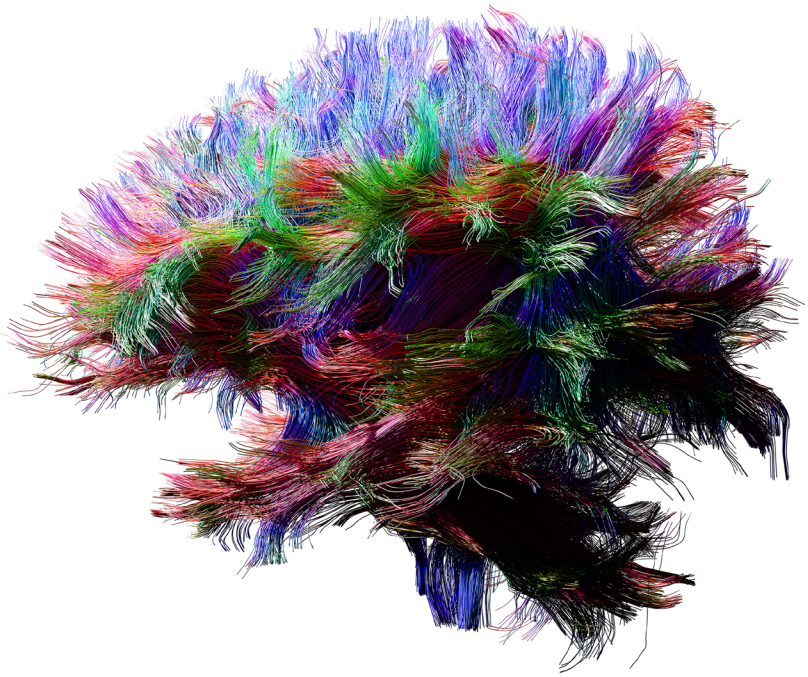
Architecture and Neuroscience

Advanced Architecture Studio V, Section 004, Fall 2017
Laura Kurgan with Jochen Hartman



"How do we know where we are? How can we find the way from one place to another? And how can we store this information in such a way that we can immediately find the way the next time we trace the same path?"[1]

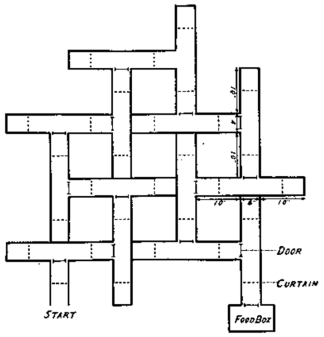
These questions — about knowledge, location, space, memory, learning exploration — link neuroscience and architecture, and will form the field of inquiry and design for the studio. The connection between architecture and the new science of mind and brain is exploding right now, but it is dominated by designers and critics who claim to discover in neuroscience a set of fundamental human traits and who use those as standards to criticize the present state of the built environment. We will not seek to use science as a tool for what used to be called 'slum clearance.' Rather, we will investigate the surprising convergence between the fields on questions of orientation and location, and use them as the starting point for design projects that create new spaces for memory, learning, and curiosity.

The image above was generated by the Center for Spatial research. It shows a Tractography / Diffusion MRI image utilizing 64 directional full brain tracking with data from Daphna Shohamy, The Learning Lab, Columbia University

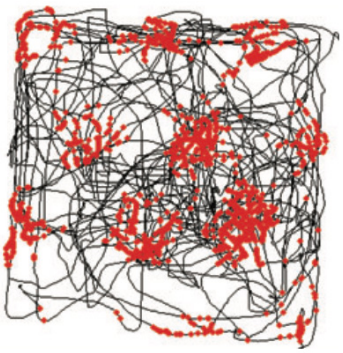
These are familiar themes in the canons of architecture and urbanism. Think of Kevin Lynch, whose still influential The Image of the City focused on the 'legibility' of the American city and proposed that "in the process of way-finding, the strategic link is the environmental image, the generalized mental picture of the exterior physical world that is held by an individual. This image is the product both of the immediate sensation and of the memory of past experience, and it is used to interpret information and to guide action."[2] Lynch went on to propose that mental maps of the city can be reinforced by the design of paths, edges, districts, nodes and landmarks, to be most effective. Fredric Jameson's equally influential reconsideration of Lynch, in the "Postmodernism" essay, rejected the premises that these 'cognitive maps,' formed with such simple images and so few criteria, were either necessary or shared. He proposed that contemporary urban space was too complex simply to be 'mapped,' and instead generated "something like an imperative to grow new organs, to expand our sensorium and our body to some new, yet unimaginable, perhaps ultimately impossible dimensions."[3]

The 5 elements that make up our mental map of a city, as proposed by Kevin Lynch in 'Image of the City' (1960)

We owe the term 'cognitive map' to a 1948 essay by the psychologist Edward C. Tolman. Neuroscience has come a long way since then. How might we rewrite some of these patterns proposed by Lynch in The Image of the City by engaging with contemporary neuroscience and the impossible dimensions that Jameson proposes? We will start with the work of a team of three scientists who were awarded the Nobel Prize for physiology and medicine in 2014: John O'Keefe, who discovered what are called 'place cells,' and Edvard and May-Britt Moser who discovered 'grid cells.' When the award was announced, the Nobel committee explained what was at stake: "This year's Nobel Laureates have discovered a positioning system, an 'inner GPS' in the brain that makes it possible to orient ourselves in space, demonstrating a cellular basis for higher cognitive function. ...The discovery of the brain's positioning system represents a paradigm shift in our understanding of how ensembles of specialized cells work together to execute higher cognitive functions. It has opened new avenues for understanding other cognitive processes, such as memory, thinking and planning." "Inner GPS" is, of course, a metaphor, and we will unpack it carefully and critically, with the help of architects, urbanists, and scientists, to ask about the role of these concepts (place, space, location, orientation, memory, learning, curiosity) in both architecture and neuroscience.



Typical maze setup from 'Cognitive Maps in Rats and Men, Edward C. Tolman (1948)



Grid cell firing locations (red dots) superimposed over the trajectory of an animal moving around an enclosed environment as documented by Edvard Moser, Emilio Kropff and May-Britt Moser (2008)

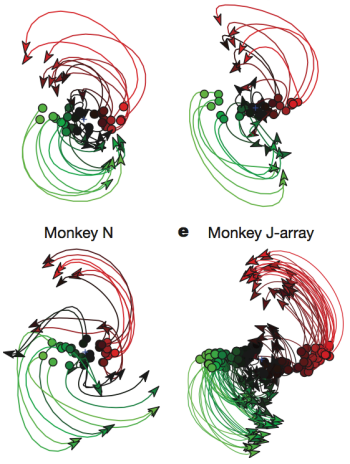
We will work with three leading neuroscientists from the newly-established Zuckerman Institute on Columbia's Manhattanville campus, whose research focuses on spatial navigation (Dmitriy Aranov), learning and memory (Daphna Shohamy), and curiosity (Jackie Gottlieb). We will also collaborate with

[1] https://www.nobelprize.org/nobel_prizes/medicine/laureates/2014/press.html
[2] Kevin Lynch, The Image of the City, pg4.
[3] Frederic Jameson, Postmodernism or the Cultural Logic of Late Capitalism, pg. 39

Kelley Remole, Director of the Education Lab in the Zuckerman Institute, to engage with its mission of facilitating and contributing to public science.

Drawing on all of this, we will ask how these findings in neuroscience might affect what we do as architects, as well as how we define architecture. We will also explore how architectural concepts and practices can have an influence on neuroscience research.

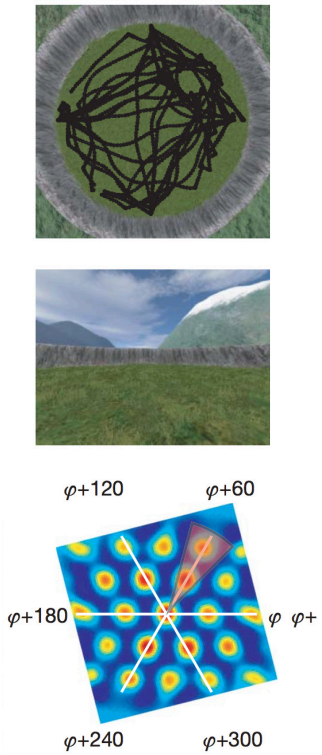
We will apply what we learn at the scale of the city, the building, and the individual — and perhaps even at the scale of a single synapse between two neurons. We aim to unlearn what are often considered to be the familiar dimensions of architecture — extra-large, large, medium and small — and engage with what scientists call high-dimensional space (recall Jameson). Extracting just few key themes from recent claims in neuroscience, and building on the work of our scientific collaborators, our projects will be experimental, seeking to uncover invisible patterns and images of the city that help us grasp questions of spatial navigation, learning and memory, and curiosity. We use these terms to designate not simply positive values or desires, but rather to mark architecture as a fundamental encounter with and exposure to what we don't know, and as a call to respond to that experience.



Models that show dynamic high dimensional activity in neurons from 'Neural population dynamics during reaching' by Mark Churchland and John Cunningham (2012)

Work

During the first three weeks of the semester, students will learn from the scientists. As of today, no scientist has explained in a complete way how the networks and chemistry that connect the one trillion neurons of the human brain work the way they do. Scientists are creating a variety of models, or maps, of the brain – functional, networked, and mathematical. Each model or map tries to understand different ways in which the brain works for specific reasons. When we visit with the Zuckerman Institute scientists, we will learn how they do their experiments and create evidence for their theories. They use sophisticated imaging devices, mathematical formulas, and sometimes simply games. All of this material will become part of the vocabulary and method of our work, from 3-d modelling to game theory to VR environments. We will have access to images from contemporary neuroscience by way of the instructors' multi-year collaboration with the Zuckerman Institute, and with VR hardware available to the studio, students will be encouraged to test how their designs perform under multiple conditions for different users.



Virtual reality area (above) and corresponding grid cell activity in human subjects from 'Evidence for grid cells in a human memory network' by Christian Doeller (2010)

During the first half of the semester, you will navigate toward a specific site: a public, institutional, or commercial place in which you think learning takes place. Parks, libraries, schools, hospitals, museums, supermarkets, or any space that you can justify as a learning environment all count. Your work will be to analyze that space and discover how it helps or hinders learning. Next, you will add multiple dimensions to that space, such that

you will re-design it in a way that inspires curiosity. Your work should be insightful, political, formal, and innovative.

After the midterm you will do a project or a series of projects which propose new learning environments. You can choose a scale at which to focus your primary work(1.1, 1000:1 or 1: 1000, for example), but your work from there forward, must incorporate high dimensional space (you will by this point in the semester, understand this term). Based on what you have done in the first half of the semester, your final project could be dispersed as a network in the city as a series of environments or a game, concentrated into a new building or theretrofit of a building, or an entirely virtual project which engages the experiments of the scientists. In other words, your work should be 'legible' to both architects and neuroscientists in ways in which architectural innovation might be advanced by the encounters between these two disciplines. Keep in mind, both architecture, and neuroscience, consider themselves as the disciplines which to incorporate all other disciplines.

Select Bibliography

* We will add to this in expanded syllabus and notes on science

Kevin Lynch, The Image of the City, The M.I.T Press, 1977

Frederic Jameson, Postmodermism, or, The Cultural Logic of Late Capitalism, Verso Books, 1992

Antoin Picon and Alessandra Ponte, eds. Architecture and the Sciences, Exchanging Metaphors, Princeton Architectural Press, 2003.

Sarah Williams Goldhagen, Welcome to your World: How the Built Environment Shapes our Lives, Harper Collins, 2017

Beatriz Colomina and Mark Wigley, Are We Human? Notes on an Archeology of Design, Lars Muller, 2017

Richard Neutra, Survival Through Design, Oxford University Press, 1954

Studio Schedule

Part 1 - Introducing Principles of Neuroscience to Architecture

Week 1

Wednesday, Sept 6
- Studio lottery presentation

Thursday, Sept 7
- First studio, introduction, intro assignment

Week 2

Monday, Sept 11
- First Pin Up (location TBD)
- Presentation: Neuroscience Notes for Architects

Thursday, Sept 14
- visit to the Education Center at the Jerome L Green Science Center
- Lecture: Introduction to Neuroscience with Kelley Remole @ 2.15pm
- visit to the Learning Lab. Lecture about memory, learning and decision making with Daphna Shohamy @ 4pm
- hand out second assignment and discussion

Week 3

Monday, Sept 18
- Pin up: Kit of Parts (1)
- group discussion about contemporary neuroscience readings

Thursday, Sept 21: Spatial Navigation in the Brain: Grid Cells / Place Cells /VR / Mazes, Curiosity & Games
- discussion about spatial navigation and cognitive maps
- visit with Jackie Gottlieb and discussion about curiosity and games (exact time TBD)
- visit with Dmitriy Aranov and discussion around spatial navigation, mazes and VR @ 4pm

Week 4

Monday, Sept 25
- pin up: Kit of Parts (2)
- hand out mid-term assignment

Thursday, Sept 28 - Desk Crits

Part 2 - Applying Principles of Neuroscience to Architecture

Week 5

Monday, October 2
- pin up: Kit Of Parts (final)

Thursday, October 5
- Lecture and discussion about data visualization, higher dimensional data, machine learning
- desk crits

Week 6

Monday, October 9 - desk crits
Thursday, October 12 – desk crits

Week 7

Monday, October 16 – desk crits
Thursday, October 19 - last desk crits before mid term

Week 8

Monday, October 23rd - Midterm Review 300 Buell South, 1.30

Part 3 - Bringing Architecture to Neuroscience

Thursday, October 26
- mid term debrief discussion, introduction of final assignment
- lecture and discussion: topics in ‘cognitive architecture’

Week 9

Monday, October 30 - desk crits
Thursday, November 2 - pin up

Week 10

Monday, November 6 - desk crits
Thursday, November 9 - desk crits

Week 11

Monday, November 13 - pin up
Thursday, November 16 - desk crits

Week 12

Monday, November 20 – desk crits
Thursday, November 24 - no class / thanksgiving

Week 13

Monday, November 27 - desk crits
Thursday, November 30 - pin up

Week 14

Monday, December 4 - desk crits
Thursday, December 7 - dry run of final presentations

Week 15

Monday, December 11 - last desk crits before the final
Thursday, December 12 - Final review: 115 Avery