Neuroscience Laboratory Design:
Understanding the Cognitive Processes of Neuroscientists at work

Workshop Report

Dana Center, Washington DC
May 8 – 10, 2006

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The Academy of Neuroscience for Architecture (ANFA) invited neuroscientists to critically examine environments most familiar to them – their own laboratories and offices. By identifying key characteristics common to this end-user typology, and proposing hypotheses about the cognitive processes affected by these characteristics, we explored the interface between the neuronal and architectural aspects of laboratories and offices used by neuroscientists.

Neuroscience and Neuroscience Laboratory Design
John P. Eberhard, FAIA

On the surface we are here to look at Neuroscience laboratories, and how the design of Neuroscience Laboratories affects the cognitive activities of neuroscientists who work in those laboratories, and by the end of the workshop we want to have come up with some hypotheses about what those relationships could be. But underlying that, are the words that I would like to use by my one time colleague, neurophilosopher Patricia Smith Churchland, in her great book *Brainwise:* “The brain is what makes humans capable of making the Sistine chapel, or designing the Thorncrown chapel, or playing Chopin, it’s a truly astonishing and magnificent kind of ‘wonder tissue’. The brain is what makes us human”[1]. Neuroscientists by and large in their research regard the human brain as an organ to be studied at the cellular and molecular level, and we would like to look at it at the macro level.

The overarching theme of Churchland’s book: “If we allow discoveries in neuroscience and cognitive science to butt up against old philosophical (and architectural) problems, something very important will happen: we will see genuine progress where progress was deemed impossible”. These are still early days for neuroscience. Unlike physics or molecular biology, neuroscience does not yet have a firm grasp on the basic principles explaining its target phenomena. For those who have an architectural background, I would like to point out how much we use Physics in our work as architects, and yet there wasn’t a science of physics until the end of the 19th century! The scientists who developed physics at the end of the 19th century did not care very much about the design of buildings. It wasn’t until the physicist Sabine, who was working at Harvard, was asked to improve the acoustic quality of one of the theaters at Harvard that he began to make a link between what he knew from physics and what he knew as a problem from his architectural design issues. In doing so, he used the scientific method to solve the acoustical problem, and subsequently came up with what essentially is the field of architectural acoustics. Students in schools of architecture are exposed to the subject of architectural acoustics, and they also are exposed to lighting design, heating ventilating and air conditioning design, and structural design. All of those phenomena grew out of the basic science of physics. My hunch is that in the next 20 or 30 years, there is going to be the same phenomena grow out of the base of neuroscience, and we will begin to make connections between the kinds of problems we try to solve as architects and the kind of knowledge that is available from neuroscience world.

And that’s the business that we are in. ANFA is trying to build intellectual bridges between the world of the practice of architecture, and the world of research in neuroscience. So, we are going to get your brain started thinking about the subject of the design of laboratories: the architectural challenges that neuroscience laboratories pose to the architectural community, and the kinds of issues that neuroscientists see as important to them when they ask that a lab be provided for their work.

“The opportunity here is: How well does this building actually support the idea of creative problem solving? One of the issues I have thought about prompted by discussions here - to what degree does

the researcher perceive or understand, even at a subliminal level, how the physical environment of the labs or the lab complex really changes his/her ability to do the work? And I think the point is about having choice – having the ability to be in a place that may be open, and loud, and full of people, but to be in a quiet and reflective area with palm tress and bamboo when you want. Instinctively, I would like to believe that it should provide you the ability to change modes of thinking, to break creative log jams if you are stuck. I know that works for me as an architect, and I am curious to know whether it works for scientists."
Roger Goldstein, FAIA


The Brain and Cognitive Science Complex, MIT
Goody Clancy

Workshop presenters included three "experts" on Neuroscience Laboratories offering three unique perspectives for consideration in the working groups to follow: an end-user Neuroscientist's view, An Architect/Laboratory Designer's View, and an ethnographic researcher's view.

1. A Neuroscientist's perspective
Neuroscience Laboratory Activities
Eduardo Macagno, Ph.D.

Common to Most Research Labs:
- Accomplish and Publish research results
- Train the next generation of scientists and technicians
- Foster exchange and communication

What is a research lab. A research lab is a place where funded research is accomplished, and results are published. Communication is important to this endeavor, by thinking through what you have done (or plan to do) and telling someone, you are beginning to publish it. A research lab trains the next generation of scientists and technicians, hence education and instruction through exchange and interaction are important to the goals of a research university.

What neuroscientists do. Neuroscience is studied in four dimensions – including time. Work encompasses multiple scales of interest: from nanoscale at the atomic level (single sodium atoms moving through a channel), to large molecules and cells, to living organisms such as complex primates. Some neuroscientists work on simple organisms, measuring the activities of individual neurons such as their firing action potentials and chemical signaling. Others work on the brains of larger organisms. Research spans multiple scales. Work can be extremely invasive on model organisms, to much less invasive when working with the human brain. Ultimately, neuroscientists are trying to figure out what nerve cells are telling each other in order to gain a better understanding of how those events underlie important processes like consciousness and memory.

Neuroscientists are trained in different ways, and come from different background such as physics, chemistry, psychology and engineering. The field of neuroscience is extremely multidisciplinary.

Specific to Neuroscience:

- Neuroscientists study the nervous system, structure and function, in 4D, both normal and pathological
- Our work encompasses from atoms and molecules (small and large) to intact living organisms
- Our approaches span from chemistry to physiology and behavior, psychology
- Our subjects include worms and primates, including humans, and many in between
- Our methods are heavily instrumentation based.

How neuroscientists work. Neuroscience research is heavily instrumentation oriented. The precision of the instrument is dependant upon having control over environmental conditions: vibration, temperature, air flow, light, sound, odors, electrical and magnetic fields. While certain instruments require isolated and shielded rooms which are specialized and fixed conditions, there is also the need to be able to adapt and shift laboratory design as experiments change and technology is updated.

2. The Architect's Perspective:
Architectural challenges to Laboratory Design
P. Richard Rittelmann, FAIA

(INSERT PICS OF EQUIP – fMRI)

In order to understand how neuroscience knowledge can impact the architectural design of the neuroscience laboratory, there is a need to understand the variables, the programmatic considerations, involved in neuroscience research. Neuroscience research is changing much more rapidly than the architectural environment is able to respond and adapt to such change. In anticipation of future research methodologies and the impact that they will have on space and programmatic requirements, it is necessary to begin to identify the drivers of the research. One trend which has emerged over the last decade is the decreasing scale of research; ten years ago scientists were working at the 40μm --50μm scale. Today they are working at the nanometer scale. The shift in scale from macro to micro experimentation is causing major changes in lab requirements, such as:

- Enormous increases in electronic equipment.
- Major impacts on elecrical power and grounding.
- Significant EMI / RFI problems.
- New (reduced) limits for vibration control.
- Finer requirements for temperature and humidity.
- Major changes in laboratory configuration.
- Reduced emphasis on "benchtop" chemistry.

More power with greater precision, improved vibration criteria, and shielding will eliminate the independent variables from the research.

Current measurement techniques in neuroscience, such as neuroimaging, require large pieces of equipment and precise housing for the equipment. The result is that the research equipment dictates the architecture. The design of a neuroscience laboratory is becoming equipment-based, designed to enhance the receipt of the equipment, rather than people-based.

Laboratory planning is often based on an 80 year old model of the lab. Such laboratory design is not responding to the way in which experimentation has changed. Instead of forcing equipment to adapt to the model of existing labs, and assigning people to occupy the leftover spaces, it is necessary to address the specific requirements of the equipment and to design the appropriate interface between the equipment spaces and the occupant spaces.

Equipment spaces, while highly complex and expensive, should be regarded as secondary spaces in the building as it is the interactive spaces where ideas are shared, challenged, discussed, and defended.

National Institutes of Health
Porter Neuroscience Research Center (CITE)

3. *An ethnographic researcher's view*
Environments for Discovery
Margaret Alrutz, Steelcase Research and Development, Workspace Futures

Understanding the Cognitive Processes of Neuroscientists at work, the topic of the workshop, can be aided and inspired by an understanding of the everyday activities of the neuroscientist, at the human versus the building scale. Laboratory design is a complex business as it requires careful consideration of multiple elements such as: energy, site, materials, people and mechanics. Much of the research on laboratory design deals with the equipment and the materials, while information about the activities – the people and the work they are doing – is sparse. Through a strategy of observing people in the field - going into their workplace, asking them about their milieu, and using their environment to relate information about it - insights can be gleaned as to how scientists see themselves, how they demarcate space, and how they interface with the equipment. Thus, insights about work processes such as work flow, concentration, creativity, and communication can be made evident, and furthermore can serve as an inspiration for developing hypotheses about the relationship between the activity and the environment.

To facilitate discussion and an understanding of your activities as they relate to neuroscience laboratory environment, each of the neuroscientists attending the workshop was asked to complete a Photo Survey and log of their respective laboratory environments. They were asked to identify and record specific spaces associated with behaviors and performance outcomes, such as "The place in your building most often used for collaboration". The neuroscientists acting in the unique position of both "researcher" and the "object of the research" provided raw data to the group which was then synthesized and utilized as background information during the workshop sessions.

This "discovery through observation" approach brings to light not only individual activities, but also the underlying laboratory culture. For example, scientists tend to see their own labs in terms of modules and stations; lineal footage of a lab bench can reveal professional hierarchy. Issues of territory are manifest at both the individual and group level. One scientist remarked that, "sharing a rig is a sure way to break up a friendship". Spaces designated for the people using the equipment, and not just for the piece of equipment itself, speak to issues of territory. Making small accommodations in the lab design to create, for example, creating a feeling of a village versus a big corporation, has the potential to increase productivity.

Neuroscientists need not only their own space, but also require different types of spaces. One of the neuroscientist participants reported that he spent 30% of his time doing experiments, and 70% of his time writing and collaborating, "A lot of time is spent thinking 'what is the right question?'." The nature of which requires concentration and spaces free from mental and physical distraction.

Working Group Reports

*Interdisciplinary small groups assembled to engage in directed discussion on one of four topics: Creativity, Productivity, Stress and Memory. These topics were selected as specific performance characteristics of laboratory related activity. Participants examined a) the brain processes involved in each performance characteristic, and b) the potential contributions the designed environment makes to each. The groups we*re asked to employ their interdisciplinary knowledge and background to flesh out potential connections and convergence points in order to arrive at relevant relationships and hypotheses according to the e*nvironment/brain/outcomes matrix and hypotheses framework developed in previous workshops. Refer to Appendix I, Methodology: Developing Neuroscience/ Architecture Hypotheses*[2] *by John Zeisel, Ph.D.*

- Creativity

Major question

How do environmental conditions facilitate or hinder neural aspects of creativity and discovery in scientific investigations? In identifying key research topics related to constructing answers to this question, the group may also wish to consider: What it means to be creative in neuroscientific terms? What it means to be a creative neuroscientist? What creative processes are specific to scientific inquiry? What are potential influences or obstacles to creative output in the lab?

Background

"Creativity is the epitome of cognitive flexibility. According to Scheibel (1999), 'we must assume that the more nimble the prefrontal cortex, the more capable it is of playing with new combinations of stored items' (p. 3). The ability to break conventional or obvious patterns of thinking, adopt new and/or higher order rules, and think conceptually and abstractly is at the heart of most theories of creativity. Moreover, the fact that stored knowledge and novel combinations of that knowledge are implemented in two distinct neural structures is critical to understanding the relationship between knowledge and creativity, as well as the difference between creative and noncreative thinking.

Problem solving is marked by impasses, particularly when the solution requires 'outside the box' thinking. One common method to overcome impasses is known as incubation, which *'refers to the process of removing a problem from conscious awareness temporarily as a means of gaining new perspectives on how to solve it' (Finke, 1996, p. 389)."*[3]

Creativity happens randomly
Cross fertilization in your brain (incubate)
The space should not impinge on you negatively and keep your thought process going. Does not make you creative but reduces stress and allows you to be creative. (flow)
Sometimes your most creative moments come from visiting other peoples labs (outside portals)
Reflect
Talking while thinking
Communicating your thoughts
7 plus or minus 2
Jonas Salk escape from abject failure (spiritual inspiration, keep you going in face of failure)
Different kinds of inspiration (St John the Divine, releases you in different directions)

Intersection and overlap for communication
    between lab teams
    between lab and office
Feeling of having something on the tips of your tongue but in your mind and talking with your colleague and something clicks (activity, getting something surfaced to get feedback for you brain) (getting better access to memories and subconscious)
Connection between conscious and sub-conscious (lost in Alzheimer's patients)
Connection to history and knowledge, feel good being with my books (library, etc. for old knowledge and experiences) (lateral and sequential)
Need the feeling of being in a big space like housing trends of house that takes up entire lot (american? prestige)

Top ways for getting inspiration:
Society for neuroscience meetings (overwhelming, decide what experiment is worth doing)
On-line discovery, somewhat counterproductive because you filter things that are not closely related to what you are doing, print used to just read all abstracts, trading bringing in something new
Retreats like Woods Hole and taking an intensive course
Order and logic? As managers logic and order become a quintessential need and depend on asst to keep order and not disappear. But as undergrad, grad or post doc they are looking for less order to get ideas. First do random experiments to then bring order to it.
Need to have blank walls. In the lab there are no walls because we have shelves to store things. Every year we try to get post-docs to present their work. Museum of what has been happening in the lab for five years and how ideas have changed over time. Institutional memory of the science (storage and retrieval) Institutional memory tends to be within the PI but the time of that person is highly circumscribed.
If space can be designed to access all these kinds of creativity
20 year old employee talking about a large document. Was not looking at a hard copy of the document and could place the changes in the digital document easily.
Design principle that says "make or force people" is not as good as "allow"

Three principles: transparency, proximity, public space
Neuroscience questions: stimulation/stress, ind/group, order/chaos
Stress is overstimulation

Understimulation also develops pathologies
Appropriate level of stimulation changes from ind to ind and time of day, etc. (e.g., could not quite cut other team out of our conversation in breakout team, that's one place where stimulation became stress, but this changes depending on circumstances)
Balancing stimulation levels = group stimulation and stress levels
No earphones because might miss a dangerous incident and also a negative signal
Stimulation is something that happens outside your head. Stress happens inside your head.
Good and bad stress, fighter pilots for short periods.

In an open and active discussion, what is going on in your brain inbeing modified by what you are hearing, common thought process as a group that is a subconscious undercurrent. (groupthink)
Nobel prize winners had a pattern of being able to do whatever they wanted in their labs, no constraints. (Eduardo: if you take a different set of Nobel prize winners you might find something different)
Creative process has different stages, early ones being very gentle approaches, many approaches and retreats (Cal IT2 open plan and being in the middle ground of being too easily distracted)
Process may be explicit for learners and more off-hand for experts (creative and communication processes) important because this is an academic situation where there are clear levels of experience and reliance on learning from each other
Labs that are trying to understand how the brain works may be an order more complex than basic chem or bio labs with standard prodecures
Order/disorder.
The less you know the more disordered you have to be (Eduardo)
You make no progress if you are not disorganized enough because you are not bringing enough things to bear. To discover something you do not already know and therefore have a messy path. More relational and network.

Students are open to seeing things and not having preconceived ideas and making discoveries that the experienced scientist may not be open to
Playroom of confusing environment, private thinking room

What do we need as baseline measurements before we conduct these experiments?
How measure outcomes? What is baseline?
Change in pattern of activity of brain that leads to more creative dimension
Brain activity that demonstrates a change in response to an experimental condition such as enriched versus impoverished environment.

The knowledge base that one begins with, such as EEG technology, demonstrates commonality of brains across individuals, and 'noise'.
First step is to demonstrate a repeatable baseline of EEG activity in a single environment. Thus, neuroscience may not be the entire answer for correlating neural activity with decision making and the ultimate pathway that leads to behavior in a changing context. Technology is advancing toward the goal of measuring the human response in the real environment, and in terms of creativity, which is so ephemeral.

Space planned for high interaction can prime individual to problem solve by controlling stress and stimulation levels.
Concentrative work supports creative activities.

Size of group and relative space can support the creative output - The right density of people is conducive to creativity.

Interaction: individual versus group activity
Perception: How people encounter the environment
Learning/ Problem Solving: Learning is affected by the nature of the environment.

Learning and enriched environments during teaching activities has an effect on subsequent performance of individual and team students.
Sound, light, temp, content display
fMRI
EEG pre and post class experience, Measure learning in 2 different environments.
More discussion, questions, change in animation during class

Eg. Student competition
Environ character around student differs
Over what period of time could measures be made (neuro innovation)

How design experimental situations and establish a baseline? Begin be determining appropriate ways to measure (w/o making hypotheses about the environment). Review of literature: how do we measure creativity? Need baseline over one month to show difference with learning
Absence of any knowledge whatsoever
First step
Look at literature
Set baseline
Then look at interactions

How get more neuroscientists involved
Will if go back to nsi that YOU could measure
Baseline information on which some of these ideas can be tested

Schwartz center EEG

Still not seeing the connection, apart from intellectual level
Need to get down to experiments

Steve
Creativity and decision making
Never thought of in context of environment
Still struggling with how to measure ephemoral nature of what what to study

One of most important questions want
Dalai lama and bush as baselines

Joyce
Problem compounded by lack of design of environments that are explicitly created to enhance specific to the task
Put people in similar environments to do different types of tasks

Melissa/Mike Mobley, BioDesign Institute:
Have designed spaces of interaction…
Goal was to create human feedback loops through spatial adjacencies – forced interactions (Engineers next to Microbiologists)
Post-occupancy – what works, what does not work?

- Productivity
Major question
How can environmental conditions positively impact neural aspects associated with productivity in laboratory research? In identifying key research topics related to answers to this question, the group may also wish to consider: What are appropriate measures of productivity unique to scientific inquiry? What are potential influences or obstacles to productivity in the lab? In laboratory productivity what role is played by competition, communication, and focus of attention and how can environment influence these? What traditional design solutions implemented in the work environment to enhance productivity might be particularly appropriate for laboratory work?

Background
"Productivity is the amount of work done in a given amount of time: P = W/t. Traditionally, time management has consisted of increasing productivity (P) by increasing the work (W)—squeezing more out in the same lump of time. By this math, time (t) never decreases. That's not time management, that's work management. There is a better way: What if we could increase productivity by leaving W alone and making t smaller? What if we could slow down time, make each moment seem to last longer so more work could be extracted from it? ... Neurobiologists are slowly coming to realize that "real time" is just a convention foisted upon us by our brains. In any given millisecond, all kinds of information—sight, sound, touch—pours into our brains at different speeds and is reprocessed as hearing, speech, and action. Our perception of time can be manipulated in ways that researchers have already begun to exploit."[4]

PRODUCTIVTY = Getting out the Product
Bill
Measures of Productivity

Creativity is necessary for productivity, but it is not sufficient (SEE DEF OF CREATIVITY)

The output criteria in basic science (= a measure of success) are:
Refereed pubs: number x quality x impact/importance
Citations
Fewer errors in research

Training of docs and post docs (quality of placements)
Proof of concept for production
Outreach to community
Productivity of individual, sum of individuals, and team
Patents (productivity not creativity)

Number of pubs x quality of pubs x impact
75% important
6 publications = standard that you have made it.

Perspiration = productivity
Inspiration = creativity

Environmental factors:
Productivity
Not in communication spaces
The group considered -
Interaction space
Ways to keep people in the lab – e.g. Ping pong table
Daylight
Nature
Repeat experiments
Visually rich
In lab collab spaces
Easy reconfig
Large small shared lab
Seredipidous meeting spaces

Brain issues:
Mood = happy excited
Stress
Optimum stress levels
Over
Relaxes
Cognitive rehabilitiation
    Kaplan – nature can reduce stress
Energy in / out ratios:
    Energy spent coping with negative environments is NOT energy spent being productive.
    Space .. status .. Jacquiline Fisher
Bonding
    Board work commun – help each other – altruistic
    Interactions in the hallway
    Know more than others
Caring/Nurturing

Not among other animals (!!! How define???)
Non threatening

Executive control
Focus of attention

BEHAVIORs:
Working long hrs
Share data and concepts
Test ideas
Pay attention to sensory demanding tasks
Focus on repeated experiments
Accuracy and precision in experimentation

Dick (Richard)
Productivity in office work place
Job satisfaction

Effect of workplace on job sastisfaction
(from Mike Brill)
10,000 people surveys
BOSTI = Buffalo Organization for Social and Technological Innovation

BOSTI Associates (the Buffalo Organization for Social and Technological Innovation), founded by Mike Brill, is a Buffalo, NY based group with a 30+ year history of continuous innovation in workplace planning and design, based on active research in each project, and informed by extensive experience with comparable situations.

- Our rigorous, research-based client engagements are documented in a proprietary database of information encompassing 21,000 people in some 120 organizations in many industries, used to enrich and inform our workplace analyses and consulting processes and recommendations (http://www.bosti.com/about.htm)

Productivity as a financial investment: companies want ways to increase productivity and affect human behavior. This brings a good justification of WHY to do the work.
tech
pay
advance
skill to task
analyss direaction
work life bal
95%

team performance 11%

owner 24%

10 year interval:

measure productivity change relative to influence

new cost	3.8%
furniture	0.8
maint operations	3.5
technology	10.2
people	81.6%

If you know the brain stuff, can change what environment does to brain response
Gives alternatives to create change

What is a real metric for productivity in a research environment? Is it a psf measure?
Richard
How to make impact with research must communicate results in meaningful way

Hypoth:
Day and daylight with views reduce cog fatigue and enhance attention / clarity, perform longer in experiment cycles
Experiment cycles are lengthy; therefore, you want to account for time to rest and relax in order to increase focus and decrease errors. Improved attention, memory and clarity-> ability to focus.

Focus
Muskudo skeletal tension
Eeg
Galvanic skin rep
Cortical imaging over time

Attention
Decision making
Cog function

Hypoth:
Exercise results in reduce cog fatigue and enhance attention / clarity, perform longer in experiment cycles (bobby Fisher hypothesis).

Epinephren, dopamine, serotonin, cortisol

Arch solution - Exercise room or space. Therefore include an exercise room.

Issue:
Spatial configurations of manager and research team.

- self-motivation
- individual control of sensory aspects to decrease stress.
- Ambient environment = control, quality

Hypoth:
Close proximity of lab manager to research team results in sense of reward punishment that results in optimal stress

Location of proximity, visual access to and presence of supervisor (reward/punish)
Cortisol bp

Hypoth
Individual control sensory aspects of ambient enviorn result in reduced stress, enhanced attention, productivity

Ambient, vis, therm, acoustic, comm., degrees of commun, ambient
Control (executive .. I am in charge)

What happens in the brain when feel increased sense of control?

What is the relationship between control and immobility to stress?
Conflicting "I"s .. different needs

Richard
Ability, desire to control increases with sense of immobility
Frustration, stress

Hypoth

Physical qualities of lab (air, vibration) contibute to stress
Reporting of information about environment is important to individuals, and provides an underlying tension regarding the lack of quality of the environment. Levels of insecurity about meeting needs for experiment, resulting perhaps in errors, or reduction of productivity
Communicating information about the facility will increase the level of security.

Hypoth

Relationship between open and closed space:
Optimum relationship between open, collaborative space in the lab, and closed territorial space that must be achieved. Need to have the option of both types of spaces.

Level of choice, time diary, squre foot ratio, eeg, gsr, musk skeletal tension,
Rhythm of group

- Stress
Major question
How can environmental conditions in the laboratory temper biological aspects of stress? In identifying key research topics related to answers to this question, the group may also wish to consider: What psychological, social, physical, and emotional stressors are unique to scientific inquiry? What are examples of positive versus negative aspects of stress in the lab? How can laboratory environments be constructed so that the optimum stress for creativity and discovery is achieved?

Background

"To understand the difference between good stress and bad stress, said neuroscientist Robert Sapolsky, consider the fact that a roller coaster ride lasts for three minutes, not three days. 'There's a reason that we'll pay money to go on a roller coaster and be terrified' for a brief period, said the Stanford University professor. This kind of stressful episode can be invigorating and empowering, he said. Blood circulates better, senses are heightened, memory sharpens, energy peaks and chemicals producing pleasure increase in the brain. But if that same stress continues for an extended period, Sapolsky said, the body continues straight downhill.

To explain how different people respond to chronic stress, Sapolsky used the analogy of living in New York: For someone with good mental health and a strong social support system, he said, the city offers an exciting life and an intense, beneficial sensory experience -- good stress. But if you are someone who has developed a lot of scar tissue putting up with what the city can throw at you, or you live in a place with no running water and drug dealers on the corner, the city and its stressors can be 'one more nail in your coffin'."[5]

Presentation:
Problem: How can laboratory environments be constructed so that the optimum stress for creativity and discovery is achieved?

Stress Defined: "Any external stimulus that threatens homeostasis, the normal equilibrium of body function"* ….
"Lack or loss of control is a particularly important feature of severe psychological stress that can have psychological consequences"*
Adaptation to stress is possible – memory / experience / learned / rewarded event
Stress caused by *Neophobia*
(Neophobia = fear of "new", dislike of change)

What causes stress for a neuroscientist?

- Financial Pressures
- Scientific Experimentation
- Product / Output … Publication
- Peer Criticism
- Patents … Translational vs. Academic Freedom

What reduces stress?

- visual contact
- choice
- control

Stress is not always bad.

"The psychology of optimal experience" –
Getting into a state of flow* requires:

- Difficulty of task / challenge
- Time constraint
- Appropriate level of stress

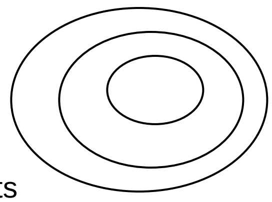
The environmental and emotional conditions for achieving flow* vary by individual and are generational.

Getting in – Being in – Relief from

    - Exercise
    - Shower
    - Starbucks
    - Airplanes
- Different environmental conditions for different cognitive activities
- Different performance outcomes require different optimal stress levels

<u>Our hypothesis</u>:
The individual's ability to control environmental factors is correlated to higher effectiveness and is a function of his/her degree of stress.

Notes from session:
(Joyce) Proximity – closer to things = better
Levels of security versus interaction:



1 – individual
2 – lab
3 – institution (all labs in bldg)
4 – outsiders = human subjects, students

How does stress enhance or prevent performance outcomes (memory, creativity, productivity)?
Flow = optimization of experience (CITE: Mihaly Csikszentmihalyi, PhD, 'Flow: The Psychology of Optimal Experience,' (Harper & Row, 1990)). Parameters that are required for flow: - certain level of difficulty, time constraint, some anxiety about completing the goal (a healthy dose of stress), loss of sense of time. Cycle of Flow > < Relief from flow.
To get into flow, you need the appropriate amount of stress.

Stress versus anxiety: anticipation versus fear

Stress is not always bad. Stress is not always the same type or degree.
- We have different environmental conditions for different cognitive activities (see Interviews)
- We have different levels of stress for each activity,
- We have different performance outcomes based on stress levels.

Systems in the brain – circuits and chemicals - have evolved which perceive and react to stress. This is a high interest topic b/c of drugs that decrease anxiety. Chronic stress is debilitating versus mobilizing. Adaptive phenomenon.

Sensory events (afferent) -> processed and distributed in circuits (hypothalamus, amygdale, prefrontal cortex) -> efferent action (alert)

Stress is movement away from homeostatic conditions. Inappropriately high levels of stress leads to disease and death – is a compromise of homeostatic mechanisms.

Environmental means to decrease stress:
- Individual control over environment (light, views, privacy, temperature) & control over the ability to get into and out of flow. Control over the environment is key to stress management.

Stress is decreased when you have control over it. Adaptable. Control of distractions, of comfort -> make things familiar.
- Neophobia = fear of the unknown
A quiet mind can be achieved through emotional and environmental support

Open labs = flexible, collaborative, interdisciplinary, dynamic – respond to a need for change (versus static equipment).

Productivity = effectiveness, efficiency and innovation
STRESS
Neophobia
Stress cause dislike change

What causes stress for neuroscientist
Financial
Scientific experiment
Prduct / output publication
Peer criticism
Patents
Translational – scientific endeavor related to translation into application
vs academic freedom

What reduces stress
Visual contact
Choice
Control

Stress is not always bad
The psch optimal experience
Getting into state of flow
Difficulty of task – challenge
Time constraint
Appropriate level of stress

Envir and emotional conditions for achieving flow vary by individual and generation
Getting in being in relief from
Stimulation / deprivation :Exercize, shower, airplane, starbucks

Who are you solving for
Focus on PI controlling a situation

Benchtop people .. diff needs

WHAT TYPE OF NEURO LAB??

Different env condtions for diff cog activities

Diff perform outcomes require diff stress levels

High stress

Low stress

Lo perform hi perform

Product bell curve

Stress

Andreas

NEED 3D thinking tools

Stress .. env condition .. productivity (shorter time, less money, more quality)

Think each block at at ime

Env cond that can be controlled

Visual privacy
Acout priv
Light
Respite
Security
Distract
Interact
Scale
Each is experimental condition

Hypoth
Indiv abilty to control env factors is correlated with higher effectiveness and is function of their degree of stress.

Stress *opt productivity
Level

Atten, aware, distract
Level stress
Musc skel tone
Alert
Eexec

Sympathetic tone
Conceptual thinking

Correlate both stress and productivity
Weakly able to assess simultaneous
EEG
Evoked pot
CRF
Cant now meas stress directly as one single entity

Behav
Indiv and group perform

Pre post occ
Ethnographic
Participatory design at up front of design

Outcome
Ability to attain flow
Paper
Lab report
Present
Effective collab
Experience
Time
Money
Quality

- Memory
Major question
How can environmental conditions facilitate neural aspects of learning and memory in scientific investigations? In identifying key research topics related to constructing answers to this question, the group may also wish to consider: What learning processes are unique to scientific inquiry? What are potential influences or obstacles to learning, teaching, and memory recall in the lab?

Background
"To remember something a person must do three things successfully: acquire a piece of information, retain it, and retrieve it (p. 277). Learning refers to the acquisition process and memory to the storage and retrieval process (p. 300). Learning can be defined as a permanent change in behavior as a result of experience (p. 300)." [6]

- Hypothesis: Sensory rich environments stimulate recall and creativity -> What is "rich"? and what becomes distraction?

Broad band noise influences learning and memory. Background and signal noise.

Is there a value in retaining outdated equipment as artifact/source of inspiration? Issue = history and memory. The "Alexander graham bell effect" – preservation of artifact as an aid to memory recall. There is personal but also institutional memory and value. Human capitol and social capitol = intellectual capital of organization. If add artifacts – you get the knowledge capital of an organization. Artifact's ability to generate internal cuing – (example of a clean drug addict when shown a picture of where got drugs). Artifacts help us remember the past.

Proximity of write up space to lab space – serves short term memory function.
Which technologies support memory? Ipod, implant – these keep us in isolation
How technology changes our interactions – socially, memeory cuing?

7. Conclusions

What ways could these questions be tested? What is the appropriate paradigm to study these questions?

Bill
Specific proposals that one could encourage
Flesh out before go
Come along way..more substance

Ed
Seed funds for simple, early studies
25-50K
RFP

pilot experiment to flesh
that will attract nsi who don't yet see how to incorporate

need to codify the field
bibliographies
make accessible on web page

commission with seed money tht would allow lab EEG to hire student to do experiment with volunteer
this will get interest of community
sees legitimate follow of scientific endeavor in their perspective

don't drop out because don't like ideas, don't see how they can provide an input

at early stage of understanding what brain is doing using our measurement systems
can measure heart, persperation, anxiety
want to see what brain is doing that gives clue about what interaction with environment means

proactive in creating field
fund raising should be applied to put together proposal to seed ideas in neuroscience community. Money should go to funding projects in the neuroscience community.

Business Opportunities:

- Accenture
- Pharmacetical corps building a lab
- Baseline research with bill – set up situations to generate research (for new lab bldg)
- Robert wood Johnson foundation

bill
evoked, event related potentials, must repeat stimulus 50-100 times to see signal
how measure with creativity.
Cant predict when, how long, how to have again
Needs clever design to learn in pieces
That is legitimate question that they would like to develop – a design of how to record brain activity of creative aha moment .. no good control

Gehry
Sfn at aia

Additional material:

208 Words

Understanding the Cognitive Processes of Neuroscientists at Work

The Dana Center in Washington DC hosted a group of 30 neuroscientists and architects for a three-day workshop, May 8 – 10, on "Neuroscience Laboratory Design: Understanding the Cognitive Processes of Neuroscientists at Work". The event, produced by the Academy of Neuroscience for Architecture (ANFA), provided an opportunity for neuroscientists to critically examine environments most familiar to them – their own laboratories and offices – in an effort to foster dialogue exploring the interface between the neural and architectural aspects of these environments.

The welcome address, led by **William Safire**, chairman of the Dana Foundation, and **John Eberhard**, ANFA's Founding President, was followed by a series of presentations describing the broad range and the specificity within that range of what constitutes a "neuroscience lab". Teams of interdisciplinary working groups spent a day's session examining Creativity, Productivity, Stress, and Memory, the performance outcomes of a neuroscientist. Recognizing that different environmental conditions exist for different cognitive activities, the general question posed to the groups was: what might be the environmental characteristics of a "cognitively reinforcing space", and how can we test this? By fleshing out potential connections and convergence points between a neuroscientist's physical space and the desired performance outcomes, the working groups were able to hypothesize about how these processes may be influenced by the designed environment.

Steelcase's Margaret Alrutz interviews Dr.

The workshop concluded with presentations from each working group speculating on potential research questions and hypotheses, appropriate metrics and “baselines”, and how to construct research paradigms in which to study these questions. For example, the group on Memory suggested potential fMRI studies on contextual and technological means of stimulating recall and generating internal cuing, while the group on Creativity discussed the sociological implications of creating positive feedback loops and collaborations through spatial adjacencies.

ANFA was established in 2003 to promote and advance knowledge that links neuroscience research to a growing understanding of human responses to the built environment. ANFA became a partner of the Dana Alliance in 2006.

This workshop was made possible by the generous financial support of Steelcase, Inc., and additional funding from the Dana Foundation. A workshop report will be available on ANFA’s website in the upcoming months: www.anfarch.org.

Photos courtesy of Weiner Productions.

Appendix I

Methodology: Developing Neuroscience/Architecture Hypotheses[7]
John Zeisel, Ph.D.

"What is nice about what is happening (with the ANFA initiative), is that it is neither a break with the tradition of architecture, nor a break with the tradition of the behavioral sciences in architecture. It is an addition and growth, and building on 30 years of trying to figure out the linkages. We know that the environment affects people, but what this is allowing us to do is to figure out the how, and the what, and the why by going into the brain in order to get a better evidence base for what we do as architects."

Variables

There are at least three sets of variables implicit in each set of questions asked of the working groups: environmental design, brain processes, and performance outcomes.

Environmental design. This variable comprises characteristics of the physical environment—in this case of laboratories. Subsets of variables include such characteristics as:

- Objects, spaces, relationships, and circulation
- Scale, size, volume, …
- Materials, colors, textures, …
- Ambient conditions of heat, sound, humidity, air changes, …
- Views within and views out
- And so on

(This list is meant to indicate the range of considerations in this variable. It is not meant to be exhaustive.)

Brain processes (neural activity). This variable deals with brain (neural) activity that mediates environmental design influences on behavior, feelings, mood, and so on—essentially the neuroscience of the equation. These include all levels of neuroscience.

- Levels of consciousness
- Gene activation
- Associative brain systems
- Neurotransmitter release and uptake
- Evoked potentials
- And so on

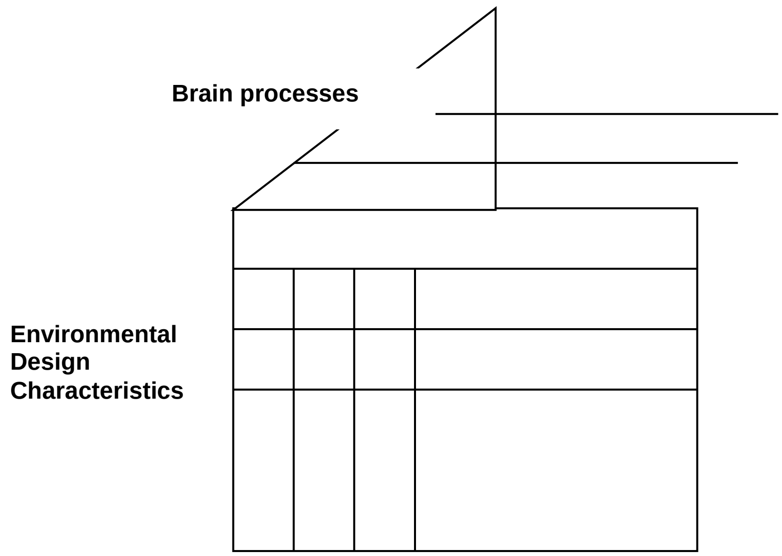
(This list is meant to indicate the range of considerations in this variable. It is not meant to be exhaustive.)

Performance outcomes. This variable deals with individual and group behaviors that the environment is intended to affect. These include such variables as:

- Degrees of creativity of thought
- Degrees of learning
- Individual and group performance
- Appropriate levels of stress
- And so on

(This list is meant to indicate the range of considerations in this variable. It is not meant to be exhaustive.)

The following 3 dimensional matrix indicates how these three major sets of variables interact and can be addresses in hypotheses:



Developing Neuroscience/Architectural Hypotheses[8]

In previous ANFA workshops the following model was developed for robust neuroscience hypotheses connected to environmental characteristics. The model indicates the discrete elements that constitute an E/B/N hypothesis: physical environmental characteristics, neuroscience dimensions, physiological factors, behavioral outcomes, and performance outcomes—with measurement techniques suited to each subject matter.

Model for E/B/Neuroscience Design Research Hypotheses				
Domains of Study				
Design	***Neurosciences***		***Behavior-performance***	
Variables in each domain				
Physical environmental elements	***Neuroscience dimensions***	***Physiological factors***	***Behavioral outcomes***	***Performance Outcomes***
Measurement techniques targeted to specific disciplines				
Measures describing the characteristics of environment such as plans and dimensions	***Neuroscientific methods to measure this dimension such as PET scans, MRI, and ERP evoked potentials***	***Indicators of physiological reactions such as cortisol saliva tests and blood pressure readings***	***Behavioral observation and other measurements such as systematic observation, photography, & self-report***	***Paper and pencil test, performances, portfolios, expert judgment***

Were we to turn the discussion above of the relationship between environments in Neonatal intensive Care Units (one of the topics in a previous workshop) into a set of hypotheses for future research, the hypotheses generated employing this model might look like this:

E/B/N Design Research Hypotheses

That the light and noise characteristics of neonatal intensive care units, if not controlled to respond to the developmental needs of premature infants, will have both immediate and long term negative health impacts on the person's auditory and visual systems and associated behavioral and performance outcomes.				
Domains of Study				
Design	***Neurosciences***		***Behavior-performance***	
Variables in each domain				
** Lighting intensity, duration, and frequency * Sound levels*	**Neuronal development in auditory and visual systems*	**Characteristics of the eye and ear*	** Ability to discriminate frequencies * Myopic vision*	**Hearing problems, lack of musical skills, and learning and work problems*
Measurement techniques targeted to specific disciplines				
Lux and decibel measures	*PET scans, MRI, ERP evoked potentials*	*Physiological interventions—CAT scans*	*Auditory testing, vision tests*	*Test scores, school performance, job performance,*

[1] Churchland, P.S. (2002). Brainwise: Studies in Neuorphilosophy. MIT Press. PAGE NUMBER! The term "wonder tissue" adopted from philosopher Daniel C. Dennett.

[2] From Zeisel, J. Inquiry by Design: Environment/Behavior/Neuroscience for architecture, interiors, landscape, and planning, Second edition, W.W. Norton, New York, 2006 (Chapter 14)

[3] From: Dietrich, A. (2004). The cognitive neuroscience of creativity. *Psychonomic Bulletin & Review, 11,* 6, 1011-102.
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Finke, R. A. (1996). Imagery, creativity, and emergent structure. *Consciousness & Cognition, **5***, 381-393.

[5] From: Simon, C. (2005). To Survive Stress, Keep It Brief: Short Episodes of Stress Can Invigorate. It's the Long-Lasting Ones That Kill. *The Washington Post*, December 13, 2005, Page HE04.

[5] From: Burdick, A. (2006). The Mind In Overdrive: Can we increase productivity by revving up the neural pacemakers in the brain? *Discover, 27*, 4, 21-22.
[6] From: Bloom, F., Nelson, C. A., Lazerson, A. (2001). *Brain, Mind, and Behavior,* Third Edition. Worth Publishers.

[7] From Zeisel, J. Inquiry by Design: Environment/Behavior/Neuroscience for architecture, interiors, landscape, and planning, Second edition, W.W. Norton, New York, 2006 (Chapter 14)