Mapping Memory of Space & Place:

Report on the 2005 Workshop on Neuroscience & Health Care Architecture

J. Erik Jonsson Center, National Academy of Sciences, Woods Hole
August 15 – 17, 2005

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Origins of a New Discipline
John P. Eberhard, FAIA

“Architecture stands on the threshold of a new era. The enormous body of knowledge being created by neuroscientists is about to dramatically change what it means to be a professional designer. Architects will benefit from the knowledge base made possible by neuroscience, but the real beneficiaries are future generations of school children, hospital patients, and office workers who will have their environments more carefully tuned to their needs and desires.”

The Academy of Neuroscience for Architecture (ANFA) frames a new discipline that unites the emerging field of Neuroscience with the process and experience of Architecture. Its objective is to produce a steadily increasing level of thoughtfulness in design, so that environments may be developed utilizing a significant body of knowledge relating features of architecture to the individuals who occupy those spaces. In bringing together seemingly disparate disciplines and modes of thought, a novel set of questions pertinent to the practice of architecture can be addressed using methods not fully applied to the understanding of the human response to built form. The goal becomes one of establishing the knowledge base, protocols and skills needed for defining, collecting and sharing neurophysiological and architectural data to be used for further collaborative studies within architectural projects. The connection between neuroscience and the design of functional building types includes the breadth of built settings, including health care, laboratory, office, spiritual and educational architecture.

Neuroscience & Health Care Architecture
Eve A. Edelstein, Ph.D., Assoc. AIA

The Academy of Neuroscience for Architecture hosted a series of workshops, held at the National Academy of Sciences, to engage in interdisciplinary dialog about human responses to health-care facilities.

A working premise was developed to consider how each variable of the environment affects a certain brain process that in turn, alters a specific outcome measures.

Many studies which highlight the correlation between hospital design and medical outcomes have used behavioral methods. ANFA seeks to add neuroscientific information to provide further insight about the causes of such behavior and scientific validation of observations and conclusions. This next phase of inquiry seeks to utilize the depth and breadth of knowledge available from all relevant biomedical research.
**Translational Design**  
*Eve A. Edelstein, Ph.D., Assoc. AIA*

In order to extend the evidence base that might inform design, a ‘translational design’ approach was proposed as a conceptual framework. Modeled on ‘translational science’, fundamental knowledge from the laboratory bench can be applied to solutions at the hospital bedside. The translation of science into terms relevant to architecture offers the opportunity to understand and predict human response to a place by interpreting the functional principles of brain processes into design hypotheses. In addition, the rigorous scientific methods used for validating findings provides a structure for generalizing results into built applications. This translational model, when carefully followed, has served medicine well, and offers great potential for the creation of a credible evidence base for design, and perhaps, for greater intellectual leaps toward effective and predictable design solutions.  

**Translational Research**  
*Esther M. Sternberg, M.D.*

Much basic research in the area of spatial perception, memory and spatial navigation has not only elucidated the brain pathways underpinning these functions, but also shows that many variables, including stress, illness and gender affect these perceptual functions. Understanding these connections can help explain how people’s moods, performance and problem solving ability might be affected by elements of the built environment, and how one by one, these brain responses can affect immune responses and health. This knowledge can ultimately be applied to inform the design of built environments to minimize negative and maximize positive health outcomes, as well as to facilitate performance in particular kinds of environments. These principles have important implications for people’s way-finding ability, especially in healthcare facilities, since illness may profoundly affect spatial navigation, recognition and memory of spatial cues, as well as mood and stress responses to novel environments. Although these principles of neuroscience have not been directly applied to address these clinical effects, the goal of the workshop is to address what basic research has been done, where there are gaps, and what research could be done to fill these gaps. Furthermore, by bringing neuroscientists and architects together, the workshop will move the interdisciplinary field of research linking neuroscience and architecture forward. Knowledge of the basic principles of how the brain receives and responds to different elements of the built environment can therefore inform architectural design to optimize health.

Recent scientific advances have shown that there are many ways in which the brain and the immune system communicate and modify each other's functions. This is the scientific underpinning of the so-called “mind-body” interaction. Hormones of the brain’s stress response and nerve chemicals released from adrenalin-like nerves activated during stress tend to dampen immune system activity and can lead to greater susceptibility to infection. In turn, immune molecules released during illness can change memory, cognition and mood.

Workshop discussions lead to the development of a series of hypotheses that addressed the relationship between hospital design, patient outcome and staff performance.

Four general hypotheses were explored:

- Daylight influences the healing process and cognitive function.
- Interior layout influences staff performance and patient outcomes.
- Privacy and control influence patient emotional responses and outcomes.
- Neural processes sub-serving memory influence the response to navigation cues within complex settings.

Leaders in health care architecture and scientists with specialist expertise in navigation and memory processes assembled to explore potential research opportunities related to the many factors of importance identified as important to the practice of design and construction of health care facilities.

Navigating Health Care

The 2005 workshop focused on navigation strategies. Designers and users alike have identified wayfinding as a problem within complex hospital settings. The density and complexity of hospital programs often results in a labyrinth of indistinguishable corridors and room arrangements. Zimring’s study of a 300 bed hospital in Atlanta revealed that the staff spent 4500 hours a year helping patients and visitors find their way. The calculated lost staff time was equivalent to US $220,000 a year.

Cognitive neuroscience has sought to understand how space is represented in the mind and brain. Three decades of research reveal an association between areas involved in memory and those subserving scene perception. Brain regions have been identified that respond preferentially to visual stimuli including photographs of landscapes, cityscapes, interior scenes, buildings, and the presence of large immovable barriers such as walls that define the spatial layout of the local scene. In addition, changes in neural processing that occur with different points of view or repeated presentations, began to reveal how the brain forms spatial maps of the world.

Individual and environmental factors have specific influences on memory, navigation and wayfinding performance. Behavioral and medical status influence the rate of learning and persistence of memory. Changes associated with dementia or Alzheimer’s disease can selectively affect the memory centers involved in navigation tasks. It is predicted that 20% of the US population will be 65 years and older by 2030. Vision changes associated with aging will add to the difficulty of navigation using visual cues. The National Eye Institute predicts that blindness or low vision will affect 5.5 million Americans by 2020 (an increase of 2.2 million in 15 years).

Designs based on evidence from neuroscience research offers the potential to inspire the design of navigation systems that accommodate the broad needs of patients, visitor and staff populations within healthcare facilities.
The Neuro-Architectural Charrette
Pam Milner, RID

The 2005 ANFA Workshop used a unique process, in which neuroscientists specializing in memory and navigation, discussed neural principles that might provide insight to navigation strategies. Design hypotheses and potential experiments were discussed as they relate to patient, medical, and business outcomes. Three working groups considered how existing knowledge of human and mammalian responses from basic neuroscience could inform architectural decisions in the following contexts:

- Communication & navigation in neuroscience laboratories
- Stress & gender in neurological intensive care units
- Navigation in complex hospital environments

Designers provided generic plans of complex health care facilities as a starting point for further analysis. The objective was not to critique these generic plans, but to consider how neuroscience concepts could be applied to each building type, and to proposals for research studies in operational and experimental architectural settings.

For the architect, the data derived could inform improved design of the built environment incorporating a broader base of knowledge that includes a neurological overlay intended to benefit all occupants. For the neuroscientist, the data will help to inform the design of spaces in which scientists create and apply their research. Discussion after the charrettes focused on the means and methods to advance this discipline toward the collection of useful data, and its appropriate application to the design of health care and laboratory settings. Data collection proposals considered a broad evidence base ranging from behavioral to neural and physiological responses. The architectural profession will benefit from the development of the following application frameworks:

- Acquiring and sharing of data & knowledge
- Applying knowledge to architecture
- Applying knowledge to neuroscience
- Forming collaborative ventures

Each group was asked to focus discussion on principles from existing neuroscience results that relate to architectural issues. A framework posed questions found in neuroscience papers that are relevant to brain processes involved in navigation and memory. Discussion considered measurement techniques that could address a related design issue and provide information on outcome measures. (See Appendix I).

An annotated design approach was used to identify neuroscience and behavioral issues. Observations, comments, and hypotheses were written directly on architectural plans with the aim of making issues explicit and sharing them with others. (See Appendix II).
I. Navigation in Complex Hospital Environments

David Allison, Georgio Ascoli, Gert Cauwenberg, Russell Epstein, Frank Pitts, Tom Regan, Jane Rohde, Margaret Tarampi, Joan Whaley, John Zeisel

The working group considered specific architectural features that might subserve the multiple neural systems that respond to virtual navigation tasks. These neural substrates have also been shown to be involved in memory processes and navigation strategies.

Neural Principles

It is proposed that the processing stream for navigation which activates the parahippocampal place area, analyzes the geometric structure of the currently visible local scene. The retrosplenial area situates the local scene within the larger environment, and the hippocampus forms associations into map-like representations of locations and the routes between them.

Design Hypotheses & Experiments

The neural functions involved in navigation processes described by Epstein, Wilson and others bear direct relevance to architectural concepts of place memory expressed by Lynch and other authors, including cues, landmarks, paths, nodes, edges, districts and boundaries.

Hypotheses lead to suggested experiments to investigate environmental features and strategies that might best serve the neural mechanism that make up human perception of space, place and location. The time taken to navigate to a determined end point and accuracy in navigation (error rate), and stress levels before, during and after navigation tasks would reveal important information about the efficacy of navigation cues and strategies.

Virtual Experiments

Experiment #1: Virtual navigation & analysis of “lost places”
- Have subjects navigate through a virtual reality version of a hospital.
- Indicate with button press if lost
- Test navigation as a function of different aspects of design (eg curved vs straight corridors)
- Analyze the physical attributes of “lost places”
- Analyze neural responses to lost place attributes using fMRI techniques.

Experiment #2: Analysis of ‘wayfinding’ features
- Familiarize subjects with the hospital.
- Show them images of different places in the hospital.
- Analyze PPA activity using fMRI techniques.
- Analyze the results from imaging studies with reference to architectural concepts of “nodes”, “landmarks”, etc.
### Analysis of navigation cues in health care settings

<table>
<thead>
<tr>
<th>Question</th>
<th>Question</th>
<th>Question</th>
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</thead>
<tbody>
<tr>
<td>Do architectural features address perceptual or organizational thresholds?</td>
<td>Are doorways thought of as navigation cues?</td>
<td>Which aspects of gardens assist in wayfinding?</td>
</tr>
<tr>
<td>What are the cultural impacts related to building elements?</td>
<td>Does the geometry of entry features function as landmarks?</td>
<td>Do “pauses” or “stopping places” help users to find their way?</td>
</tr>
<tr>
<td>Do the curved corridors help orientation?</td>
<td>Do the sectional qualities help orient people?</td>
<td>Do secondary gardens help orient to corridor?</td>
</tr>
</tbody>
</table>

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*Workshop analysis of design for navigation with permission The SmithGroup*
Studies on topological continuity in rat experiments indicate that spaces are stored in memory according to their contiguity versus their metric distances. Impediments and barriers (visual, physical or psychological) create disparate memories of distinct spaces. A barrier within a space confers two spaces versus one single space. This cognitive separation of spaces also restricts physical movement between areas.

Impediments or barriers can be defined as anything that segregates space and therefore people. By increasing physical connectivity, it may be possible to reduce the barriers to collaboration. It is suggested that this might be achieved by increasing physical connectivity (thereby decreasing the number of memories of disparate spaces.

If free flow of ideas is directly related to the free flow of the architecture, collaborative free flow should be served by contiguous space. Architects have conventionally grouped things like demountable walls, doors, and transparent (glass) walls / windows into a “soft-barrier” category (like the semi-permeable membrane). Research in animal studies has shown that these are perceived by the brain as barriers nonetheless. A window may create an opportunity for visual exploration but it does not serve to unite two spaces. Though regarded as easily surmountable barriers, “soft-barriers” still disconnect the space, serve to create disparate memories of spaces, and restrict movement. When a partition is put in place, one space physically and perceptually becomes multiple spaces and results in a diminished opportunity for movement between spaces.

In addition to getting people to flow to a space, observations from animal studies suggest that we should design stopping points – to encourage people to linger within a space. “Placemaking” (or memory of place, versus any space) can be achieved with spatial calibrators: 3-D objects which are interactive, thereby more likely to create richer experience. More neural systems would likely be dedicated when space is interactive across diverse or multiple behaviors (versus strictly circulation, or spaces where nothing happens) with the result being that the associated places are more salient, more important. Two-dimensional architectural attempts to define a space (such as changing the wall color) have been shown to be weak cues with respect to placemaking. The most effective strategy may be to place 3-D, interactive objects and instruments at critical intersections.

Research has also shown that when rats are engaged in consummatory behaviors (e.g. eating, grooming and defecating), they enter into memory recall mode. The architecture associated with these activities should facilitate recall and stimulate memory. Private offices or lounge areas might provide similar qualities in that they are safe, familiar, and comfortable so as to set the stage for the scientific “Eureka” moment to occur.
Analysis of collaborative spaces in laboratory settings.

Workshop analysis of design for collaboration:
With permission Goody Clancy
Design Hypotheses: Continuity & Communication

Neural Principles: Topological Continuity
- Spaces are stored in memory according to their contiguity versus their metric distances.
  - Cognitive proximity versus metric proximity
- Visual, physical or psychological divisions create disparate memories of distinct spaces.
  - A barrier within a space confers two spaces versus one single space.
- The cognitive separation of space limits physical movement between areas.
- Stopping behavior is associated with memory formation.
- Interactive and consummatory behaviors are associated with memory of place.

Design Hypotheses
Several design suggestions were created, based on generalized understanding of these scientific observations. Empirical observations of the effectiveness of such designs would demonstrate their efficacy in facilitating navigation and collaboration.

Design Hypothesis:
- It is hypothesized that the free flow of ideas is directly related to the free flow of the architectural setting.
  - Increasing physical connectivity might enhance collaboration.
- It is suggested that anything that segregates space may separate people.
  - A window may create an opportunity for visual exploration but it does not serve to unite two spaces. It may create disparate memories of spaces.
  - A moveable partition might create cognitive separation of multiple spaces and results in a diminished movement between spaces.
- It is hypothesized that encouraging people to linger or interact within a space may enhance “placemaking”.
  - Interactive 3-D objects may be more effective as they engage more neural responses.
  - 2-D (eg. color) have been shown to be less effective.
  - Spaces where nothing happens (strictly circulation space) are likely to be less salient or than spaces where interaction takes place.
The working group considered a range of stimuli that have been identified as stress triggers in all mammalian species. Clinical and physiological data demonstrate a wide variety of factors associated with stress responses. In addition, the precise context and condition of the environment also exert great influence on the responses to these variables. Individual circumstances including gender, personal history, and the task being performed provide an additional layer that must be considered when designing an experiment, or indeed a setting that is intended to elicit a specific stress response.

**Neural Principles: Stress & Healing**

- All mammal species demonstrate physiological responses to stress triggers.
- All mammalian species demonstrate the influence of stress on healing and memory.
- Stress levels relate to neural, endocrine and immune responses.

**Relevance to Health Care Architecture**

A list of environmental stressors were generated which have potential relevance to the design and function of health care facilities. Sensory system perception and stress levels could be improved by taking into account auditory environments for better speech clarity, and reduction of stressful hearing conditions due to background or unwanted noise. Appropriate lighting conditions could improve visual clarity for reading instructions and thereby assist in minimizing error. Thoughtful use of overhead lighting would provide a more relaxing environment for patients who spend many hours on gurneys staring at the ceiling or florescent lighting. In addition, opportunity to serve circadian functions that support normal sleep / wake and mental activity cycles could be explored. Medical staff spend many stressful hours in the absence of the natural rhythm of the sun, and without associated respite. A hypothesis was proposed to examine the influence of emulating daylight on mental acuity by introducing temporal changes in the angle of light, simulating solar movement.
Hypotheses & Experiments:

- It was hypothesized that environmental variables influence stress levels that may be associated with patient healing and provider performance. It was further suggested that measurement of neural, endocrine and immune responses may reveal the association between specific environmental variables, stress levels, and healing, performance and satisfaction outcomes.

- It was suggested that increased stress levels may be advantageous for certain functions or environments, such as for the surgeon in the midst of a complex procedure, or the patient fighting to recover.

- It was proposed that observations of repeatable behavior patterns in hospital environments might reveal stress responses. Investigation should explore the environmental and physiological variables associated with those patterns.

- It was hypothesized that gender, personal history, and the task itself influence the stress response, and should be considered in any study. In addition, the context and condition of the environment exerts great influence such on responses.

Analysis of Stress and Functional responses in Intensive Care Unit settings

A case example of a neurological intensive care unit was discussed as such units are recognized as some of the most stressful environments for patients, their families and the clinical team providing care. Consideration was given to multiple neural systems and their influence on desired outcomes for both patients and staff. Thus, analysis can be broken down into sensory, motor, emotional and cognitive systems. The influence of environmental variables on these systems and the influence on function and patient, staff and business outcomes is described below.

Action, reaction and outcomes: Edelstein
Blog Programming

James L. Olds, Ph.D., John P. Eberhard, FAIA,
Meredith Banasiak Assoc.AIA

Jim Olds, Director of the Krasnow Institute for Advanced Study, George Mason University, described a novel system designed to collect and disseminate information about their programmatic needs to add 12,500 square feet of laboratory to its existing 25,000-square-foot higher education facility.

An open blog site was created to glean insights from the laboratory users (cognitive neuroscientists) about how they use their space and which environmental variables were of importance. The blog format provided space and a means to conveniently access each individual’s opinion without regard to schedule. Analysis identifies trends anonymously, by user function, task, or location.

“Because of the interdisciplinary—yet collaborative and communal—nature of the institute, each person’s input was necessary to develop a cohesive understanding about the way that a diverse group of people and their work come together.”

The Academy of Neuroscience for Architecture undertook an independent programming study, using the blog format to increase user input and to inform competing architect/contractor teams who often do not have much opportunity to research the Krasnow Institute’s existing culture and its use of space.

The information obtained was made available to competitors responding to Request for Proposals, hence offering pre-programming information early in the design process. In addition, a “honey pot” of information was posted on the blog to encourage data-seeking from the competing teams, and to feed them relevant programming data that would ideally materialize in their designs.

The contributions of the scientific investigators included testament to environmental factors of importance to the end users.

Giorgio Ascoli noted that:

“the trees (woodlands) are a source of inspiration in my study because the branching helps me visualize neurons. The window acts as a microscope in the office providing a view of enlarged neurons.”

Armed with this specific insight, the location, size, and orientation of windows and the conservation of trees can become integrated design elements in planning the offices and labs.

The blog system was found to be an effective and almost cost free system, to establish a virtual interface with self-sustaining feedback loops that could target users, contractors and architects. It created an electronic database that enabled design intent conveyed throughout the construction phases to follow, as well as for post-occupancy evaluations and to all trades involved in the many phases of design or construction.
Conclusions

Discussions at the 2005 Workshop on Neuroscience & Health Care Architecture hosted by the Academy of Neuroscience for Architecture reflected on the breadth and depth of information that may be required to translate scientific information into design applications. The participants recognized the need to incorporate the entire continuum of knowledge from anecdotal behavioral observations, to clinical and basic science experiments in order to validate design proposals. Whilst the principle of a broad basis of evidence was widely recognized, the concept of translating basic science into design was relatively unfamiliar. It became clear from discussions, that both scientists and architects desire examples of the application of this translational approach. Literature reviews will provide the first step in exemplifying how studies of cellular neural mechanisms can be related through a ‘battery’ of tests ranging from animal models to human studies. The value of incorporating knowledge from clinical research in addition to basic science was recognized.

In order to incorporate this burgeoning information base, the development of an integrated knowledge database designed to serve both disciplines is being pursued. Meta-analyses and research of validated data should be created to provide a substantial and valid base of evidence that would, in its breadth and depth, offer a sound foundation for the generalization of principles that could be more effectively interpreted into design theories and generalized into design applications and guidelines. Methods to facilitate the transfer of information between architects and scientists should be developed in order that building programs would better serve the function and influence of designed settings.
The following table exemplifies a discussion framework that can be used to focus dialog on principles from existing neuroscience results that relate to architectural issues. Questions posed are from neuroscience papers related to navigation and memory. Consideration was given to the data measurement techniques that could address the issue and provide information on outcome measures.

<table>
<thead>
<tr>
<th>NEURAL FUNCTION</th>
<th>ARCHITECTURAL ISSUES</th>
<th>DATA MEASUREMENT</th>
<th>OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place Fields.</td>
<td>What are the most easily remembered characteristics of cues, landmarks or nodes, etc.?</td>
<td>Path finding, Neural imaging, Ocular tracking</td>
<td>Efficacy in finding destination</td>
</tr>
<tr>
<td>Aging, illness and disability influence on navigation &amp; memory</td>
<td>How can cues be optimized cues for multiple modalities &amp; abilities?</td>
<td>Utilize wireless silicon intelligent systems</td>
<td>Universal proficiency despite ability or disability</td>
</tr>
<tr>
<td>Place cells respond to current location</td>
<td>How does knowledge of current location index memory of space?</td>
<td>Neuroimaging EEG and/or MEG</td>
<td>Efficacy of cues that index memory</td>
</tr>
<tr>
<td>Activation of hippocampal function at intersections</td>
<td>What is the optimal placement of navigation cues?</td>
<td>Observation, Neuroimaging EEG and/or MEG</td>
<td>Location of navigation cues for multiple navigation strategies</td>
</tr>
<tr>
<td>Visual priming</td>
<td>Which features assist priming?</td>
<td>Observation Visual infrared</td>
<td>Subliminal cues that assist navigation</td>
</tr>
<tr>
<td>Navigation strategies</td>
<td>Connecting movement between landmarks</td>
<td>Observation, Neuroimaging EEG and/or MEG</td>
<td>Navigation cues for different user groups and abilities</td>
</tr>
<tr>
<td>Virtual Navigation strategies</td>
<td>Computer strategies</td>
<td>Neuroimaging EEG and/or MEG</td>
<td>Investigate neural substrates. Explore navigation strategy &amp; cue efficacy.</td>
</tr>
<tr>
<td>Increased stress associated with impaired memory recall</td>
<td>How can cues be optimized?</td>
<td>Stress markers, Time to goal, Accuracy to goal</td>
<td>Repetition, number of cues, relationship of cues to rewards</td>
</tr>
</tbody>
</table>
Design Annotations: Bridging the Neuroscientist / Architect Gap

John Zeisel, Ph.D.

Annotation of plans is a useful communication method in collaborative and group design projects to identify neuroscience and behavioral issues in plans. This is in order to point out which are significant to the use and impact of the eventual environment, identify which have been addressed, and indicate which have been adequately responded to in design. Annotation simply means writing observations, comments, and hypotheses directly on architectural plans with the aim of making issues explicit and sharing them with others. What is difficult and requires time and skill is to do this without obscuring the message the plans themselves are intended to impart.

Four types of plan annotations can be used at specific points during the design process.

- **Issue identification annotations:** At the start of design, plans can be annotated with questions to be addressed in the next phase of design such as: “Wayfinding: Will this entry location contribute the most to building users being able to find their way easily?” and, “Privacy: Will the windows between the corridor and the offices provide enough privacy for employees to concentrate adequately?”

- **Critique annotations:** In design reviews during design development, plan annotation can be employed when research data and evidence are being brought to bear on design decisions. Critique annotations identify where behavioral and neuroscience design performance criteria are met well or are in need of improvement. For example: “Wandering or walking: Is the hearth destination at the end of the hallway path for Alzheimer’s residents in an assisted living residence large enough and clearly identified to make sense to them?”

- **Presentation annotations:** During the client review process, presentation annotations can focus the group’s attention on neuro-scientific and behavioral intentions and goals of the design. For example, “Territory: Laboratory work areas are clearly separated from all circulation to provide scientific teams with a sense of territory and cohesion necessary for creative work.”

- **Hypothesis annotations:** Plans can also be annotated as part of ongoing design research. In preparation for a post-occupancy evaluation study it is useful to draw out and indicate on the plans those elements that represent hypotheses that future research can test. These often are re-statements of presentation annotations in language that makes explicit how the design intention might be tested. For example: “Stress recovery: The employee cafeteria has been located on an exterior wall with access to a garden to reduce work-related stress (cortisol levels) as quickly as possible (time) when breaks are taken.”

In order to be most effective, critique annotations should describe positive as well as negative elements in the design. If annotations do not lay down a balanced viewpoint, authors of the plans are likely to react by either disregarding the annotations entirely (too negative), or focusing on improving problem areas while unwittingly making successful areas less so.

When presenting designs to clients, presentation annotations can be organized on plans to highlight selected attributes that respond well to Environment/Behavior/Neuroscience (E/B/N) evidence. For example, a presentation annotation for a hospital with an accessible therapeutic garden could point out how the garden is located and designed to improve patients’ recovery time after surgery. In a plan for a commercial setting, an annotation might describe how the location of a display near the entrance but off the main pathway is likely to improve sales of the item displayed, and why. Notice that these presentation annotation examples include a variable such as recovery or increased sales that a post-occupancy evaluation (POE) could eventually measure. Annotations help the design process move forward. Presentation annotations at the end of a design cycle can alternatively be treated as hypothesis annotations at the beginning of a subsequent cycle identifying testable hypotheses that serve as the basis for a future POE.
References


ii Academy of Neuroscience for Architecture; available at http://www.anfarch.org [accessed November 30, 2005]


