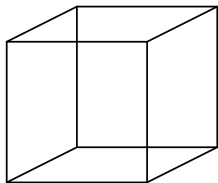# CS-E577005 - Computational Theories of the Brain
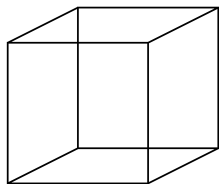
Raymond Khazoum
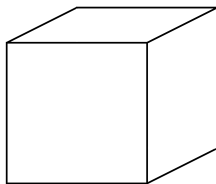Aalto University, April 25th 2024 (Lecture 1)

T1. Psychophysics

Necker Cube
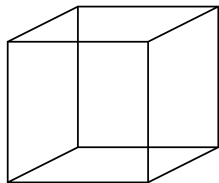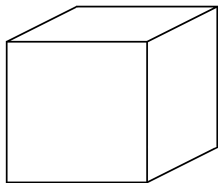
T1. Psychophysics

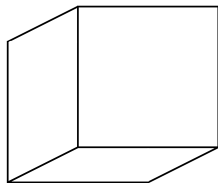Necker Cube   Interpretation A

T1. Psychophysics
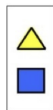

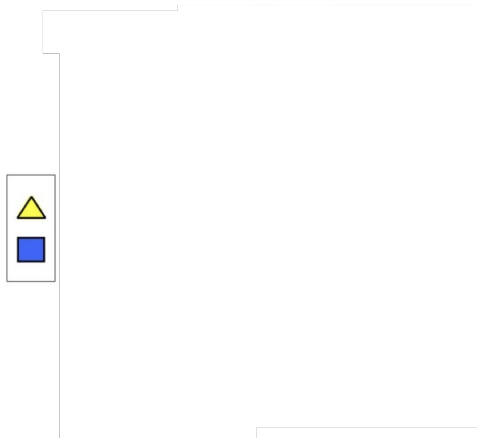Necker Cube   Interpretation A   Interpretation B

T1. Psychophysics
ST1. John and Irv's Model (JIM)

Binding Problem

T1. Psychophysics
ST1. John and Irv's Model (JIM)

Binding Problem
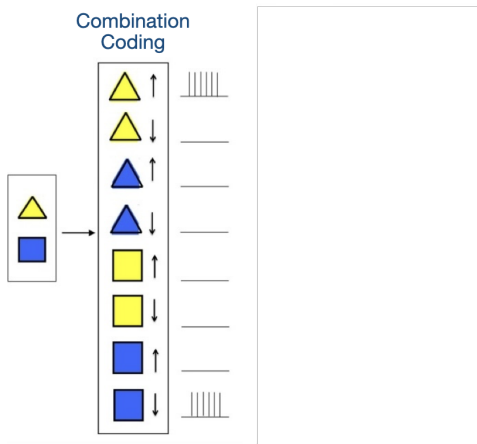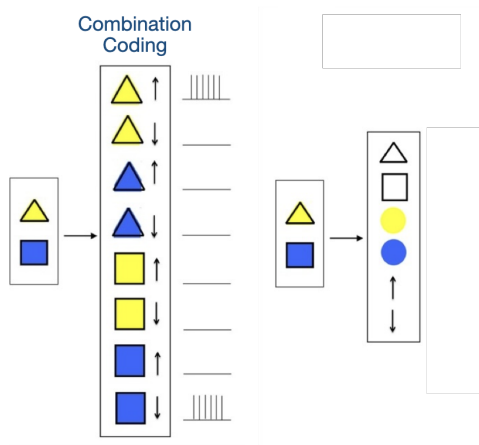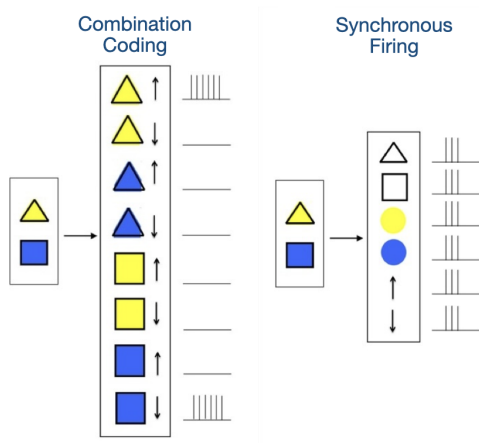
T1. Psychophysics
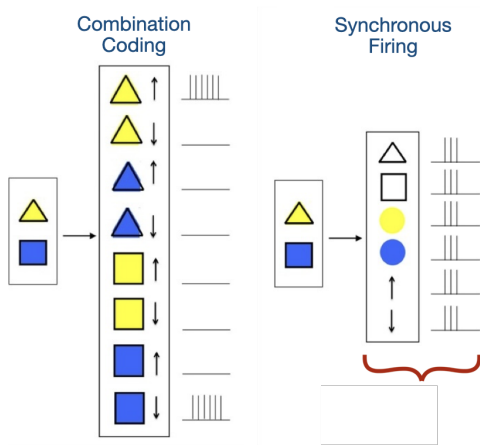**ST1. John and Irv's Model (JIM)**

Binding Problem

T1. Psychophysics
ST1. John and Irv's Model (JIM)

Binding Problem

T1. Psychophysics
ST1. John and Irv's Model (JIM)

Combination Coding

Synchronous Firing
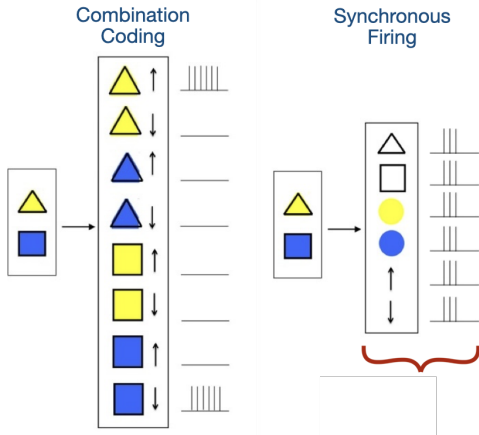
Binding Problem

T1. Psychophysics
ST1. John and Irv's Model (JIM)

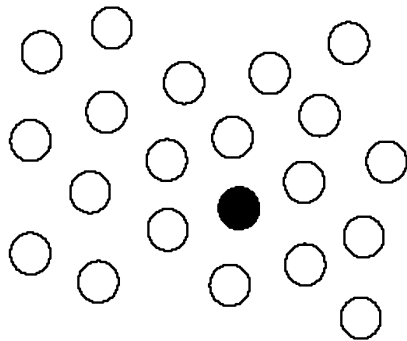Combination Coding

Synchronous Firing

Binding Problem

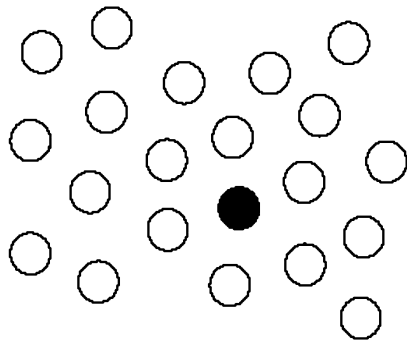[Hummel & Biederman, 1992]

T1. Psychophysics
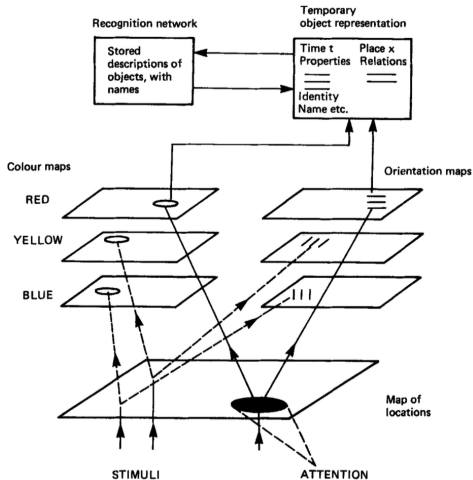**ST2. Feature Integration Theory (FIT)**

Visual Attention

T1. Psychophysics
ST2. Feature Integration Theory (FIT)

Visual Attention

[Treisman & Gelade, 1980]

T1. Psychophysics
ST3. Adaptive Resonance Theory (ART)

Canestra di frutta
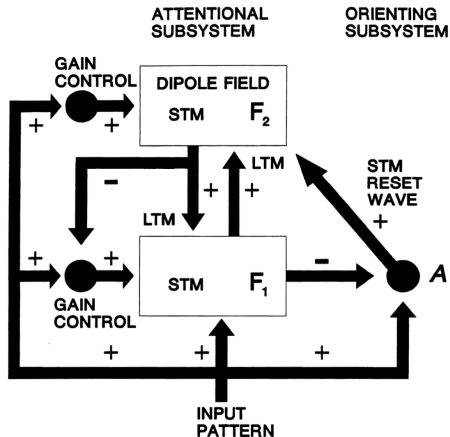Michelangelo Merisi da Caravaggio (1571-1610)

Stability-Plasticity Dilemma

T1. Psychophysics
ST3. Adaptive Resonance Theory (ART)

Canestra di frutta
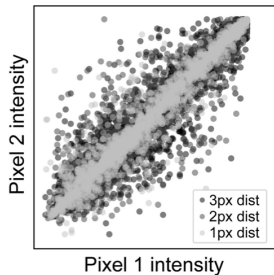Michelangelo Merisi da Caravaggio (1571-1610)

Stability-Plasticity Dilemma

[Carpenter & Grossberg, 1985/87]

T2. Efficient Coding
→ **Hypothesis** [Horace Barlow, 1961]
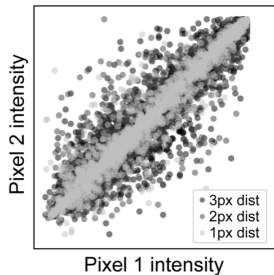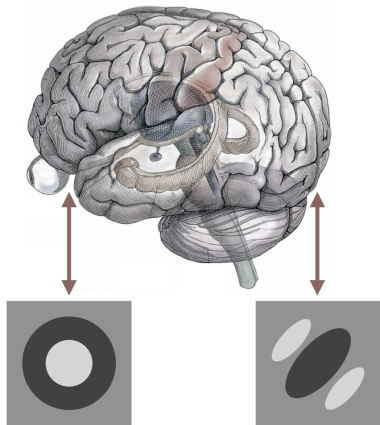

correlation between the intensities of
neighboring pixels

[David J. Field, 1987]

T2. Efficient Coding

→ **Hypothesis** [Horace Barlow, 1961]

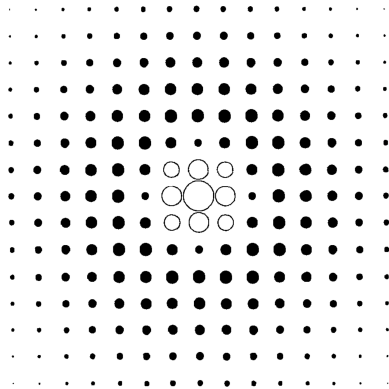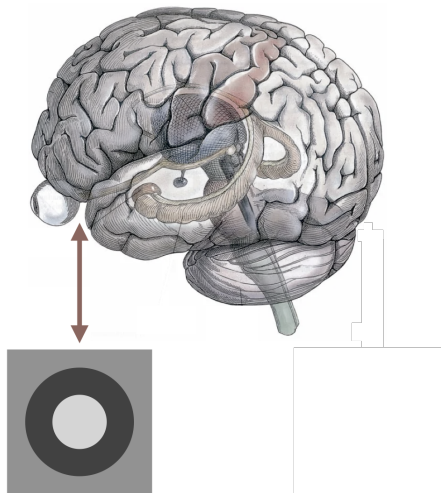correlation between the intensities of
neighboring pixels

[David J. Field, 1987]
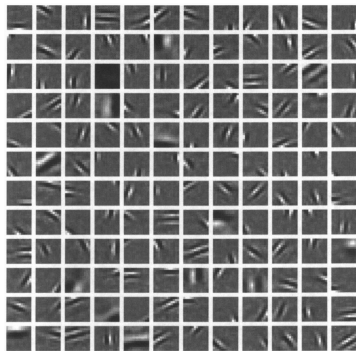
T2. Efficient Coding
ST1. Retinal Cell Model
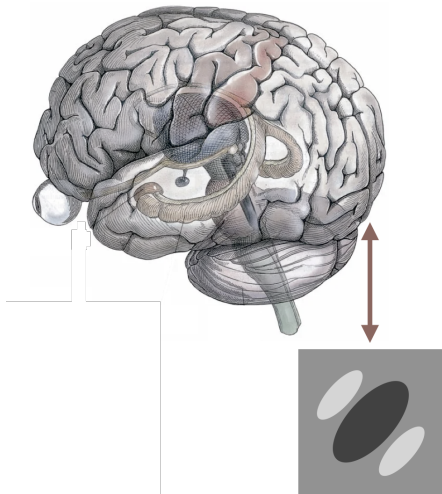

Emergent receptive fields

[Atick & Redlich, 1990]

T2. Efficient Coding
ST2. Primary Visual Cortex Model

Sparse Coding: $I = \sum\limits_{i=1}^{k} \alpha_i \boldsymbol{\phi}_i = \boldsymbol{\alpha}\boldsymbol{\Phi}$

where $I \in \mathbb{R}^n$, $\boldsymbol{\alpha} \in \mathbb{R}^k$ and $\boldsymbol{\Phi} \in \mathbb{R}^{k \times n}$

[Olshausen & Field, 1997]

T3. Deep Learning Models

Samples from ImageNet Dataset [Deng et al., 2009]

AlexNet

[Krizhevsky, Sutskever & Hinton, 2012]

T3. Deep Learning Models

Samples from ImageNet Dataset [Deng et al., 2009]

AlexNet

[Krizhevsky, Sutskever & Hinton, 2012]

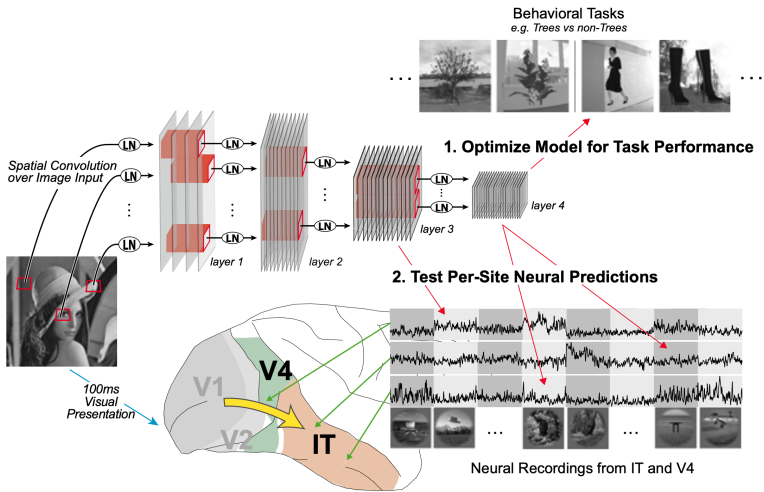Q? what about the other layers

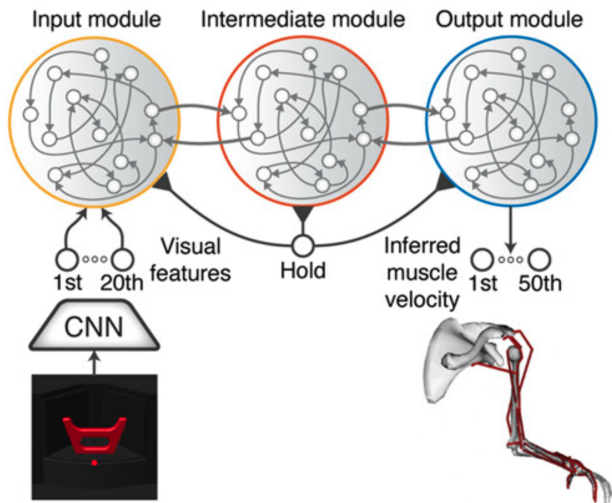# T3. Deep Learning Models

ST1. Visual Perception

[Yamins et al., 2014]

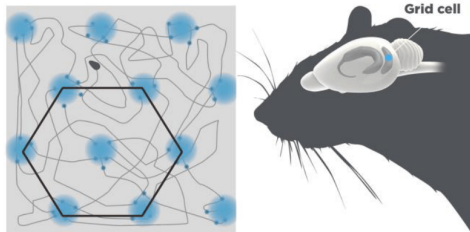# T3. Deep Learning Models

ST2. Motor/Navigation

[Michaels et al., 2020]
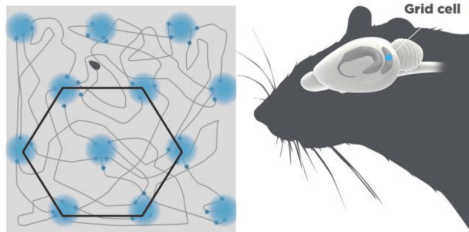
T3. Deep Learning Models
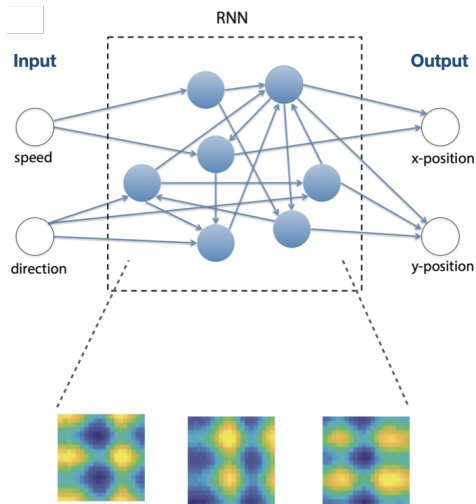**ST2. Motor/Navigation**

[M. Moser & E. Moser, 2014]

T3. Deep Learning Models
ST2. Motor/Navigation

[M. Moser & E. Moser, 2014]

[Cueva & Wei, 2018]