one smell with a particular color. The most common color-smell associations are tabulated in Table 6-3.

Table 6-3

Common color-smell associations

<i>Colors</i>	<i>Smells</i>	<i>Number of Respondents</i>
Green	Smell of trees/plants	9 respondents
	Fresh Smell	5 respondents
Red	Smell of Fire	8 Respondents
Blue	Smell of Nature	5 respondents
	Smell of air	5 respondents
	Smell of water	5 respondents
Orange	Smell of Orange/citrus	7 respondents
Black	Smell of burning/ Carbon	9 respondents

Responses for other colors were more varied than the ones shown in the table: yellow was associated with the smell of lemon (4 respondents), and white with the smell of clean (3 respondents) and fresh (3 respondents). Violet was the most interesting;

while 9 of the 19 respondents associated the color Violet with flowers, these flowers varied from violets to roses, tulips, and lavender. The strongest correspondence was in the smell of trees or plants for green, smell of flowers for violet, and the smell of fire for red.

Again, certain smells were associated consistently with one color. For example the smell of water-bodies like oceans and lakes were exclusive to blue; whereas in other cases, the same type of smell was associated with different colors. Fresh smells were associated with green, blue, red, yellow and orange.

6.2.3.3. Color-Texture/Temperature Correspondence

The largest number of texture/temperature associations were for the color black, followed by blue, green, red, white, yellow, and violet and orange. While there was variability in the associations made by different respondents, similar to the other correspondences, there was a surprising degree of homogeneity in the most commonly used, images which is tabulated in Table 6-4.

Table 6-4

Common color-temperature/texture associations

<i>Colors</i>	<i>Texture/Temperature Associations</i>	<i>Number of Respondents</i>
Red	Hot	12 Respondents
Blue	Cool	11 Respondents
Green	Cool	6 Respondents
Orange	Warm	8 Respondents
Yellow	Warm	7 Respondents
Black	Smooth	8 Respondents
White	Smooth	7 Respondents

Interestingly, while most of the colors were associated more homogeneously with temperatures, black and white were again distinct by a greater association with textures. Individual responses to colors were both in tactile and thermal imagery, but these varied across the board. Blue for example was both plain, and prickly; green was bumpy, and soft; yellow was plain, and rough for different respondents. Red and orange had the most homogeneous responses while violet had the most diverse. It was evident that tactile/thermal associations were largely subjective, but with certain underlying themes.

6.2.3.4. Color-Emotion/Object Correspondence

Emotion and object associations to different colors were the most prevalent in all responses. It was evident that purely sensory associations (such as sounds or smells) were more difficult to conjure than images of emotions and objects that they could associate with certain colors. This was consistent with the domain of sensory integration observed in the first case study.

The maximum number of associations was with the color black and red, followed by blue, green, white, orange, violet and finally, yellow. The emotion/object associations were more varied across respondents than the associations made with other sensory modalities, especially the tactile/thermal associations. Even so, certain commonalities were evident as represented in Table 6-5.

Four respondents each associated violet with flowers, orange with happiness or oranges, and white with calmness. While some colors, like green, had an underlying theme that was equated to nature and tranquility, other colors like red were associated with anger on one side, and fun, excitement and energy on the other.

Table 6-5
Common color-emotion/object associations

<i>Colors</i>	<i>Emotions/ Objects</i>	<i>Number of Respondents</i>
Green	Trees/ Plants	9 respondents
	Serene/ Calm	7 respondents
Red	Anger	7 respondents
Blue	Relaxation	4 respondents
	Peacefulness	4 respondents
Yellow	Happiness	6 respondents
Black	Sadness	5 respondents

In summary, sensory imagery, across modalities, was subjective, but adhered to certain commonalities. While there was a certain ease in associating images across sensory modalities, this was facilitated by the use of words. That is, the visual stimulus of color was not equated or matched with audio/tactile/olfactory stimuli. Moreover, one cannot be certain of what particular shade of color respondents visualized while making their associations and the exact sensory image to which the associated words used referred. In fact, often different words were used for the same theme (such as serene/calm, silence/ quiet); this made it difficult to classify the words since we cannot know the precise sensory imagery connoted.

The association process was therefore more high-level, and cannot be considered conclusive of crossmodal “sensory” processes. Although the crossmodal associations cannot tell us exclusively about specific sensory images that are associated with different colors, the findings are significant in the ease with which people cross over modal boundaries and the recurrent common themes in the mental images corresponding to

different colors. The high number of associations made with emotions and objects, which are multimodal/ amodal (objects have more than one sense that defines them, emotions are not experienced via the senses) is proof of the close link between the sensory and the cognitive, and the ongoing dialogue between how we “sense” the world, and how we make sense of it.

6.3. *Senshetics: A Theoretical Model for Addressing Cross-modal Concerns in Design and Education*

Based on the background information on crossmodal and multimodal processes in the literature we can argue that the simplicity of living in a world that seems continuous and seamless comes from a fluid interaction between different plastic modalities, filtered through different intentions. In our day-to-day lives, a certain organization of attention occurs across the different modalities, an organization that is dynamic and constantly modified by the task at hand and the position of the body in space, in addition to the sensory stimuli. Within this context Gibson’s theory (Gibson, 1966) of considering the senses as active sensation seeking mechanisms is an ‘approach’ that becomes even more significant to place-design. However, the complexity of the perceptual process is such that not all interdependent factors can be studied simultaneously within the environmental context which is also ever-changing. Thus, it becomes important to address specific aspects of the connections between modalities.

The findings from the three studies bring to light different aspects of our multi-sensory interaction with the world. They show that we cross over sensory modalities every day in the way we perceive our environment. The literature survey and the

mappings study illustrate how perception often results in the creation of our own subjective worlds based on our perceptual choices. Certain hierarchical and lateral relationships between the different modalities are emergent from the data, but difficult to isolate within the real-life complex environment. The studies with architecture students show that hierarchical and lateral connections between sense-modalities are perceived by architecture students at an abstract level. While vision remains one of the most important senses when we think of our environments, this is not the case for all types of environments. In addition, visual perception is affected in both subtle and not so subtle ways, by the stimuli to the other senses. The literature shows that such crossmodal affects are true of the other senses as well. The most significant finding from all the studies is that our senses cannot be considered independent from each other, especially in the context of our interaction with our environments.

6.3.1. The Sensthetic Model

A theoretical framework was developed in Section 3 based on the findings from the literature and the case study on what users pay attention to in an environment. This framework was condensed into a 'Sensthetic Model' for sensory and kinesthetic interaction for what people attend to in their environments (Figure 6-2) in terms of a dynamic and constantly re-forming pie-chart of senses. The underlying assumption was that the senses are plastic modalities that are fused together, with links between the different modalities. Based upon the changes in the external and internal environment there is an organization of attention across modalities, which is a dynamic function of the intention (sum total of cognitive factors such as function, emotion, intent, and

memory), motion and position (kinesthetic factors coupled to the changes in sensory modalities), and action (consequence of perception, and responsible for subsequent changes in the environment).

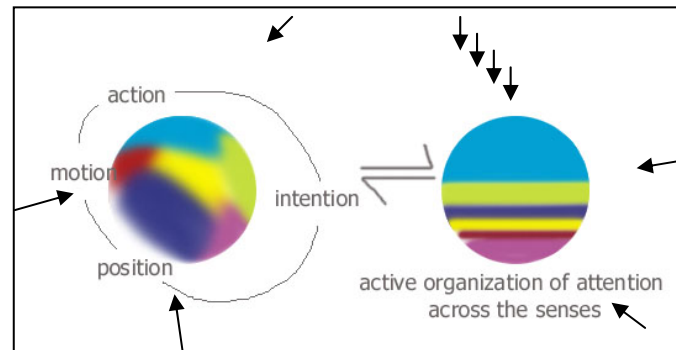


Figure 6-2. Sensthetic model of sensory and kinesthetic interaction. Colors represent the different sense-modalities and arrows indicate the changes which could be in the physical or cognitive environments

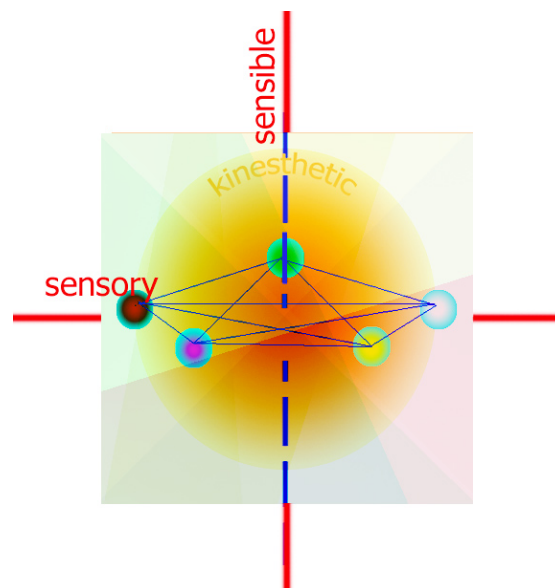


Figure 6-3. Sensory vs. sensible axis

represented conceptually in Figure 6-3. Our sense-modalities (represented as the 5 nodes) are not only connected to each other, but also they are connected to kinesthetic factors, represented by the spherical membrane that touches all the modalities.

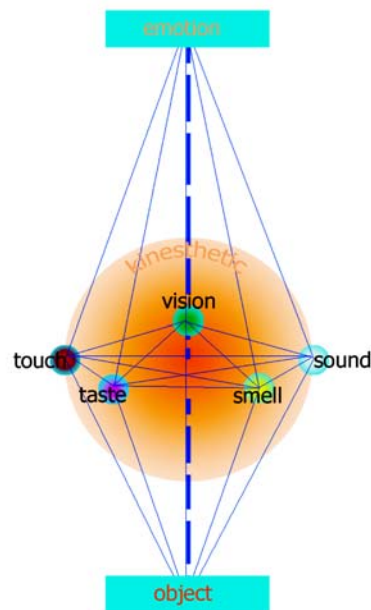


Figure 6-4. Modal interconnections with the external and internal plane

The sensibility axis is, in turn, defined by taking the purely internal, (or emotional plane) on one end, and the external, (relationship between objects) in external space at the other end (Figure 6-4). Each one of the modalities is a node connected to this axis, to other sense-modalities, and finally to the kinesthetics of the body.

6.3.2. Node-Connection Model for Sensory Connections

The Sensthetic model is a theoretical framework in place that addresses the interaction between sensory modalities within an assumption of interdependency. In

order to do so the hierarchical relationships among modalities, or the sensory orders prevalent in different environments, must be identified. At the same time, there must be an emphasis on the connections, or correspondences, between the different modalities, which can tell us about the sensory quality of the environment. By focusing on the sensory modalities (nodes) and the connections between them we can distill some of the complexity of the sensory processes, in order to make it usable for professionals involved in the creation of sensory environments.

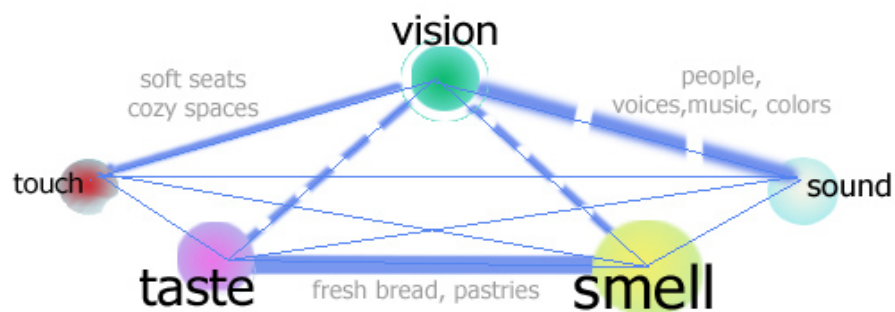


Figure 6-5. Sensory connection model for a bakery

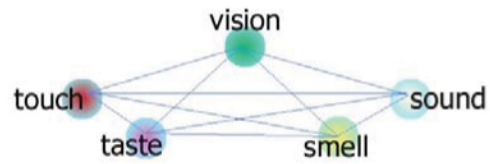
For example, the node-connection model for a bakery, based on the data from the rankings study, will result in a model in which the olfactory node is more pronounced than the others (Figure 6-5). When we focus on the correspondences between the modalities, we will realize that there is a correlation between smell and taste (flavor requires both smell and taste), vision and touch (a cozy space must be such that volume, color and texture correspond), sound and vision (volume and acoustics are linked).

Although these correlations may vary in degree of strength (smell-taste may not be as strong as audio-visual), nevertheless the complementary nature of stimuli define the experience of an environment. A model of sensory connections can be used to explore this purpose; to focus on the sensory nuances of an environment, and to address it in a more simple and communicable manner.

In designing the sensory environment for any space the Senshetic Framework is based on the following:

1. *Concurrence*: Simultaneous/ sequential occurrence of the sensory stimuli (lighting, acoustics, temperature, texture, smells associated with the physical fabric, and sensory stimuli from the inhabitants of that fabric),
2. *Correspondence*: How these different stimuli co-relate and correspond to each other, and ;
3. *Coherence*: Whether this correspondence is meaningful and contributes to the intended experience of the place.

It is possible that the design intent is not always to create an environment coherent to the point of simplicity. We can investigate the changing nature of these connections in different environments, conceptually, as illustrated in Figure 6-6.



Node-Connection Model

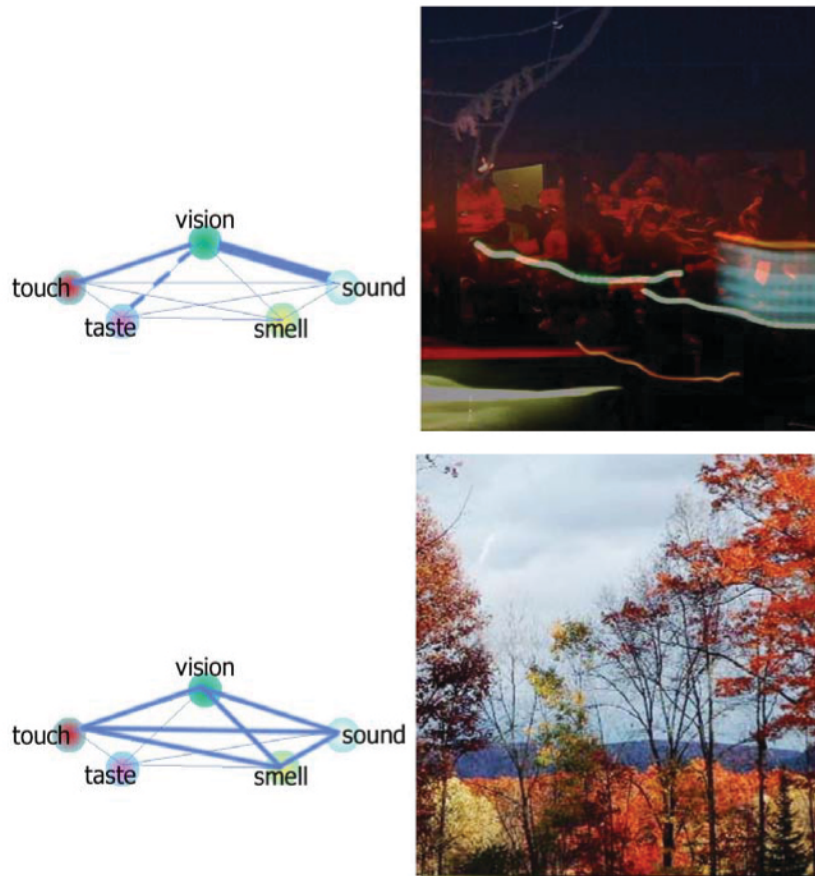


Figure 6-6. Sensory Connections. Conceptualized in a Bar-setting (above) vs. a Nature setting (below). Density of the lines denotes the intensity of the connection. Dotted lines denote missing connections.

6.3.3. *Design and Education Implications of the Theoretical Framework*

An environment in which the sensory-connections are too intense and constantly changing could result in sensory-overload, but if they are extremely muted, or if some connections are absent, it could result in sensory-deprivation. Similarly, in an environment where the connections are absent, even while each of the nodes are strong, or where more than one of these “node-connection” models seems present, with a sense-modality in one model connected to a sense-modality in a different model, this could result in a sensory-fragmented/ disconnected environment. The themed casinos in Las Vegas are a typical example of when more than one model is in play. With our bodies firmly in Las Vegas, Nevada, it is possible to experience the sensory qualities of Rome or Paris (Figure 6-7).

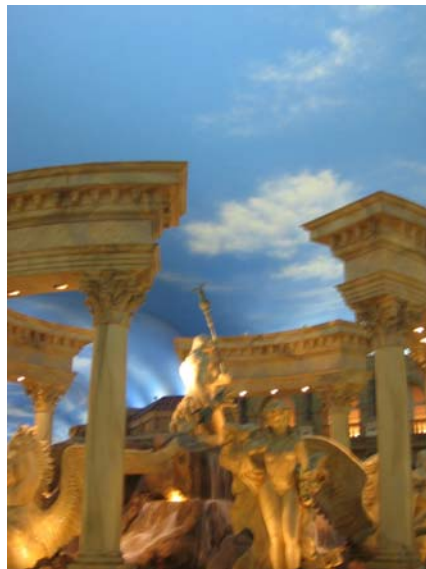


Figure 6-7. Rome in Las Vegas. Caesar's Palace, Las Vegas

Successful illusions balance the correspondences between the senses, allowing only the optimum time of exposure until the brain catches up to the situation at hand. The dynamic balance between the modalities, by carefully choreographing the intensity of the connections (as determined by design intention), might be a key to a successful sensory environment. It can allow us to optimally design environments according to the design intent, be it for healing/relaxation, engagement/excitement, or simply non-intrusive functioning of daily life. Nuanced understanding of modal interactions, more broadly defined within the crossmodal paradigm, can be particularly useful in designing environments for special populations, impaired in one or more modality.

For example, many visually impaired children have partial vision; they can see bright colors but they cannot discern the details of the form. Therefore, contrary to popular belief, color is something that remains important. Texture can be used at the scale of providing way-finding elements within the building that children can explore with their hands; change in the textures on the floor and wall can help to identify spaces. Light is pertinent to the partially sighted, but its warmth can be felt by the completely blind as well, thus play with the quality of light and temperature is also a possibility. Change in air quality, acoustics and smell can be intentionally used to identify sensory zones which are not demarcated by physical barriers. The congruence of these sensory zones is critical, for example, textures explored with the hand, or felt under the foot, must be consistent with the sounds generated. It is possible that the touch-sound correspondence may be as important to the visually impaired as the audio-visual

correspondence is for the normal person. Exploring these correspondences can provide new design opportunities.

Furthermore, while designing, the sensory qualities of the environment must be considered in conjunction with the movement through that environment, and our subtle actions in it. For example feeling the temperature of the room (imposed stimulation) is different from actively touching a doorknob and feeling the texture (obtained stimulation). The act of touching is proprioceptive and effects our perception. In fact studies prove that while we can identify a shape of an object when we actively explore it with our fingers, the same object if placed on our fingers directly is often unidentifiable. Thus environmental stimuli must be considered not only in relation to each other, but also in conjunction with the body movement and orientation. The simplicity of any scheme must be layered with coherence of the sensory environment, and our experience within it.

Education in the field of environment-design, architecture and interiors, has difficulty in communicating sensory priorities and qualities, not only because of the visual bias, but also because the ephemeral nature of the senses is such that it cannot be communicated effectively. Using the Sensthetic model for education can allow students to look at specific nuances of how the different senses come together in the design of an experiential environment.

6.3.4. The Crossmodal Paradigm and Sensthetic Thought

The crossmodal paradigm is a dynamic appreciation of a fluid experiential world that occurs across sensory modalities, rather than in discrete pockets of sensory

perception. Because our worlds are shaped by our individual interactions with what we perceive, and what we ‘choose’ to perceive, or attend to, there is no homogeneous experience across human beings that can be captured and frozen in time. But in the usage of the term “frozen time” we can appreciate that our senses are fused together and are never completely separable. At the same time, only a look at their separate, but relational, identities can help us to create a dynamic whole.

At every point of using the *framework for sensory connections* it is important to realize that it is nested within the *sensthetic model*, and is highly dynamic. Furthermore it is important to realize that there is no simplistic linearity or cause-effect hierarchy to these connections. Any hierarchy that we see, or we conceive, is dynamic, and constantly emerging and changing based on changes in our internal and external environment. At the same time, the abstract exercise of seeing the connections among the modalities is crucial. Such a model is only a moment, a particular statement, in an ongoing conversation or dialogue. Our modalities are negotiating with each other in order to provide us with a stable, desirable, perception of our environment.

6.4. *Future Directions of Work*

Although it is not possible to have the accuracy with which cognitive neuroscience studies can show the impact on our perceptual systems in a complex real-life environment with constantly changing variables, information from controlled lab-studies can help us to understand better the inter-relationship between senses better, and exploit these interactions in order to design more sensitive and sensory environments. Conversely, it is possible to develop sensory environments with a measured interplay of

the senses, and to test its effect in terms of brain-behavior (cognitive neuroscience), or behavior (psychology/ sociology). Such studies can be placed between the cognitive and environmental disciplines, and spearhead yet another cross-disciplinary initiative. A nuanced investigation into human-environment interaction is now possible and can finally allow us to exploit the non-visual, but experientially powerful senses.

In mainstream architectural thought the overly simplistic approach to the senses, when they are acknowledged, must be challenged. For example, good acoustics are a function of volume and material. There is a visual and tactile manifest to the audio interventions. Furthermore, even with the greatest acoustics in the world, a play in which the viewers cannot see the lip movement of the artist could be disconcerting, because of the perceptual need to ‘match’ the input from different sense-modalities. We may choose to close our eyes, and change the hierarchy of senses as we appreciate music, but when we open our eyes, we want to believe that what we see, and what we hear, co-relate. When this correlation is absent, and a coherent explanation unforthcoming, then the mind struggles with the effort. As a result the mind often creates its own reality, and its own credible explanation.

In successful theme parks that rely on the suspension of disbelief, maximum correlation between what we see, hear, touch, and smell is attempted, to make fantasy come to life and become memorable. On the other hand, in bars and night-clubs minimum correlation between what we see, hear, and touch ensures that our memories of what was on TV, or the music that was playing, is feeble, and the experience is almost like being in a repetitive loop. Investigation of the cognitive effects of sensory correspondences is

another direction that could branch from this study. In fact, an investigation of appropriate sensory correspondences for different place-types could result in a *synesthetic palette of complementary sensations* for designers to draw from.

As designers we rarely create environments that substantially alter the neurological structure of the brains of our users. However, environments do dictate, to a large extent, what users pay attention to, which is, in turn, responsible for the perceptual choices we make in our interaction with our environment. Technology allows us great opportunity in creating experiential environments, but only an insight into the human body and mind can guide us on how to use this technology optimally and experientially, rather than just extensively. A good sensory environment is not one that assaults all the senses, but one that creates an engaging conversation within them. This dissertation is an initial step beyond the aesthetics of appearance, towards the *Sensthetics* of experience.

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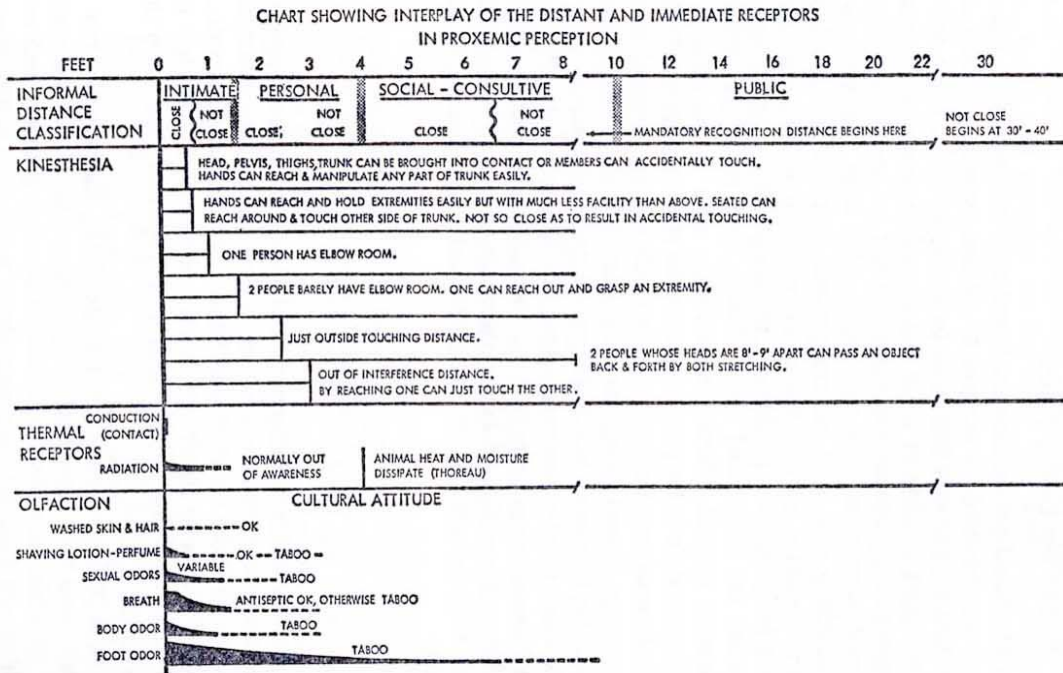
APPENDIX A

The perceptual systems, adapted from Gibson (1966)

<i>Name</i>	<i>Mode of Attention</i>	<i>Receptive Units</i>	<i>Anatomy of the Organ</i>	<i>Activity of the Organ</i>	<i>Stimuli Available</i>
The basic orienting system	General Information	Mechano-receptors	Vestibular organs	Body equilibrium	Forces of gravity and acceleration
The auditory system	Listening	Mechano-receptors	Cochlear organs with middle ear and auricle	Orienting to sounds	Vibration in the air
The haptic system	Touching	Mechano-receptors and possibly thermo-receptors	Skin, joints and muscles	Exploration of many kinds	Deformation of tissues, configuration of joints, stretching of muscle fibers
The taste-smell system	Smelling	Chemo-receptors	Nasal Cavity	Sniffing	Composition of the medium
	Tasting	Chemo- and mechano-receptors	Oral Cavity	Savoring	Composition of ingested objects
The visual system	Looking	Photo-receptors	Ocular mechanism	Accomodation, papillary adjustment, fixation, convergence exploration	The variables of structures in ambient light

APPENDIX B

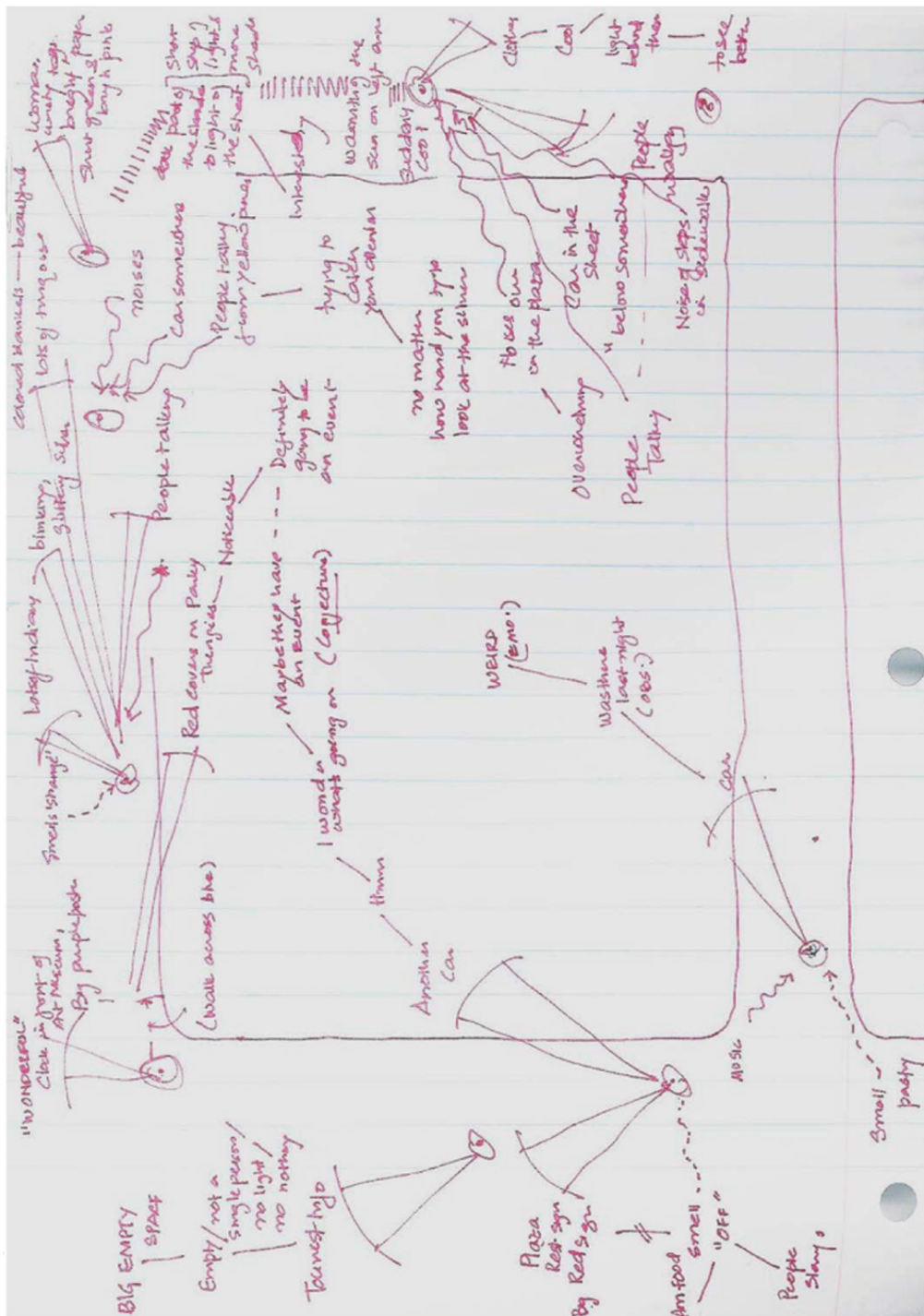
Interplay of distant and immediate receptors in proxemic perception (Hall, 1969, p.126)



FEET	0	1	2	3	4	5	6	7	8	10	12	14	16	18	20	22	30	
VISION	VISION BLURRED / DISTORTED																	
DETAIL VISION (VIS < OF FOVEA 1°)	ENLARGED DETAILS OF IRIS, EYEBALL, PORES OF FACE, FINEST HAIRS		DETAIL OF FACE SEEN AT NORMAL SIZE; NOSE, SKIN, TEETH, CONTOUR, HAIR, EYELASHES, HAIR ON BACK OF NECK		SMALLEST BLOOD VESSELS IN EYE LOST. SEE WEAR ON CLOTHING HEAD HAIR SEEN CLEARLY.		VESSELS IN EYE LOST. SEE WEAR ON CLOTHING HEAD HAIR SEEN CLEARLY.		FINE LINES OF FACE FADE DEEP LINES STAND OUT SLIGHT EYE WINK LIP MOVEMENT SEEN CLEARLY		ENTIRE CENTRAL FACE INCLUDED		SHARP FEATURES DISAPPEAR, EYE COLOR NOT EXCESSIVE, SMALL-SCALE VIBRATIONS MORE PRONOUNCED		SHILLEN'S STANDARD FOR DISTANT VISION - EMPLOYING ANGLE OF 1 MIN. GOLD OPTICONS OF AMERICA EYE CHART A PERSON WITH 20-40 VISION HAS TROUBLE SEEING EYES & DISPRESSION AROUND EYES THROUGH EYE BLINK IS VISIBLE.			
CLEAR VISION (VIS < AT MACULA 12° HOR, 3° VERT)	29" x 3" ON EYE, 12" OR LOWER FACE		3.75" x .74" UPPER OR LOWER FACE		6.25" x 1.60" UPPER OR LOWER FACE		10" x 2.5" UPPER OR LOWER FACE OR SHOULDERS		20" x 5" 1 OR 2 FACES		31" x 7.5" FACES OF TWO PEOPLE		42" x 11.6" TORSOS OF TWO PEOPLE		6' 3" x 1' 7" TORSOS OF 4 OR 5 PEOPLE			
60° SCANNING	1/3 OF FACE (EYE OR MOUTH AREA) DISTORTED		NOSE PROJECTS WHOLE FACE SEEN UNDER-TORTED		UPPER BODY CAN'T COUNT FINGERS		UPPER BODY & GESTURES		WHOLE SEATED BODY VISIBLE PEOPLE OFTEN KEEP FEET WITHIN OTHER PERSON'S 60° ANGLE OF VIEW		WHOLE BODY HAS SPACE AROUND IT, POSTURAL COMMUNICATION BEGINS TO ASSUME IMPORTANCE							
PERIPHERAL VISION	HEAD AGAINST BACK - GROUND		HEAD & SHOULDERS		WHOLE BODY MOVEMENT IN HANDS - FINGERS VISIBLE		WHOLE BODY		OTHER PEOPLE SEEN IF PRESENT		OTHER PEOPLE BECOME IMPORTANT IN PERIPHERAL VISION							
HEAD SIZE	FILLS VISUAL FIELD OVER LIFE SIZE		OVER NORMAL		NORMAL SIZE		NOTE: PERCEIVED HEAD SIZE VARIES EVEN WITH SAME SUBJECTS AND DISTANCE		NORMAL TO BEGINNING TO SHRINK.		VERY SMALL							
ADDITIONAL NOTES	SENSATION OF BEING CROSS-EYES		PEOPLE & OBJECTS SEEN AS ROUND UP TO 12' - 15'										ACCOMMODATIVE CONVERGENCE ENDS AFTER 15' PEOPLE & OBJECTS BEGIN TO FLATTEN OUT					
TASKS IN SUBMARINES	67% OF TASKS IN THIS RANGE		23% FALL IN THIS RANGE		DIMMICH, F.L. & FARNSWORTH, D. VISUAL ACUITY TASKS IN A SUBMARINE, NEW LONDON, 1951													
ARTISTS' OBSERVATIONS OF GROSSER	VERY PERSONAL DISTANCE		ARTIST OR MODEL HAS TO DOMINATE		A PORTRAIT, A PICTURE PAINTED AT 4 - 8' OF A PERSON WHO IS NOT PAID TO "SIT"		TOO FAR FOR A CONVERSATION		BODY IS 1/3 SIZE		FULL LENGTH STATE PORTRAITS HUMAN BODY SEEN AS A WHOLE, COMPREHENDED AT A GLANCE, WARMTH AND IDENTIFICATION CEASE							
ORAL AURAL	GRUNTS GROANS		SOFT VOICE WHISPER INTIMATE STYLE		CONVENTIONAL MODIFIED VOICE CASUAL OR CONSULTIVE STYLE				LOUD VOICE WHEN TALKING TO A GROUP, MUST RAISE VOICE TO GET ATTENTION FORMAL STYLE		FULL PUBLIC SPEAKING VOICE FROZEN STYLE							

NOTE: THE BOUNDARIES ASSOCIATED WITH THE TRANSITION FROM ONE VOICE LEVEL TO THE NEXT HAVE NOT BEEN PRECISELY DETERMINED

APPENDIX C
Field notes mapping the network of associations during self-reports

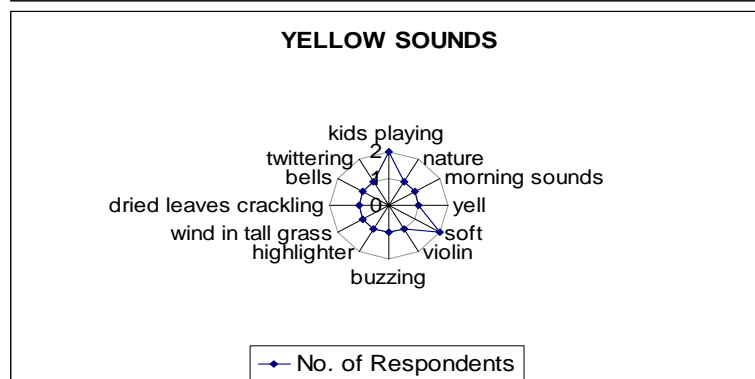
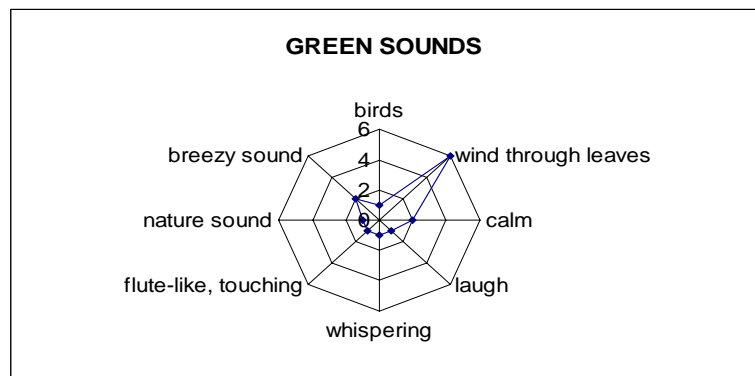
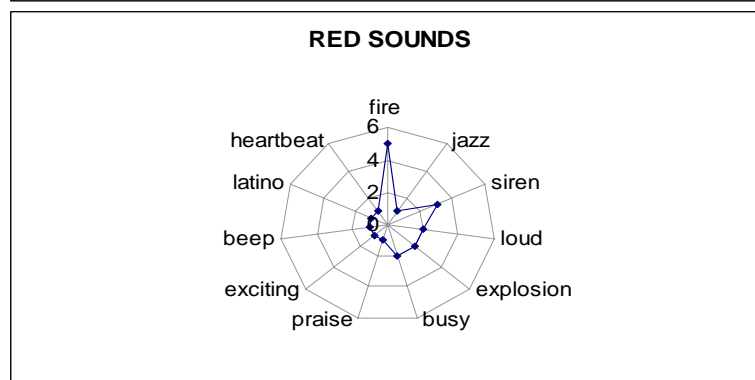
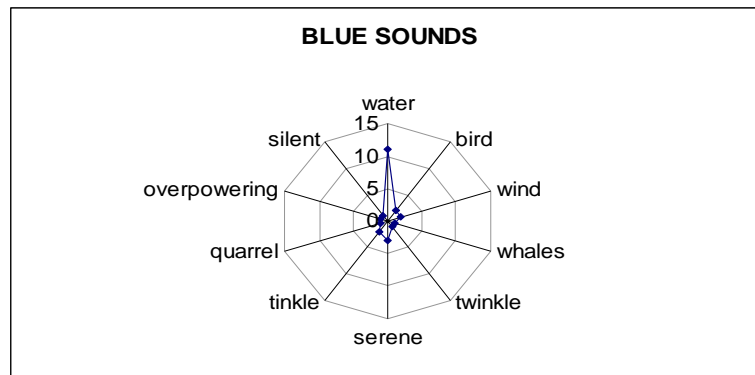


APPENDIX D

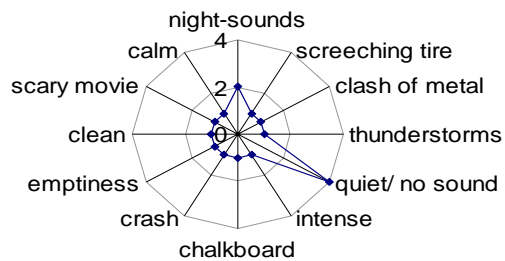
Sample of survey results for crossmodal associations

<i>Colors</i>	<i>Sounds</i>	<i>Smells</i>	<i>Textures/temperatures</i>	<i>Emotions/objects</i>
BLUE				
	Serene	Clean and spring	Smooth	Calm
RED				
	Explosion	Fresh	Hot	Excited
GREEN				
	Serene	Fresh	Smooth	Tranquil
YELLOW				
	Quiet	Fresh	Excited	Bright
BLACK				
	Intense	Intense	Strong	Sexy
VIOLET				
	Quiet	Sad	Curved	Sad
ORANGE				
	Fun	Fresh	Fun	Encouraging
WHITE				
	Quiet	Clean	Plain	Clean and sexy

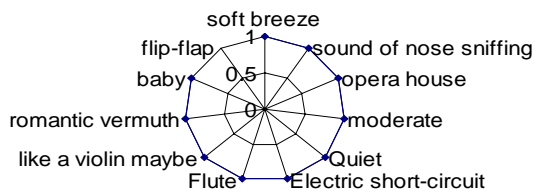
APPENDIX E



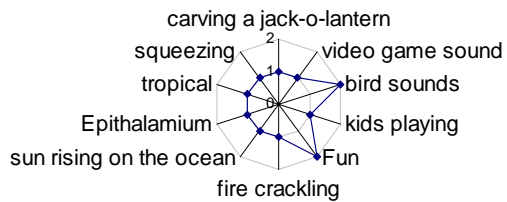
BLACK SOUNDS



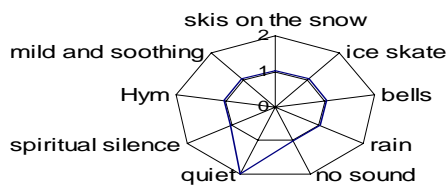
VIOLET SOUNDS



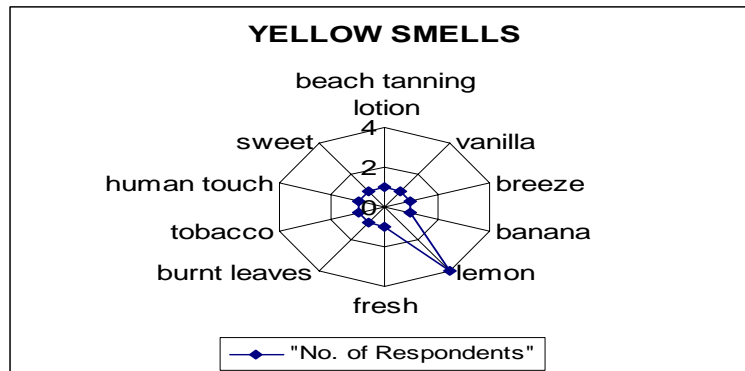
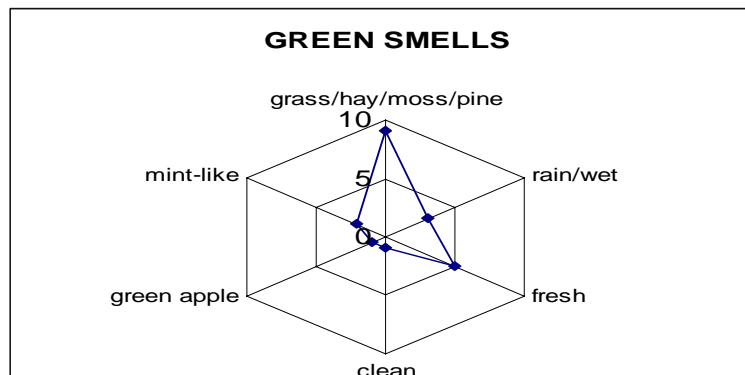
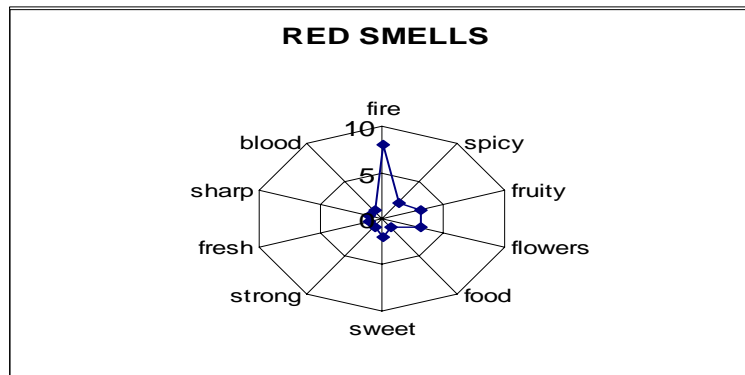
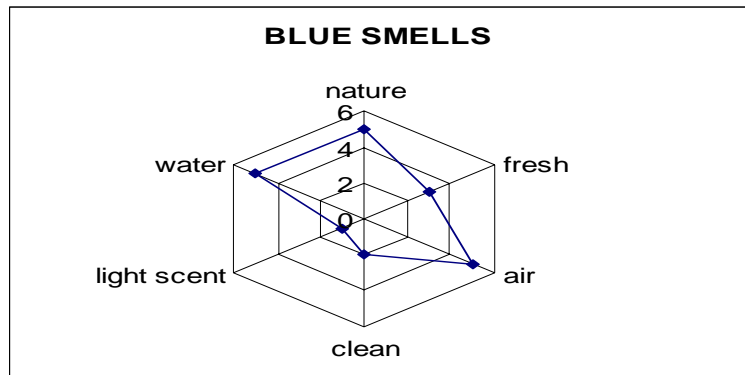
ORANGE SOUNDS

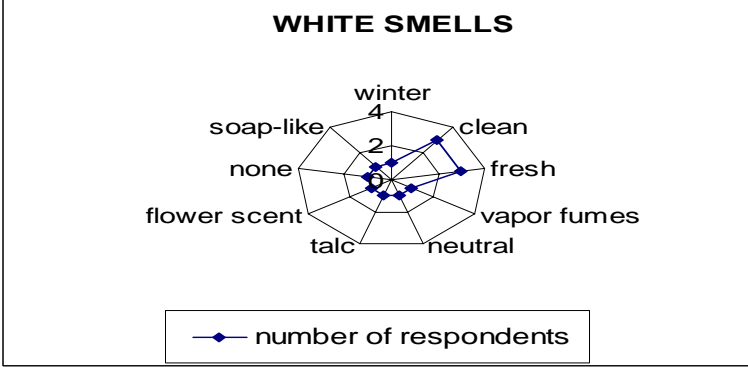
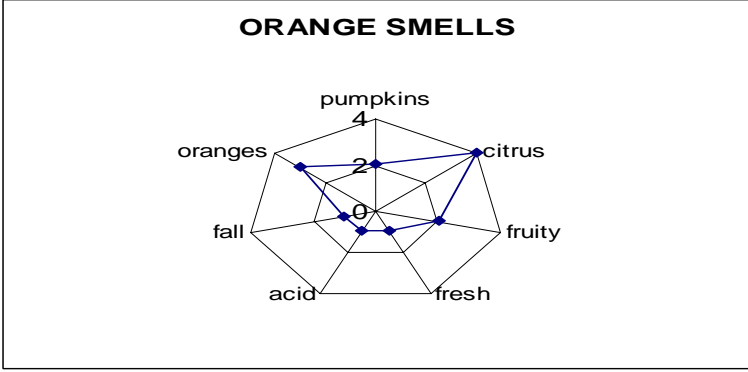
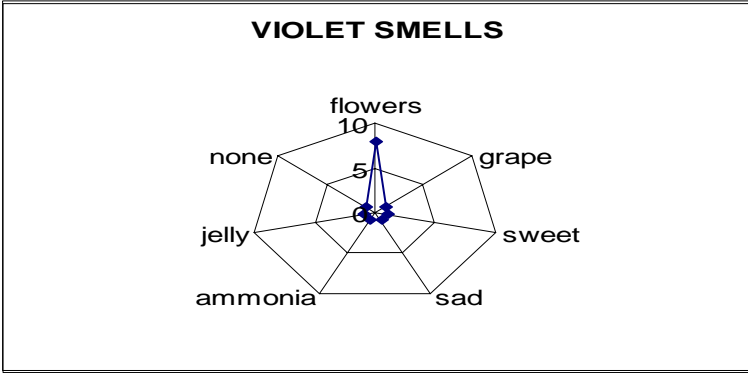
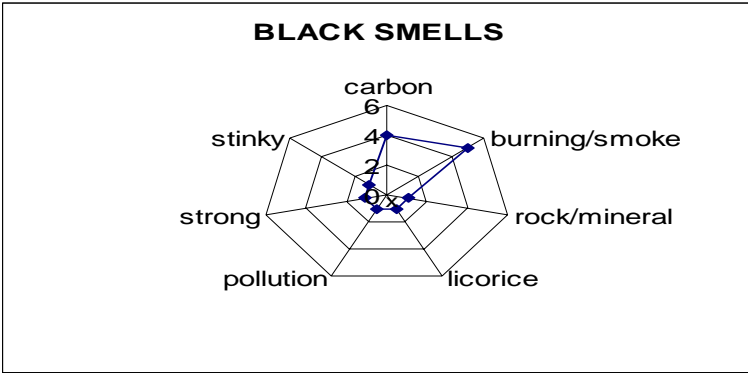


WHITE SOUNDS



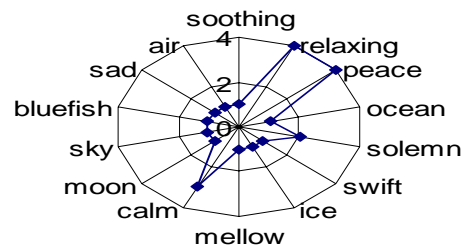
— No. of Respondents



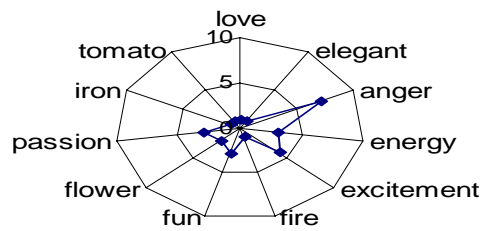


◆ number of respondents

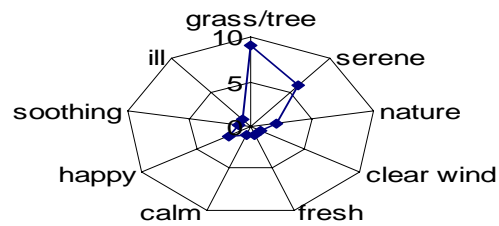
BLUE EMOTIONS/OBJECTS



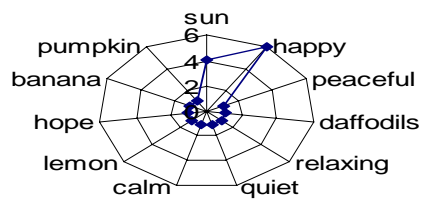
RED EMOTIONS/OBJECTS



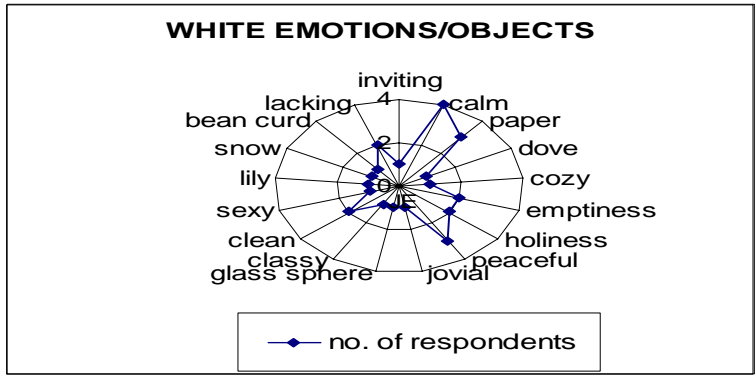
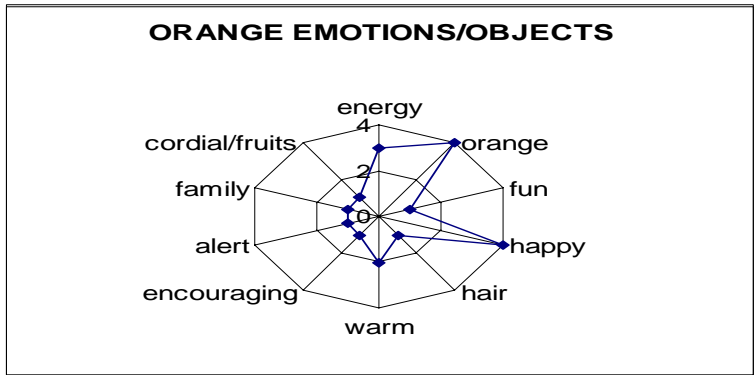
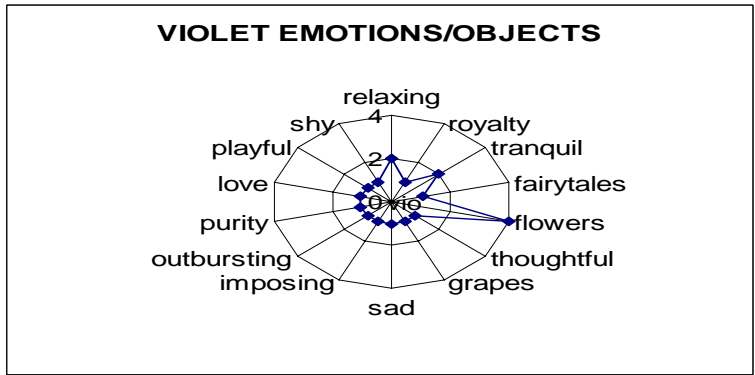
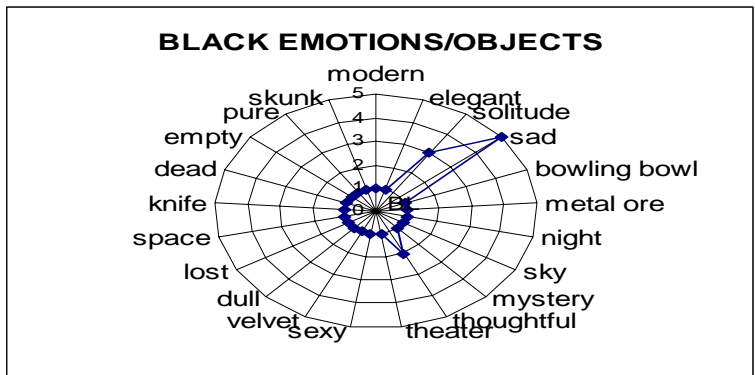
GREEN EMOTIONS/OBJECTS



YELLOW EMOTIONS/OBJECTS

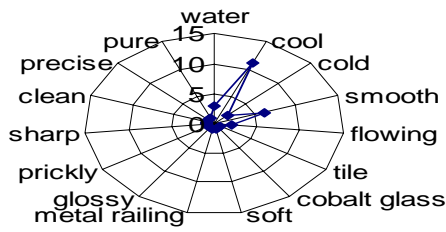


◆ no. of respondents

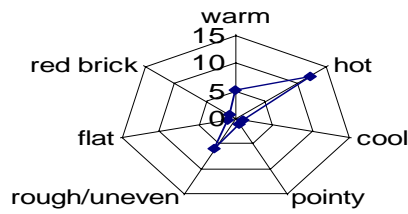


—●— no. of respondents

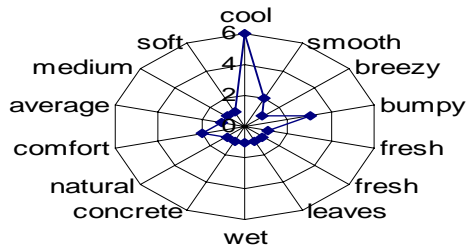
BLUE TEXTURES/TEMPERATURES



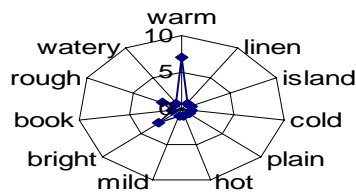
RED TEXTURES/TEMPERATURES



GREEN TEXTURES/TEMPERATURES

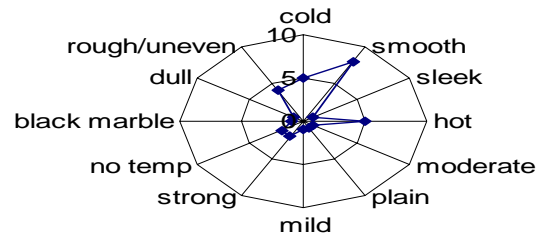


YELLOW TEXTURES/TEMPERATURES

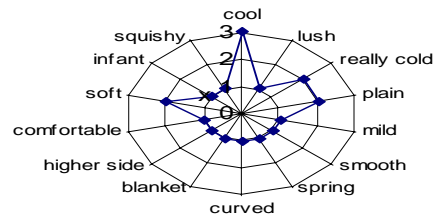


—●— No. of respondents

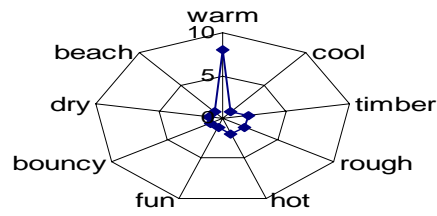
BLACK TEXTURES/TEMPERATURES



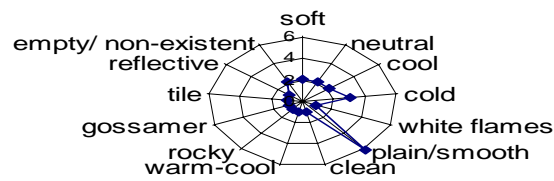
VIOLET TEXTURES/TEMPERATURES



ORANGE TEXTURES/TEMPERATURES



WHITE TEXTURES/TEMPERATURES



—●— No. of respondents

VITA

Upali Nanda, daughter of Alka Nanda and Prof. Janardan Nanda, was born in New Delhi, India on June 25th 1976. She received her high school education from Delhi Public School, New Delhi, her Bachelor of Architecture from the School of Planning and Architecture, New Delhi, India and her Masters degree from National University of Singapore in 2001. She continued her studies in Architecture at Texas A&M University under the direction of Professor Frances E. Downing and received her Doctor of Philosophy in December 2005.

She currently lives in Houston with her husband, Veerabhadran, and her permanent address is,

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