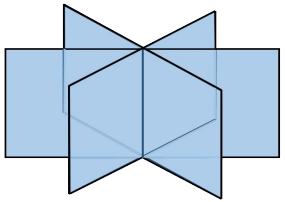
Computational Virtuality as a Form of Artificial Intelligence



Orthogonal Research and Education Laboratory

Champaign-Urbana, IL and Worldwide

Bradly Alicea

http://bradly-alicea.weebly.com

Two big ideas (1)

"Being Virtual" is an interplay between naturalistic human performance and novel experiences

Virtuality occurs in environment in which person experiences telepresence (VR, AR, Movie, Zoom).

Experience is NOT the act of simulation itself, but activity of unspecified cognitive functions.

However, acts of simulation introduces stressors (or perturbations) to experience, effects on a host of cognitive systems.

Two big ideas (1)

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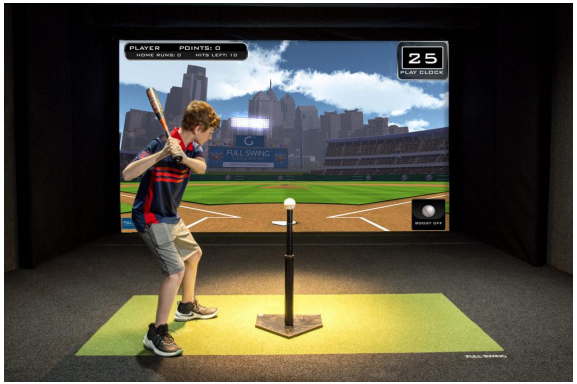

Two big ideas (2)

The Brain is an Allostasis Machine (that differentiates)

The process by which the body responds to stressors in order to regain homeostasis.

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The process by which the body responds to stressors in order to regain homeostasis.

Allostasis: maintaining stability through altering physiologic parameters to counteract challenges.

Two big ideas (2)

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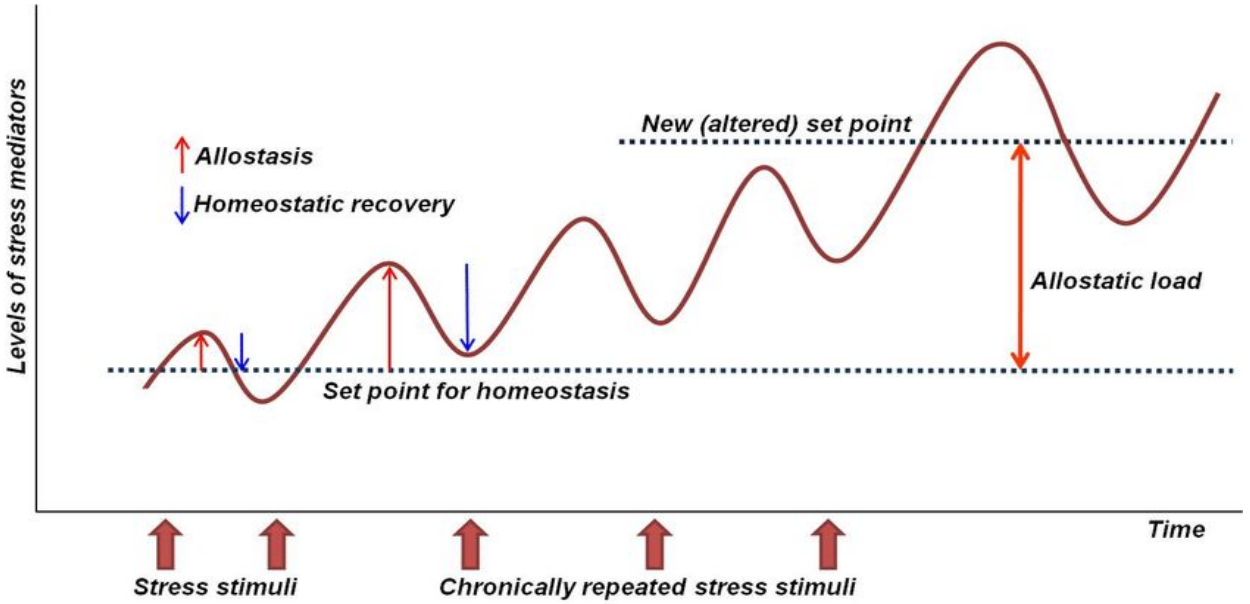

BMB reports 48(4), doi:10.5483/BMBRep.2015.48.4.275 (2014).

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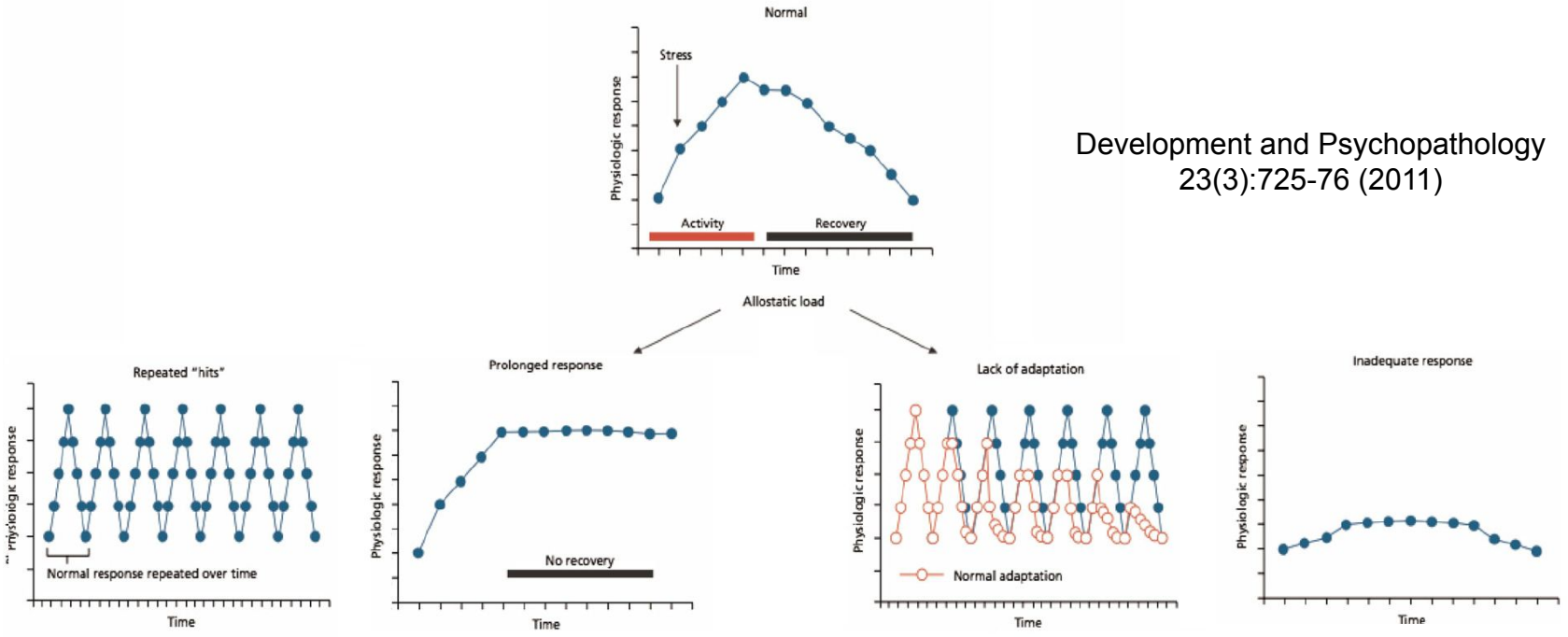


Development and Psychopathology 23(3):725-76 (2011)

Constructive Sensory Experience

Virtuality includes examples, experimental synthesis from a number of concepts and areas

IMMERSION

ATTENTION

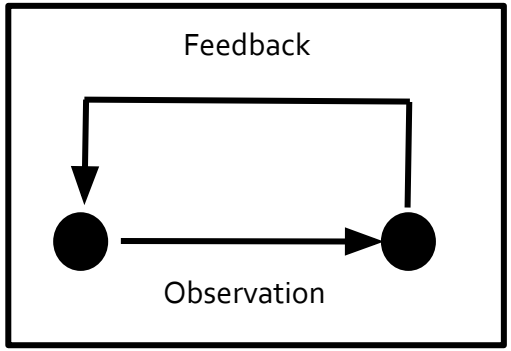
NEUROMECHANICS

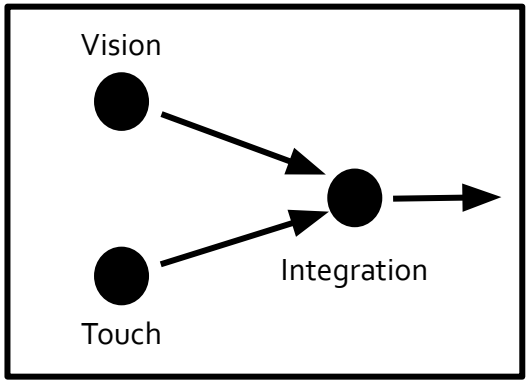
CONSCIOUSNESS

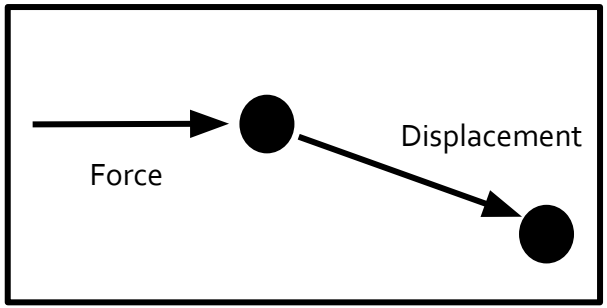
PRESENCE

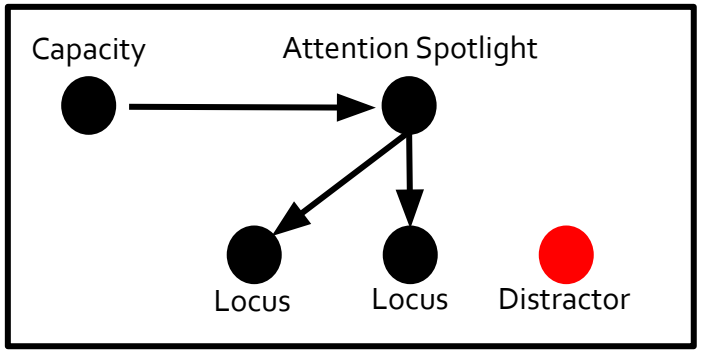
MULTISENSORY PERCEPTION

Cognitive Gaps: difference between mental model and interactions with the world. Expressed as latencies and mismatches, but ultimately dysregulation.









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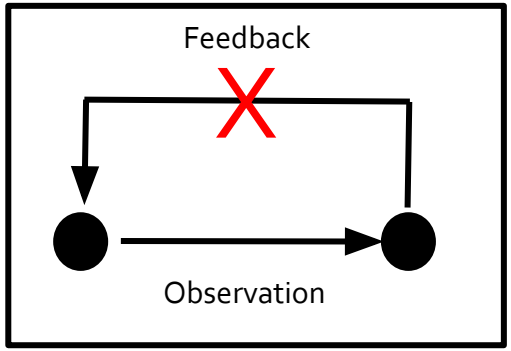
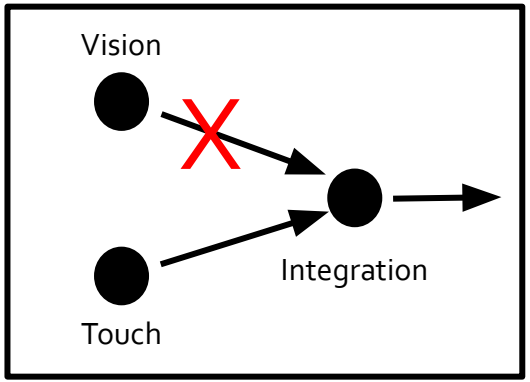
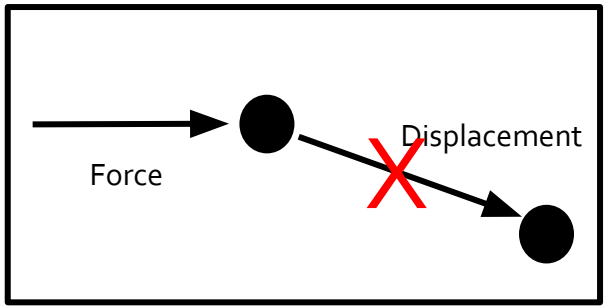
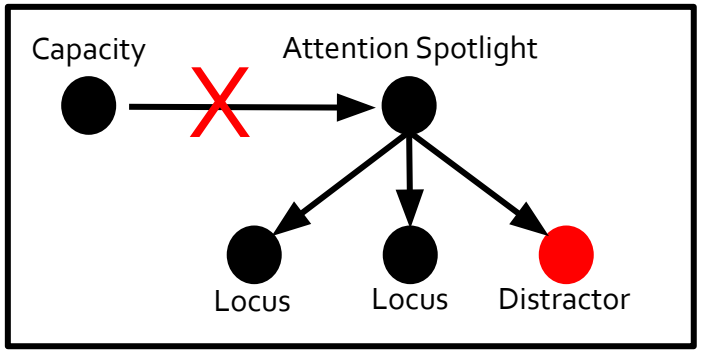




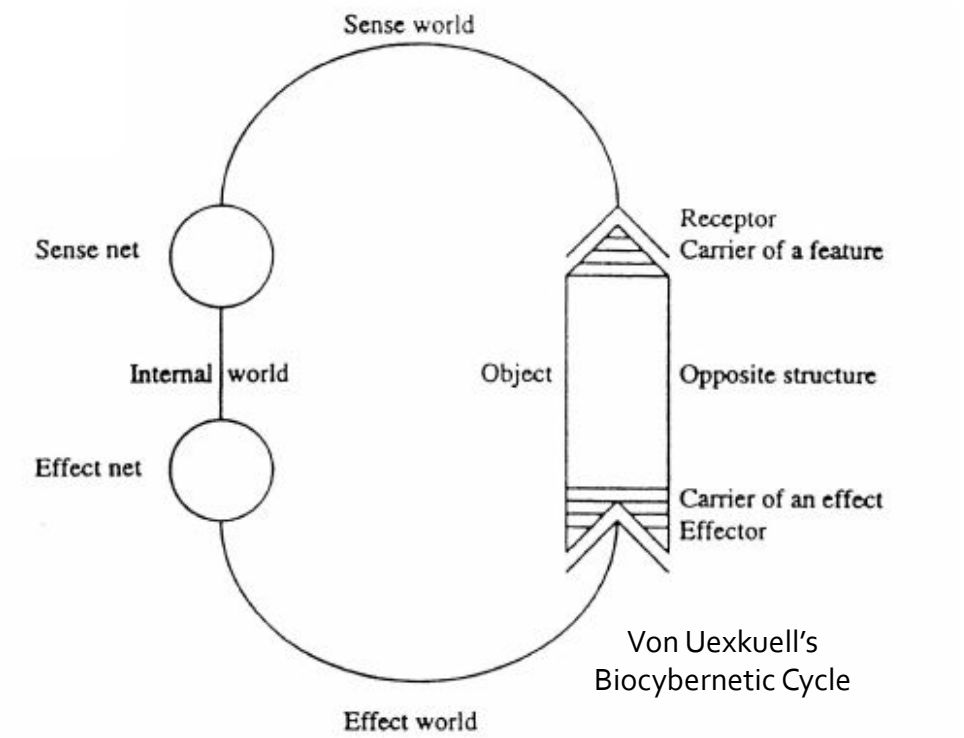




Internal Dysregulation

Disruption of sensorimotor feedback loop has consequences on adaptive behavior.

Internal models can be computational (sensorimotor coordination), or representational (mental, attentional).



Von Uexkuell's Biocybernetic Cycle

Internal Dysregulation

"Every good regulator of a system must be a model of that system" Conant and Ashby, 1970.

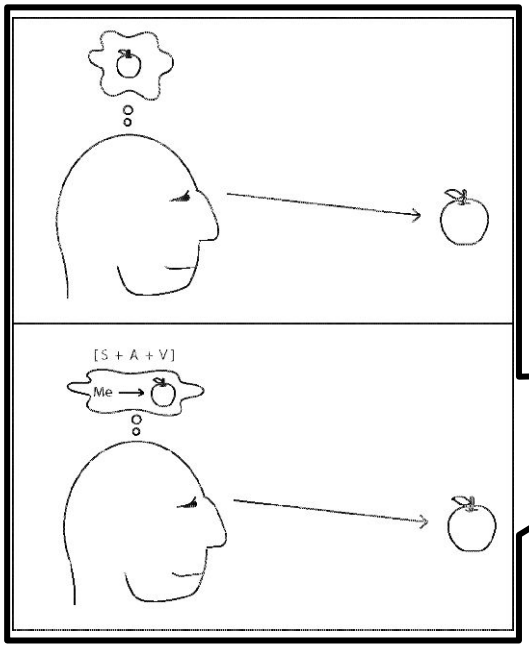
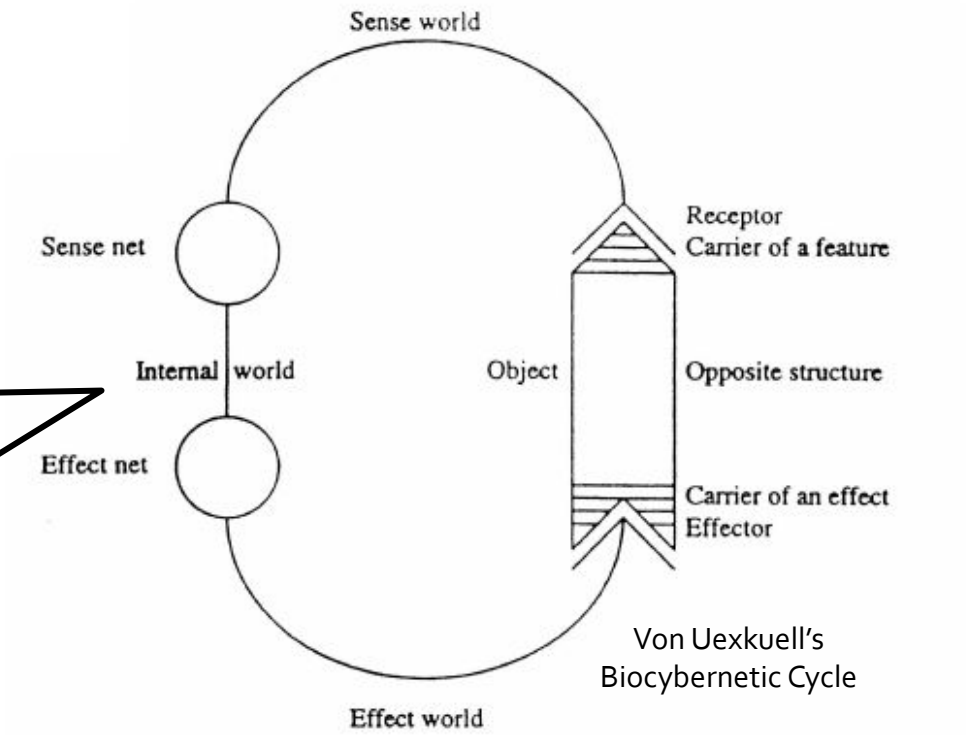


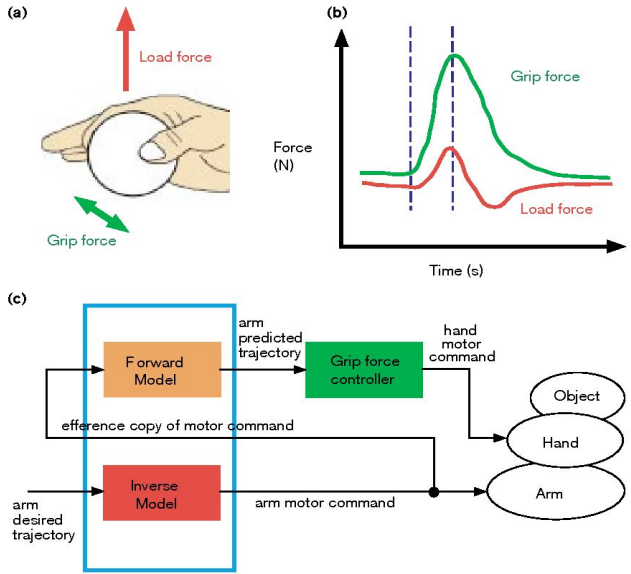
IMAGE: Graziano and Webb, The attention schema theory: a mechanistic account of subjective awareness. *Frontiers in Psychology* (2015).

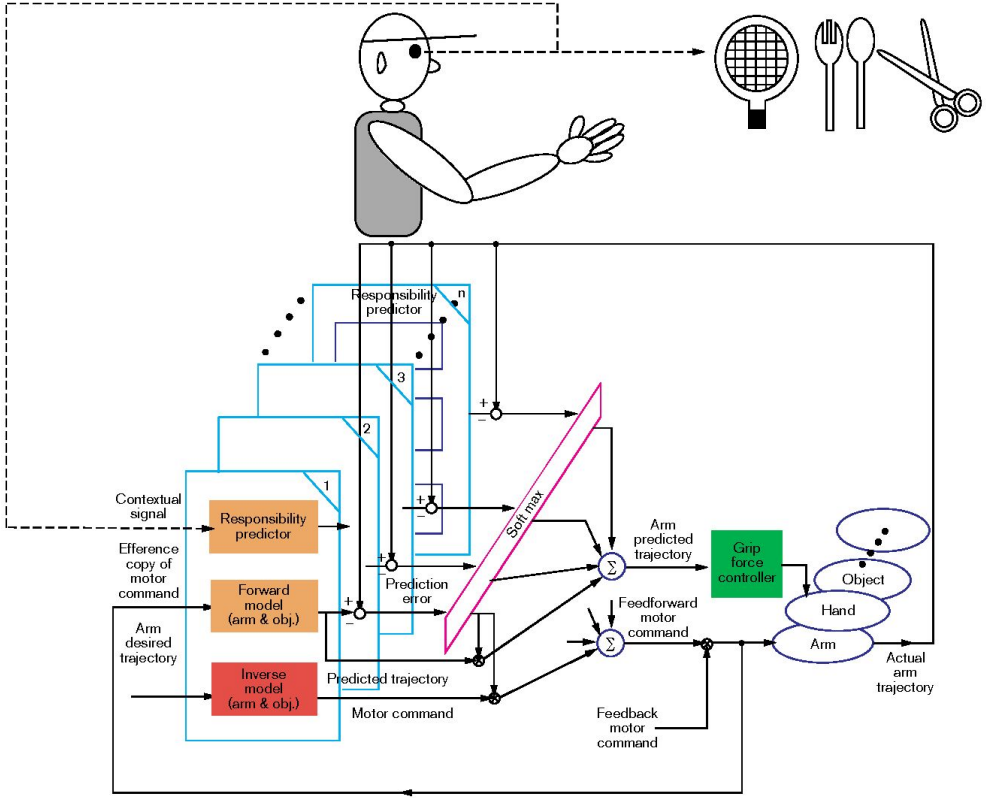


Von Uexkuell's Biocybernetic Cycle

Internal Dysregulation

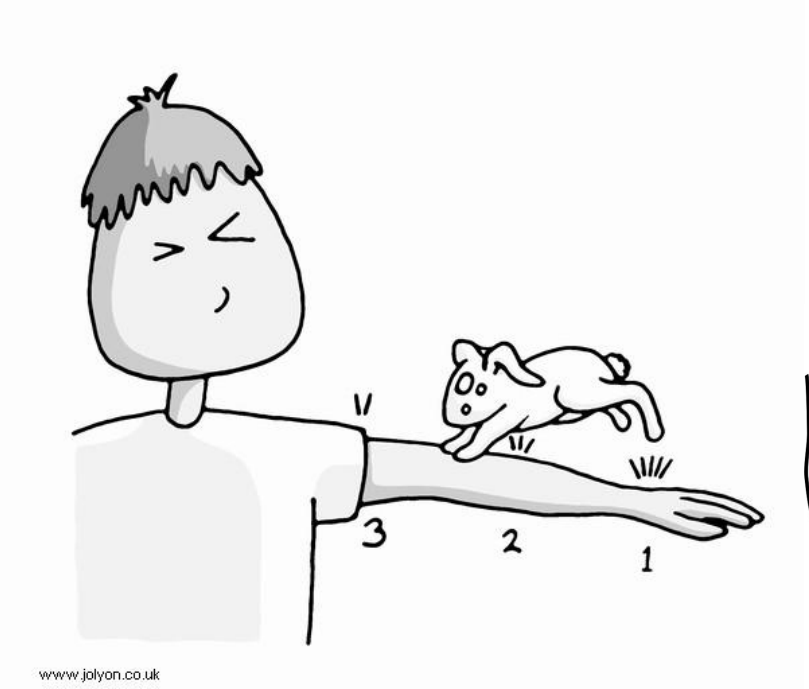
Internal Model for coordination (but can be perturbed into a dysregulated state).





IMAGES: Kawato, M. (1999). Internal models for motor control and trajectory planning. *Current Opinion in Neurobiology*, 9(6), 718-727.

Internal Dysregulation



Cutaneous Rabbit Illusion

- patterned haptic stimulation along the arm mimics rabbit hopping.
- phantom sensations can fill in the experience (differs from initial pattern of stimulation).

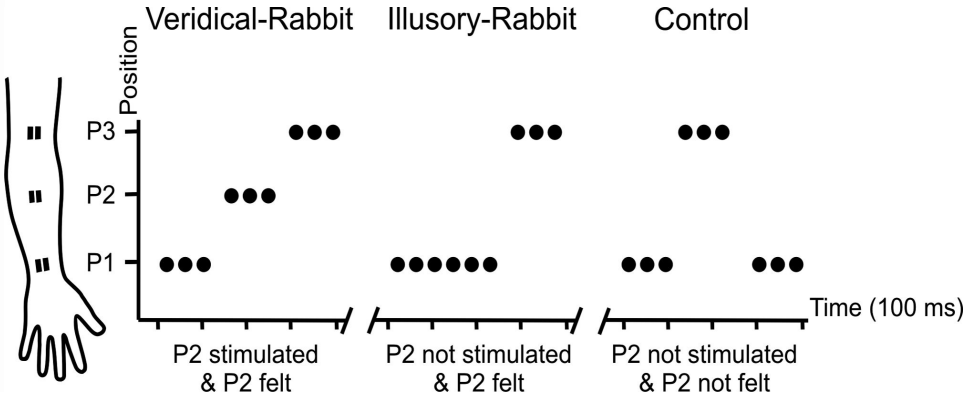


IMAGE: Blankenburg, Ruff, Deichmann, Rees, and Driver (2006). PLoS Biology, 4(3), e69.

Internal Dysregulation

When sensory modalities (vision, touch, audition) are non-coincident in space and time:

- sensory disarticulation events.
- interferes with superadditive effect of integrated stimulus.

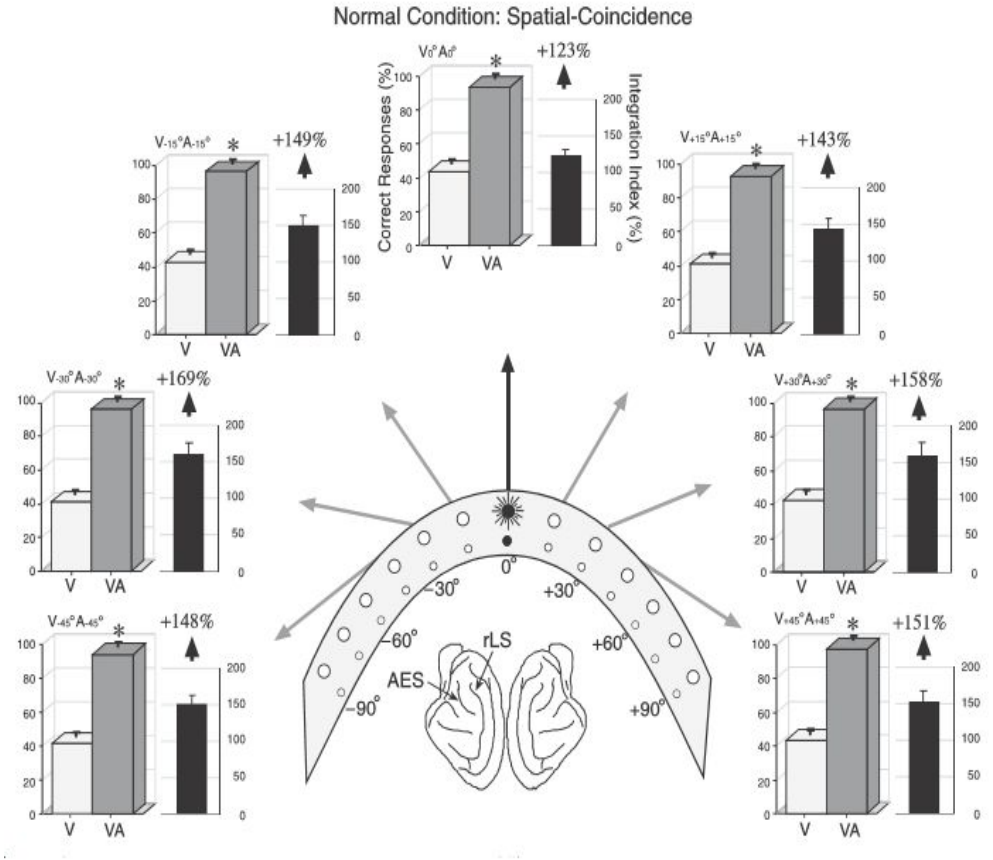
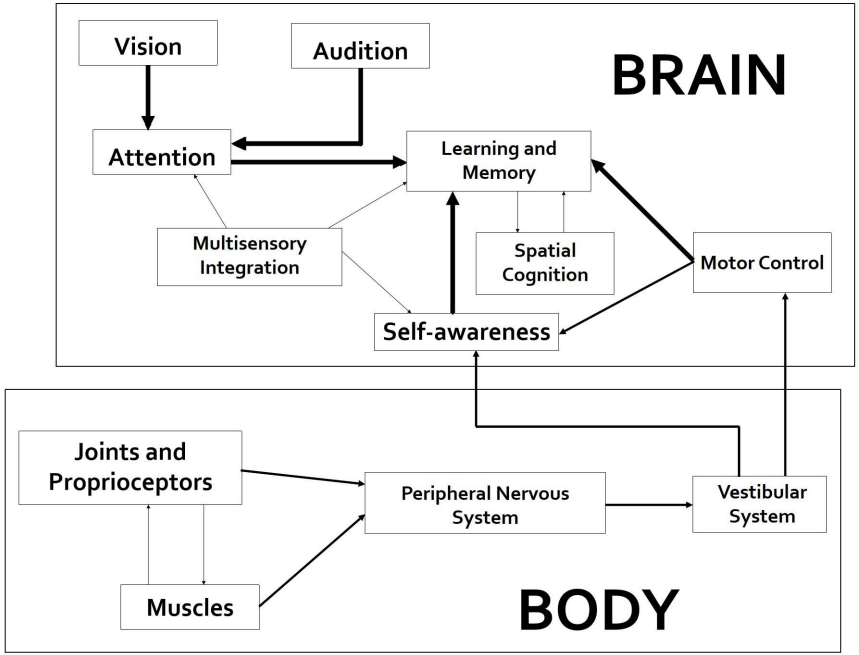


IMAGE: Jiang, Jiang, and Stein (2002). *Journal of Cognitive Neuroscience*, 14(8), 1240–1255.

Virtual Reality for Communication Neuroscience

Handbook of Communication Neuroscience (Routledge), Chapter 32

First-pass approximation of "Virtuality" network



Naturally Supervised Learning in Manipulable Technologies

arXiv, 1106.1105 (2011)

Physics of environment (forces, light, surfaces) act to supervise the nervous system (plasticity, learning).

When these cues are removed (or decoupled) in a virtual setting, it creates a cognitive gap.

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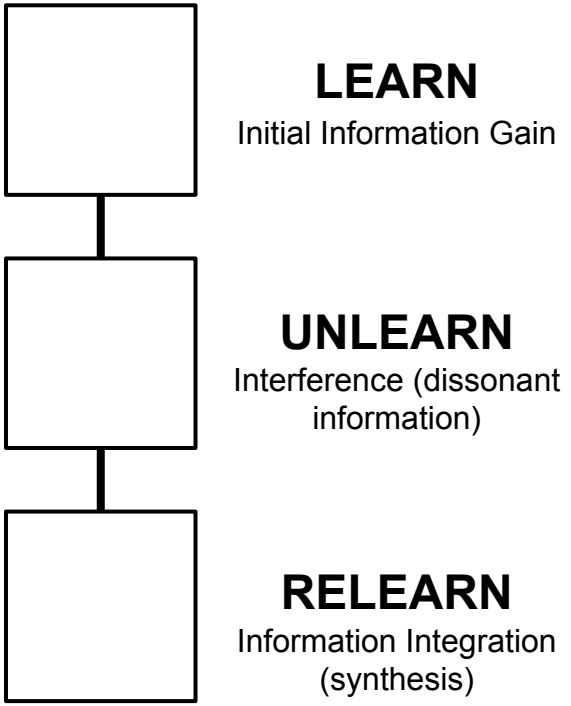
Alternating simulated surfaces used to learn-unlearn-relearn haptic information flow.



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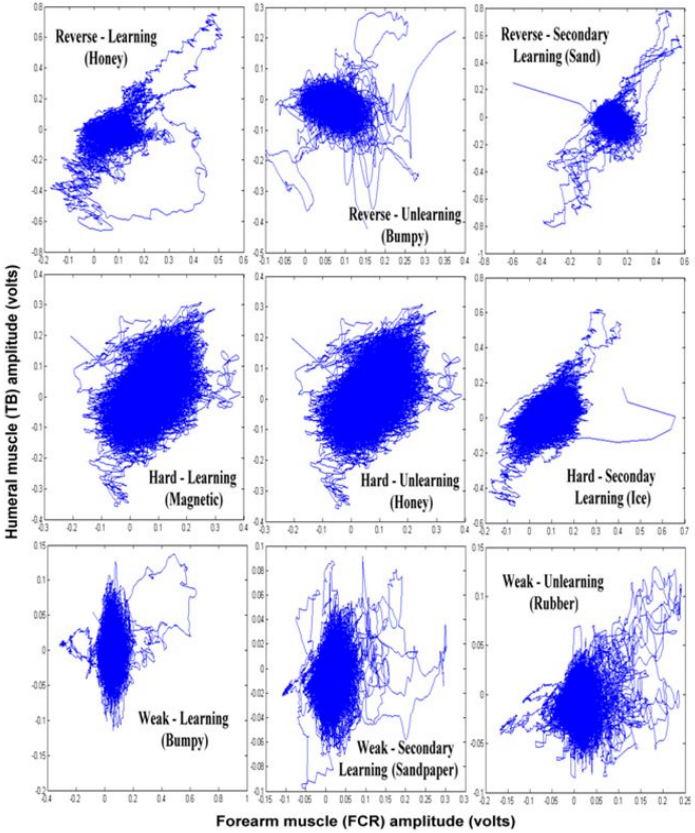
Novint force-feedback device used to simulated surfaces, muscle activity (EMG) measured using Biopac



Stimulus switching: changing the environment rapidly over time

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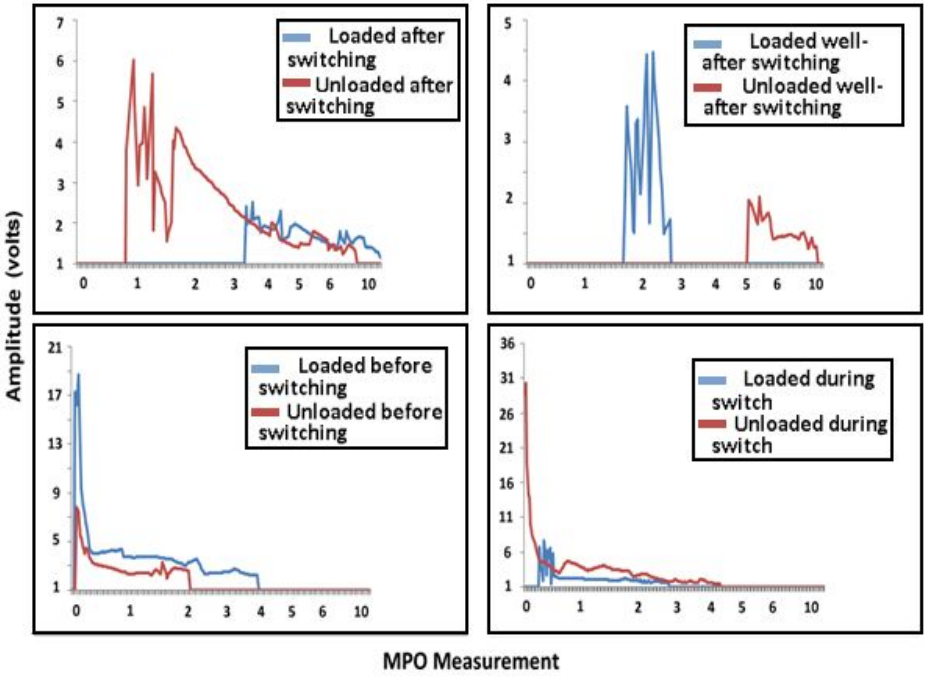

Stimulus switching: changing the environment rapidly over time

Computational Agents

Virtuality can be modeled in a computational agent, where basic functions of the nervous system are distilled into a series of functions.

- these functions can in turn be regulated or dysregulated using various forms of perturbation.

Computational Agents

Virtuality can be modeled in a computational agent, where basic functions of the nervous system are distilled into a series of functions.

- these functions can in turn be regulated or dysregulated using various forms of perturbation.

What is the universal basis for virtuality in an embodied nervous system?

- virtuality likely exists in non-human animal brains, so a realistic model of brain regions is not desired.

Agent Architecture

Attentional Attributes:

Integrate: how to integrate information from different sources, senses.

Adjacency: how to associate things from different spatial or representational contexts.

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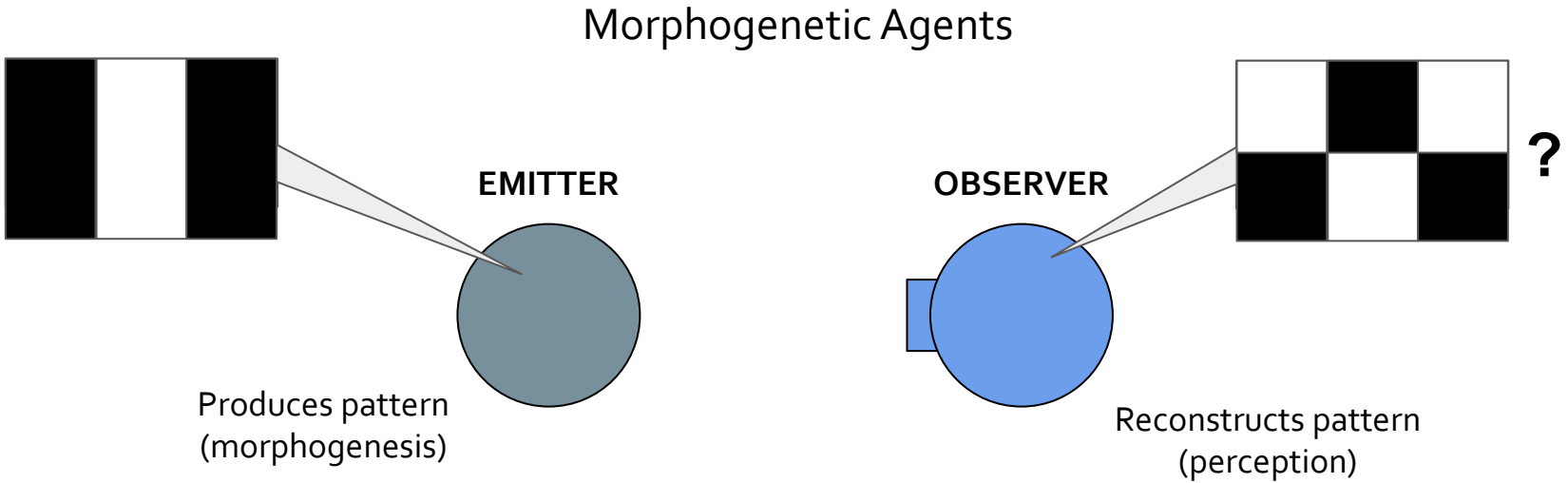
Sensorimotor Attributes:

Displace: what is the displacement of sensorimotor alignment when perturbed (e.g. prism adaptation)?

Track: how are changes in the ability to track objects affected by perturbations?

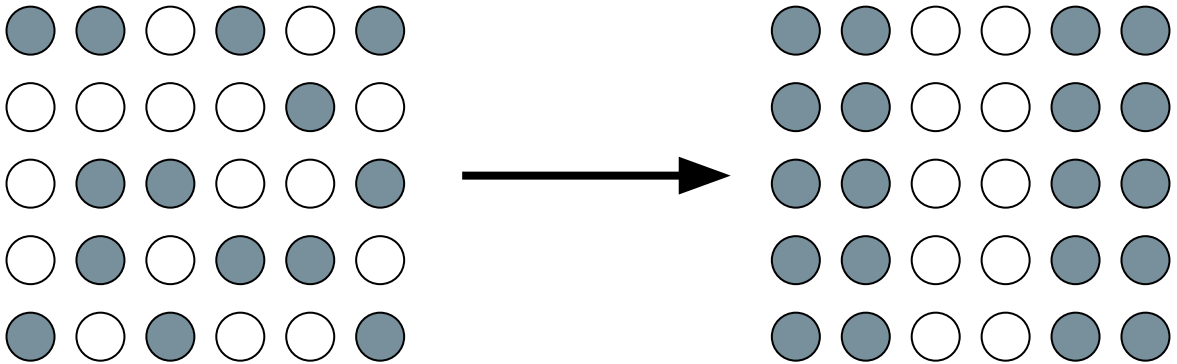
Sample: how do changes in environmental sampling affect the internal state during virtual interactions?

Synthetic Experiments



Allows for coevolutionary relationship (arms race) that can serve as a fitness function to train the model.

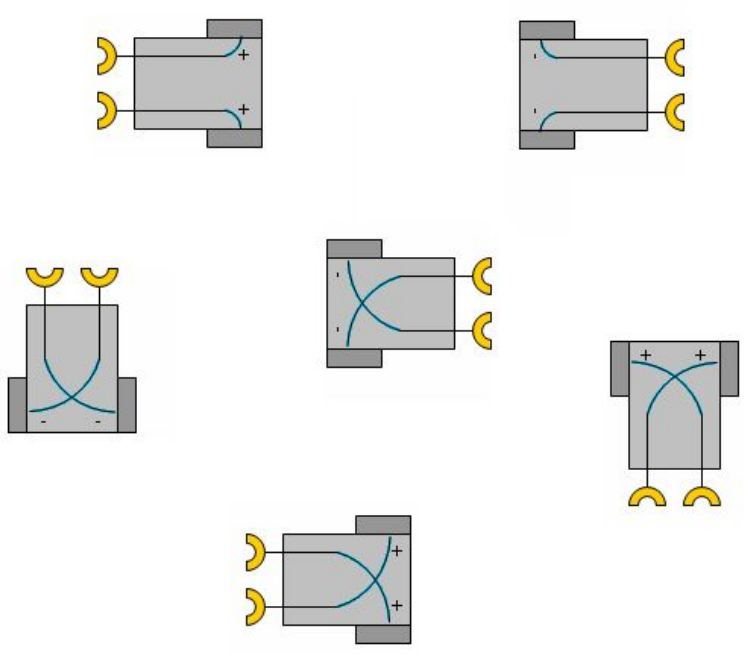
Synthetic Experiments



Learning where to focus attention: enforces spatial restriction in array of cells (enforced strips of cells with different functional roles). 6x5 cell array, nearest-neighbor connectivity.

Synthetic Experiments

Modified Braitenberg Vehicles

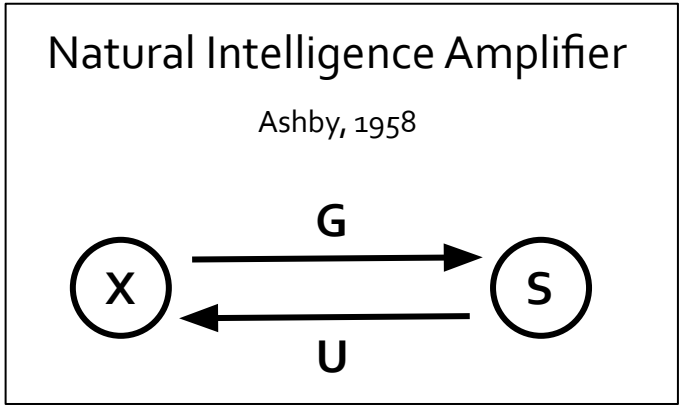


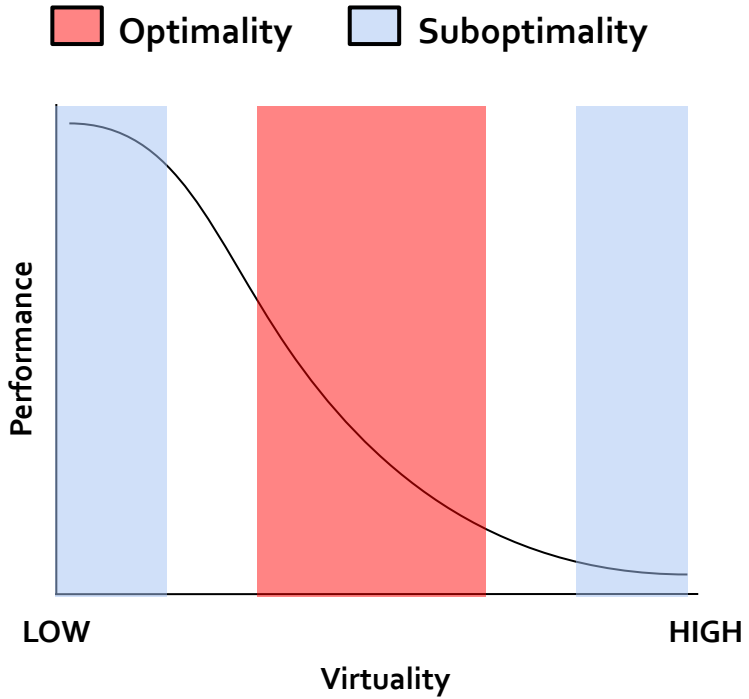
Instead of phototaxis, physics engine functions (force-feedback or gravity) with implausible scenarios and transitions.

Incongruous physics simulations can also be used to train embodied neural networks and genetic algorithms.

Intelligence Augmentation

arXiv, 1804.10521 (2018)



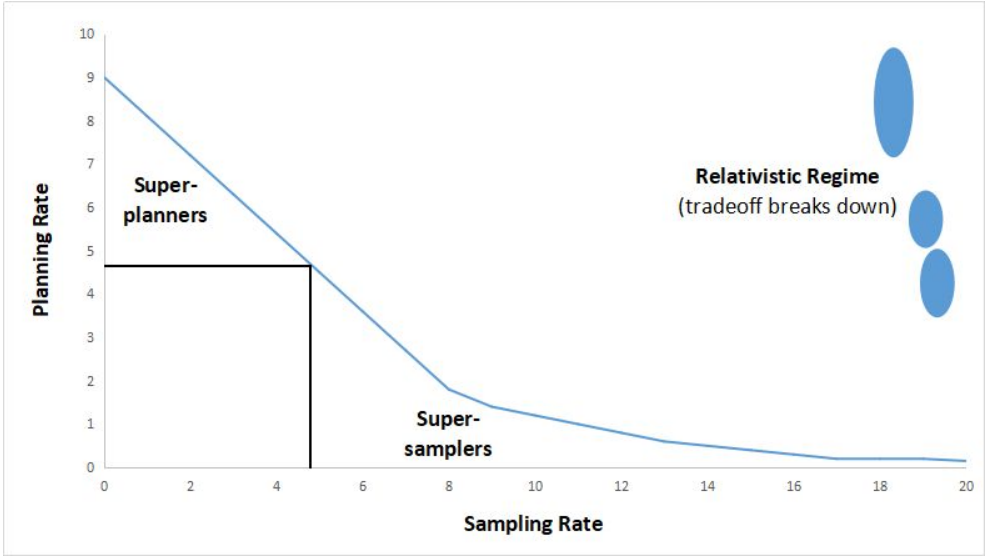


Suboptimality: behaviors that are suboptimal in terms of performance, but lead to future adaptability.

Cognitive Gaps in Development and Evolution

How does a fly avoid the predatory swatter?

Graph of hypothetical supersamplers



Perceptual Time and the Evolution of Informational Investment.
Synthetic Daisies blog, September 24 (2013).

Thanks For Your Attention!