Thermal counterpoint in the phenomenology of architecture – A Phsychophysiological explanation of Heschong's 'Thermal Delight'

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ABSTRACT

Typically about half of a commercial building's energy input is allocated to the pursuit of thermally neutral indoor environments. In developed countries we find ourselves spending more than 90% of our daily lives inside built environments, most of which are now sealed off from the outside world and fully air-conditioned such that their indoor climate typically hovers within a single degree some theoretical optimum - circa 22°C. Yet despite the prodigious energy costs of thermally neutralising buildings, large thermal comfort field-studies consistently report overall levels of occupant thermal satisfaction rarely getting above 80%.

In this paper I'll take another look at Heschong's (1979) eloquent diatribe against thermal neutrality. Using a phenomenological rather than scientific analysis, Heschong's 'Thermal Delight in Architecture' succinctly put the case that architecture was profoundly impoverished when it outsourced to engineers responsibility for the thermal realm of buildings. Heschong contends that, under certain combinations and sequences, the elements of indoor climate can infuse our total sensory experience of space with layers of affect, emotion, even delight, in ways that other dimension of the built environment can't. But these opportunities are squandered when thermal design falls into the hands of those whose stated mission is to neutralise buildings.

Although she didn't know it at the time of writing her book, the phenomenon Heschong describes as thermal delight has a name in contemporary physiology – alliesthesia. It refers to situations in which a given thermal stimulus can be subjectively experienced as either pleasant or unpleasant, depending on whether it is likely to restore or perturb the milieu interior's target set-points. The hallmark of positive alliesthesia is pleasure, which is made available across all our senses through contrast, transience, non-steady-state, light and shadow. So in the thermal context of buildings, the HVAC engineer's design objective of eliminating all thermal sensation from the occupant's experience of the space efficiently precludes thermal delight. When we engineer spatial and temporal thermal uniformity into a space the building ceases to have any physiological significance or meaning for its occupants – thermal affect and hedonics are extinguished when a building is neutralised.

The paper will conclude by illustrating the phenomenon of alliesthesia with Gujarat's architectural treasures. The Adalaj Stepwell is a magnificent water cistern close to Ahmedabad in the Indian state of Gujarat. Since the structure is five storeys deep, people wishing to draw water from the well experience a pronounced thermocline upon descending from the heat of the sub-continental climate at ground level, down to the luxurious subterranean coolth at water-level. The thermal textures and counterpoint along this trajectory beautifully exemplifies the psychophysiological principle of alliesthesia, reinforcing and amplifying the visual delight of the step-well's carved sandstone with another exquisite delight of the thermal variety, engendering a deeply poetic sense of place.

KEYWORDS:

Thermal comfort, isothermal, transient, thermoreceptor, alliesthesia, topophilia, step-well.

THERMAL HOMOGENEITY INSIDE BUILDINGS

The twenty first century lifestyle is now almost completely air conditioned. The air-conditioning industry's "target temperature" for comfort typically comes from an engineering model of comfort called PMV that posits the subjective thermal state of "neutral" for building occupants as the ultimate objective for installed HVAC systems. Thermal neutrality is now permanent and all pervasive in the developed world – the thermal realm has become all but imperceptible for most of our day-to-day lives, all based on the HVAC industry's unquestioned assumption that this is what building occupants actually want.

Pervasive, persistent and precise thermal homogeneity is fundamentally unnatural. It requires a great deal of sophisticated engineering, including "intelligent" building management systems, proportional/integral/differential control logic, and delicately balanced heating/cooling loads countered by conditioned air volumes delivered and mixed into the space gently, uniformly and as unobtrusively as modern diffusers permit, to be imperceptible to the occupants. Table 1 lists the ISO-7730 comfort standard's building classification scheme based on whole-body (PMV/PPD) and local thermal comfort control criteria. The local discomforts include perceptible air movement (draught), vertical temperature gradient (stratification), cold/warm floor, and radiant asymmetry.

Despite the prodigious energy costs of persistent, pervasive and precise thermal neutrality, the large databases of thermal comfort field-surveys of actual occupants of buildings around the world (Arens et al., 2010) consistently indicate levels of thermal satisfaction rarely gets above 80% of occupants at any one time. Table 2 shows some actual data on this point. The four Australian field surveys reported here were part of an ASHRAE funded research program aiming to field-validate the recommendations contained in the global comfort standard of ASHRAE-55 and ISO-7730. Laboratory-grade instruments were used to classify office environments into the ISO-7730's three-tier nomenclature described in Table 1 – Classes C, B or A – depending on their compliance with increasingly stringent or tight whole-body (PMV) and local discomfort control limits.

Table 1. ISO Comfort Standard 7730 thermal homogeneity performance criteria. Grades C, B and A are based on increasingly more stringent control criteria for combined whole-body (PMV) and local discomforts (draft, radiant asymmetry, stratification) (Source: ISO, 2005)

Building Class	Whole Body Comfort		Local Discomforts			
	PMV range	PPD (%)	Draft Risk (%)	Vertical Temp. Gradient (K)	Cool or Warm Floor (K)	Radiant Asymmetry (K)
A	-0.2<PMV< +0.2	<6	<10	<3	<10	<5
B	-0.5 <PMV<+0.5	<10	<20	<5	<10	<5
C	-0.7<PMV<+0.7	<15	<30	<10	<15	<10

The first generalisation to emerge from Table 2 is that overall levels of thermal acceptability rarely exceeded 80% saryBut more relevant to the theme of this paper is the observation that there is no appreciable pattern of diminishing thermal acceptability levels as we descend from ISO Class A to Class B, or even Class C in Table 1. In short, there seems to be no discernible enhancement of thermal acceptability with increasingly tight spatio-temporal temperature and air movement control inside buildings.

The clear implication of these observations is that evidence justifying the substantial HVAC engineering costs, alarming operational costs of thermal neutralisation, not to mention the greenhouse gas emissions attributable to HVAC processes, is scant. Where that notion, that thermally imperceptible is best, actually came from is an interesting question in itself, but what is relevant to the current paper is that it's built on the assumption that actually experiencing the warmth or coolness of a building's internal microclimate indicates a need for physiological or behavioural thermoregulatory effort to restore thermal neutrality. This effort, ipso facto, represents a shortcoming of their building and/or its HVAC services. With the deeper penetration of HVAC into every aspect of our lives there has been a steady, one-way transfer in the locus of thermal control, away from occupant and towards the building services. Although it's rarely discussed, somehow we've accepted uncritically that thermally neutralised buildings are superior to those that activate our thermal sensory system and its associated physiological temperature regulation apparatus. The purpose of this paper is to question this quest for neutrality and to re-evaluate what has actually been lost from architecture in our pursuit of it.

Table 2. : Observed levels of thermal acceptability in four Australian office building field studies, compared with the ISO Comfort Standard 7730 thermal homogeneity performance criteria outlined in Table 1. (Source: data from de Dear and Fountain, 1994; Cena and de Dear, 1999)

Office ISO-7730 Rating	Townsville Australia Hot/Humid Season	Townsville Australia Warm/Dry Season	Kalgoorlie Australia Hot/Dry Season	Kalgoorlie Australia Warm/Dry Season
Class A 2K deadband	81% acceptability (n = 62)	76% acceptability (n=99)	67 % acceptability (n=12)	86% acceptability (n=50)
Class B 4K deadband	79% acceptability (n=365)	80% acceptability (n=403)	87 % acceptability (n=203)	84% acceptability (n=327)
Class C 6K deadband	78% acceptability (n=467)	78% acceptability (n=515)	87 % acceptability (n=382)	84% acceptability (n=494)

THERMAL DELIGHT IN ARCHITECTURE

Lisa Heschong's 1979 diatribe against the heavily engineered, thermally neutralised indoor climates characteristic of modern life, seems more relevant now than ever before. The basic premise of *Thermal Delight in Architecture* (Heschong, 1979) is that it's perfectly fine, indeed desirable to engage with our thermal sense; it enriches our lives more than it detracts, and under the right circumstances, can actually be a source of sensory delight. Rather than eradicate all trace of thermal stimulation within buildings, Heschong urges architects to regard the thermal realm as another expressive element of design to work with, and to actively consider the subjective thermal experiences their work will engender in the occupants.

The American geographer Yi-Fu Twan uses the term "topophilia" to refer to the feelings that we associate with particular locations, and which collectively define a sense of place – our "emotional landscape." The loved place is a repository of meanings that arise from the accumulation of the more profound emotional experiences in that space. Much has been written about the architecture of topophilia. The phenomenological branch of architectural theory is replete with eloquent descriptions of how specific spaces prompt particular emotions in their occupants. For example, Gaston Bachelard's (1964) Poetics of Space. In his foreword to the 1994 English translation, John Stilgoe notes that the book "…resonates in an era suffused by television and video games, fluorescent lighting and plastic floors, airconditioning systems [author's emphasis] and too-small closets. It is a book that makes its readers dissatisfied with much contemporary structure and landscape, for it demonstrates to its readers that space can be poetry." Heschong's book continues the phenomenological tradition with specific focus on the poetics of indoor air as a setting for our lives, arguing that the thermal affect or delight engendered by a particular space, like hearth, melds with the visual, acoustic, olfactory and tactile sensory streams informing its occupants' total experience of place. Hearth crops up repeatedly in this discussion; an enclave of warmth juxtaposed against a colder climatic backdrop, the centre of family life in the European cultures of northern latitudes. But there are hearth-like counterparts in many disparate cultures and climate zones (Heschong, 1979). In northern China and the Korean peninsula the k'ang serves a similar social function. Typically constructed as a brick platform along the side or at one end of a room, and heated by fire underneath the k'ang provides a warm sleeping place, but also a focal point for family life in the depths of winter. Across the tropical Indian subcontinent the hearth's equivalent thermal place is traditionally the dignified old shade tree at the centre of the village. It provides a venue of thermal relief from the excessive daytime heat and simultaneously the epicentre of the village's social life. In Japan it's the traditional *kotatsu*, a low table covered with a quilt to contain the warmth of a pot of hot coals around the family's feet during winter.

Through colourful thermal anecdotes Heschong explores how our subjective experience of the thermal environment around us is overlain with emotion – "*When the sun is on my face and the breeze is cool, I know it is good to be alive*" (1979, p.18). Despite being a primordial sense, certainly more basic than vision, there is simple pleasure to be had from just exercising our thermal sense. Indeed, the intimate connection between our more primitive senses and our emotions has been noted by other writers on the phenomenology of architecture as well (Holl et al., 2007). Each sense brings us different information about the environment, and so the more senses engaged by a particular scenario, the richer the whole experience. "*If sight allows for a three-dimensional world, then each other sense contributes at least one, if not more, additional dimension. The most vivid, most powerful experiences are those involving all of the senses at once*" (Heschong, 1979, p.29).

And so reinstating the thermal sense to the Architect's palette enriches our total experience of built space, but only if light-and-shadow or thermal texture are embedded. By way of gastronomic analogy, a gourmet meal comprises a variety of tastes and textures, skilfully harmonised such that each primes the palate in preparation for the next. An example from the natural thermal environment; we experience a very particular joy when moving through a variegated thermal space such as dappled vernal sunlight under a majestic oak's spring canopy. Each glint of warmth on our face is exquisitely accentuated by an opposite brush-stroke of coolth, and the stochastic oscillation between warmth and coolth sustains the element of surprise, serving to further heighten our pleasure. No one can be impervious to the thermal delight in this scenario. It is irresistible and our total experience is more than the sum of the atomised thermal sensations. The delight resides in the complementarity of warmth and coolth, light and shadow. Holl et al. put it succinctly: "*Homogenization eliminates the experience of place*" (Holl et al., 2007).

Further out towards the extremities of the thermal counterpoint spectrum we can find a rich variety of "thermal recreation," in all cultures and all climatic contexts. For example, high metabolic effort elevates an alpine skier's core temperature that is contrasted by the crisp chill across their exposed face as they sashay down the piste. The Japanese are well known for their love of hot spring baths, *hon sen*, but the *hon sen* experience is most completely enjoyed when the excess heat storage in our body's tissue is purged by periodically dousing with cold showers or baths nearby. Similarly the Finn's love of *sauna* is almost written into their national identity, but the *sauna* experience would be incomplete without intermittent excursions out of the heat and into the snow, or even better, a nearby lake of frigid water. In all these scenarios the delight resides not so much in a single thermal stimulus, but rather the counterpoint of contrasting sensations. A more familiar example, closer to home for the Australian author, is the summertime beach experience. The swimmer lying prone on parched, golden sand, unprotected by clothes or shelter, maximally exposed to direct-beam, unfiltered Australian solar radiation, soon initiates thermoregulatory sweating and marginal heat stress. But this is instantly converted into exquisite thermal delight when the mild thermal stress is interspersed with bouts of high-energy immersions in 22°C Pacific Ocean. The underlying principle of thermal recreation resonates across all these examples; the thermal delight resides in the contrast and juxtaposition. Thermal textures, layered warmth and coolth, constitute a primal thermal aesthetic. People deliberately seek out these stimuli – pay good money for them in fact. The basic point is that thermal stimulation is not, in and of itself, undesirable. Quite the opposite, we relish thermal sensations. We certainly don't indulge in thermal recreations in the hope of experiencing "neutrality."

The idea of thermal contrast, or counterpoint, is eloquently described in Heschong's Thermal Delight in Architecture (1979, p.27).

"When we get cold, our muscles tense up, trying to generate more heat, and capillaries at the skin's surface constrict. These physiological responses leave us feeling tense and numb. Places that seem warm offer an antidote to the tension and numbness with things that are comforting and soothing: a soft, flowing light; the deep plush of a velvet chair; or the low, resonant notes of a blues song. They help to relax us in the same way that the warmth of a fire, or even a drink of liquor, penetrates through the body and relaxes the muscles. When we are overheated we often need the opposite antidote. The heat makes us lethargic and slow-witted. Any action requires too much effort. There is delight, then, to be had in things that provide a little liveliness for us, like the splashing of a fountain or the sparkle and flutter of Japanese street decorations. Their activity helps the mind feel a bit more quick-witted and lively in spite of the dullness of a hot, muggy day. A hot day, however, can also be stressful because it overstimulates. The sun can be too bright, glinting off of every surface, accompanied by an inescapable dry wind that exhausts the nerves. The antidote then is not something that moves and sparkles but a deep, quiet coolness, a place to retreat from the sun and rest in peace. Deeply shaded Islamic prayer halls, with their seemingly endless repetition of columns and arches, produce this calming effect. The classical Persian garden is intended to provide the antidote to both the lethargy and the exhaustion of the senses. There is the liveliness of the fountains and the overhanging vines with their fluttering leaves that create a dappled light. And there are also areas of still water and large stone pavilions that create a deep, quiet shade. One is free to move among these different elements and to choose the place where the balance of liveliness and quietude are just right. The Persian garden offers an amazing richness and variety of sensory experiences which all serve to reinforce the pervasive sense of coolness."

PHYSICS AND PHYSIOLOGY OF THERMAL COMFORT

Probably the most widely known and used model of thermal comfort is the PMV/PPD model of Fanger (1970), but because it's based on a stead-state heat-balance equation for the human body and its thermal environment, it's largely irrelevant to the dynamic or spatially heterogeneous thermal contexts of Heschong's Thermal Delight in Architecture. Too much of our day-to-day life is spent in thermally non-steady-state to ignore, so de Dear (2011) proposed the physiologists' concept of alliesthesia as a fundamentally different framework to understand the neurophysiological and perceptual processing in such situations.

Alliesthesia

In defining the physiological significance of pleasure to the human species, Cabanac (1971) coined the term "alliesthesia" to describe how the affective tone (pleasantness or unpleasantness) of an environmental stimulus is determined by the subject's internal state. In each of the body's homeostatic processes such as hunger, thirst or heat, the affective valence is determined for each stimulus by its utility for restoring the equilibrium of the system. The physiological role of pleasure is that it motivates behaviours that restore internal equilibrium. For example, a dehydrated person finds the taste of water especially pleasant, which in turn reinforces more fluid replenishing behaviour. But once the subject has been rehydrated, the desirability of water is extinguished and the associated behaviour is demotivated.

Alliesthesia integrates the behavioural dimensions of the body's homeostatic systems into negative feed-back or feed-forward loops. Another illustration, this time related to caloric intake and hunger; we appreciate how food tastes better on an empty stomach, but once sated, our desire to eat is extinguished and previously desirable food loses appeal, or even become unpleasant (negative alliesthesia). This simple concept can now be summarised; any external or environmental stimulus that has the prospect of restoring the controlled variable within the milieu interieur to its set-point will be perceived as pleasant (positive alliesthesia), while any environmental stimulus that will further displace the error between the controlled variable and its set-point will be perceived as distinctly unpleasant (negative alliesthesia).

Bringing a specifically thermal context to this discussion, Cabanac (1992) noted that an… "… hypothermic subject will report pleasure when stimulated with moderate heat, and displeasure with cold. The opposite takes place in a hyperthermic subject. Pleasure is … [most clearly] … observable in transient states, when the stimulus helps the subject to return to normothermia. As soon as the subject returns to normothermia, all stimuli lose their strong pleasure component and tend to become indifferent."

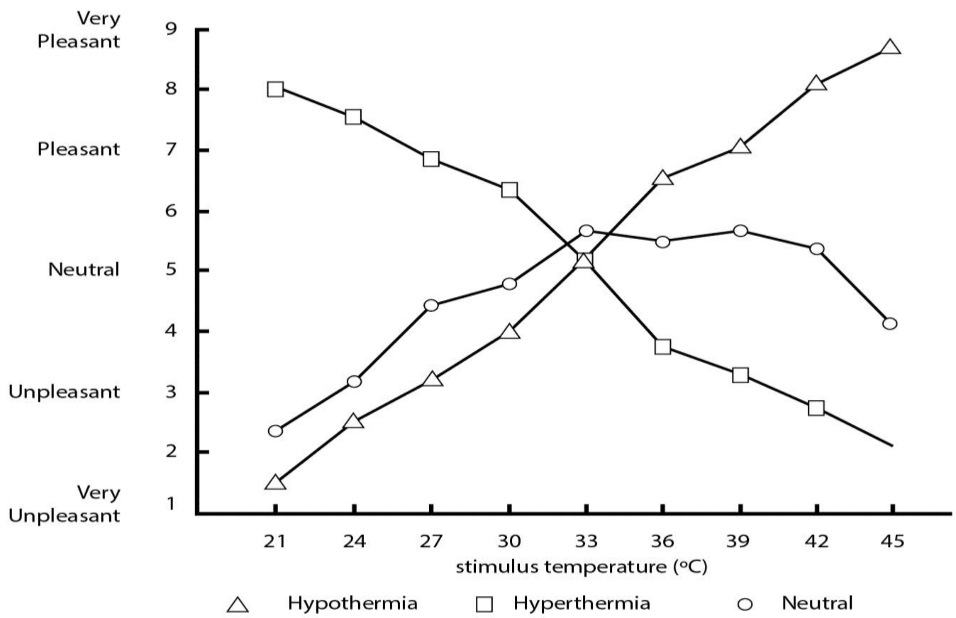

Figure 1: *The intensity of thermal pleasure of displeasure resulting from hand immersion in water of differing temperatures is dependent on the subject's overall thermal state - hypothermic, hyperthermic, or neutral. (Source: modified after Mower, 1976).*

Cabanac's generalisation is clearly evident in Mower et al.'s (1976) experimental data on subjective evaluation of hand immersion in water baths of differing temperature (see Figure 1). For the overheated, hyperthermic subjects, the cooler hand bath elicited pleasant (or very pleasant) subjective responses, but same temperature stimuli prompted unpleasant evaluations from the overcooled, hypothermic subjects, and vice versa for the warm temperature hand baths. In contrast, for those subjects whose general thermal state was neutral, neither warm nor cool, none of the temperature stimuli was able to achieve a subjective evaluation better than nondescript neutral;warm and cold stimuli were both equally unpleasant.

While a comprehensive, quantitative understanding of the neurophysiological workings of thermal alliesthesia is some way off, one thing seems generally agreed – that thermoreceptors in the skin are central in the process. Thermoreceptors are the temperature-sensitive endings of sensory neurons that transduce temperature data from the tissue surrounding them. Their general properties were summarised as follows by Hensel;

a) Cold and warm thermoreceptors are anatomically separate.

b) Cold cutaneous receptors are closer to skin surface than warm receptors.

c) They have a static discharge frequency at a constant surrounding tissue temperature T, peaking in warmer temperatures (41~47°C) for warm receptors, and cooler temperatures (17~36°C) for cold receptors.

d) They also have a dynamic impulse discharge in response to tissue temperature changes dT/dt, with negative temperature transients simultaneously exciting cold receptors and inhibiting warm receptors, while positive transients simultaneously excite the warm receptors and inhibit cold receptor outputs. Hensel (1981) estimated the dynamic coefficients to be about an order of magnitude larger than the corresponding static temperature coefficients.

Both static and dynamic firing characteristics of cutaneous thermoreceptors undergoing temperature up-steps and down-steps has been schematically represented in Figure 2 (after Hensel, 1981). In that hypothetical sequence of temperature exposures, skin was initially maintained at a cool temperature (T1) and the static (steady) discharge rate from cold receptors is greater than that from the warm receptors at the same surrounding tissue temperature. The skin is then exposed to a temperature up-step (T2) and the output from warm receptors shows a sudden spike in response to the sudden increase in dT/dt. Upon reaching the new equilibrium with T2 warm receptors continue to show a higher output frequency than the cold counterparts due to the enhanced static output of warm receptors under warm tissue temperatures. When skin temperature is brought back down to T1 again, there is a sudden spike in cold receptor output (dynamic sensitivity) which decays back towards to the static or equilibrium discharge frequency once skin temperature is nearing its cooler steady-state temperature.

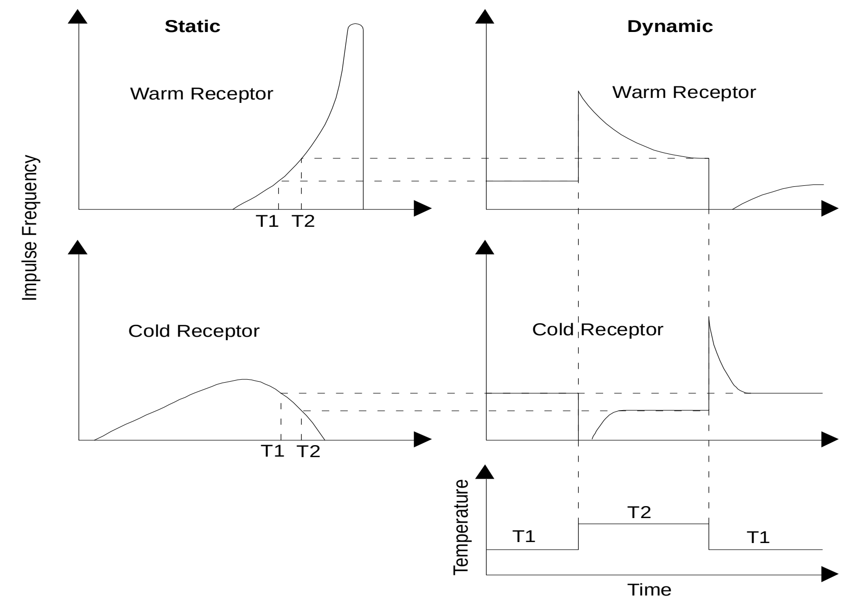

Figure 2: *Cutaneous thermoreceptor firing rate under transient stimulation (source: modified after Hensel, 1981, p.35).*

This dynamic sensitivity of cutaneous thermoreceptors is apparently transferred to sensation, and anecdotally, thermal comfort as well. It amplifies the sensation of directional gradients, and drives anticipatory (feed-forward) thermoregulatory behaviour. The immediate pleasure experienced upon entering a warm room after a cold exposure outdoors, or in the humid tropics, being enticed into a wastefully over- air-conditioned department store by a tongue of frigid air lolling out onto the sidewalk and lapping around one's feet. Both scenarios are familiar quotidian instances of the heightened cutaneous sensitivity to temperature dynamics which, in turn, drives decidedly positive thermal alliesthesia and motivates thermally corrective behaviour.

An experimental investigation into perceptual effects of these characteristic transient thermoreceptor responses by de Dear et al. (1993) exposed a sample of human subjects to temperature step-changes comparable in magnitude to those experienced when entering or leaving a heated building in winter, or a mechanically cooled building during summer. Subjects sat quietly for 90 minutes in one climate chamber and before moving abruptly into an adjacent chamber where the operative temperature differed from the first by a up to eight degrees for an additional exposure lasting 90 minutes. Whole-body thermal sensations on the ASHRAE seven-point scale were rated at one-minute intervals for the first five minutes after each transition. Immediate thermal sensations resulting from the temperature up-steps closely resembled their final steady-state responses to the warmer chamber, but initial impressions of temperature down-steps were typically twice the magnitude of the equal-but-opposite up-steps. This cold "overshoot" lasted only for a few minutes and was reasonably replicated with a numerical skin model by placing the cutaneous thermoreceptors closer to the skin's surface (0.2mm) than the warm receptors (0.5mm), as described in Hensel (1981).

A comprehensive numerical model of thermal alliesthesia has not yet been developed, for several reasons. To date no-one has quantified spatial (regional) sensitivities, or even relative weighting of dTsk/dt versus dTcore/dt. Nakamura et al. examined regional differences in thermal comfort (pleasantness) by applying water-perfused pads to subjects' face, chest, abdomen, and thigh (Nakamura et al., 2008). During mild heat exposure, facial cooling was most comfortable and facial warming most uncomfortable. However during mild cold exposure, neither warming nor cooling of the face had a major impact on comfort, whereas localised heating of the chest and abdomen produced strong comfort alliesthesia. The conclusion reached by Nakamura et al. (2008) was that humans prefer to cool their head in warm environments, and warm their trunk areas during whole body cool exposures.

Clearly there's a lot of research to be done before a fully functional, numerical model of thermal alliesthesia is ready for application in the design of indoor environments. But this brief sketch of the basic concept and underlying neurophysiological processes provides a compelling explanation for Heschong's Thermal Delight in Architecture. It's all about the counterpoint between displaced core-body temperature and opposite-trending skin temperatures (temporal alliesthesia), or the regional variation of local skin temperature stimuli against broader, whole-body pattern (spatial alliesthesia).

THE STEP-WELL OF ADALAJ, GUJARAT – QUINTESSENTIAL THERMAL ALLIESTHESIA

FROM the fifth to the nineteenth centuries, the people of western India built stone cisterns to collect and store monsoonal rains through the remaining dry months of the year. These magnificent structures, known as step-wells (Gujarati: અડાલજની વાવ) are much more than just utilitarian water reservoirs (Livingston, 2002). Their lattice-like walls, profusely carved columns, ornamented towers, and intricate relief sculptures throughout make them exceptional architecture. For these past 500 years, step-wells have been an integral part of western Indian communities as sites for drinking, washing, and bathing, as well as for colorful festivals.

Blending Hindu and Islamic styles of architecture, the Adalaj step-well is located about 20km from Ahmedabad in the Indian state of Gujurat. The step-well consists of three main entrances carved in sandstone, each comprising octagonal terraces with intricately carved colonnades and niches. The terraces form a subterranean sequence descending six storeys below the surface, terminating at the variable level of the water table. Ablutions are performed at each of the six levels, bringing the villagers down to progressively darker, cooler thermal strata.

The pillars and walls evince influences from Buddhist, Jain and Solanki rulers of Gujarat 500 years ago. The carvings on the panels include that of a king sitting on a stool with two bearers, a scene depicting women churning buttermilk, musicians accompanying dancing women, and representations of various Hindu gods and goddesses.

A legend describes the start of Adalaj step-well by King Rana Veer Singh of the Vaghela Dynasty in 1499. Mohammed Begda, a Muslim ruler of a neighbouring state invaded Adalaj and killed King Rana Veer Singh. Deeply covetous of Rana Veer Singh's widow Rani Rudabai, Begda put forward a marriage proposal that was accepted under a condition that he should complete the five-storeyed Adalaj step-well for her. The pre-condition was executed post-haste, but the very next day after the step-well's completion, Queen Rani Rudabai said her final prayer before a suicidal dive into the cool water of the well.

Figure 3: *Adalaj step-well near Ahmedabad, Gujurat India, circa 1500AD.*

Even though it was never a religious temple as such, Adalaj step-well's first mention in Heschong's book occurs in the concluding chapter, *Sacredness*. Its subterranean architecture fully exploits thermal properties of the site to provide a communal resource of coolth, relief from the extreme heat of the arid west Indian climate. Sunlight cannot reach directly down to water -level, but openings in the ceiling enable muted illumination and fresh air to cascade past profusely carved galleries and chambers providing cool, tranquil retreats. This deliberate exploitation of shade and thermal mass maintains the well's precious water resource and stonemasonry up to ten degrees cooler than five storeys up at surface-level. And it is this thermal counterpoint that reinforces the step-well's significance within the Adalaj region's culture, making the basic resource of coolth available to the local community and long-distance travellers on trade routes alike – quintessential thermal alliesthesia if ever it existed.

"*In all these ways thermal qualities enrich one's experience of a place and increase its value. Perhaps the simple bodily experience of thermal conditions is sensed as a metaphor for the more abstract meanings represented by a place; the comfort, the delight, the social affinity, each reinforcing the overall significance of the place in people's lives*" (Heschong, 1979, p.65).

Adalaj's perfect blend of visual and thermal delight prompts the telling of another myth; after the well was completed, Mohammad Begda inquired of the master stonemasons responsible for Adalaj if they could make another one as stunning. Their ill-considered answer in the affirmative was all it took for Begda to have them put to death forthwith. Their six graves can be found on the surface-level, just outside the Adalaj step-well.

CONCLUSION

Mechanically-generated, isothermal and spatially homogenous indoor climates are never the subject of rapturous delight for their occupants. There is no thermal delight in a machine. To quantify this simple point a very large Post

Occupancy (POE) database of over 40,000 questionnaires from office buildings around the world was recently analysed (Kim and de Dear, 2012). Individual impacts of a slew of indoor environmental quality factors – lighting, aesthetics, tidiness, furniture, temperature, ventilation, etc., on occupant ratings of overall building quality were examined. It was found that office buildings with high quality HVAC do not receive praise because of their indoor climatic excellence. How can they be when they are engineered to be imperceptible? But an underperforming air conditioning system is almost certain to drag down an office building's overall evaluation (Kim and de Dear, 2012). This prompted Kim and de Dear (2012) to apply the label "basic factor" to HVAC – something that gets only noticed when performance falls below occupant expectations, in contrast with "bonus factors" that register strongly with occupants when the building's performance on that dimension exceeds expectations.

The central point of this paper is that creation of indoor thermal environments with truly positive hedonic tone requires an understanding of both spatial and temporal domains of thermal alliesthesia, and their relationship to the various bioclimatic design strategies. Exploitation of convectively driven alliesthesia through purposive natural ventilation in warm climatic contexts, or thermal gradients in vertical or horizontal planes, re-engages us with our thermal sense and enriches our experience of buildings with a deeper sense of place. Then there is the temporal dimension of thermal alliethesia. The concept of alliesthesia prompts exploitation natural diurnal-cycle, weather-cycle and seasonal rhythms in the broader climatic setting. Rather than engineering indoor climate to hold occupants' skin and core temperatures perfectly constant perhaps we need to start thinking about how variations in the body heat content can be manipulated to stimulate dynamic thermal alliesthesia. In Heschong's own words;

"*A parallel might be drawn to the provision of our nutrition needs. Food is as basic to our survival as is our thermal environment… It is … theoretically possible to provide all of our nutritional needs with a few pills and injections. However … no one would overlook the fact that it also plays a profound role in the cultural life of people. A few tubes of an astronaut's nutritious goop are no substitute for a gourmet meal… They are disconnected from all the customs that have developed around eating… The thermal environment also has the potential for such sensuality, cultural roles, and symbolism that need not, indeed should not be designed out of existence in the name of a thermally neutral world*" (Heschong 1979).

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