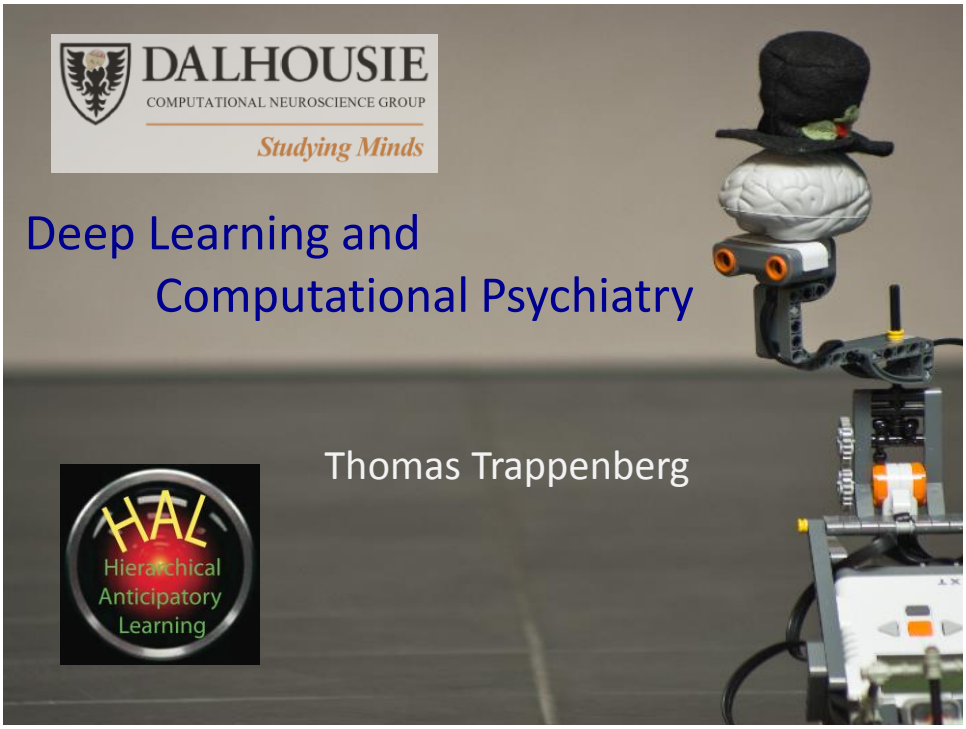
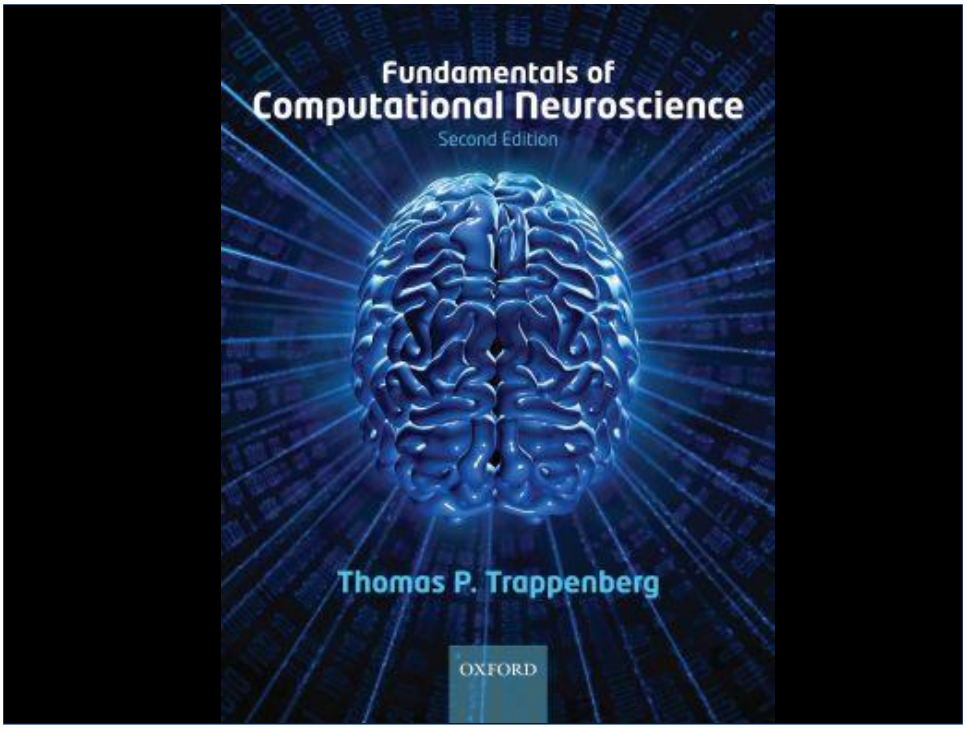
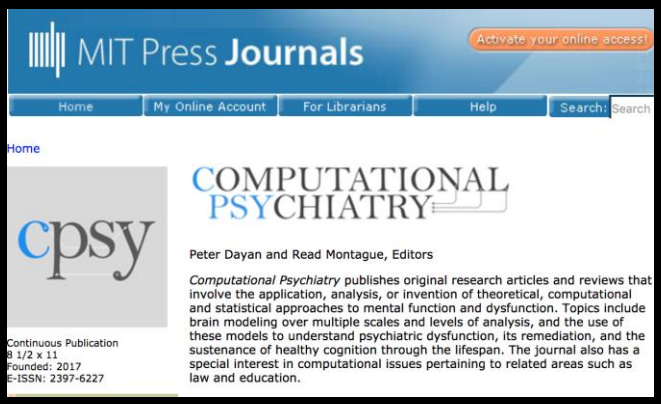

DALHOUSIE
COMPUTATIONAL NEUROSCIENCE GROUP
Studying Minds
Deep Learning and
Computational Psychiatry
Thomas Trappenberg
HAL
Hierarchical
Anticipatory
Learning


Fundamentals of
Computational Neuroscience
Second Edition
Thomas P. Trappenberg
OXFORD

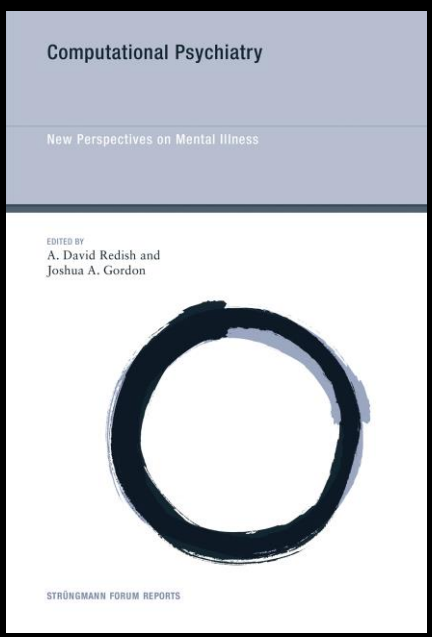



Challenges

- Diagnostic Nosology
  symptoms instead of cause and pathogenesis
- Biomarkers
- Treatments

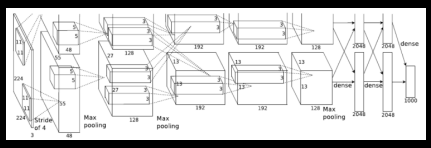
Promises

- Genetics as Destiny
  pathways and networks
- Circuits Drive Behaviour
- Personalized Medicine

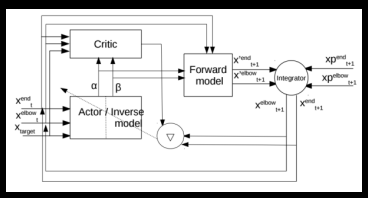


Outline

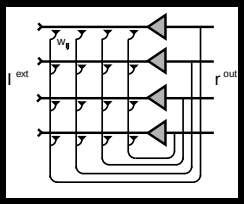
- Deep Learning and Small Data



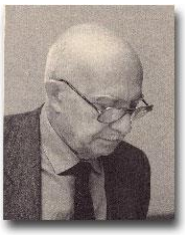
- Functional Models




- Neurodynamic models

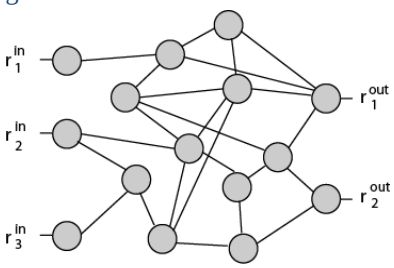



# Universal Learning machines



Eduardo Renato Caianiello
(1921-1993)

1961: Outline of a theory of Thought-Processes and Thinking Machines




(neuronic equations, N.E.):

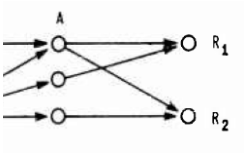
$$u_h(t+\tau) = \mathrm{I}[\sum_{k,r} a^{(r)}_{hk}\, u_k(t - r\tau) - s_h]$$

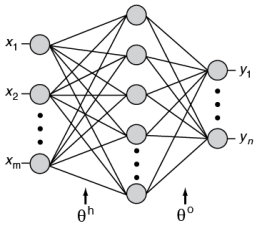
mnemonic equations (M.E.)

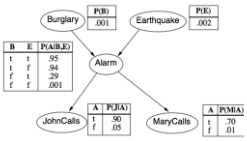
D.O Hebb
(1904-1985)

$$\frac{da^{(r)}_{hk}(t)}{dt} = \{\alpha^{(r)} u_k(t-\tau)u_h(t) - \beta^{(r)}\mathrm{I}[a^{(r)}_{hk}(t) - a^{(r)}_{hk}(o)]\}a^{(r)}_{hk}(t)\mathrm{I}[A^{(r)}_{hk} - a^{(r)}_{hk}(t)],$$

# Neural Networks and AI





Frank Rosenblatt
(1928–1971)

$$((p \to q) \wedge (q \to r))$$

$$\vdash (p \to r)$$

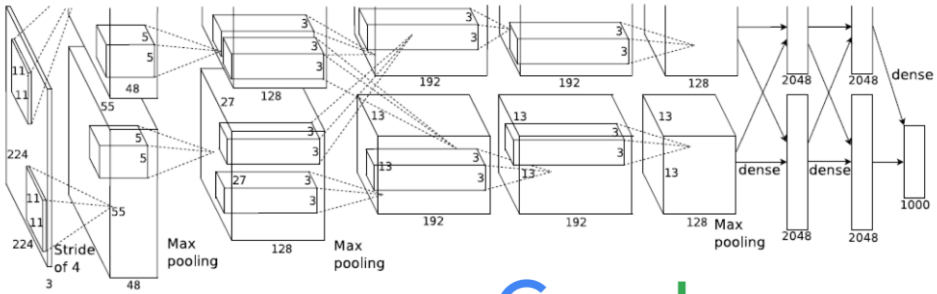
Marvin Minsky
(1927-2016)

David Rumelhart
(1942-2011)

Judea Pearl

# Perceptron and deep learning

Alex Net




Google

Hinton

Bengio



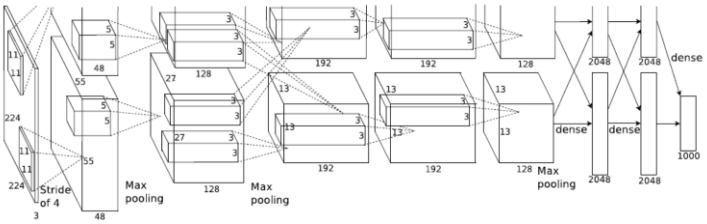
LeCun

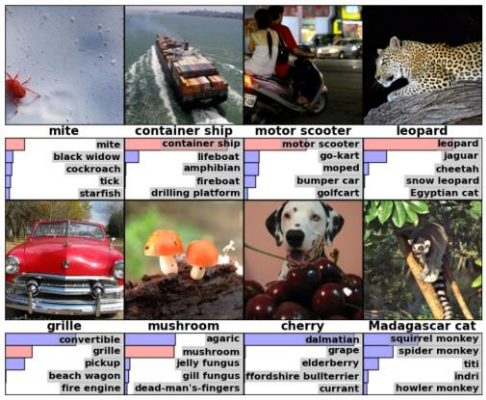
...

DeepMind

# Perceptron and deep learning

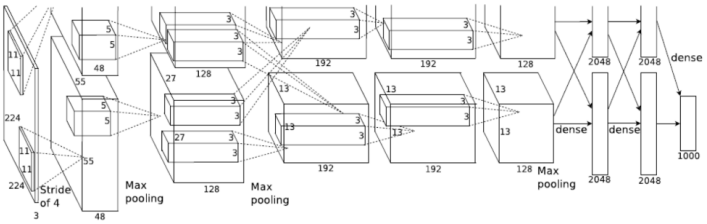
Alex Net:
Krizhevsky, Sutskever and Hinton 2012



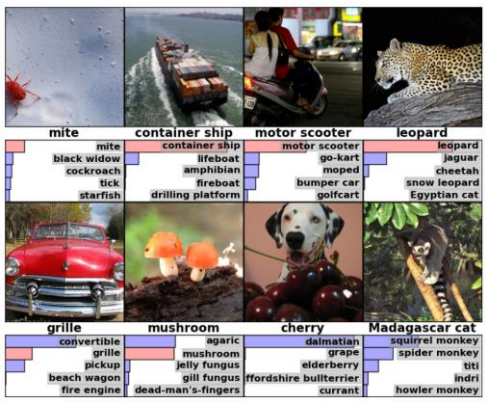

# Perceptron and deep learning

Alex Net:
Krizhevsky, Sutskever and Hinton 2012





$$x(t) = a_1 y_1(t) + a_2 y_2(t) + a_3 y_3(t) + a_4 y_4(t) + \ldots$$



Jürgen Schmidthuber et al.

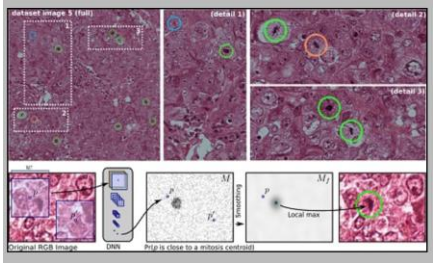
**On February 1, 2017 I will quit my position at IDSIA to focus on my startup.**

**Dan Claudiu Cireșan**

Senior Researcher - Dalle Molle Institute for Artificial Intelligence (IDSIA)

**Traffic Sign Recognition**
**(IJCNN 2012)**

**Mitosis Detection**
**(ICPR 2012 & MICCAI 2013)**




Andrej Karpathy, Li Fei-Fei, CVPR 2015
Deep Visual-Semantic Alignments for Generating Image Descriptions

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."

"boy is doing backflip on wakeboard."

"girl in pink dress is jumping in air."

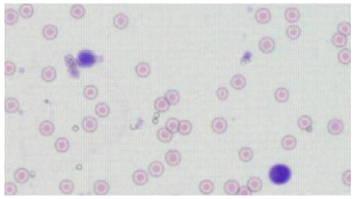
"black and white dog jumps over bar."

"young girl in pink shirt is swinging on swing."

"man in blue wetsuit is surfing on wave."

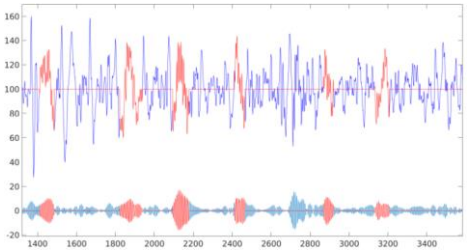
Complete Blood Count:

Paul Hollensen, Michal Lisicki, Alan Fine



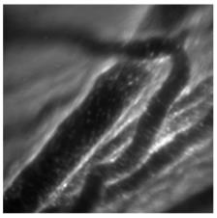
Sleep Spindle Detection:

Francesco Usai, Yaeesh Sardiwalla, Benjamin Rusak




Blood flow analysis:

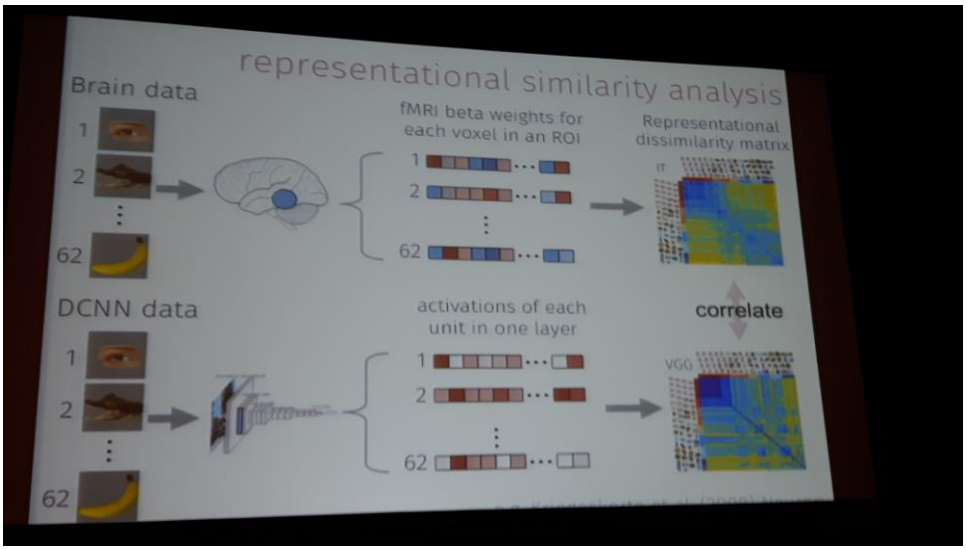
Stuart McIlroy, Yoshimasa Kubo, James Toguri, Christian Lehmann



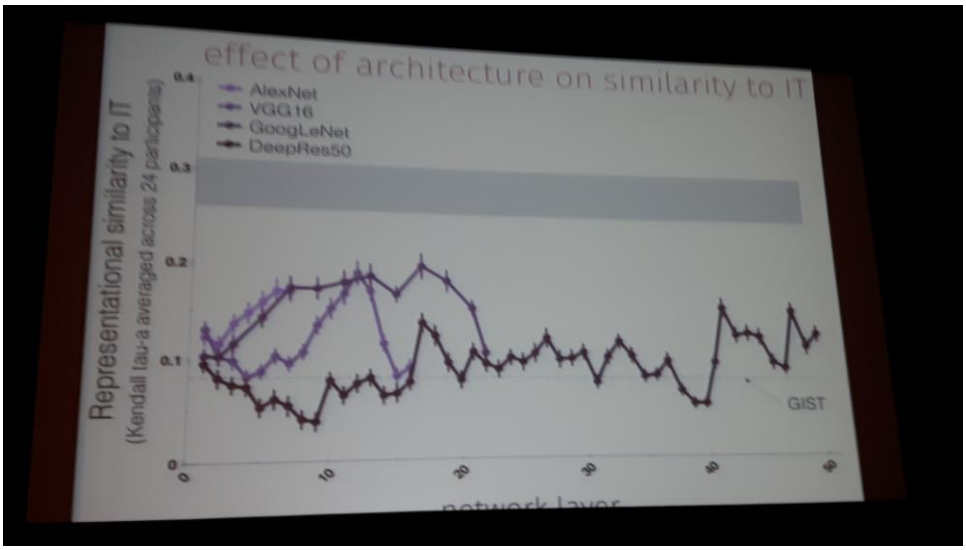
sMRI: ENIGMA-Bipolar consortium

Abraham Nunes, Yoshimasa Kubo, Tomas Hajek, Martin Alda

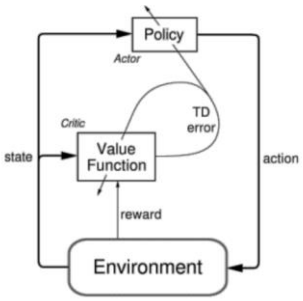
Cosyne 2017

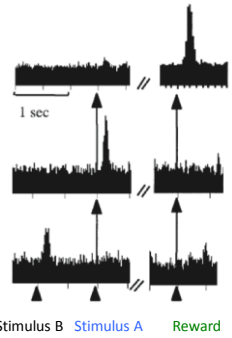


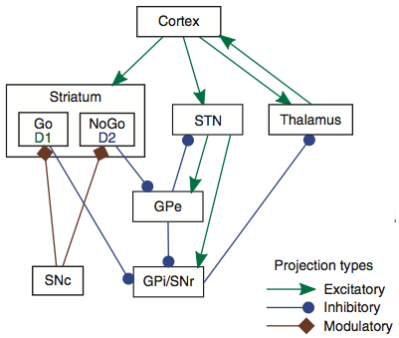

Domain-specialised CNNs of realistic depth best explain FFA and PPA representations.
Katherine Storrs, Johannes Mehrer, Alexander Walther, Nikolaus Kriegeskorte


effect of architecture on similarity to IT
AlexNet
VGG16
GoogLeNet
DeepRes50
Representational similarity to IT
(Kendall tau-a averaged across 24 participants)
0.4
0.3
0.2
0.1
0
0
10
20
30
40
GIST


Google DeepMind
Challenge Match
8 - 15 March 2016
AlphaGo
ALPHAGO
02:00:00
LEE SEDOL
01:59:42
AlphaGo
Lee Sedol



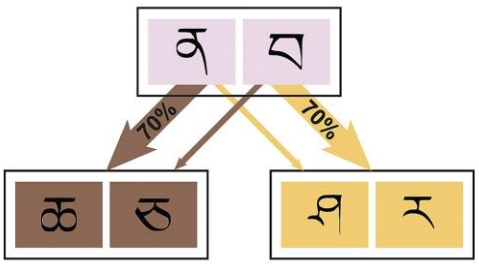




Maia & Frank 2011

NSHARF Study: A study of goal-directed and habitual control in patients with eating disorders using computational modeling

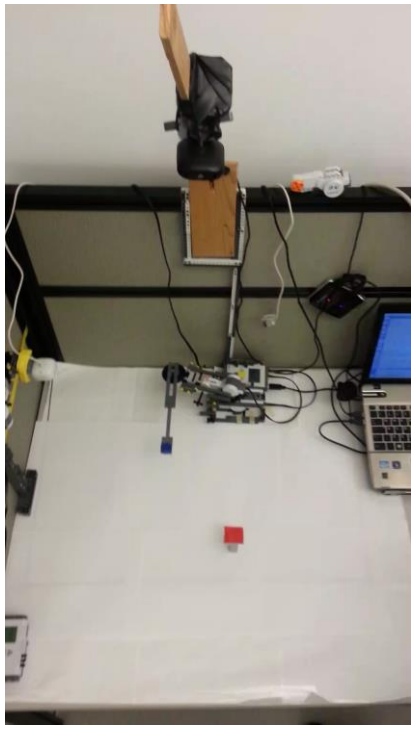
Abraham Nunes, TT, Aaron Kechen



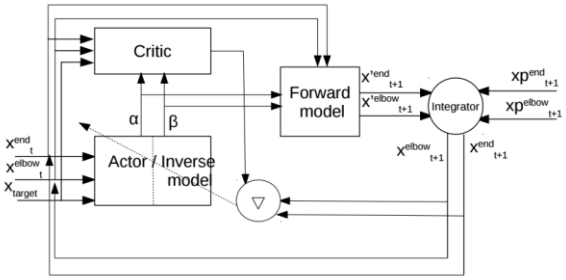

Habitual (model-free): Temporal Difference Learning

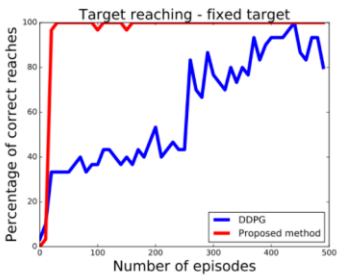
Goal-directed (model based); Learn transition probability + Bellman equation

→ Bayesian model fitting (Abraham)

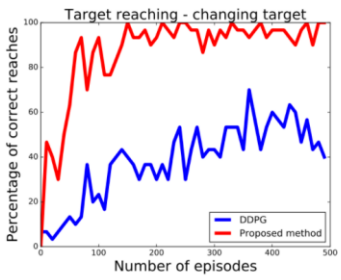


Farzaneh S. Fard & Abraham Nunes



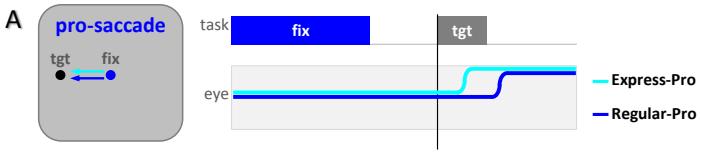

(a) Fixed target



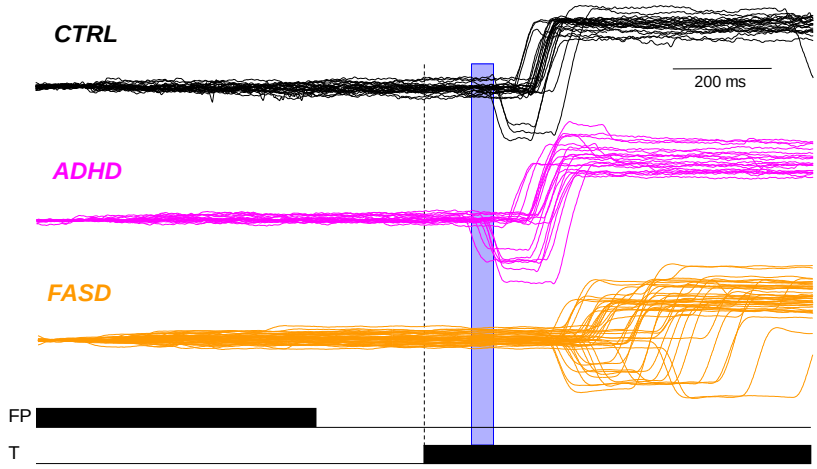

(b) Changing target

# Neural Fields & Eye Movements

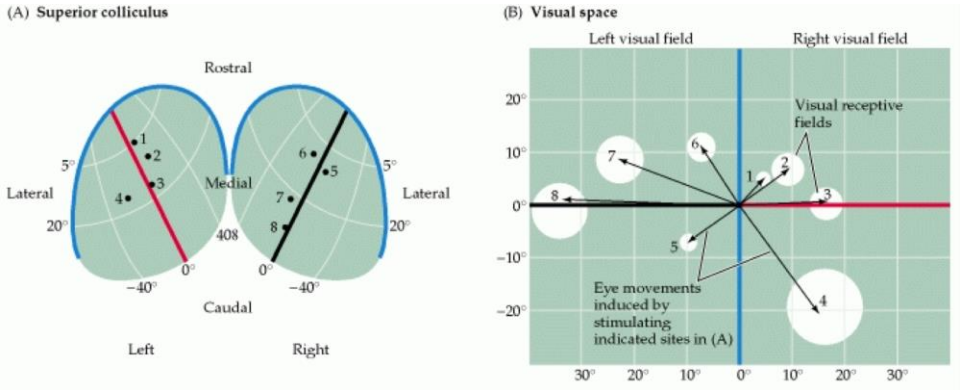
with Brian Coe & Doug Munoz, Queen's Univ.



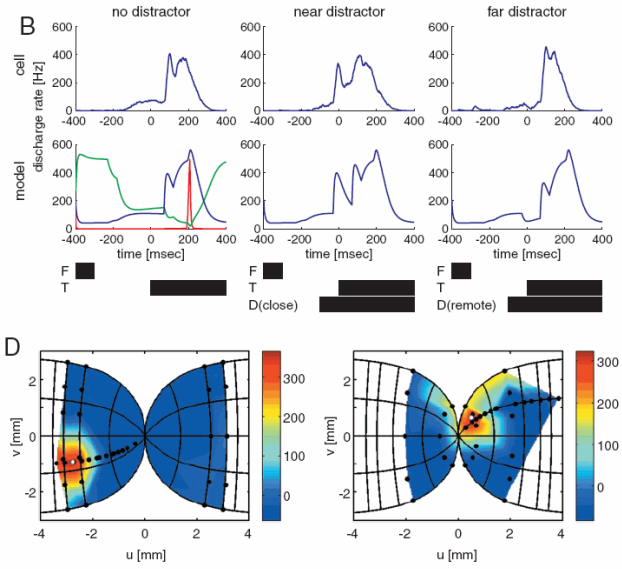
# Anti-Saccade Task

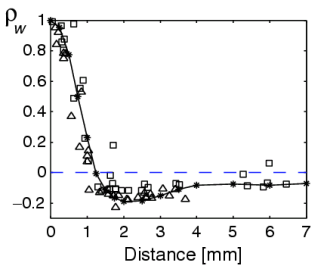


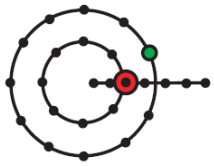

*Green et al. (2007) Alcohol. Clin.Exp. Res. 31: 500*



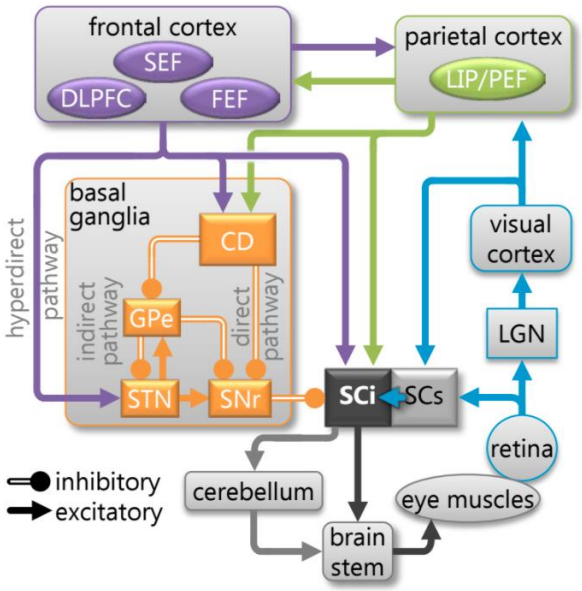
# DNF model of the Superior Colliculus



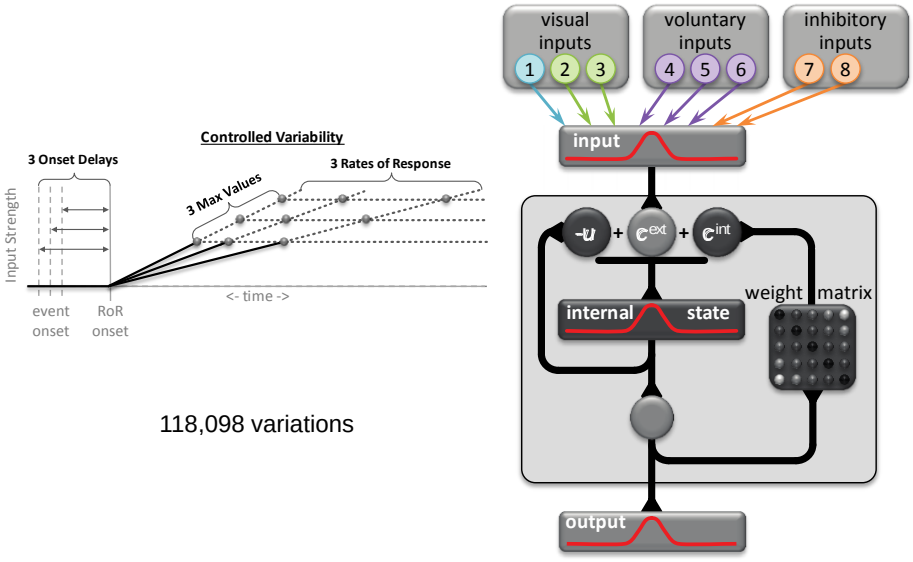



Trappenberg, Dorris, Klein & Munoz, *A model of saccade initiation based on the competitive integration of exogenous and endogenous inputs* J. Cog. Neuro. 13 (2001)

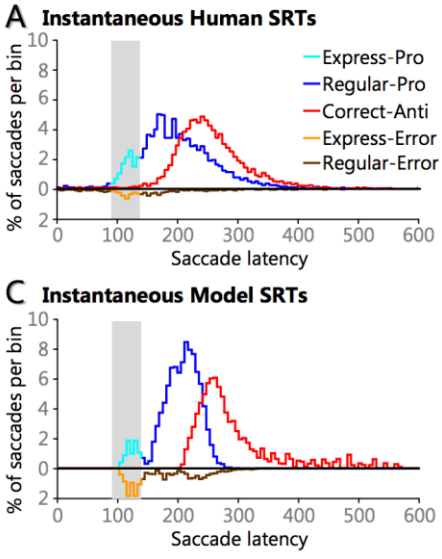


**Brian Coe**, TT, Doug Munoz (2017)




118,098 variations

**Brian Coe**, TT, Doug Munoz (2017)



# DeepMed