Towards Unity

Emergic Approach: Philosophy Applied to Cognition

Agenda

> I hope they don't ask difficult questions.

| Time (pm)	Slides	Item
1:00	3-14	Prologue
	16-17	Research Problems
	18	Answers
	19-24	Philosophy & Metaphors
	25	Hypotheses
	26-32	Solution: Emergic Approach
	33	Lilac Chaser Illusion
	34-35	Lilac Chaser Model
2:30	36	Discussion (@Mikes?)

Prologue

Setting the mental scene

"vision science is not just one branch of cognitive science, but the single most **coherent, integrated, and successful** branch of cognitive science."
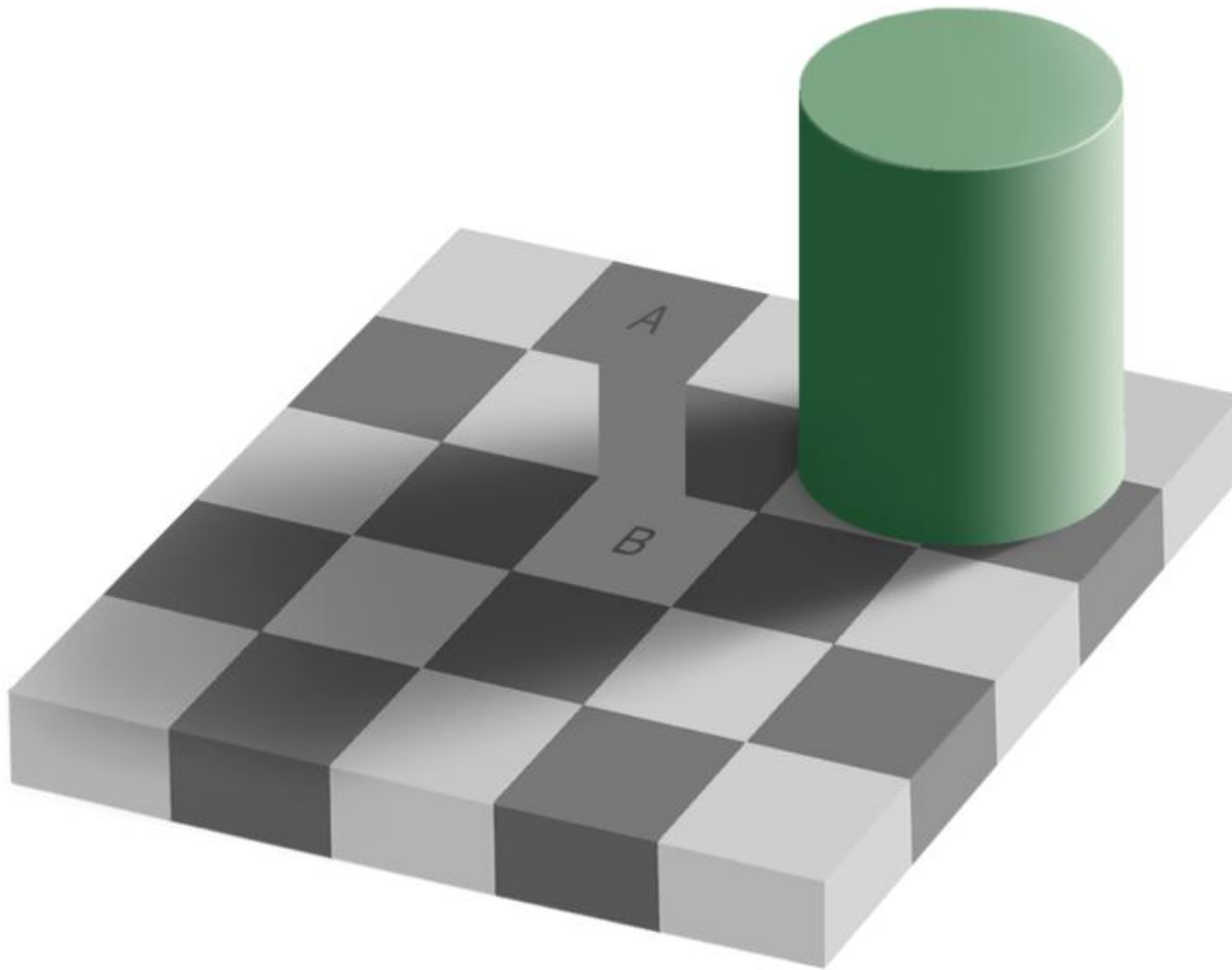
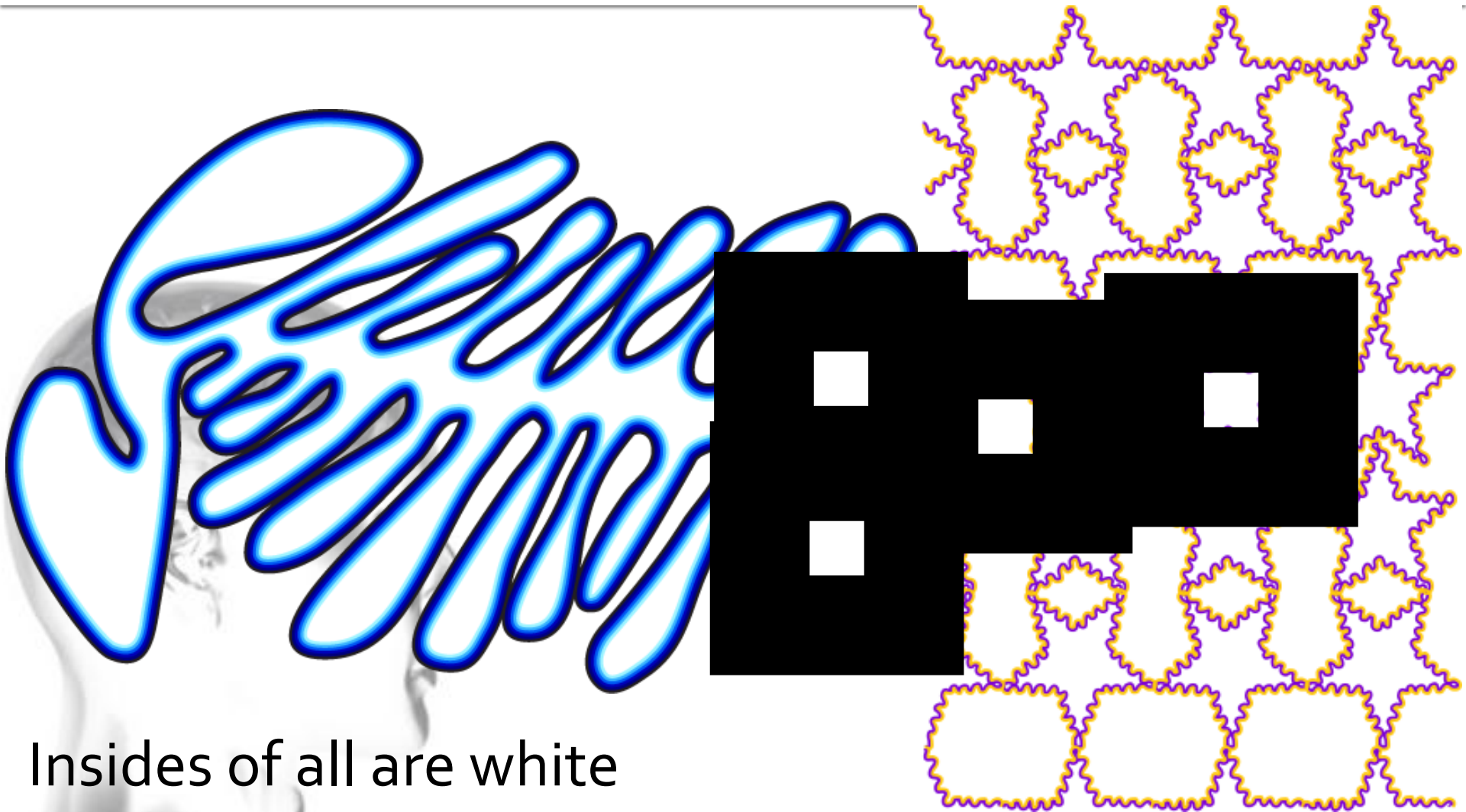– Palmer, S. E. (1999). *Vision Science: Photons to Phenomenology*
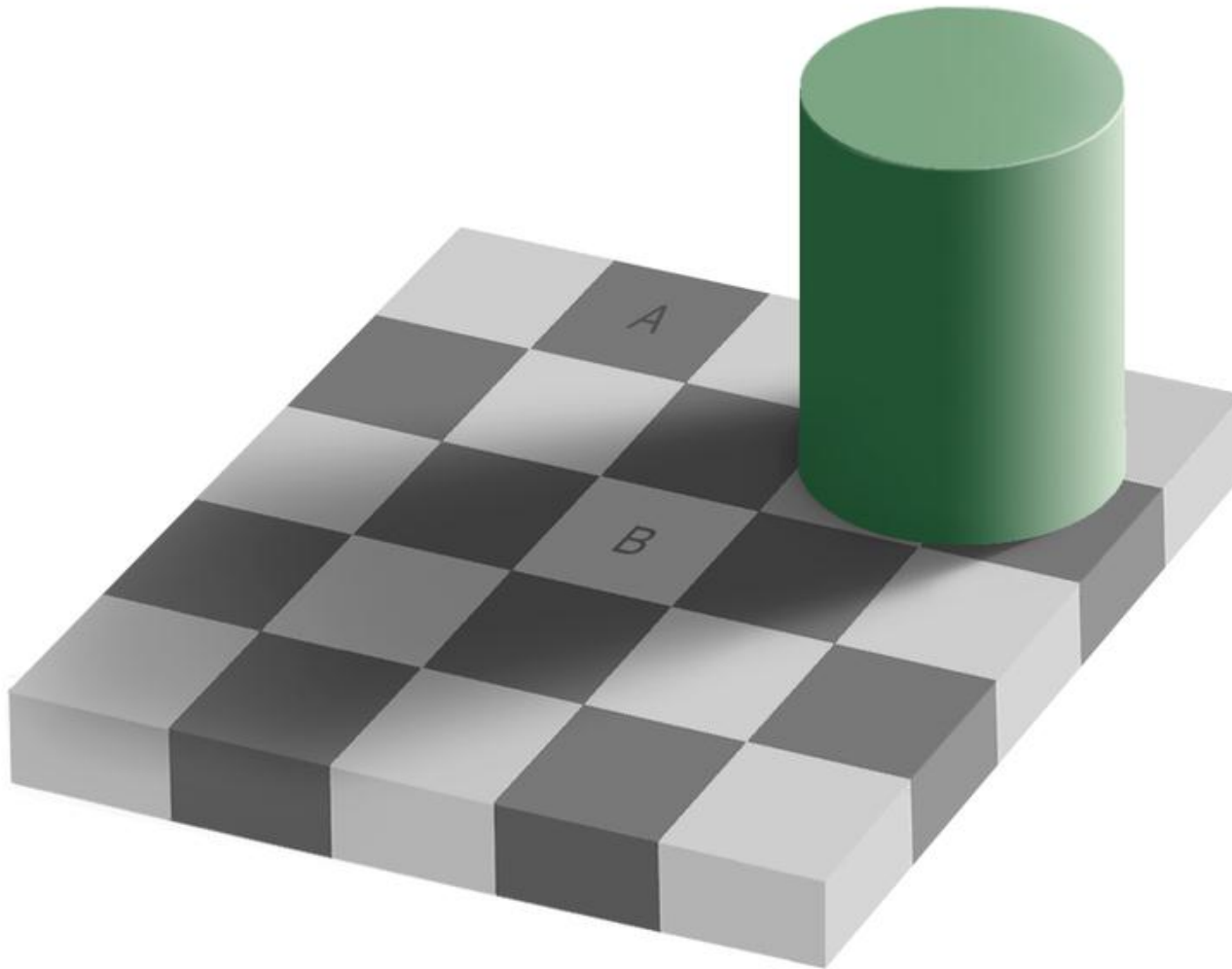
Square A darker than square B.

A==B !

Insides of all are white

Act II

"However, the mechanism of brightness induction evident in several optical illusions, is **not yet understood even after 200 years of intense research** that saw George Berkeley, Maxwell, Helmholtz and the modern Gestalt school, that include both the intrinsic image theorists as well as the anchoring model theorists, following the "top-down" approach on one hand and Weber, Fechner, Mach, succeeded by the modern contrast theorists following the "bottom-up" approach on the other."

— Ghosh, K., & Bhaumik, K. (**2010**). Complexity in Human Perception of Brightness: A Historical Review on the Evolution of the Philosophy of Visual Perception. *Journal of Biological Sciences*, *10*(1), 17-35

Diagnosis

- Much neurobiological knowledge accumulated
- Much behavioural (phenomenological) knowledge accumulated
- Plethora of mental wisdom (hypotheticals) exponentially accumulates (poor S/N)
- Zero mental knowledge accumulated

  ➤ **Not Integrated**

  ➤ **Not Coherent**

  ➤ **No Success**

- Challenge: find 1 fact about mental 90% accepted

Prognosis

- Normal means of science might not suffice
  - No microscope on the non-physical "mental"
    - Microscope: Four Humours   → Microbiology
    - Prism/Particle Accelerator: Chemistry → Quantum Mechanics
    - Telescope: Astrology → Astronomy
    - Nil: Temperaments → Psychoanalytics → …
  - Introspection Unreliability
  - Brain microscope (fMRI, EEG, Patch clamps)
    - Poor spatiotemporal resolution
    - Default network always active
  - Inter/Intra Subject Variation
  - Outward Behaviour vs. Inner Explanation
    - Emergent behaviour (also non-physical like mental)
    - Epicycles vs. Equations of Gravity/Motion
   - Glider, breeder, oscillator, spaceship, … (shadows?) vs. Game of Life
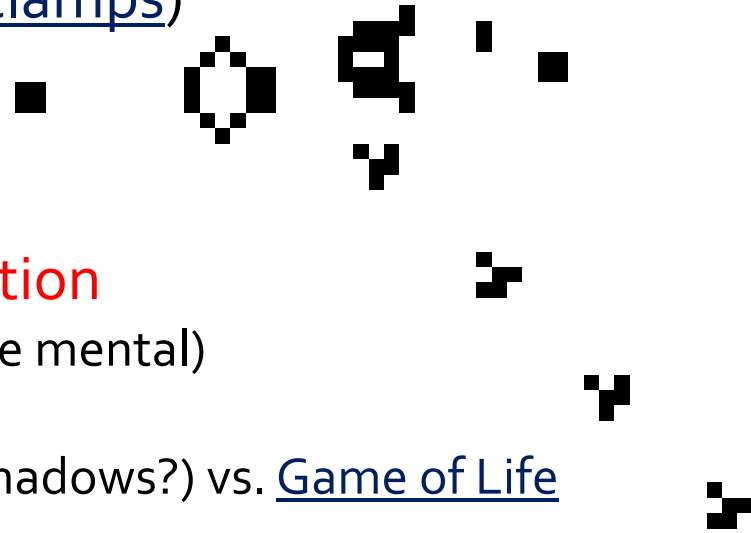
X-ray Crystallography
- Techniques
  - [Powder Diffraction]
  - [Goniometer]
- Crystals pure
  - Perfect diffraction Pattern
  - **Each part identical to another**
  - **Each part consistent over time**

- This is a paradigm for all [empirical] work

crystal

x-rays

diffraction pattern

phases

electron density map

fitting

refinement

atomic model
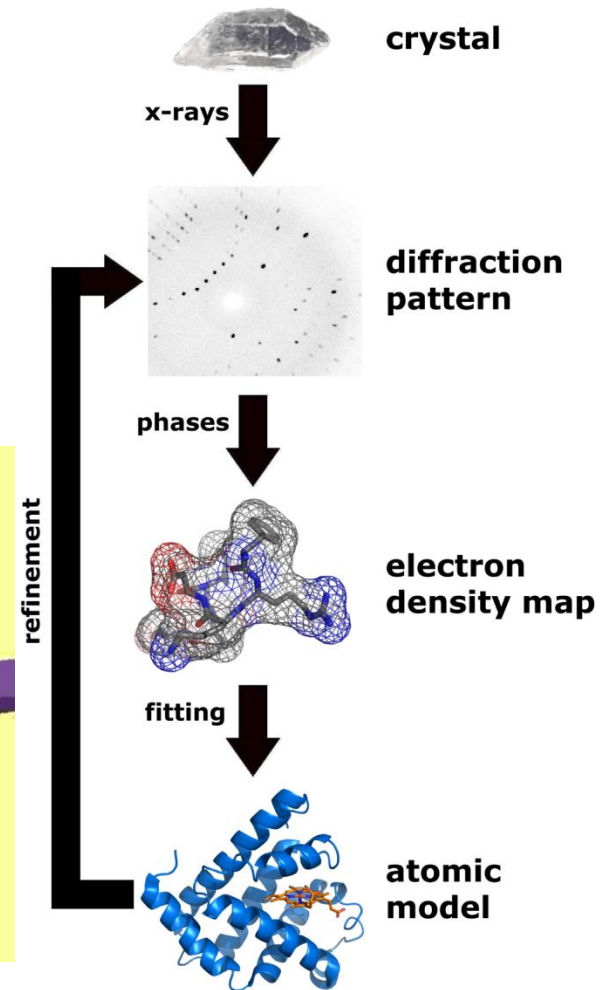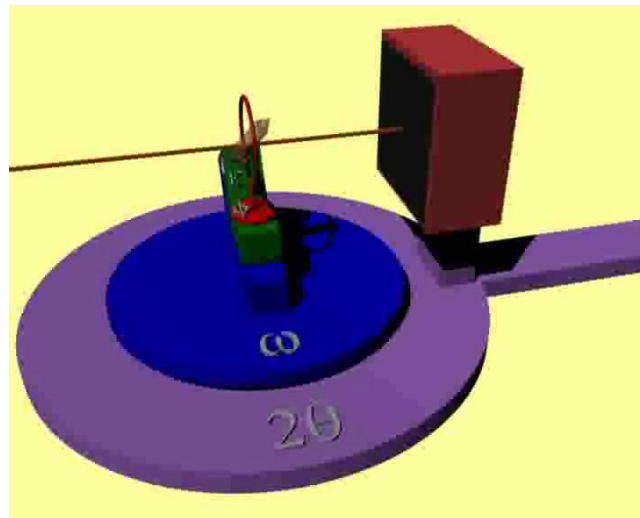
Prediction Accuracy

- Precision of QED
  - fine structure constant, α → 10^{-8} sigs
- Psychology
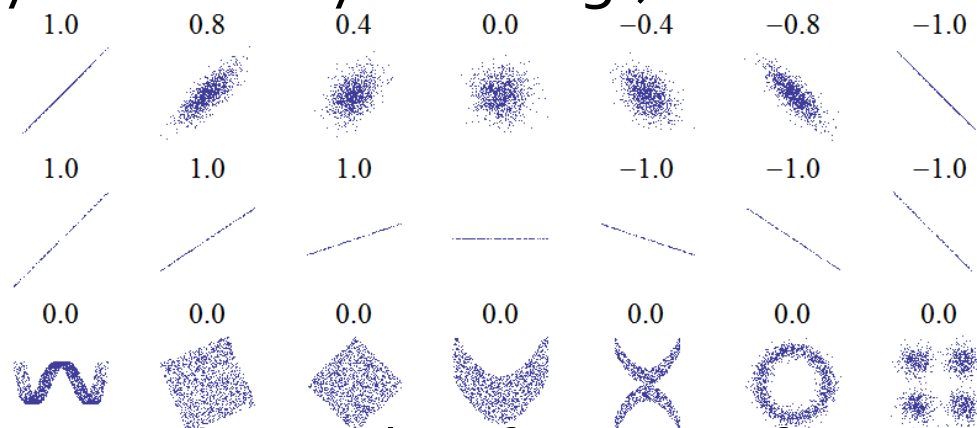 - P-value significance: (every 20th theory is wrong!)
    <.05, <.01
    (chance of false positive)
  - Pearson correlation:
    - $|r^2| > 0.3$ → Medium
    - $|r^2| > 0.5$ → Large
    - Wikipedia: "A correlation of 0.9 may be very low if one is verifying a physical law using high-quality instruments, but may be regarded as very high in the social sciences where there may be a greater contribution from complicating factors"

Result

- Lots of overly simplistic theories that apply to a limited domain

  - "Surrogates for Theories" - Gigerenzer, G. (2009). Surrogates for Theory. *APS Observer*, 22(2), 2-3.

- Incommensurable theories

- Cannot build up more powerful explanatory theories

  - Even among the various models of the same researcher and even when using cognitive architectures such as ACT-R

"The first suggestion is to **construct complete processing models** rather than the partial ones we now do."

– Newell, A. (1973). You Can't Play 20 Questions with Nature and Win: Projective Comments on the Papers of this Symposium. In W. G. Chase, *Visual Information Processing: Proceedings of the 8th Symposium on Cognition*.

- Unfortunately, these have not been forthcoming.

- (I convert software control flow to hardware flow)

Unity – Classical Non-Empirical

| Time	Psychology – Behaviour	Medicine - Symptom	Physics - Property
	Temperament (=Myers-Briggs)	Humour	Element
Spring	Sanguine, Artisan Aspire, Inspire, Extrovert, Sensitive, Compassionate, Thoughtful, Forgetful	Blood Courageous, Hopeful, Amorous	Air Hot & Wet Power, Spirit
Summer	Choleric, Idealist Energy, Ambition, Assertive, Passion, Lead	Yellow Bile Easily Angered, Bad Tempered	Fire Hot & Dry
Autumn	Melancholic, Guardian Thoughtful, Considerate, Worried, Perfectionist, Independent, Focused	Black Bile Despondent, Sleepless, Irritable	Earth Cold & Dry Heaviness, Matter, Fertility
Winter	Phlegmatic, Rational Content, Kind, Accepting, Affectionate, Receptive, Shy, Stable, Relaxed	Phlegm Calm, Unemotional	Water Cold & Wet
Timeless	Divine, Unchanging, Pure		Aether, Space Clear, Essence

Research

Research Problems

P1) **What obstacles prevent the modelling of unified cognitive systems beyond a certain set of interactions?**

P2) **What are some viable solutions?**

Answer P1: Recursion

- **Brain Modelling**
  - Mostly Bottom-Up
    (with top-down modulation)
  - Stimulus-Response
  - Response reacted (reflex)
- **Mental Modelling**
  - Mostly Top-Down
    (with bottom-up modulation)
  - Intentional: Goal Oriented
  - Stimuli pulled (read)
- **Behaviour Modelling**
  - Stimulus-Response (controlled)
  - Previous behaviours affect subsequent ones
  - Cybernetic (control theory)

Perception

Top

A   B

Stimuli - Pushed

A1   A2   B1   B2

Intention

Top

A   B

Stimuli - Pulled

A1   A2   B1   B2
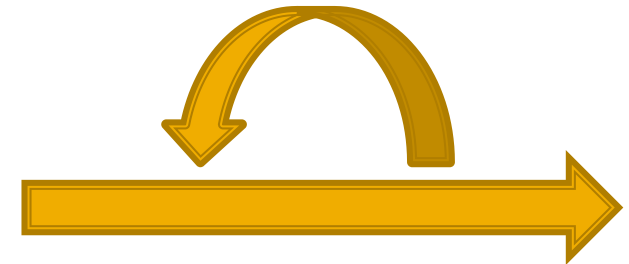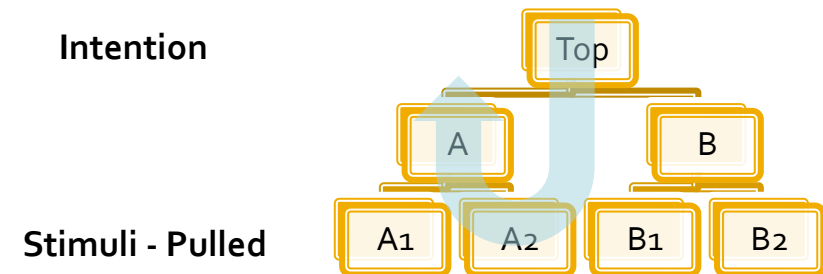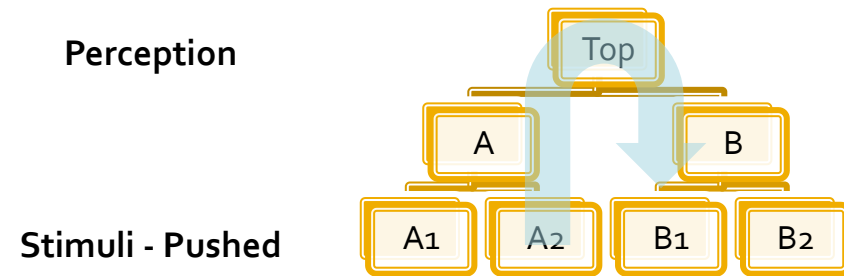
Recursion & Philosophy

- Current "substance" philosophy cannot handle recursion
  - "This sentence is false." ← True or False?
    - Gödel's **incompleteness theorems**
    - Tarski's **semantic theory of truth**
  - Zeno's Paradoxes of Motion & Time
    - Recursion highlights that continuous change cannot be analytically broken up into discrete steps/values. Requires an infinity of steps and infinitesimally small values.
  - Identity and Change
    - Heap of Sand – arbitrariness of definitions; DSM
    - Ship of Theseus
    - Are you the same person today as after, losing an arm, being tortured?
- Need a Process Philosophy

Metaphors as Guides

- Metaphors guide our construction or deconstruction activities. E.g.,
  - Unstructured code → Structured → Functional → Object Oriented
- The more disciplined and explicit understanding of our ontology, the better the result
  - Lots of incompatibilities in cognition (function, computation, cause, representation); too many fallacies
- Remove bad metaphors (top-down, stimulus-response) and add better ones (interactive processes)
  - These are philosophic, metaphysical, and are about inducing theories rather than about specific theories

Metaphors & Wisdom

- *Keep it simple stupid.* *(KISS Principle)*
- *Nothing is ever as simple as it seems. (Murphy's Law #2)*

- *Knowledge vs. Wisdom*
  - *Analytic   - 1 possible outcome; "truth"*
  - *Mystic   - 2+ possible outcomes; experience*
- *Empiricism, Hardware & Software Engineering are mystic enterprises and currently not deducible*
  - *Keep our jobs!*
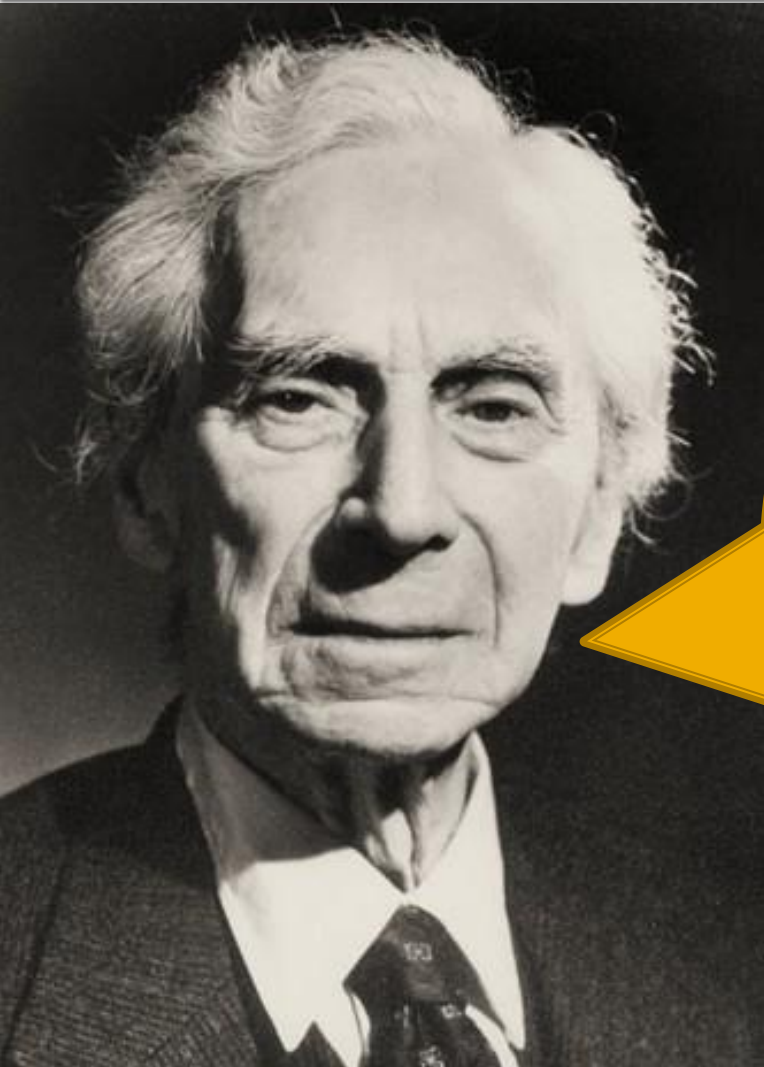- *Lots of wisdom about mental, simply no knowledge of mental*

Metaphysics Frustrations
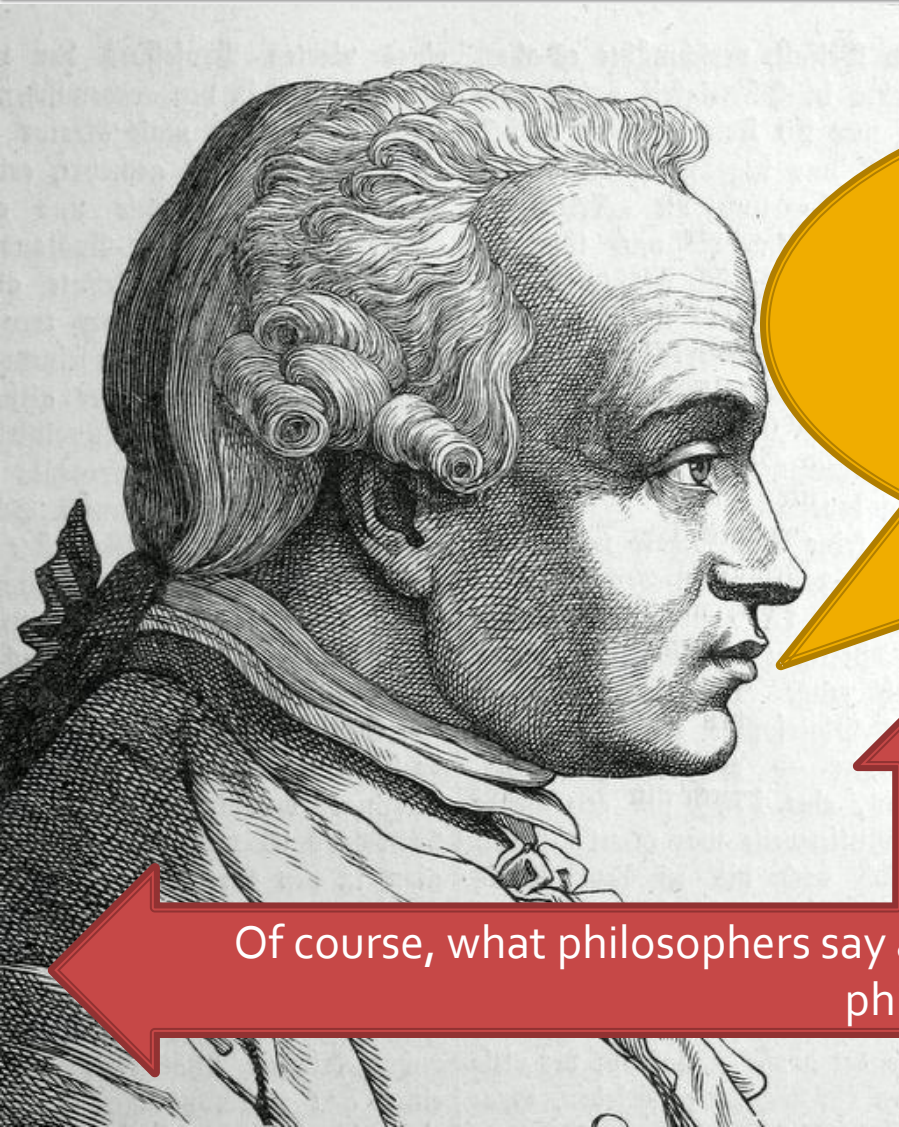
Metaphysics is a dark ocean without shores or lighthouse, strewn with many a philosophic wreck. — Immanuel Kant

Of course, what philosophers say about metaphysics, many can say about philosophy!

Philosophy Frustrations

> **The point of philosophy is to start with something so simple as not to seem worth stating, and to end with something so paradoxical that no one will believe it.**
>
> – Bertrand Russell (1872 - 1970), The Philosophy of Logical Atomism

Metaphysics - History

- ~500 BC Process Metaphysics lost out to Substance Metaphysics
  - Due to bad timing (poor mathematical tools)
  - Buddhism took on mystic
- ~1900 AD Physics implicitly rewrote metaphysics for themselves with great success
  - Huge foundation of Substance Philosophy to overcome
- Philosophy of Cognition and Cognitive Science are still thrashing
  - Is it time to put physics explicitly back into metaphysics?

Answer P2: Hypotheses

- **H1:** The Emergic Approach (EA) can help induce unified theories of cognition, especially in highly recursive systems such as the brain

  - Mostly mystic philosophic advice geared toward cognitive induction – not a cognitive theory

  - First? Analytic process metaphysics

- **H2:** The Lilac Chaser Model (LCM) demonstrates H1

  - Proof by empiricism, not rationalism

  - All design choices here constitute our cognitive theory

Emergic Approach

Harnessing Change

Heraclitus (535-475 BC)
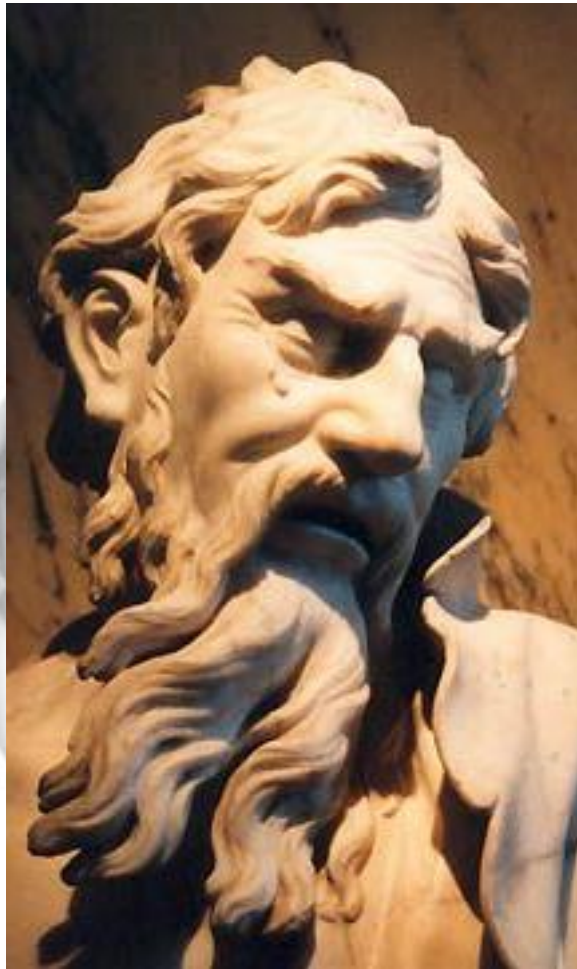
- Father of Process Metaphysics/Philosophy
- Aphorisms
  - "Everything is in a state of flux"
  - "The only constant is change"
  - "All things are one"
    - All things change at the same time and affect each other
  - Unity of opposites
    - Equilibrium
- Completely mystic

EA Summary

Emergic Metaphysics	Process philosophy adopting change interactions as a unifying metaphor
Emergic Networks	Analytic brain simulation of above as Lego™ bricks of change
Emergic Design Principles	Unify, Bottom-Up Re-Engineering, Bottom-Up/Top-Down/Lateral interactions, Model deep structure not surface phenomena via simplify globally but complexify locally, i.e., many phenomena by fewer interactions – "emergic", cognitive plausibility
Emergic Vision System	Manage world/brain interaction where we place our Lilac Chaser Model

- A simple observed process is analytic and formulated as

  "A becomes of –A/2"   or   A += -A/2 or (1)

- The change operator ("+=")

  - Usually small snippets of functional code rather than "+="

- Example could produce the sequence $\{1, \frac{1}{2}, \frac{1}{4}, \ldots 1/2^n\}$ every Δt

  - This could represent a battery becoming discharged

  - Note: non-linear exponential behaviour emerges despite being simply a linear sum of parts. This is due to recursion.

- Process eventually must have self-reference (recursion)

  - Allows it to change over time even if stimuli removed

  - (This is explicitly not allowed in Causal Bayesian Networks)
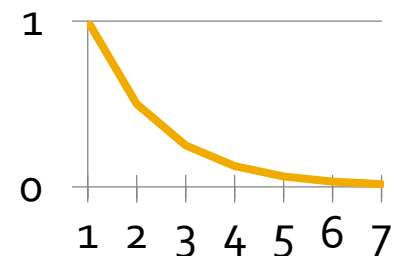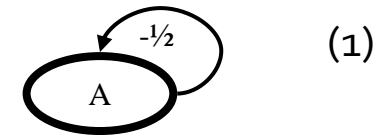
Process Metaphysics – Simple Process Ensemble

- All processes in a system interact continuously and are shown in an ensemble. Here is the [Lotka–Volterra](#) predator-prey example
  - *Rabbit* += (α*Rabbit) – (β*Rabbit*Fox)
  - *Fox* += – (γ*Fox) + (δ*Rabbit*Fox)
- The Rabbit*Fox term is not recursive, is not independent, has no observable reality and is simply shown for simplicity
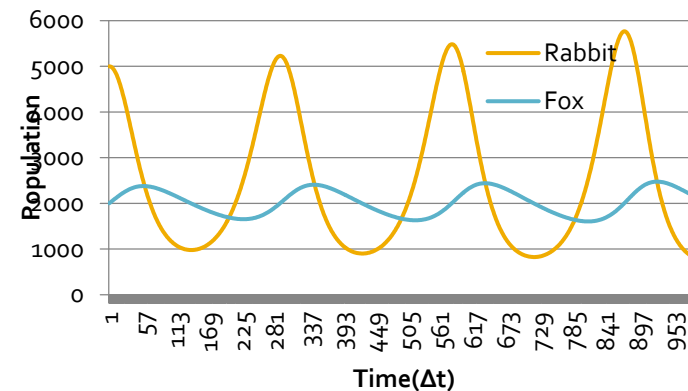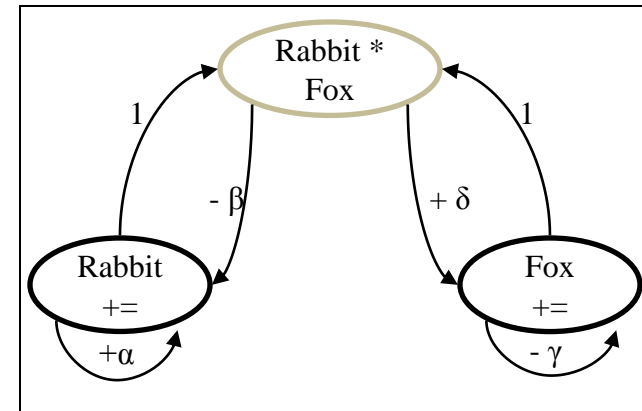 - Represents the chance that fox and rabbits will meet
  - Has no delays
- RHS influence LHS often
  - Interactively
  - Terms of Opposition (+ vs. -)
- System is [time invariant](#)

Interaction

- When two particles collide, they interact.
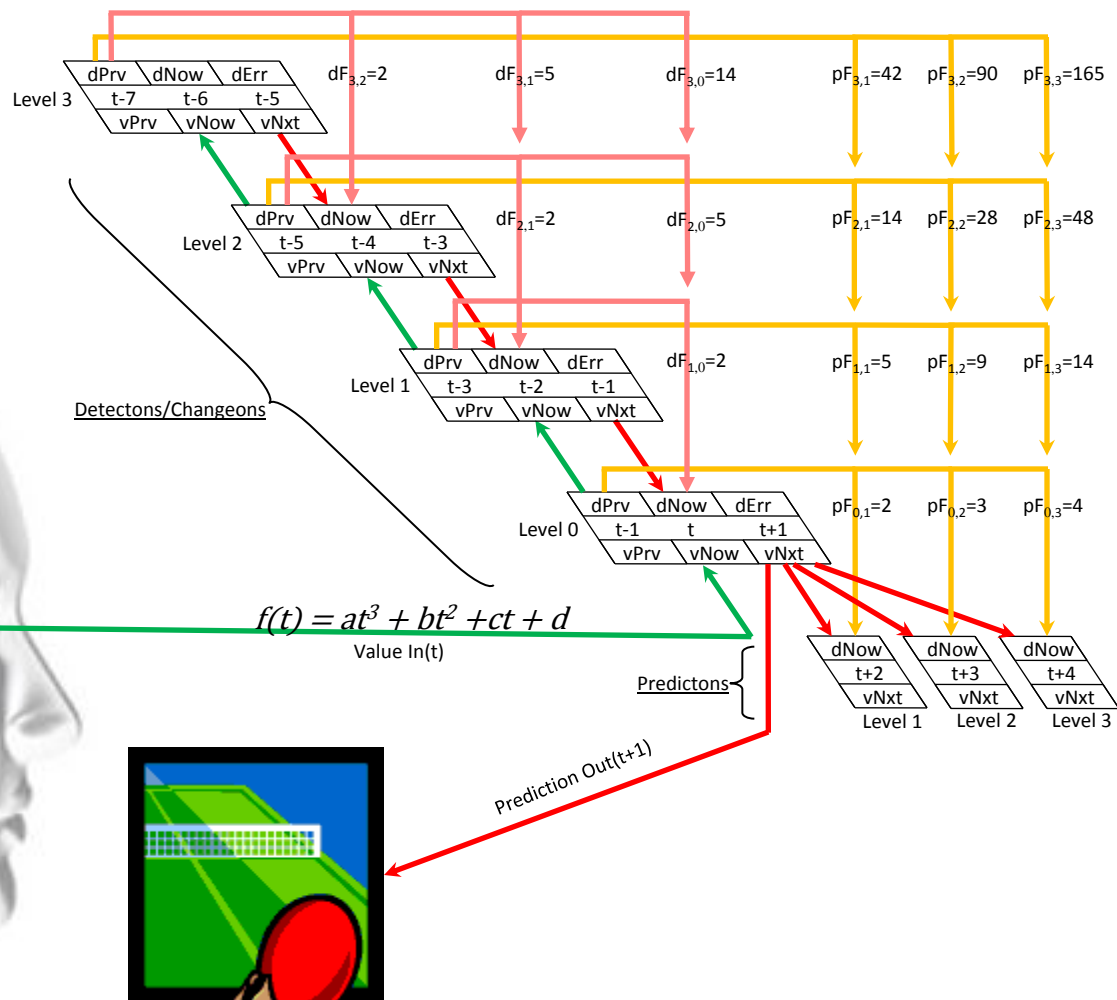
  A

- Informationally, this can be shown as

  B

  A_i → [Short Code for $A_o = \ldots$ $B_o = \ldots$] → A_o

  B_o ← [ ] ← B_i
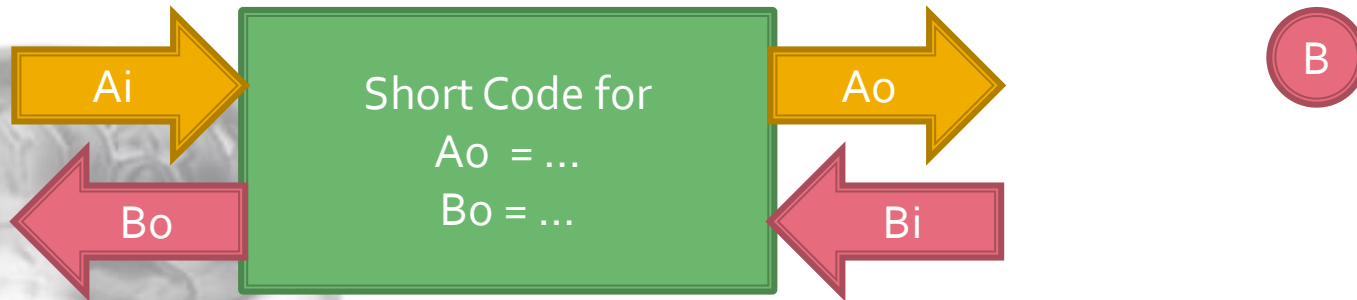
- In practice, "+=" is conceptual and replaced with short functional code segments

- Automatically generates missing info
  - blink
  - Optical blind spot
- Continuous Interaction
  - Bottom-up
  - Top-down
- Incremental Learning of Dynamics
  - Not solution
  - No substance (weights)
  - Adaptive
- Incremental Levels
  - Improve accuracy
- No Delay
  - 8 Spreadsheet Columns
- Delay
  - Need Network
  - +Efferents
- Far Predictors
  - Not needed

Level 3

dPrv	dNow	dErr
t-7	t-6	t-5
vPrv	vNow	vNxt

$dF_{3,2}=2$ $dF_{3,1}=5$ $dF_{3,0}=14$ $pF_{3,1}=42$ $pF_{3,2}=90$ $pF_{3,3}=165$

Level 2

dPrv	dNow	dErr
t-5	t-4	t-3
vPrv	vNow	vNxt

$dF_{2,1}=2$ $dF_{2,0}=5$ $pF_{2,1}=14$ $pF_{2,2}=28$ $pF_{2,3}=48$

Level 1

dPrv	dNow	dErr
t-3	t-2	t-1
vPrv	vNow	vNxt

$dF_{1,0}=2$ $pF_{1,1}=5$ $pF_{1,2}=9$ $pF_{1,3}=14$

Detectons/Changeons

Level 0

dPrv	dNow	dErr
t-1	t	t+1
vPrv	vNow	vNxt

$pF_{0,1}=2$ $pF_{0,2}=3$ $pF_{0,3}=4$

$$f(t) = at^3 + bt^2 + ct + d$$

Value In(t)

Predictons

| dNow |
| t+2 |
| vNxt |
Level 1

| dNow |
| t+3 |
| vNxt |
Level 2

| dNow |
| t+4 |
| vNxt |
Level 3

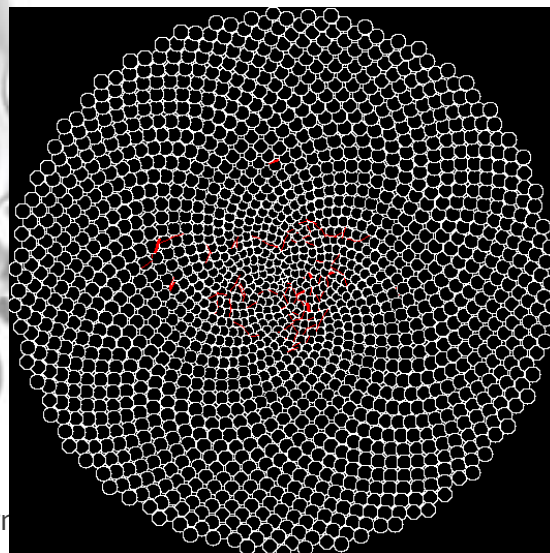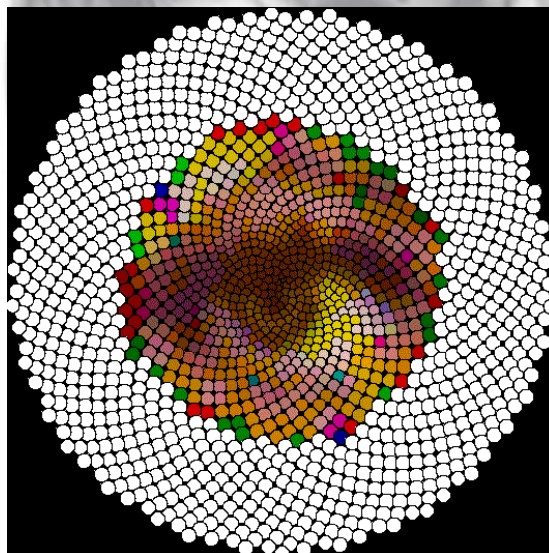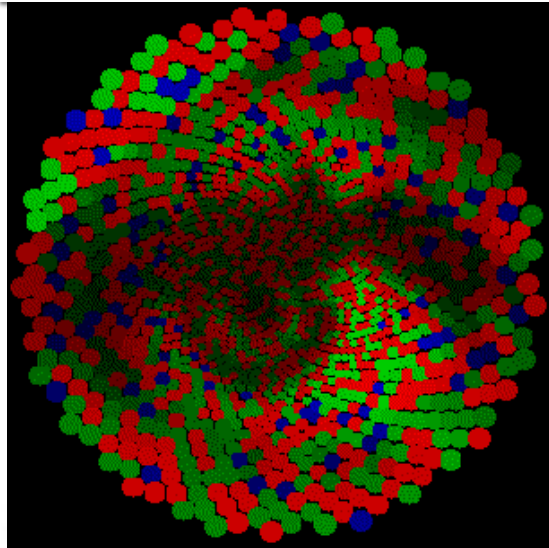Prediction Out(t+1)

Lilac Chaser Illusion

- Standard Explanation

  - Perception of motion due to beta movement

  - Troxler's fading

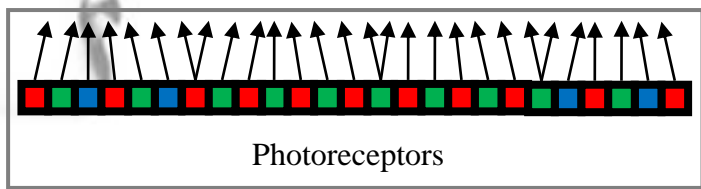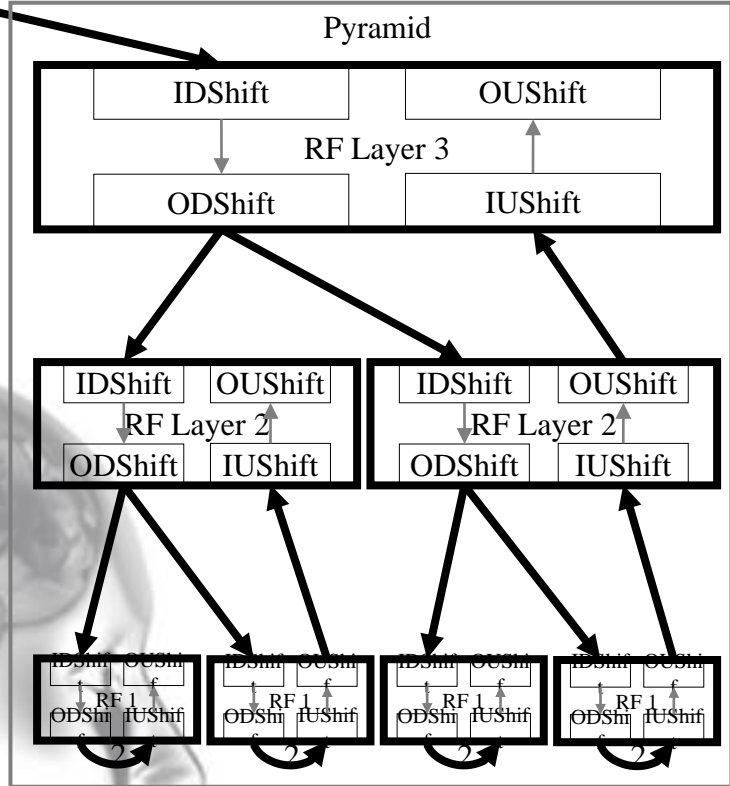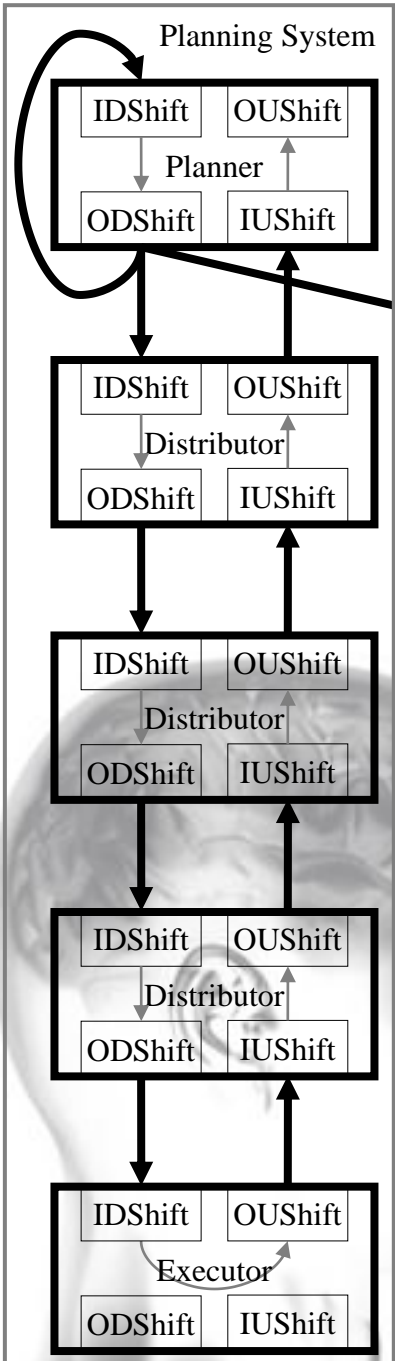 - Negative afterimage is due to neural adaptation and colour opponent processing
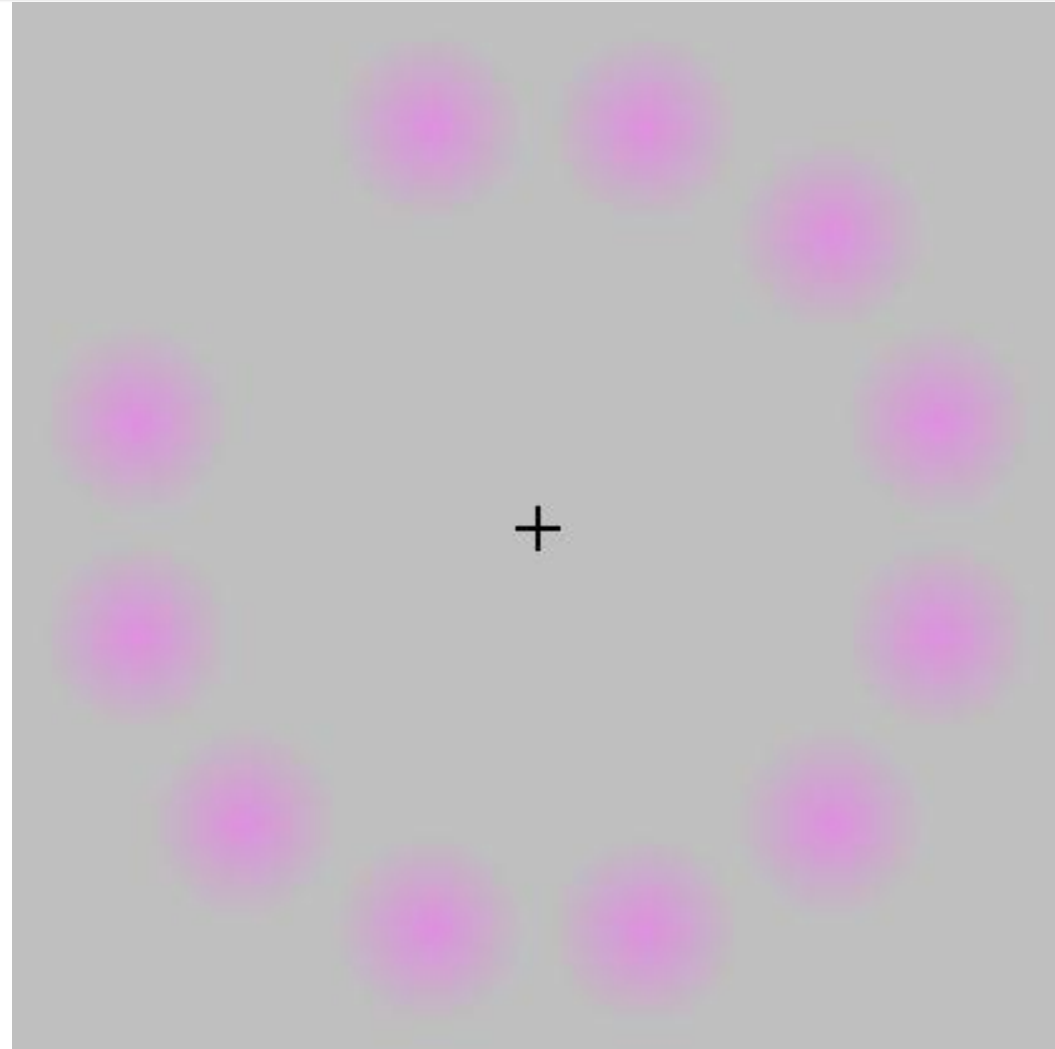
Demonstrate LCM Simulation

- Jittering on Lena's eye
- Photoreceptor Level
- Two Pathways
  - Spatial Summation
  - Change detection

Planning System

IDShift | OUShift
Planner
ODShift | IUShift

IDShift | OUShift
Distributor
ODShift | IUShift

IDShift | OUShift
Distributor
ODShift | IUShift

IDShift | OUShift
Distributor
ODShift | IUShift

IDShift | OUShift
Executor
ODShift | IUShift

Legend:
I: Input
O: Output
U: Up
D: Down

Pyramid

IDShift | OUShift
RF Layer 3
ODShift | IUShift

IDShift | OUShift
RF Layer 2
ODShift | IUShift

IDShift | OUShift
RF Layer 2
ODShift | IUShift

IDShift | OUShift
RF 1
ODShift | IUShift
2

IDShift | OUShift
RF 1
ODShift | IUShift
2

IDShift | OUShift
RF 1
ODShift | IUShift
2

IDShift | OUShift
RF 1
ODShift | IUShift
2

Photoreceptors

LCM Model Motor Planning

- Lateral value movement not shown

Q & A

- Mikes?