Preface:

The following is my personal report of what was accomplished at the K-6 Classroom workshop. It should not be considered a report that reflects the views or contributions of each of the participants, but more of a personal set of observations. I have taken the liberty of quoting from a number of the presentations in order to provide the reader with a sense of what was discussed

The participants were all volunteers who generously gave ANFA almost three days of their time in order to achieve the purposes of the workshop. Both the Academy and I are thankful to them for their time and their thoughts. Just as we are grateful to the many organizations who provided the financial support that made the workshop and the film about the workshop possible.

Finding ways to bridge the intellectual concepts of neuroscience, architecture, and education is not an easy task. Some of the working groups were more successful with doing this than others, but each of them contributed to the potential development of this new field of study. I hope those of you who are reading this report find it a useful input to your own understanding of the potential that lies ahead. I see the eventual development of intellectual bridges between these three disciplines as rewarding to all of us, but especially to future generations of students whose interests are uppermost in our concerns.

John P. Eberhard, FAIA
Latrobe Fellow
Executive Director

ANFA K-6 Classroom Workshop
The Westin Horton Plaza, 910 Broadway Circle, San Diego, CA 92101

Wednesday, February 9, 2005

6:30 PM	Reception - HMC Architects 1010 Second Avenue, Studio 810, West Tower, San Diego 92101 (Across from the Westin Horton Plaza) Phone (619) 744.4077
7:30 PM	Dinner - The Westin Horton Plaza The Coronado Room – 3rd Floor
9:00 PM	Assembly for Self-Introductions by Participants Opening Remarks - Randy Peterson and Alison Whitelaw

Thursday, February 10, 2005 – The Library Room, Main Lobby Floor

8:00 AM	Buffet Breakfast
8:30 AM	Presentation: "The architectural concepts used for K-6 schools" Thom Penny, FAIA, Past President of the AIA
8:50 AM	Presentation: "Educators criteria for K-6 schools" Dr. Glenn Massengale, Ph.D. HMC Education Practice Leader
9:20 AM	Presentation: "Forming Hypotheses for Neuroscience" Dr. Thomas Albright, Ph.D. The Salk Institute for Biological Studies
9:40 AM	Plan for the Day – John Eberhard
9:50 AM	Divide into 6 Task Groups for Working Sessions
Noon	**Lunch**
1:30 PM	Reassemble for Mid-Course Corrections
2:00 PM	The 6 Task Groups return to their Working Sessions
5:00 PM	Adjourn (Suggestion - task groups might plan to have dinner together to prepare presentations for next day.)

Friday, February 11, 2005 – The Harbor Room, 3rd Floor

8:00 AM	Buffet Breakfast
8:30 AM	Assembly – Task Group Presentations
Noon	Adjourn

ANFA K-6 Classroom Workshop
Thursday, February 9, 2005

Opening remarks – John Eberhard

Welcome everyone. If all goes well here over the next few days, someday you all will be remembered for creating something new in education and architecture. Our plan for the next hour is to have talks by Thompson Penney, Glenn Massengale, and Tom Albright. The notion for the morning is to give some background on architecture and school design, background on education and K-6 schools, then background on neuroscience hypotheses.

This workshop began with the publication to those who were invited of a set of premises that would underlie the topics to be discussed. The basic premises were:

1. Brain development between five years and twelve years of age is significant and understood. Cognitive psychologists and neuroscientists are intrigued with how cognitive capacities change with age. They know that:
    a. Regions of primary functions (in the brain) mature first (e.g. primary motor cortex)
    b. Complex/integrative task regions mature later (e.g. temporal lobe)
    c. The superior temporal cortex, which contains association areas that integrate information from several sensory modalities, matures last.

2. There is an intuitive, but not well documented, understanding that the architectural attributes of classroom spaces affect cognitive (learning) activity.

3. Neuroscience research is likely to provide evidence to support this intuition – including the advantages of classrooms geared to stages in brain development.

4. Therefore, hypotheses are required to provide a research agenda that will bring together interdisciplinary teams to work together in creating the new knowledge needed.

The group reports indicate a wide variety of responses by each group. Some groups elected to change their original subject, some groups had difficulty finding good hypotheses, but overall the report provides a rich input to the ongoing development of a knowledge base.

 **Thom Penney on Architecture and School Design**

My last trip to San Diego was in the spring of 2003 as President of the AIA during our national convention. The convention theme "Design Matters! Poetry and Proof" provided a forum for discussions linking the two ancient disciplines of architecture and education with one of the newest disciplines – neuroscience. Twenty-three thousand architects in attendance gained insight into the connections to new knowledge that neuroscientists can provide. We architects have long awaited this knowledge to prove how design matters to the children, teachers and public who use our school buildings every day.

At the present time, the average age of our school infrastructure is 50 years. Demographics have been and are currently driving huge growth in school construction. According to *American School and University*, districts from 2004-2006 will spend an estimated 90 billion dollars on K-12 construction, and elementary schools are 36% of the total amount. There are incredible opportunities to reinforce the education of children, through understanding the connection between architecture and learning. As architects, we are the creators, coordinators, and communicators that turn this dream into a reality. Often we are bound by a lack of understanding of the potential architecture has to enrich lives. We struggle with the challenges of practice in a world where cost and speed of construction are valued more than quality.

One of the first things we do when we receive a commission for a school project is to have an advance-planning workshop that brings all stakeholders and issues to the table in order to outline the direction of the design. The issues not only includes the obvious … the site constraints and opportunities, the program of spaces required, and the budget and schedule…but also the more obscure aspirations for the project. Clients understand and can typically agree on quantitative issues, but often find it hard to discuss much less agree on abstract issues of quality and design.

For example, our firm once asked a group of teachers what they wanted their new elementary school to feel like with the focus on the image and character of the building. One teacher said, ""I want the school to feel like it has a lot of electrical outlets." She was having a hard time understanding how architecture can go beyond the quantitative and actually affect lives within it.

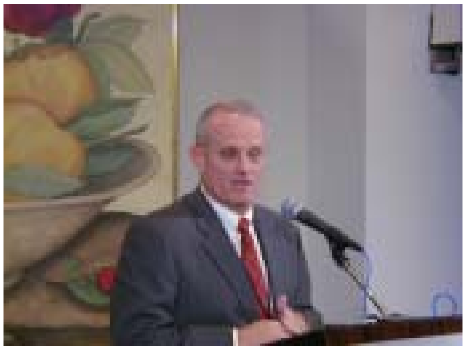
Once, we completed the design of a great school. It was beautiful, in budget, and extremely functional. When we took it to the school board, we were dumbfounded and demoralized by their response. The Board, under extreme public pressure to reduce taxes and minimize expenses, responded accordingly: "It looks too good, it looks expensive." Even though it was in budget, the construction manager added that the windows could be smaller and save money, so the board reduced the window size to absolute code minimum. Had we been aware of a research study by Pacific Gas and Electric in California, we would have had the compelling evidence and convincing argument that students with the most exposure to daylighting in their classrooms had improved test scores.

The population of the U.S. is rapidly growing and rapidly changing and demographic trends are changing the needs of our schools. We are living longer, we are more diverse, and we have more families where both mother and father are employed. More children are in need of before and after school care. A more diverse population increases the need for adult education programs. An aging population will be seeking life-long learning and wellness opportunities. What do these trends mean for schools?

Schools are being re-programmed and designed to serve as centers of communities to address these needs. They serve the leisure, recreational, and wellness needs of the community. They are used for town meetings, community theatre, continuing education, and day care centers. They reduce duplication of precious resources in facilities such as libraries and they become truly integrated into the life and activity of communities.

And as they do, schools become part of the continuum of life and a tool for true life-long learning and quality of life. As architects, we understand in our hearts that school design matters…but in today's "show me" world we must be able to prove it.

I am thrilled that we have educators and neuroscientists working together to determine how we can all understand in our minds as well as in our hearts that design matters!



Glenn Massengale on Educators Views of K-6 Classrooms

While some people may disagree with this viewpoint, I think that educators' views are often the problem in the design process of schools.

First, I need to explain that schooling is different from education. Schooling is the formal processes of providing education—it is the system. Education is the act of developing cognition and learning. Therefore most of my comments are about the formal process of schooling – about the system that surrounds the relationships between teachers and students.

One major question is how do teachers know what to do? When I explored where teachers learn to teach, I came up with four premises from a research paper I found:

1. Teachers learn to teach in the college prep programs.
2. They learn through professional development.
3. They learn by imagining a mental model of the job while they are students, then they act out that model.
4. They learn through collegial exchanges on the job.

The results of asking teachers themselves are that they said they learned through collegial interaction. So it's an oral tradition, shared day by day. However, the research paper said it was the third option. This is important because we might be designing for the wrong people – if we are designing for teachers. When you go into a classroom, the activities that take place assume that there is a cause and effect between teaching and learning. However, there is a disconnect. In a classroom there are two kinds of participation - teaching and learning. Teaching is active and learning is passive. That's not good. We want to make learning active, though it's been the other way for decades.

When educators evaluate teaching, we don't evaluate learning. In fact there is resistance to link teacher evaluation with student performance. For example, what is the role of language in cognitive development? Schools are bound to the idea that intelligence is only developed through language. The idea that there is other cognition in the class room is foreign to most people in the system. The No Kid Left Behind program is all about language as a measure of intelligence, which is very damaging when you think about how to design schools. Non-English speakers can be left behind, if teaching is solely through language.

Scientists learn through conceptual experiments, yet it is such a shame that science experiments in schools are based on primarily on language. How do you assess things like design, music and art in a language-based system? The majority of students in public schools don't see any point to school. This is because contextual learning is removed from the experience. Kids see an academic experience that doesn't have any connection to them.

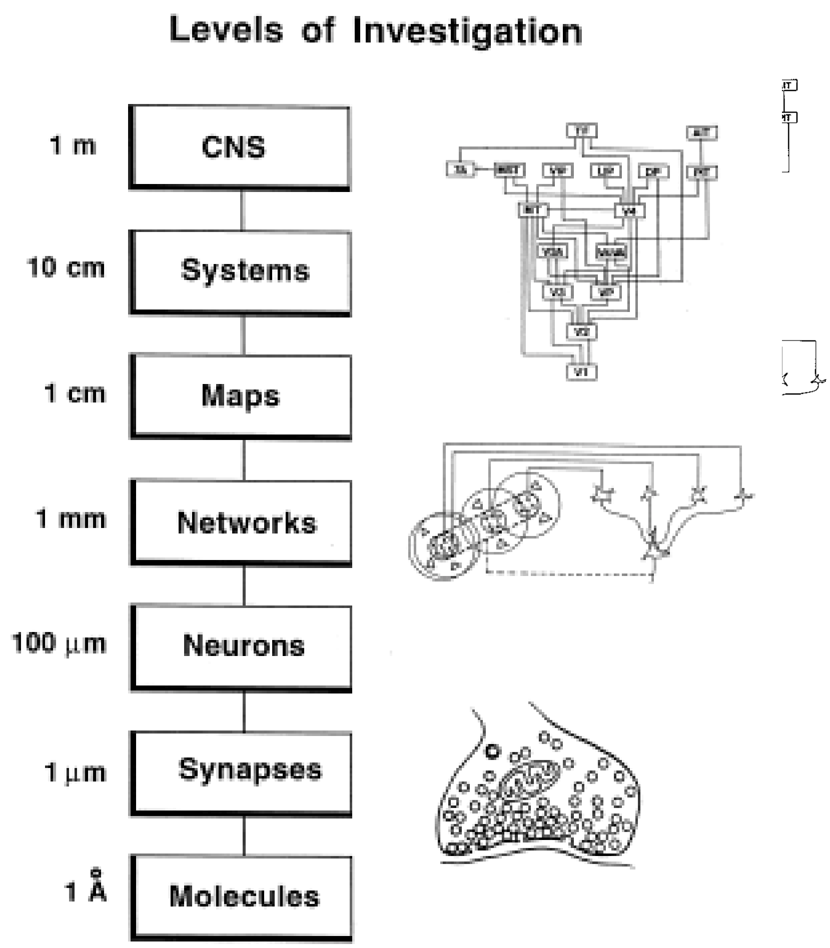
Diversity of students is another important issue. There is a tendency to make correlation into causation.

Another distinction I'd like to make is hard science versus soft science. Education is soft and neuroscience is hard. Education is intuitive and anecdotal and therefore is soft because there's not a lot of evidence on which to base methods. The purpose of research is to make a difference in practice. The only way that the results of this workshop will move into practice is if hard and soft sciences merge. Whatever research comes out of the workshop should not stay in a vacuum. The learning of teachers and of students both should be compatible, and seen as a high priority.

**Tom Albright on Developing Neuroscience Hypotheses**

Thank you. While I am here with other neuroscientists today, I'd like to make the distinction that this workshop is particularly interested in cognitive neuroscience. Sensation and perception are among the most well-developed and understood areas of neuroscience. Learning and memory are two other major areas of cognitive neuroscience.
Some of the most important areas we study in the systems of brains include:

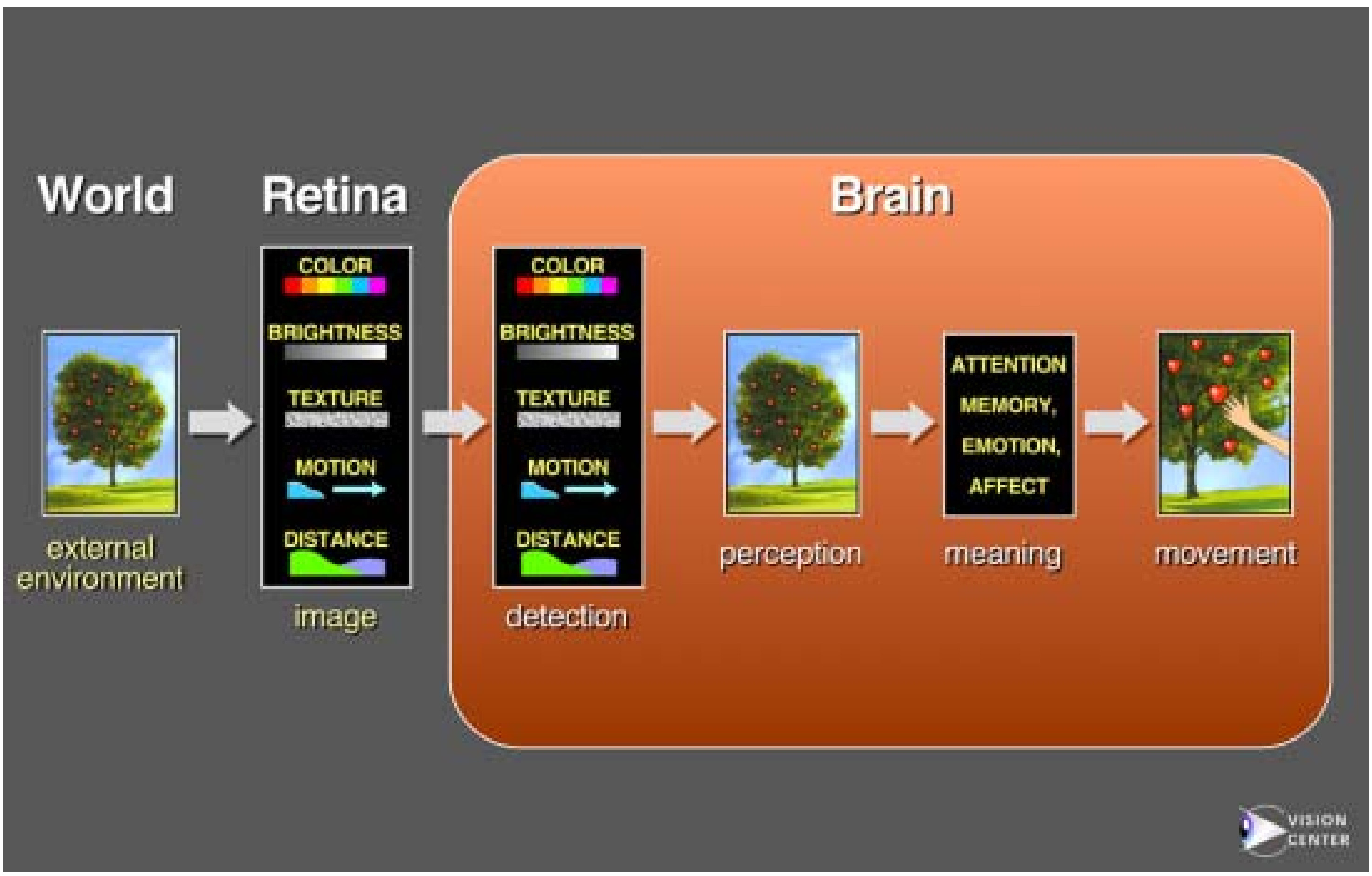
- Sensation and Perception (how do we see, hear, smell, taste, etc?)
- Learning and Memory (how do we store and recall our sensory experiences?)
- Decision-making (How do we evaluate the potential consequences of our actions?),
- Emotion and affect (How do we become fearful or excited? Or what makes us feel happy or sad?),
- Movement (How do we interact with our environment and navigate through it?)
- Language (How do we communicate with others?)



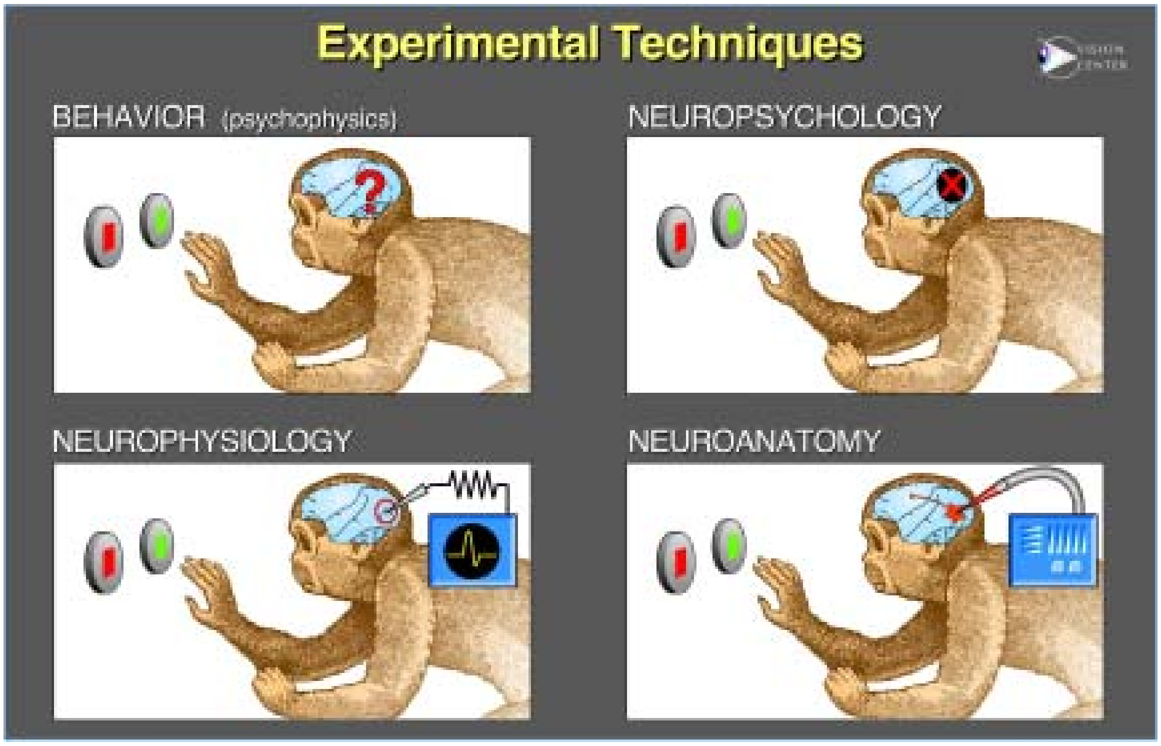
I work with the visual system, which helps in understanding other areas of the brain and can act as a model for general principles of brain function. There are three ways to study vision including:

FUNCTIONS
WHY DO WE SEE?
COMPUTATIONS
WHAT DOES THE VISUAL SYSTEM DO?
BIOLOGY
HOW DOES THE VISUAL SYSTEM WORK?

Vision is important for social communication, understanding the environment, mediums of communications, and mediums of expression and impression, like art. In principle, there isn't sufficient information just in a visual image to gain a perception of it, so vision depends on prior experience.



Rhesus monkeys are used for research because their vision is roughly the same and their visual cortex is very large. Different properties of the visual images are processed by different parts of the brain, then combined in the brain. This research often is through behavioral and neurophysiology. In our labs, we do research by lowering an electrode in the brain.



One quote I'd like to leave you with is about the painter Turner. He was told by a woman who saw one of his paintings of a wildly colorful sunset, "I never saw a sunset like that Mr. Turner." He replied, "Don't you wish you could, madam?"

From the Architectural Community

A. Lee Burch, PhD, AIA	V.P. /Community College Practice Leader 3D/I
Jaime Canaves, FAIA, IIDA	Director of Research, FIU School of Architecture
Betsey Olenick Dougherty, FAIA	Partner, Dougherty + Dougherty Architects LLP
James Dyck, AIA	Principal, The Architectural Partnership
Cheri Henricks, Assoc. AIA	Principal, Broadview Associates, LTD
Pamela Maynard, CID	Principal, HMC Architects
Robert Moje, AIA	President, VMDO Architects
Thompson Penney, FAIA	President/CEO, LS3P Associates LTD
Randal Peterson, FAIA	President/CEO, HMC Architects
Alan Sandler	Exec. Director, Architectural Foundation of San Francisco
Allison Whitelaw, FAIA	President, Platt/Whitelaw Architects
Douglas Wickstrom, AIA	Vice President/Principal, Fanning/Howey Associates, Inc.

From the Education Community

James Brady, AIA, REFP	Executive Director, America's Schoolhouse Council
Randolph Carter	Director, Eastern Educational Resource Collaborative
Janet R. Dobry, Ph.D.	Principal, Robert Taylor Elementary School, Henderson, NV
Will Fowler	Programs Director, Architectural Foundation of San Francisco
Judy Hay	Teacher, Albuquerque Public Schools
Eric Lehew	Director of Curriculum, Instruction, Standards, & Assessment, Poway Unified School District
Glenn W. Massengale, Ph.D.	K-12 Education Practice Leader, HMC Architects
Ernest C. Nevares, Jr.	Principal, Pepper Drive Elementary School
Devin Vodicka	Principal, Carlsbad Unified School District
Gilda Vogel	Asst, Principal, Albuquerque Public Schools
Grant Williams	Principal,Riley Special Education Center

From the Research Community

Nancy Rottle, RLA, ASLA	Asst. Prof., Landscape Architecture, Univ. of Washington
Henry Sanoff, AIA	Professor Emeritus of Architecture, North Carolina State University, College of Design
Cynthia Uline, Ph.D.	Associate Professor, Ohio State University
Emily Ulrich	Design Researcher, Steelcase Inc.
John Zeisel, Ph.D.	Hearthstone Alzheimer Care

From the Neuroscience Community

Thomas Albright, Ph.D.	Vision Center Laboratory, The Salk Institute for Biological Studies
Geoffrey Boynton, Ph.D.	Systems Neurobiology Laboratories, The Salk Institute for Biological Studies
Steven Jon Henriksen, Ph.D.	Professor, The Scripps Research Institute

From ANFA

John Eberhard, FAIA	Executive Director and Latrobe Fellow
Eve Edelstein, Ph.D.	Member, Academy of Neuroscience for Architecture
Kate Meairs	Member, Academy of Neuroscience for Architecture
Ilya Monosov	Member, Academy of Neuroscience for Architecture
Margaret Tarampi	Member, Academy of Neuroscience for Architecture
Peter Soutowood	Member, Academy of Neuroscience for Architecture
Joel McKellar	Guest recorder for ANFA

The following task groups were formed to discuss six subjects

Spatial Competence – coding the location of things
Alison Whitelaw
James Dyck
Randolph Carter
Eric Lehew
John Zeisel
Kate Meairs

Audition – noise and reverberation
Randy Peterson
A. Lee Burch
James Brady
Will Fowler
Eve Edelstein
Judy May

Light – attention related difficulties, modulation of alertness
Thom Penney
Pamela Maynard
Janet Dobry
Jeff Lackney
Glenn Massengale
Geoffrey Boynton
Peter Soutowood

Visual Function – good stereo-acuity and depth preception
Betsey Dougherty
Robert Moje
Ernie Nevares
Gilda Vogel
Steven Henriksen
Illya Monosov

Color – perception and representation changes with maturation
Thomas Albright
Douglas Wickstrom
Henry Sanoff
Cheri Henricks
Devin Vodicka
Margaret Tarampi

Wayfinding – understanding and description
John Eberhard
Alan Sandler
Jaime Canaves
Cynthia Uline
Emily Ulrich
Grant Williams
Joel McKellar

THE SOUND OF LEARNING

Summary of the Discussions of Task Group on Audition – noise and reverberation

Randal Peterson FAIA, Chair
Jim Brady AIA,
Lee Burch, PhD AIA,
Eve Edelstein PhD,
William Fowler,
Judy Hay MA,

Original Premise:

Audition – noise and reverberation

Speaking and listening are the primary communications modes in most educational settings. Therefore noise levels and reverberation times of these learning spaces should be such that speech produced by teachers, students, and others is intelligible. Unfortunately, many learning spaces have excessive noise (unwanted sound inside or outside of the room) and reverberation times. All students and teachers are negatively affected by noise and reverberation, but young students, English language learners, and students and teachers with hearing, language, or learning problems may be at a greater disadvantage. The acoustical properties of classrooms are often the "forgotten variables" in ensuring students' academic success, particularly for students with unique or communications or educational needs.

Referenced from American Speech-Language-Hearing Association (2005).

PRIMARY HYPOTHESIS (adopted by task group):

"The sound quality of a learning environment can significantly affect learning"

DISCUSSION:

Childhood hearing programs (from birth through school age), which measure auditory evoked inner ear and brain potentials, have been conducted over the last 15 years across the world. Findings indicate a correlation between language, learning and hearing.

This task group of architects, educators and scientists, discussed the potential for improving classroom acoustics by means of research that considers our current knowledge of neuroscience. The group discussed the particular and varied needs of the educational environment, and the role of background noise, in the context of the physiology of hearing. Particular attention was given to the broad range of styles and methods used in teaching and learning.

SUMMARY:

The following summarizes topics of interest to the working group

What is the sound of learning?

What is the advantage of tuning the room to enhance the teacher's voice or the students' voices?

Does the sound of students learning encourage learning?

Research suggests that the acoustical profile of a learning environment can significantly improve learning

Can the introduction of sounds, or changes in the sound quality of a room enhance learning? Can:

- music enhance language performance
- music enhance math performance
- sound cancellation enhance attention and focus
- sound introduction enhance attention and focus
- reduced reverberation enhance musical appreciation

The relationship between different sounds, teaching methods and learning styles

How can different sound environments accommodate different learning styles, abilities, and disabilities?

What is the affect on learning by:

- Altering sounds to accommodate different ages and developmental stages
- Altering the focus, attention or assist individual learning styles
- Altering sounds to accommodate different learning and teaching activities, such as:
  - music
  - math
  - language
  - individual
  - small group
  - whole group

Accommodating changes in activity and sound over space
- within same room
- from room to room
- between rooms

Accommodating changes in activity over time

The affect of change, novelty or consistency of sound environment on learning
- alter attention / arousal
- responsive to circadian rhythms / natural sound environments

Multimodal / sensory stimuli enhance learning
- Auditory stimuli associated with other sensory stimuli to enhance learning
- parameters that assist rather than clutter the learning environment

Responses

Behavioral & physiological hearing responses in humans
- hearing thresholds
- frequency tuning
- suppression of background noise
- detection of signal / unexpected noise
- discrimination of speech
- imaging studies of differential activation
- responses relative to individuals, developmental stage, language, culture, learning needs / preferences

Physiological and anatomical effects in animal models (in addition to the above)
- Anatomical and physiological measures not available in clinical research
- neural growth / network
- noise induced hearing loss / cell death
- control of environment (test architectural / technical solutions)

Outcomes

- sensory responses
- activation / attention / motor
- emotion / affect
- cognitive performance
- learning outcome
  - test scores
  - reading, oral, aural, written and language proficiency
- conceptual development
  - math, science
- individual needs
  - learning style, special needs, add, autism, gender, cultural, developmental needs
- social development

inter-intra-personal skills

ULTIMATE HYPOTHESIS

Improving architectural design features that affect sound quality can improve learning

Hypothesis One:

Background sound affect reading, speech and language. The following variables are significant:

- **Developmental stage of the brain,**
- **Gender of the child,**
- **Culture and socio-economic status of the child**

The following parameters would enter into the test methods used:

Introducing sound while measuring responses and outcomes
Technical solutions: music, amplifying speech, canceling noise, natural sounds
Architectural solutions: reverberance, resonance, tuning, signal: noise ratio
Measuring responses and outcomes in "silence"
Technical solutions: canceling noise, damping, etc.
Architectural solutions: mitigate or enhance space
Site choice, site orientation, program design

Hypothesis two:

The type of sound encountered can enhance / deter cognitive activities.

Test methods used would take into consideration the following:

Sound physical parameters: (music, noise, traffic, etc)
Repetitive
Novel
Pattern
Frequency
Intensity
Phase

SUGGESTED EXPERIMENTAL PROGRAM

This program could be established as a preview of possible additional hypotheses to be tested with neuroscience methods.

Phase I

Test in controlled experimental environments

- Test methods: evoked auditory brain potentials & behavioral tests
- Learning outcomes: validated educational tests
- Test environment: Begin in university / hospital controlled conditions
- Carefully control, specify and measure sound changes
- Mock up changes to environment using architectural or technical methods
- Carefully control, specify and measure consequence of mock up modifications

Phase II

Take findings from Phase I observations, develop elements of architecture and their impact on sound effects, and test in real world classrooms.
Controlled for school environment type. Lessons learned in typical school environments; difference from special school environments.

Phase III

Tuning the classroom to enhance learning environment utilizing post-occupancy evaluation.

Cost benefit analysis / Return on Investment (ROI) while difficult to measure should be addressed to the extent possible.

Summary Discussion of task group on:

Light, Attention related difficulties, modulation of alertness

Thom Penny, Chair
Pamela Maynard
Janet Dobry
Glenn Massengale
Geoffrey Boynton
Peter Soutowood

Original Premise

Lighting varies through out the modern classrooms, as studies show. Adirondack Learning Associates study suggests that non-natural light is lowest in the front of the room. Inconsistency in the environment in most schools can cause poorer performance on certain tasks by a large populous of students.
The brain processes light information to visually represent the environment but also to detect changes in ambient light level. The latter information induces non-image-forming responses and exerts powerful effects on physiology such as synchronization of the circadian clock and suppression of melatonin. Light also acutely modulates alertness, but the cerebral correlates of this effect are unknown. When test under brain-scanning experiments, the bright broadband polychromatic light suppresses melatonin and enhances alertness. Functional imaging revealed that a large-scale occipito-parietal attention network, including the right intraparietal sulcus, was more active in proportion to the duration of light exposures preceding the scans. Activity in the hypothalamus decreased in proportion to previous illumination.

Reference: *Centre de Recherches du Cyclotron (B30), Universite de Liege, Sart Tilman, 4000 Liege,*

General Discussion:

Geoff - Our topic is light, attention difficulties, alertness. Light is what we know most about. As far as how it is related to learning, we know less. We know how the eye works, but regarding attention, it's very different.

Thom - The way architects are taught is part of the problem with designing better schools. Many of us learned it was about novelty, graphic composition, in some respects, the stranger the better, instead of understanding the impact of a space. I preached about the awards programs and pure novelty, and the problem is that sometimes they are hugely over budget and energy inefficient.

Pam - I can go to Dunkin Donuts to buy coffee more cheaply that at Starbucks. So why Starbucks for so many people? It's not the coffee, it's because it's a better space inside and the environment is better. How can we make designs of schools not cookie cutter? How can we replace the Dunkin Donuts school with the Starbucks school, where people are excited to go?

Pam - And look at the cause and affect with Starbucks and apply this to schools. Of course Starbucks spends more on the space, but look how much more profitable they've become. So how do we set up proper learning facilities?
Thom - Starbucks sells the experience, not the coffee. How do you turn it into an experiential product?

Glenn - The primary activity of most schools is the teacher conducting something. The learning center takes a traditional environment and changes it to an experiential space.

Geoff - As a teacher you feel like you're accomplishing more rather than letting students figure it out on their own. You feel like you need to say all the stuff they need to know. There is an intermediate level of research between hard and soft science, so you need someone to run an experiment to bridge between anecdotal and hard science to help tighten down the hypotheses. We've had to learn from more applied research for us to be able to set up hypotheses.

[The group then evolved the following observations and hypotheses.]

<u>Hypotheses</u>

Observations on full spectrum lighting:
Janet: All our classrooms had windows, and some windows had been taken out in Clark county for vandalism and security reasons. Each class now has 2 very small windows, and 2 classroom doors, and most doors are propped open to let in air and natural light.

Pam: Putting children in a static environment isn't as good, and windows provide a variation in light that has a positive impact. Static lighting causes agitation and claustrophobia. - We always hear from our engineers that you need more light, but what's too much?

Geoff - We know that stimulating environments and something to look at improves neuronal growth.

Geoff - Certainly an extreme is bad, and an interesting question. On a sunny day, the amount of light you get is like 1000 times more than you get inside, so our visual system adapts. Within reason, the ambient light level doesn't affect us that much. Like when you change subtle aspects to improve performance.

Thom - We have questions we need to take to the next step of hypotheses. One is the exact light level and light type. The question is whether full spectrum light is better and does it impact, enhance, and support learning? How does light level affect learning?

1. Full spectrum light enhances learning.
Observations on Diurnal Cycle.

Geoff: Neuroscience breakthroughs in the diurnal cycle and daylight spectrum of light show that it does make a difference. Understanding the circadian rhythm indicates that there are times of day better and worse for learning. If classroom light isn't natural and is disrupting sleep cycles that could be a major problem. Neuroscience still doesn't know why we sleep. It's believed that things you experience during the day are refreshed after overnight sleep.

Thom: What about the issue of circadian rhythms - do we need to design lighting to take into account recent discoveries about circadian rhythms? There are two parts - how does the circadian rhythm affect learning, and second, how does light level affect the circadian rhythm cycles?

Steven Henricksen (visiting this group) - It's independent of light, so light is a part of circadian rhythms and you can literally flip your temperature rhythm. Even during a 24-hour cycle your rhythm shifts quite a bit, so it’s important when you take medicine. How this affects kids and learning is how we should optimize education. Bright light is a good thing, but there's a different modality of temperature. And the external temperature has virtually nothing to do with that rhythm. As mammals, we have to regulate that internal temperature. So younger kids can't go to sleep at night because their circadian rhythm is delayed, and we are imposing our society on this long line of evolution. That's a huge thing with school start times—it’s almost a losing battle. A researcher at Brown University did a lot of research on this.

Thom - Is the hypothesis that circadian rhythms DO affect learning?
Are there age-related affects on circadian rhythms?

Geoff - This issue is being studied right now at Salk - how light affects the circadian rhythm.
These 4th types of photoreceptors are actually in the ganglian cells and don't fire up immediately, they fire up after a while and slowly ramp down after the light is off.

2. Changing the cycles of light to coincide with the circadian rhythms could account for improved student performance.

Observations on varying lighting conditions:

Thom - The question is, should the lighting be different for K-6 than with K-12? Is it more critical in learning?

Pam - That's an interesting question. When I did a senior center, and we painted the walls a creamy yellow color, the facility on their own painted it a bright yellow. As we get older, colors appear darker so I wonder if at what age increments do colors and light levels affect us?

Steven Henricks (visiting the group) The part that is well-established is that the learning capacity is based on core body temperature - it's the definitive variable for cognitive measures. And this temperature thing is for adults as well as children. It's almost a tragedy to start younger kids earlier in the morning when their temperature is coming up. The temperature follows the circadian cycle.

3. Satisfactory lighting conditions vary between K-6 and K-12.

Discussion of effective levels of visual distraction:

Geoff – Talking about attention, is there an optimal level of change in an environment where too much change is distracting and too little is boring?

Glenn - Is there an optimal level of irrelevant visual information?

Geoff - One of the most incredible things our system does is filter out speech from background noise. Computers can't filter it out, yet our brain can.

Pam - Even though I can hear what you say, with all the background noise, does that mean it doesn't sink in as well because of the distraction?

Geoff - Good point. I do research where a patient must pay attention to one stimuli and ignore the other, so we can see what they pay attention to. So we can compare the response in brain hemispheres to an unattended stimulus. This is where neuroimaging is really useful. So the question about attention and effort, the harder you have to work to attend to something, the more you have to suppress unattended stimuli. To focus on speech in a crowded room, you have to REALLY ignore the other stimulus. It's the same thing in the visual system. Motion is automatically distracting. In our studies, you can train subjects to attend to something, but if there's a sudden change, they will divert energy towards that thing. We're finding that for basic visual tasks, your performance will deteriorate throughout the day, which is common sense. But if you make a small change, the performance goes almost back to where it was in the beginning. So it isn't a general boredom/fatigue thing, it's something in the visual system.

4. There is an effective level of visual distraction for students.

Observations related to natural daylight:

Pam - But wouldn't that be an easy test, to take schools with fluorescent lights and change it out to full spectrum?

Geoff - You could do day lighting without natural day light and there would be no difference as far as the eye is concerned.

Pam - Although the difference is that a natural window gives you the clouds and other changes.

Geoff - But the point is that you could reproduce day lighting. We only need three lights to adjust to make a perfect match. You can compare this with how LCD and CRT monitors work. They can be any three colors, as long as they are different from each other. However you don't get UV rays from this as compared with sunlight, and then there's the weird thing with the internal clock. They've discovered a 4th photoreceptor that doesn't apply to vision but goes directly to the brain for Circadian rhythm maintenance. What keeps happening is that our sensory systems have evolved to pick up things from the natural world. Any deviation from that is a deviation from optimum. We realize that we can't build better than the natural world.

5. Natural daylight enhances learning and health more than artificial light.

Observations related to individual differences:

Janet - I think this is a real architectural opportunity. Local schools could set up these lab experiments. Make some paint color experiments with students, and then people at the district level would be interested and excited. And although it's not hard science, it would be a selling factor so that when architects walked in, the schools would know and be excited, it was more personal.

Geoff - It's hard to conduct this kind of experiment. It's difficult to look at something that's not very well controlled and predict what the effect would be of a specific stimulus change.

Thom - I want to ask Glen about individual aspects. So you're talking about the dangers of someone with ADD and someone who is not separated, maybe it's good to separate them. Would it be better to have an environment tailored for people with similar problems? I am a visual learner, and you wonder if in the future, there would custom-made spaces for visual learners.

Geoff - What you need in the future is a totally flexible classroom**.**

6. There are individual differences (related to age) and types of distractions.

Spatial Competence
Competence within space

Alison Whitelaw, Chair
Jim Dyck
Randolph Carter
Eric Lehew
John Zeisel
Kate Meairs
Nancy Rottle

Original Premise:

Spatial competence is basic to daily activities such as putting together lunch, walking to school, fitting large objects into a box of toys, using information presented in maps and diagrams, and understanding verbal descriptions of spatial materials (e.g. how to find the way to the bath room). Thus to understand human cognitive functioning, we must understand how children code the locations of things and navigate around their world, and how they represent and mentally manipulate spatial information… without at least tolerably close correspondence between internal representations and the actual physical world, children would not be able to find what they need, avoid what they fear, or imagine and construct tools that they use.

There is little evidence that young children lack an objective frame of reference. They may, however, find it more difficult than older children to integrate their spatial representations when a common frame of reference is not available. Fragmented spatial relations have to be related by inference and by the construction of mental models. They also are less likely than older children to use effective strategies of landmark selection and route examination to help them in navigating in unfamiliar areas.

We want to know when and how children acquire spatial-linguistic categories, when and how they acquire the ability to negotiate frames of reference, and when and how they acquire organizational strategies to structure their verbal descriptions of space.

Reference: *Dr. Nora S. Newcombe at Temple University and Janellen Huttenlocher at the University of Chicago*

The group discussed two issues.

1. Define the elements and characteristics of "neuroscience and architecture (n&a) hypotheses."
2. Generate a set of n&a hypotheses that include these elements.

These resulted in.

1. Elements and characteristics of "neuroscience and architecture (n&a) hypotheses
2. Nine n&a hypotheses

The group agreed that "spatial competence" meant how the spatial environment would enable and positively affect learning, rather than developing competence in spatial perception.

1. Schools should offer a hierarchy of spaces, from private to large-group, in an adaptable structure.
2. Control of the environment is essential to the teacher and the learner; manipulability of space can enable active participation of the learner.
3. The school should reflect the culture of the community; cultural relevance needs to be built in, but also flexible to reflect changing demographics so that the structure can endure.
4. Spatial transitions and flow are essential elements.
5. Appropriate scale matters to the learner/learning activity.
6. Space affects students' sense of self and others, e.g. perception of crowding.
7. A setting that evokes strong emotion may positively impact recall.
8. We may be "hardwired" to prefer certain environments that allow us to perform optimally, through restorative qualities, clarity, appropriate complexity, security, (hearth, visual connection, ability to move).
9. An environment that offers balanced qualities may be most satisfying and conducive to learning, e.g. security and risk, prospect and refuge, active and quiet, social and individual, inside and outdoors.
10. When activity is intentional, learning may be stronger. Therefore, allowance for choice in activity and environment may optimize learning.

The environment may have the power to positively and effortlessly affect learning through the individual's innate ability to absorb his or her surroundings. We perceive the environment subconsciously, often easily remember the three-dimensional environments we've experienced, and can use that memory to recall learning and events associated with the place. In addition, lessons and content can be embodied in the physical environment. Environmental design can therefore powerfully affect learning.

Definition of the elements of a complete n&a hypothesis

Our group realized that neuroscience hypotheses were linked, rather than separate from, more traditional environmental design research "behavioral" hypotheses. In fact a complete "n&a" hypothesis included in it hypotheses that focused on neural, physiological and behavioral outcomes of design environments. We adopted the following model to describe the elements that needed to be included in a full "neuroscience and architecture" hypothesis.

Full Neuroscience and Architecture Hypothesis			
Phenomena hypothesized to be related			
Physical environmental elements linked to	**Neuroscience dimensions &**	**Physiological factors &**	**Behavioral outcomes**
Measurement			
Measures describing the characteristics of the environment	**Neuroscientific methods to measure this dimension**	**Indicators for physiological reactions**	**Behavioral observation and other measurements**

The following table provides a brief set of examples for elements in each of the categories.

Elements of the MODEL				
Elements of the Hypothesis				
Environment	**Brain**		**Behavior**	**Learning Outcomes**
	Neuroscience	**Physiologic**	**Both dimensions of outcomes**	
▫ Flexibility	▫ Appropriate stress levels		▫Concentrate	▫ Transferability
▫ Scale	▫ Neural activity		▫ Manipulate	▫ Test – Retest
Relationships	▫ Sustained arousal		▫ Choose	▫ Recall—short term/long term<
▫ Fresh Air			▫ Attention	▫ Add new information
Proportion			▫ Take risk	▫ Make new……
▫ Natural Light			▫ Feel safe	▫ Synthesize competing concepts
Size	▫		▫ Play	**Making good decisions**
Access to outdoors				**Affective development**
Detail				
Texture				

Methods of inquiry			
Plans	**Experiment**	**Systematic observation**	**Paper and pencil tests**
Dimensions	▫ MRI	**Photography**	**Performance**
	▫ Cortisol	**Self-report**	**Portfolios**
	▫ ERP—evoked potentials		**Teacher judgments**

The major overarching assumptions or hypotheses we generated were.

Spatial qualities such as the following have a significant effect on a learner's ability to successfully complete a learning activity.

- Privacy / Distractions / Environmental stimulation
- Variety of settings / Learner choice
- Manipulability by learner
- Proportion / Shape
- Scale
- Location / Relationship

Children's interest in and sensitivity to spatial experience exists to meet specific developmental needs…

- Motor development
- Spatial cognition / mapping
- Sense of security

HYPOTHESES: THE FOLLOWING TEN HYPOTHESES ALL RELATE TO THE TWO MAJOR ASSUMPTIONS ABOVE.

1. Sustained periods of attention will occur if children are provided the opportunity to access private spaces that limit distraction as indicated by sustained neural activity and reduced stress

Sustained periods of attention will occur if children are provided the opportunity to access private spaces that limit distraction as indicated by sustained neural activity and reduced stress			
Phenomena hypothesized to be related			
Physical opportunity to access private spaces that limit distraction *(Physical environmental elements linked to)*	Sustained neural activity and reduced stress*(Neuroscience dimensions &)*	Sustained periods of attention *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*

Measurement			
As seen in plan **(***Measures describing the characteristics of the environment)*	**Sustained neural activity & cortisol tests** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

2. **If a child is provided with a space that is appropriately scaled to their size, the adjusted sense of time and space leads to reduced stress, greater feelings of security and competence.**

If a child is provided with a space that is appropriately scaled to their size, the adjusted sense of time and space leads to reduced stress, greater feelings of security and competence.			
Phenomena hypothesized to be related			
Space that is appropriately scaled to their size *(Physical environmental elements linked to)*	**Sustained neural activity and reduced stress***(Neuroscience dimensions &)*	**Greater feelings of security and competence.** *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in dimensions **(***Measures describing the characteristics of the environment)*	**Sustained neural activity & cortisol tests** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

3. **Sustained periods of attention will occur when a student can manipulate the environment* prior to the learning task, as indicated by sustained neuronal activity and increased academic performance.**

Such as: Personalize a location by
(define your space)

- Laying out a rug
- Building an enclosure
- Organizing materials for the task

Sustained periods of attention will occur when a student can manipulate the environment* prior to the learning task, as indicated by sustained neuronal activity and increased academic performance.			
Phenomena hypothesized to be related			
Physical space that can be manipulated *(Physical environmental elements linked to)*	Sustained neural activity *(Neuroscience dimensions &)*	Actual manipulation of the space & sustained periods of qattention *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
In the object (*Measures describing the characteristics of the environment)*	**Sustained neural activity** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

4. Sustained period of attention will occur when learners can locate themselves:

- **In an edge space in visual context/connection with the common space, with the choice to be in either.**

As indicated by increased neural activity, less stress and resulting in greater feelings of competence, greater feeling of safety, and higher academic performance.

Sustained period of attention will occur when learners can locate themselves: - In an edge space in visual context/connection with the common space, with the choice to be in either.			
Phenomena hypothesized to be related			
Having an edge space in visual context/connection with the common space *(Physical environmental elements linked to)*	Sustained neural *(Neuroscience dimensions &)*	Sustained periods of attention *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in plan (*Measures describing the characteristics of the environment)*	**Sustained neural activity***(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

5. Levels of stress appropriate to high performance in learning tasks will result from environments designed to allow controlled risk-taking activities.

- PHYSICAL (such as a climbing structure jumping platform, hidden spaces)
  or
- INTELLECTUAL (such as mastering a task to achieve a goal)

As indicated by…

Stress measurement
Cortisol levels
Neural activity
Increased learning

Levels of stress appropriate to high performance in learning tasks will result from environments designed to allow controlled risk-taking activities.			
Phenomena hypothesized to be related			
environments designed to allow controlled risk-taking activities.	**Appropriate levels of sress** *(Neuroscience*	??? *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*

(Physical environmental elements linked to)	*dimensions &)*		
Measurement			
As seen in plan **(***Measures describing the characteristics of the environment)*	**cortisol tests** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

6. Sustained attention will occur when tasks are performed during episodic periods of major spatial contrast (experienced physically or visually).

EG: Move between indoors & outdoors; quiet & loud; active & passive; as indicated by increased neural activity.

Sustained attention will occur when tasks are performed during episodic periods of major spatial contrast (experienced physically or visually).			
Phenomena hypothesized to be related			
Physical opportunity for major spatial contrast (experienced physically or visually). *(Physical environmental elements linked to)*	Sustained neural activity *(Neuroscience dimensions &)*	Sustained periods of attention & movement between contrasting environments *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in plan **(***Measures describing the characteristics of the environment)*	**Sustained neural activity***(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*	Observation	**Learning evaluation** *(Behavioral observation and other measurements)*

7. **Horizontal & Non-Linear (irregular) Spaces in the learning environment create lower levels of stress than vertical and linear spaces. As indicated by cortisol stress tests.**

Horizontal & Non-Linear (irregular) Spaces in the learning environment create lower levels of stress than vertical and linear spaces. As indicated by cortisone stress tests..			
Phenomena hypothesized to be related			
Horizontal & Non-Linear (irregular) Spaces *(Physical environmental elements linked to)*	reduced stress*(Neuroscience dimensions &)*	*(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in plan **(***Measures describing the characteristics of the environment)*	**cortisol tests** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

8. **Sustained levels of attention are created by irregular and organic shaped spaces as indicated by increased and sustained levels of neural activity.**

Sustained levels of attention are created by irregular and organic shaped spaces as indicated by increased and sustained levels of neural activity.			
Phenomena hypothesized to be related			
irregular and organic shaped spaces *(Physical environmental elements linked to)*	Sustained neural activity *(Neuroscience dimensions &)*	Sustained periods of attention *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in shape **(***Measures describing the characteristics of the environment)*	**Sustained neural activity** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

9. **Sustained levels of attention and reduced stress will occur in certain educational activities that occur in the exterior natural environment, as indicated by increased neuronal activity and cortisol levels.**

Sustained levels of attention will occur in certain educational activities that occur in the exterior natural environment, as indicated by increased neuronal activity.			
Phenomena hypothesized to be related			
Physical opportunity to access exterior natural environment *(Physical environmental elements linked to)*	Sustained neural activity and reduced stress*(Neuroscience dimensions &)*	Sustained periods of attention *(Physiological factors &)*	**Increased learning** *(Behavioral outcomes)*
Measurement			
As seen in plan (*Measures describing the characteristics of the environment)*	**Sustained neural activity & cortisol tests** *(Neuroscientific methods to measure this dimension and indicators for physiological reactions)*		**Learning evaluation** *(Behavioral observation and other measurements)*

Task Group on Color

Thomas Albright, Chair
Douglas Wickstrom,
Henry Sanoff,
Cheri Hendricks,
Devin Vodicka,
Margaret Tarampi

Original Premise:

Color – perception and representation changes with maturation
It cannot reasonably be denied that color matters in our innate perceptions. Some things can be said about color in a psychobiological interpretation. For example, blues and greens are generally regarded as restful (in our early experiences in the savannas of Africa these colors stood for shelter, water, and vegetable food sources). There are many associations with the red as an attention-commanding color – red lights, red flags, etc. It may be that given our predilection for order that degrees of saturation in the various colors we experience provide a confirmation of expectancies. Even though we can analyze our feelings when we are presented with color relationships, such an analysis is fairly obvious, and beyond it there seems to be, at present, no clear chain of reasoning about color from a survival-advantage perspective.

Reference: Grant Hildebrand, University of Washington, Seattle.

Perceived color is based on the relative activity of ganglion cells whose receptive field centers receive input from red, green, and blue cones. It appears that the ganglion cells provide a stream of information to the brain that is involved in the spatial comparison of three opposing processes: light versus dark, red versus green, and blue versus yellow.

Reference: *Neuroscience, Exploring the Brain*, by Bear, Connors and Paradiso – second edition

In addition to emotional associations, factors that affect color perception include the observer's age, mood, and mental health. People who share distinct personal traits often share color perceptions and preferences. For example, schizophrenics have been reported to have abnormal color perception, and <u>very young children learning to distinguish colors usually show a preference for red or orange</u>. Many psychologists believe that analyzing an individual's uses of and responses to color can reveal information about the individual's physiological and psychological condition. It has even been suggested that specific colors can have a therapeutic effect on physical and mental disabilities.

Reference: Encyclopedia Britannica

The group elected to concentrate on "contrast" in the field of vision rather than "color" as such. An outline of their report to the workshop follows:

Setting the Stage:

•Neuroscience of Color
- –"Hardwired" with universal perceptions
- –Experience & Culture add meaning
- –Difficult (if not impossible) to use existing neuroscience methods to better understand impact of specific color schemes)

•Behavioral science does have research on use of color (and this is an appropriate methodology due to need for self-reporting)

Process

• In construction, "color selection" process should be informed by what is most beneficial for learners (not personal preferences of committee)
• Group decided to focus on contrast as opposed to color

Visual Contrast Hypotheses and Questions

Background questions to be explored in preparation for testing hypotheses:

- What do we already think we know about environmental/inferential "messages" and their influence on behavior?
- How can we improve use of contrast to focus attention on visual aids/references?
- Does the impact of stress experienced via visual contrast vary for subgroups (ADHD, etc.)?
  What is the optimal level of visual contrast and does it differ for subgroups and at different developmental levels?
- What is the interaction between control over environment and stress experienced as a result of visual contrast?

Hypotheses:

Ambiguity and complexity (i.e. novelty-seeking) can influence the fidelity of neural response in visual systems.

There is an optimal degree of "complexity" in the visual contrast of a learning environment.

The visual environment is capable of inducing stress in children between the ages of six and twelve.

Developmental/maturational differences impact visual contrast & color preferences.

Conclusions:

- This is a promising area of study due to potential for immediate implementation in wide variety of contexts

Visual Function Group

Betsey Olenick Dougherty (group leader)
Robert Moje
Ernie Nevarces
Gilda Vogel
Steven Henriksen
Ilya Monosov

Original Premise:

Visual Functions – good stereo-acuity and depth perception

Good visual function at close range, particularly good stereoacuity, is significantly correlated to academic performance. Results suggest that children with attention difficulties have a characteristic inability to restrict visual attention to a limited spatial area so as to selectively process relevant information while effectively ignoring distracting information. Visual factors are significantly better predictors of academic success as measured by the ITBS (Iowa Test of Basic Skills) than is race or socio-economics**.** Visual motor activities are better predictors of ITBS scores than are binocularity or accommodation. These latter skills were significant predictors also, but to a lesser degree.

Referenced*: Kulp MT, Schmidt PP. The Ohio State University College of Optometry, Columbus, OH And Maples WC. Northeastern State University, College of Optometry, Tahlequah, Oklahoma*

The task group elected to concentrate as follows:

Primary Question: Is there an optimal focal length that can provide measurable increases in attention and retention?

Discussion:

The ANFA workshop gathered architects, educators, and scientists in order to potentially design a set of hypothesis to be tested by neuroscientists that could provide knowledge leading to the improvement of classroom environments. This group began by discussing the specific needs of educators in the current classroom. In particular they addressed these topics by the means of group discussion with architects and neuroscientists. The group leader, led their discussions while writing down key ideas on large sheets of paper.

They continuously reviewed these ideas in attempting to develop a hypothesis. The group was fortunate to contain a balanced array of architects, scientists, and educators.

The first and most obvious question was ‘Can classroom design effect learning’? They all agreed that it could, but to what extent and how was unclear. There was a range of opinions from believing that there was a strong impact on the ability to effect children’s learning, to minimal impacts from environmental intervention. This pattern of differing opinions continued as all of the relevant questions and topics were analyzed.

One premise was that various stages of brain development could be effected differently and to different degrees. The group was made familiar with the concepts of experience-dependent and experience-expectant maturation during so-called critical periods of pruning. Some scientists believe this goes on in the brain of all human beings all the way through the twenties, and perhaps until the end of one’s life.

Discussion was organized along the following outline:

-Summary-

Topics of Interest:

Can classroom design effect learning?

Perhaps experiments could test the effects of:
- Focal length
- Glare
- Table shape
- Effects of glare

Light variability
- Homogeneity
- Convenience lighting

Dark corners

Outdoor environment – opportunities for complex depth perception VS distraction

Classroom for teaching or learning

Does learning drop off at back of the room?

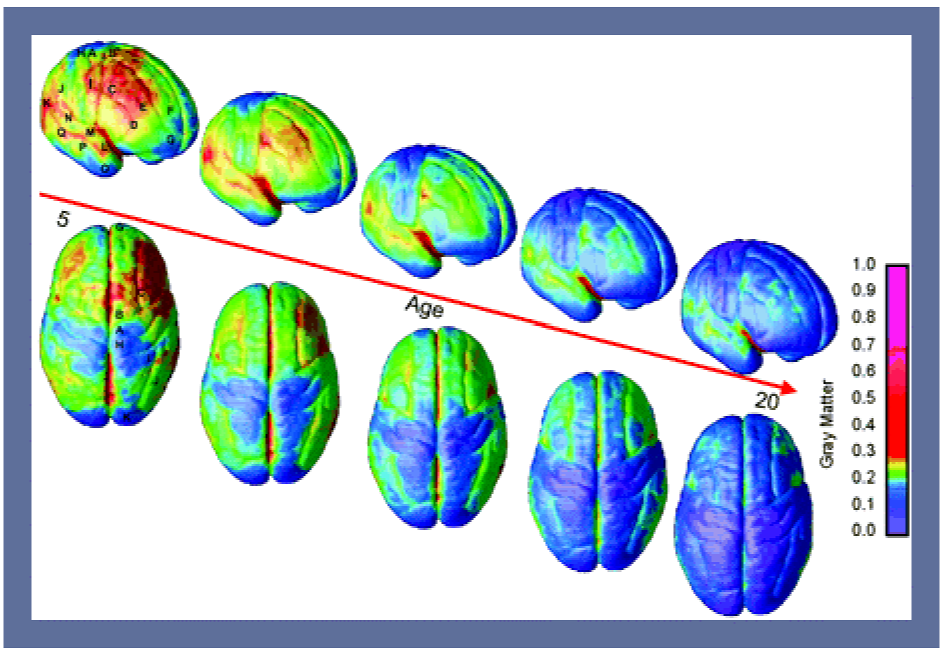
Classroom layout / orientation
Special needs.
i.e reading:
should people with special needs be provided for by
the environment

Change shape of classroom, away from rectangular shape.
Lower student teacher ratio, with regards to space, via design.
Create team-like atmosphere

Developmental difference in motor tasks / visual skills, reading ability

Effects of visual noise
Effects of background noise on children with sensory integration disorders
Comments: The group felt it was important to get away from using reading as a measuring tool for success. The architects in agreed that it is important to find new ways to assess success. An important concept that was brought up was that learning has become too segregated. In other words, different age groups and activities could be combined.

The group did not spend much time on one of the main premise of the workshop, that is that brain development of human beings is important to design. There are many convincing studies, like those of Paul Thompson from UCLA, suggesting that brain development continues through the twenties. These studies, also suggest that there are critical periods where certain areas of the brain undergo neuronal pruning.



This picture, from ‘Dynamic mapping of human cortical development during childhood through early adulthood’ headed by Paul Thompson of UCLA suggests just that. We hope that in our future workshops the concept of ‘environmental effects on various developmental age groups’ will be further addressed.

WAYFINDING
In the K-6 School Environment

Task Group:
John Eberhard
Alan Sandler
Jaime Canaves
Cynthia Uline
Emily Ulrich
Grant Williams
Joel McKellar

Wayfinding means using the physical environment to navigate from one location to another. This includes:

Home to school
Playground to school
Finding the entrance and passing the threshold of building
Finding the doorway and passing the threshold of classroom
Transitioning from one's seat to designated area within a classroom
Remembering how to access the washroom
Remembering instructions to the Principles office
etc.

And, it means accommodating special conditions of those with disabilities:

- Including visual and aural impairment
- Physical impairment including use of wheel chairs, mental retardation, etc.(the task group wondered if the ADA requirements applied to children) There are specific requirements for schools and classrooms according to ADA in combination with IDEA (Individuals with Disabilities Education Act). For additional information see the National Clearinghouse website
- www.edfacilities.org/rl/special_ed.cfm
- www.edfacilities.org/pubs/disabilities

Young children have problems managing their interaction with their environment, and finding their way is only one aspect of that management challenge. Some children learn best by visual/spatial clues and others learn best by auditory clues. It is generally understood in the world of education that children respond more positively to gaining rewards for doing something well than to criticism.

It is generally agreed that design solutions should seek to avoid mixed signals for children, but the context is so important in measuring what is "mixed" that general observations do not seem appropriate.

In most schools children in grades K through 2 will usually have a teacher who takes them on any journey outside the classroom, so that finding their way is not as critical for them.

There are clearly children who are skilled at finding their way and children who have constant problems. When tests are conducted on the hypotheses shown below, an attempt should be made to find a cross-section of children of various skill levels.

Each hypothesis proposed below should recognize these issues in formulating the appropriate test methods to be used.

The task group developed seven observations and then formulated hypotheses based on the observation.

1. **Observation**: Wayfinding skills are based on previous experiences that have been committed to either implicit or explicit memories. Such memories include landmarks, symbols, color clues, etc. Novices who are first time users of a space would likely benefit from lessons learned and recorded by experienced users.

Hypothesis:
Landmarks designed around images familiar to children (e.g. animal pictures) can assist in route knowledge (knowledge of the sequence of landmarks which must be followed to reach a goal).

2. **Observation:** Thresholds (doorways or passageways) are spaces of significant transitions where expectations are heightened, where mental models shift from the place of origin to the destination, and the mind prepares for the upcoming interaction or task.

Hypothesis:
Special designs for thresholds provide children with a sense of security and/or well-being.

3**. Observation**: Many children today lead lives that are free of challenges and unstructured time. Perhaps well-designed wayfinding paths add increased self-reliance on the part of the child as a way of compensating for their normal environment.

Hypothesis:
Well designed wayfinding paths provide stimulation to a child's brain that is positive… i.e. the cognitive abilities are enhanced.

4. **Observation:** Many children today learn to use computers (more specifically, playing challenging computer games) during the pre-school years – as early as three and four. It would seem likely that this early stimulation of their hippocampus via simulated environments is likely to produce special competences by the time they are in the first grade.

Hypothesis:
Children who have early experiences playing challenging computer games have increased ability to find their way in a complex setting.

5. Observation: Gordon Shaw's study of the "Mozart Effect" in young children, i.e. if children, while still in the womb, are exposed to structured music their brain's primary repertoire is preprogrammed to more adequately deal with complex problems as their secondary repertoires are formed by their experiences in the world (after birth).

Hypothesis:
Children who have been exposed to structured music while still in the womb have greater ability to deal with complex wayfinding.

6. **Observation:** Not until a child is at least 6 years old (sometime 8) does the child have an ability to understand what their listener will need to know in order to be able to follow directions for wayfinding. There is progressive improvement to the age of 12 in the ability to point to a landmark that is known (from previous experience) but not currently visible.

Hypothesis:
Children who are in the first grade lack the neural networks required to tell other children how to find specific places in the school environment… (specifically measure the activity of neural networks not just observe such attempts).

7. **Observation:** Children can often be concerned about entering a particular circulation path because they remember problems with safety in that place. This is especially true of children who walk to school over a distance of several blocks. They will often develop alternative paths to walk in order to avoid unsafe places.

Hypothesis:
Children who are younger than ten, and who have more than six blocks to walk to school, have more instances of perceived dangers than those who are older.

CONCLUSIONS

When the Academy of Neuroscience for Architecture (ANFA) was formed in June 2003 there was a general agreement that its mission would be:

> *…..to be the international center for interdisciplinary activities that build intellectual bridges between research on the brain, the mind and consciousness and those who design spaces and places for human use*

Over the past two years, as ANFA has grown and prospered, there have been a number of strategies tried to accomplish this mission. One of the principle strategies has been to organize workshops that brought together a cross-section of disciplines to interact around a set of issues considered seminal to the design of a category of facilities. This has included two workshops on healthcare facilities, one on sacred places, and this one on K-6 classrooms. Each workshop has concluded with a set of recommendations to the ANFA Board and a discussion of the value of holding another related workshop at some time in the future.

The K-6 classroom workshop developed recommendations as well as the hypotheses reported in the body of the report. The recommendations were:

- ANFA should organize a symposium later in 2005 to which a wide audience of architects and educators might be invited. The symposium would feature the film being assembled by David Weiner, and presentations of some of the key workshop participants.
- ANFA should plan to have another workshop in the future, but organize the events to be held at a K-6 school where the students would have an opportunity to participate.
- ANFA should make available the film and workshop reports to groups of educators and architects around the country. This could be done in a way that would enable local groups to organize their own meetings without asking for consultants from ANFA.

It is our intention to implement each of these recommendations. We will keep you posted on dates for events that we hear about if you ask to be placed on our mailing list.

Appendix A

Organizations that provided support for the workshop

The American Institute of Architects

California's Coalition for Adequate School Housing (CASH)

The Council of Educational Facilities Planners (CEFPI)

Firms that contributed support to workshop

MTW Group	Sacramento, CA
TMAD Taylor & Gaines	Pasadena, CA
Ken Rubitsky & Associates	Sacramento, CA
Anderson & Doig Structural Engineers	Sacramento, CA
ACEA, Inc.	Arcadia, CA
J. Thomas Mace, Inc.	Walnut, CA
TJ Krob Consulting Engineers, Inc.	Las Vegas, NV
John R. Byerly, Inc.	Bloomington, CA
Capital Engineering Consultants, Inc.	Rancho Cordova, CA
Armstrong & Brooks Engineers	Corona, CA
PBS Engineers, Inc.	San Dimas, CA
Hannafin / Darney Architects, LLP	Carson City, NV
Martin Associates Group, Inc.	Los Angeles, CA
Johnson Consulting Engineers, Inc.	Poway, CA
BDS Engineering, Inc.	Lemon Grove, CA
Mark Thomas & Company, Inc.	San Jose, CA