

Tamagotchi Building Project: Environmental Cues in Context

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ABSTRACT

Like the digital pets the project is named for, the Tamagotchi Project will use aspects of the building system (lighting, HVAC, audio-visual) to deliver environmental cues (colors, temperature changes, sounds, even scents) anthropomorphizing the building. The hypothesis of the Tamagotchi Project is that a feeling of nurturance may be induced, resulting in a desire to ‘feed’ the building through appropriate energy usage. In this paper, we look at the history of environmental cues, spatial design, and human behavior. This review is preliminary to the installation of experimental equipment at up to seven sites in the United States.

Hypothesis

Using well-established theories of behavior, a quasi-experimental model will attempt to determine if people’s energy use in commercial buildings can be affected through the manipulation of the environment. In this paper, I discuss how environmental context stimulates activities and affects perception—in particular, color (Küller and Mikellides, 2009), light (Igor, 2001), odor, sound, and spatial layout. This paper also addresses the role of feedback in learning and habit formation, specifically positive and negative reinforcement. The goal of this paper is to discuss how people respond to changes in environmental cues embedded in their environment, and what the implications are for creating positive habits for energy management in LEED buildings. How can some of these principles be incorporated into retrofits for lower energy costs, higher productivity, and increased employee morale?

Adaptations and Implications

We process information received through physical cues provided by our environmental context on a basis that could be informally described as something less than conscious, yet more than merely autonomic. We are constantly adapting our environments to suit our physical selves. Whether we are fiddling with the thermostat, adjusting the blinds, turning on a fan, or spraying air freshener, we are changing the temperature, lighting, air quality, and ambient odors to make ourselves more comfortable; this steady-state of change has enormous implications for commercial buildings and their energy profiles and performance, most particularly in the ‘green’ building sector. The failure of many LEED-certified buildings to realize their performance ratings^{1,2} is a possible result of such constant adjustment—a phenomena that is difficult to model in advance; a demonstration in some instances of how even well-designed systems can fail to deliver expected energy or carbon savings due to the ‘human dimension’ (Brown and Cole 2009):

¹<http://www.buildinggreen.com/live/index.cfm/2008/9/2/Lies-Damn-Lies-and-Are-LEED-Buildings-iLessi-Efficient-Than-Regular-Buildings>, accessed February 2012

²<http://chinabuildsgreen.com/2205570/10-26-11-Building-Energy-Data>, accessed February 2012

Results from a comparative post-occupancy evaluation show that while the availability and use of personal controls was higher in the green building, the quality of personal control in terms of responsiveness, the absence of immediate and relevant feed-back, and poor user comprehension may have led to sub-optimal comfort conditions.

Yet, as I allude to above, the idea that people are ‘in charge’ of their environment is not a human cultural universal—it is a relatively new one in the scope of human history, and there are ethnographic examples to support alternative understandings of how people and the ecologies within which they are embedded interact. Many cultures have found means by which they live within the constraints offered by their particular climate/biotic zone. Inuit clothing technology for handling cold weather has been compared favorably in its sophistication to space suits. Meanwhile, the Tikopia islanders, first made famous by anthropologist Raymond Firth (1936) and later revisited in Jared Diamond’s book *Collapse* (2005), have instituted strict reproductive controls and developed a ‘replacement’ ecology entirely based on food plants in order to support relatively high population densities on a very small volcanic island. Such examples can provide a source for new ways of thinking and problem-solving. Humans do not have to always make their environments do the shifting; sometimes, the environment even pushes back.

Environment and Behavior: Reward and Reinforcement

The idea that environments shape behavior is a venerable one, across all disciplines that deal with life, from plants to rats to people. At least 100 years ago, animal behaviorists began researching the effects of rewards and positive reinforcement on behavior (Hogeland Stocking 1912; Thorndike 1932); in other words, they changed the environment and animals reacted in patterned and even predictable ways. This kind of stimuli-response-learning model, often called *behaviorist* or *Skinnerian* after its most famous practitioner, was adopted for use on humans by the middle of the last century and became common in educational theory (Walker and Buckley 1968) as well as psychology, where it formed the basis for the concept of cybernetic theory and informational processes (Estes 1972). Yet despite the solid and widespread foundation for understanding that human behavior is shaped by the environment (and not always the other way around), it is instead the ‘physical-technical-economic model’ or PTEM as outlined by Loren Lutzenheiser (1993) that depends upon the Western concept of the rational autonomous individual acting upon his/her environment that has dominated energy efficiency thinking about how people manage their environments. In contrast, the two non-Western models I mentioned above both rejected traditional intensive agricultural practices in order to survive; both examples were outcomes where cultures had experienced the eco-system pushing back.

Our own relationship to environmental context is a complicated one, and changing culture is not as easy as it might seem. At one end of the scale we (humans) and the political-economic systems within which we are all enmeshed (including Inuit and Tikopians) have impacted ecologies across the globe as much as any geologic force, wreaking change upon the planet in massive and irreversible ways. At the same time, we remain subject to evolutionary forces exerted upon us every day—selective pressures push us or pull on us, forcing us to act within the constraints of an ecological niche that we have crafted. Franz Boas, who has been called the “father of American anthropology,” wrote that ‘humans have domesticated themselves,’ by which he referred to the fact that we have penned ourselves up in artificial

structures and situations along with the animals and plants we have selected and bred for food. We decide how and where all of us will live. Despite our vaunted mastery over the environment, it always pushes back, helping to determine our evolutionary trajectory. Religious and environmental historian Richard Foltz outlined this relationship in his article, “Does Nature Have Historical Agency? World History, Environmental History, and How Historians Can Help Save the Planet,” in which he discusses the role that plants have had in directing human history, where their ‘willingness’ to grow here and not there has pushed humans about the globe:

The presenter in question was writing a book on the global history of cotton, which he spoke about at the conference. I suggested in the response period after his presentation that in applying a world systems approach to the economic history of this resource, he had neglected to acknowledge the fact that humans were not solely responsible for the spread of this particular plant to areas beyond its native territory. Cotton itself was certainly a major actor in this story, since it either flourished or didn't and in doing so affected the fortunes of humans who had invested their money and energy in cultivating it. After all, he was calling his story "a history of cotton," and not—as he perhaps should have, given his humanist focus—"a history of human attempts to manipulate cotton growth."

Foltz's theory of historical agency not being limited to humans and human 'consciousness' has much in common with the paleontological angiosperm hypothesis, which posits that, in evolving flowers, nuts, and seeds as defensive measures against over-browsing, the resultant flowering plants played a major role in mammalian (and thus human) evolution. Not only does the environment often push back, sometimes it pushes us forward.

Inducing Emotions through Environmental Cues

In order to truly dispense with the notion that humans are (merely?) rational actors making empirically based decisions, it is helpful to review a few of the ways in which it has been demonstrated through experimentation that environmental cues affect human perception, judgment, and decision-making. For example, in an article concerned with measuring the impact of music selection upon wine purchases, the researchers (Areni and Kim 1993) write: “Kotler (1973-1974) coined the term *atmospherics* to describe various visual (color, brightness, size, shape), aural (volume, pitch), olfactory (scent, freshness), and tactile (softness, smoothness, temperature) dimensions of a store that can influence the purchase probabilities of consumers.” Meanwhile, in “Ambient Lighting Modifies the Flavor of Wine,” (Oberfeld et al. 2009), the authors found that the perception of the taste of the same wine changed from more favorable to less favorable depending upon whether the room had a red tint, a blue tint, or a green tint. In addition, white wines colored red were described by wine experts using the vocabulary of red objects (e.g., berries). In general, when it comes to perception, taste and color (both intrinsic and ambient), the authors write that:

The color of a beverage seems to be effective at a very basic level of sensory integration. Conscious efforts to ignore the color are largely futile. For instance, Zampini et al. (2007) asked observers to discriminate the flavor of solutions that were either colorless, colored appropriately or colored inappropriately. In the latter

case, performance was poorer than with colorless or appropriately colored liquids even though the observers were explicitly told to ignore the color....Whenever colors and odors were presented together that subjectively constituted a good match in the eyes of the observer, activity in the orbito-frontal cortex and in the insular cortex was observed.

In other words, you are not really tasting wine so much as seeing it. In another experiment with lighting and color (Igor, 2002), researchers found that:

[The] main effects of colour of light on short-term memory and problem solving showed that subjects performed better in the 'warm' than in the 'cool' and artificial 'daylight' white lighting. Interaction effects between colour of light and gender on long-term memory showed that males performed best in the 'warm' and 'cool' white lighting, and that women performed better than men in the artificial 'daylight' white lighting. All these results are generally in agreement with the proposition that light influences nonvisual psychological processes.

Other studies have found that the presence or timing of certain types of light can improve "nocturnal decrements in alertness and performance," (Daurata et al. 2000). With respect to scent it appears that the presence of lavender odors were detrimental to arithmetic performance (Ludvigson and Rottman 1989) while the same scent, along with orange oil, reduced anxiety levels during a wait for the dentist (Lehrner et al. 2005). In a casino, unnamed 'odorants' perfuming slot machines resulted in a greater "amount gambled in the same area during the weekends before and after the experiment by an average of 45.11% ($p = < 0.0001$)" (Hirsch 1995). In another experiment (Mattila and Wirtz 2001), the ways in which scent and sound interact to produce a distinct emotional response were studied:

We manipulated scent and music in a 3 (no music, pleasant low arousal and high arousal music) by 3 (no scent, pleasant low and high arousal scents) factorial design in a field setting. Our findings show that when ambient scent and music are congruent with each other in terms of their arousing qualities, consumers rate the environment significantly more positive, exhibit higher levels of approach and impulse buying behaviors, and experience enhanced satisfaction than when these environmental cues were at odds with each other.

As with color and taste, the congruence of the experience was both salient and impactful, though it is important to keep in mind that a quality such as 'congruence' is necessarily a subjective assessment; other researchers (Schifferstein and Blok 2002) found that their attempts resulted in nullification:

We selected two odors: a grass odor, congruent with soccer, animal/nature and gardening magazines; and a sunflower odor, congruent with personal care and women's magazines. In a field study in three bookstores, the ambient odors did not increase sales for thematically congruent magazines, nor did they decrease sales for incongruent magazines.

Another tangent entirely is the issue of cultural valence, and the researchers above were possibly German, meaning that a ‘sunflower’ scent carries other weight symbolically than it might in the United States. Since there are definitively established differences in how people perceive environmental cues such as scent, light, and color, the point I am making here is that people DO respond unconsciously to such cues and that their behavior changes as a result. I am not asserting that people respond universally or in a particular manner regardless of circumstances.

Architectural Applications of Shaping Behavior through Design

Because the relationship of environmental cues and human behavior change has long been recognized and validated (Foucault 1975), many aspects of our society’s built environment have such cues embedded within them to manipulate decision-making by individuals whether they are prisoners, patients, or customers. An excellent exegesis of this phenomenon is to be found in “Say Cheese!The Disney Order That Is Not so Mickey Mouse” by Shearing and Stenning(1987). In this excerpt from their larger work extending Foucault’s thesis, “From the Panopticon to Disneyworld: The Development of Discipline” (Shearing et al. 1985), they outline the ways in which Disneyworld has used environmental cues to manage park visitor behavior, encouraging compliance through “robotic voices” and “physical barriers” among other features. Walmart and IKEA are two other well-known cultural forces that have instituted proprietary planograms to manage the ability of customers to navigate space, both physically and mentally. IKEA’s design is famously confusing,³ forcing visitors to wend their way past many displays initially of little interest to them, and changing purchase decision-making and behavior⁴:

According to Professor Penn, getting lost in the store leaves shoppers feeling "licensed to impulse purchase."And the strategy works. Approximately 60 per cent of purchases at IKEA weren't on shoppers' lists. "By the time you get to the Marketplace [checkout area] you've spent half an hour walking past bedrooms and bathrooms and living rooms and all these things you didn't actually come here for, but getting subliminal messages about what goes with what," Prof. Penn says. "Before long, you've got a trolley full of stuff that are not the things you came there for.

Fast food restaurants like McDonald’s have long understood the impact of certain colors on eating behavior and speed, and implemented specific schemes (oranges, reds, yellows) to encourage rapid consumption and table turnover. More upscale department stores (Chebatand Michon, 2003) and fine dining establishments also manipulate the tempo of the customer experience through lighting choice and paint selection (Quinn 1981). Meanwhile, hospitals and mental institutions are often painted in ‘soothing’ tones of green and blue.It should also be mentioned that much of this activity has been deployed in absence of actual empirical data regarding color and its specific impact on things like worker productivity. Kwalleket al. (2007) found that the color of the walls of a room have no statistically significant impact on error rates with small repetitive tasks. On the other hand, keeping the concept of cultural valence in mind, it

³<http://ca.news.yahoo.com/blogs/good-news/real-reason-ikea-confusing-navigate-20110408-143914-275.html>

⁴http://www.youtube.com/watch?v=NkePRXxH9D4&feature=player_embedded

is likely that *beliefs* in the efficacy of a color on an activity will in fact change the outcome of that activity.

Cybernetic Systems Theory

As long as people have been studying behavior in both animals and humans, certainly since the 1930s (Tolman and Honzik 1930) but likely since antiquity, there has been an interest in feedback and behavior change. Much of this exchange takes place at the level of neuro-biology (Wolfram, 2004), with the clear implication being that it is in the context of the relationship between the organism and its immediate, physically mediated environment where the critical cues are encountered. These cues are stimuli, promoting adaptation on the part of the organism, and thus behavior change.

The concept of cybernetics, systems that are regulated by positive or negative mechanisms, was first developed by the anthropologist Gregory Bateson as ‘schismogenesis’ in his ethnography of Papua New Guinea, entitled *Naven*. The concepts of positive (reinforcing or intensifying) and negative (dampening, delimiting) feedback were accompanied by the understanding that actors are either complementary (and unequal) types or symmetrical (and equal/similar) types set up in some form of conflict or tension. These ideas were highly influential during the development of the earliest computing theories, and therefore cybernetics has come to be associated with mechanical/digital information processes, but in their purest form these systems are social. When we speak of ‘the social’ we are in effect referring to system processes and dynamics, and not individual decision-making. That will be important to keep in mind as we design stimuli for commercial office buildings.

Reward and Punish: The Final Brick in the Wall

One hundred years ago, animal behaviorists Mildred Hoge and Ruth Stocking (Hoge and Stocking 1912) wrote: “Results show that a combination of punishment and reward motives was more effective in bringing about visual discrimination in the rat than was either punishment or reward used alone. Punishment was more effective than reward in the rate of learning.” That sounds so harsh, and yet, later work seemed to bear this out (Lepper and Greene, 1978), specifically that tangible rewards can even be detrimental to learning (Deci, Koestner and Ryan 1999), and that they often backfire, stimulating the opposite reaction than was desired. This in time became something of a meme, such that by the middle of the 1990s it became necessary to refute the idea that ‘rewards are bad’ (Cameron and Pierce 1994; Eisenberger and Cameron 1996). The reality is a bit more complex. A quick review of thoughtful literature on the subject of extrinsic rewards brings one to a 1998 Harvard Business Review article, “Six Dangerous Myths about Pay,” wherein Jeffrey Pfeffer deftly pulls apart the various kinds of rewards one can offer/expect in the workplace. He offers many examples of industry-leaders who do not offer the highest pay or the most cutting-edge compensation packages, but rather offer rewards in the form of creative, fulfilling, happy workplaces. One of the most important things is congruence between message and reward (page 118) and not undermining your message about ‘what matters’ by rewarding the opposite (e.g., talking up team-work and rewarding individual contributors). Similarly, in a commercial office space, rewards may come in the form of comfort, status, and control over one’s environment, and it may even be that these are more relevant to performance and productivity than monetary incentives.

Can We Harness Environmental Cues?

One of the major questions for this research is, can we set up positive feedback through environmental cues such that people learn to manage their energy consumption more effectively? At the same time, these cues must be conducive to the comfort and productivity of commercial building occupants. How best to accomplish these goals? Since it appears that LEED (and other buildings) find that their systems are not achieving penciled-in savings projections due to human factors, first we should look at what it is people are doing that causes such variability.

As an exercise, I queried my office mates here at ACEEE about how they had modified their atmospherics. We currently have 21 offices and cubicles (14:7) housing 25 occupants. Of that set, I spoke with 16 informants.⁵ I asked them a few open-ended questions about their management of atmospherics (e.g., “What have you brought in from home?” “How have you modified your workspace?”) as well as specific yes/no questions about the presence or absence of items (e.g., “Do you have any potpourri?” “Do you listen to music?”). The answers are summarized in the chart below:

<i>Air quality</i>	2 humidifiers	1 desired humidifier
<i>Air temperature</i>	1 space heater	2 wishes for ‘more control’
<i>Air speed</i>	2 fans	1 wishes for ‘more control’
<i>Scent</i>	1 candle/1 fragrant fruit	
<i>White noise</i>	1 ‘real’ noise machine	1 finds vent ‘acts’ as white noise
<i>Music</i>	All but 2 listen to music ⁶	
<i>Lighting on/off</i>	3 offices turn lights off	3-4 wish to turn off the lights
<i>Brought in lighting</i>	3 brought in lamps	

In all but one of the 25 workspaces, modifications to atmospherics had been made. People are quite sensitive to atmospherics, as one participant said: “I have come to believe that what people want [in office buildings] is a space heater under their desk and an open window.”

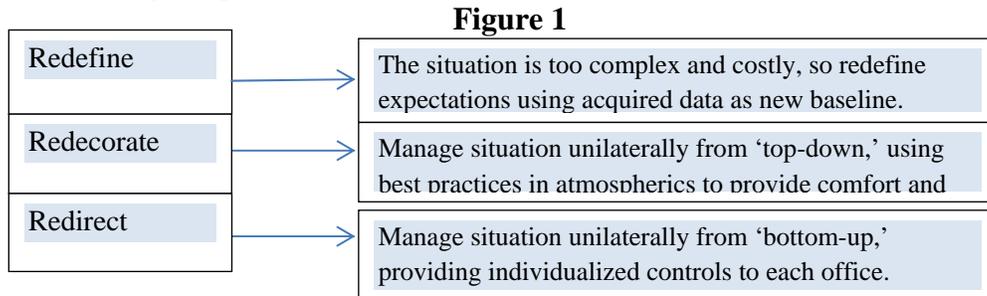
It Is Possible to Manipulate Behavior through Environmental Cues, but Should We?

On the one hand, we can demonstrate that it is possible to manipulate people’s impressions of, and interactions with, their environment through changes in atmospherics. *Providing* a pleasant environment could produce a positive impact on morale and productivity. On the other hand, common sense as well as the short exercise above tell us that *controlling* one’s environment is very important to people and may also be important to morale. Our next step is to examine what complications arise from this state of tension between two agents, operator and tenant, managing atmospherics in a commercial office building—what is the optimal state of affairs, how might it be achieved, and what impact might it have for forecasting the energy profile of the building?

⁵ Some participants spoke about absent office mates, so numbers will add to more than 100%.

⁶ Many participants made the comment that they listen to ‘non-vocal, non-verbal, or instrumental’ music (classical, jazz, and ambient) during detail work periods. ‘Active’ work or repetitive work calls for livelier music, even television shows and news broadcasts.

The Tamagotchi Building Project in the Behavior and Human Dimensions Program at ACEEE has been proposed as a way to experiment with some of these variables. The impetus behind the project was the phenomenon, discussed earlier, that *some* LEED-certified buildings seem to not be living up to expectations with respect to energy savings, and that *some* of that failure might be laid squarely at the feet of the human occupants. Below I illustrate what I believe to be the range of potential outcomes:



Each of these strategies has a set of pros and cons distributed across three agent-types: operators, tenants, and evaluators.

Figure 2

Operators

	Pros	Cons
Redefine	Inexpensive, simple	Doesn't redress failure
Redecorate	Simple, increases savings	Moderately expensive, does not capture full savings possible
Redirect	Allows for tracking of energy use on an individual basis (like plug loads)	Expensive, complicated

Tenants

	Pros	Cons
Redefine	Leaves things at <i>status quo</i>	None
Redecorate	Offers pleasant, calibrated atmosphere	Not individualized; could be seen as manipulative
Redirect	Provides tenants with desired control	Tracking of personal habits could be seen as intrusive

Evaluators

	Pros	Cons
Redefine	Using empirical data acquired in real-world is irreproachable	Forecasting from aggregates of a wide range of results is problematic.
Redecorate	Based on experimental research and 'hard' data	Hard to measure quantitatively; stochastic modeling required
Redirect	enables granular data capture of occupant behavior and thus enhances model building	Models would need to be organized into sets based on occupancy types, as well as technical specifications

Steering a Middle Course

Looking at the pros and cons across the three concerned populations, it appears that the second strategy of ‘Redecorate’ has the greatest number of benefits with the fewest number of drawbacks. It may not give perfect control over the environment over the entire range of potential individuals, but it can deliver an increased likelihood of positive outcomes with respect to comfort and productivity for a reasonable outlay. The Tamagotchi research project, referring to the literature reviewed for this paper, will be recommending to its partner, the Alliance to Save Colorado (owners of a historic building in Denver, Colorado), that it test paint in warmer tones,⁷ install lighting with a faintly pink cast, and if feasible, situate air vents so that every workspace has physical access to the airflow and the ability to open and close (using a simple physical mechanism like a lever) the vent to control air speed. We will also recommend that HVAC delivery be tested to make sure that a relative average humidity of 45% is being delivered consistently.

Prior to renovation, it is recommended that the environmental conditions be recorded and brief interviews be held with occupants. Lighting will be measured for brightness and warmth along the spectrum, airflow speed and ambient temperature will be recorded, and decibels will be measured. These will be re-measured post-renovation, and interviews will be conducted to see how occupants respond to their new environment. Energy consumption, as recorded in bills, will be examined pre- and post-renovation, while visual scans and photography will help researchers evaluate whether additional comfort has been achieved, and along with it the elimination of individual electricity-consuming devices. The interviews will also record occupants’ subjective belief as to their current productivity, since enhanced productivity is a hypothesized by-product of improved atmospherics but is not the focus of the research.

Conclusion

This paper has examined the relationship of the environment to the individual, and asserted that ecosystems (including built ones) have the ability to ‘push back’ against choices and activities engaged in by humans. In evolutionary theory, these are known as selective pressures, and force organisms, including people, to adapt. Context, including the attributes described in this paper as atmospherics, affects human perception, judgment, and decision-making. We are hypothesizing that this phenomenon can be harnessed to ‘adapt’ people to their environments, in this case commercial office buildings.

This paper also discusses the role of reward and positive feedback loops in behavior, and suggests that comfortable buildings, providing optimized atmospherics (air speed, quality, and temperature; lighting schemas; wall coloring; and noise reduction and management) could be an inducement to ‘good’ behavior on the part of occupants, helping them to streamline or eliminate energy-draining devices intended by individuals to deliver comfort to their workspaces. In such a manner, occupants, building operators, and the systems of buildings collaborate to fulfill the energy savings promise of LEED certification.

⁷Examples include but are not limited to Antique White 6119 or Natural Choice 7011 by Sherwin-Williams.

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