PRINCETON UNIVERSITY

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From Hopfield Models to the Neural Networks Toolbox: Implementing Neural Networks in Matlab and Applications in Biomedical Research

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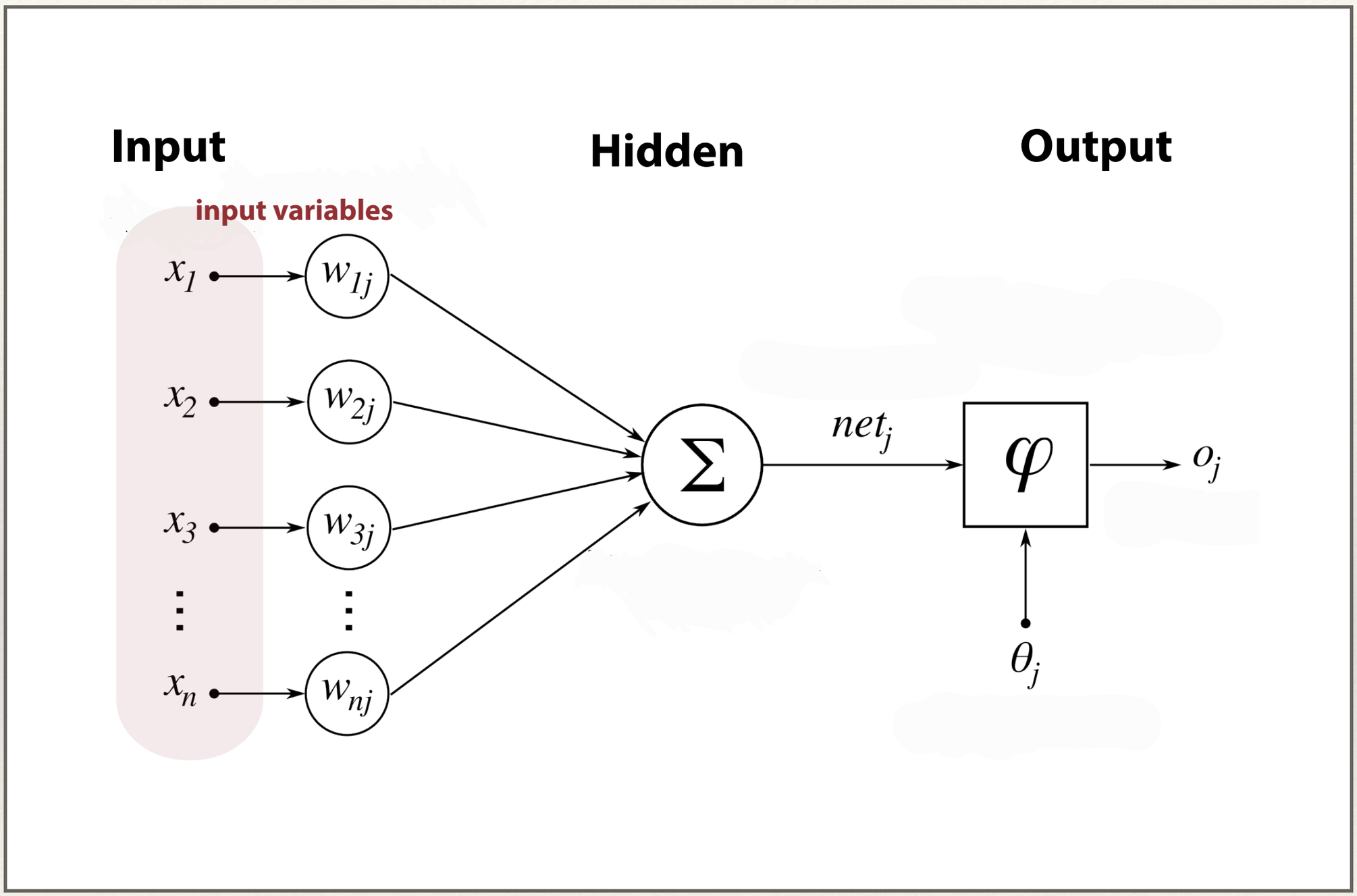
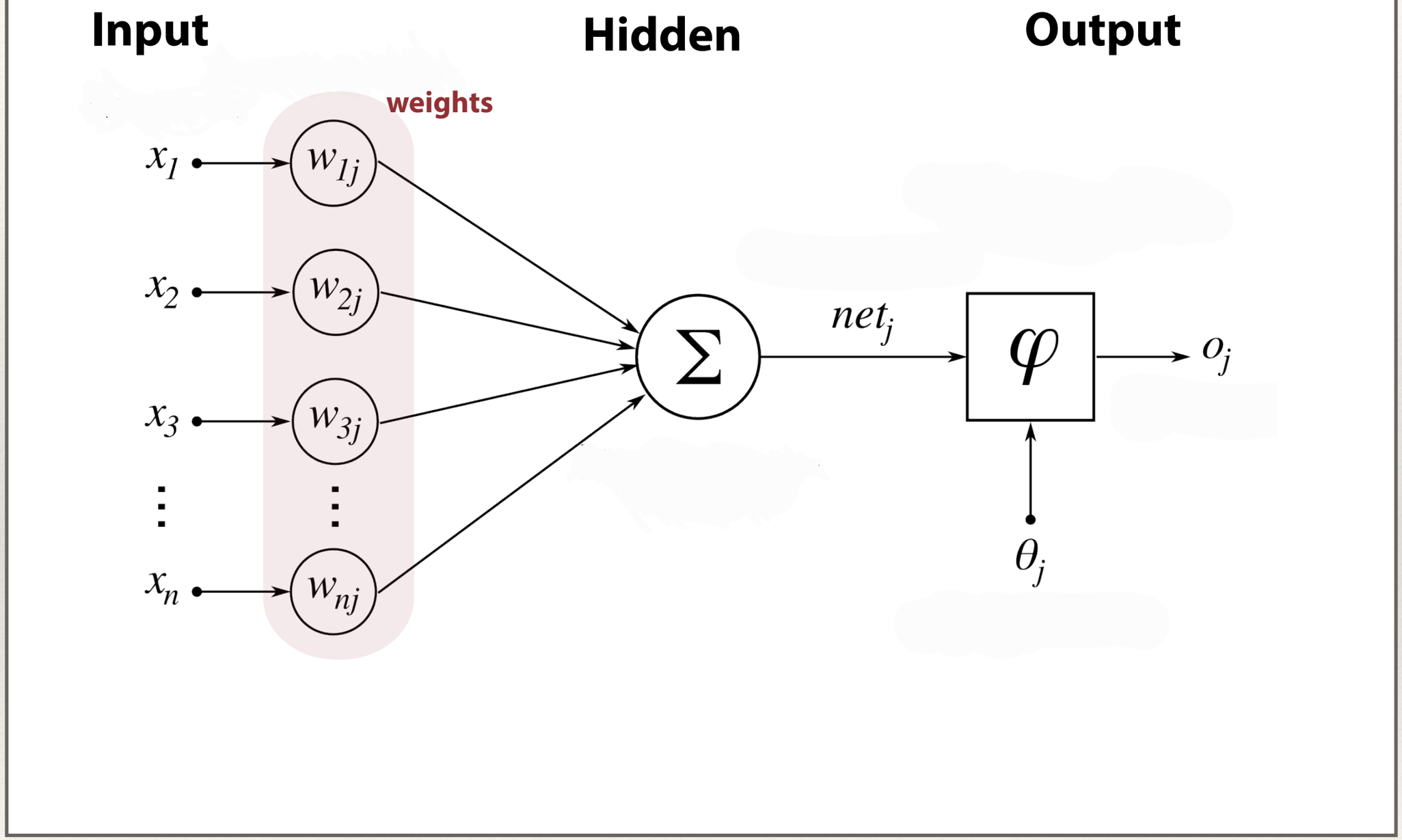
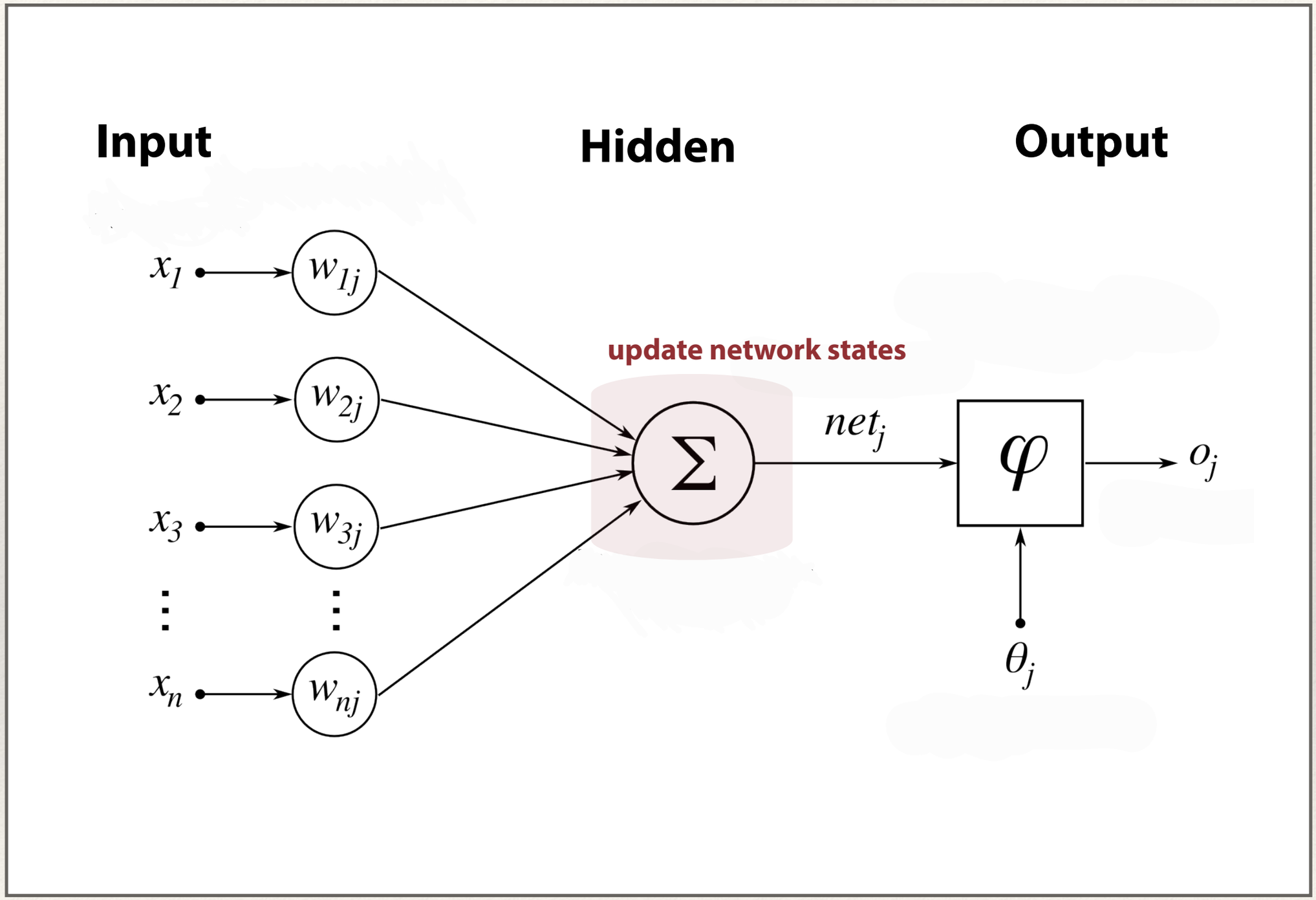
Outline

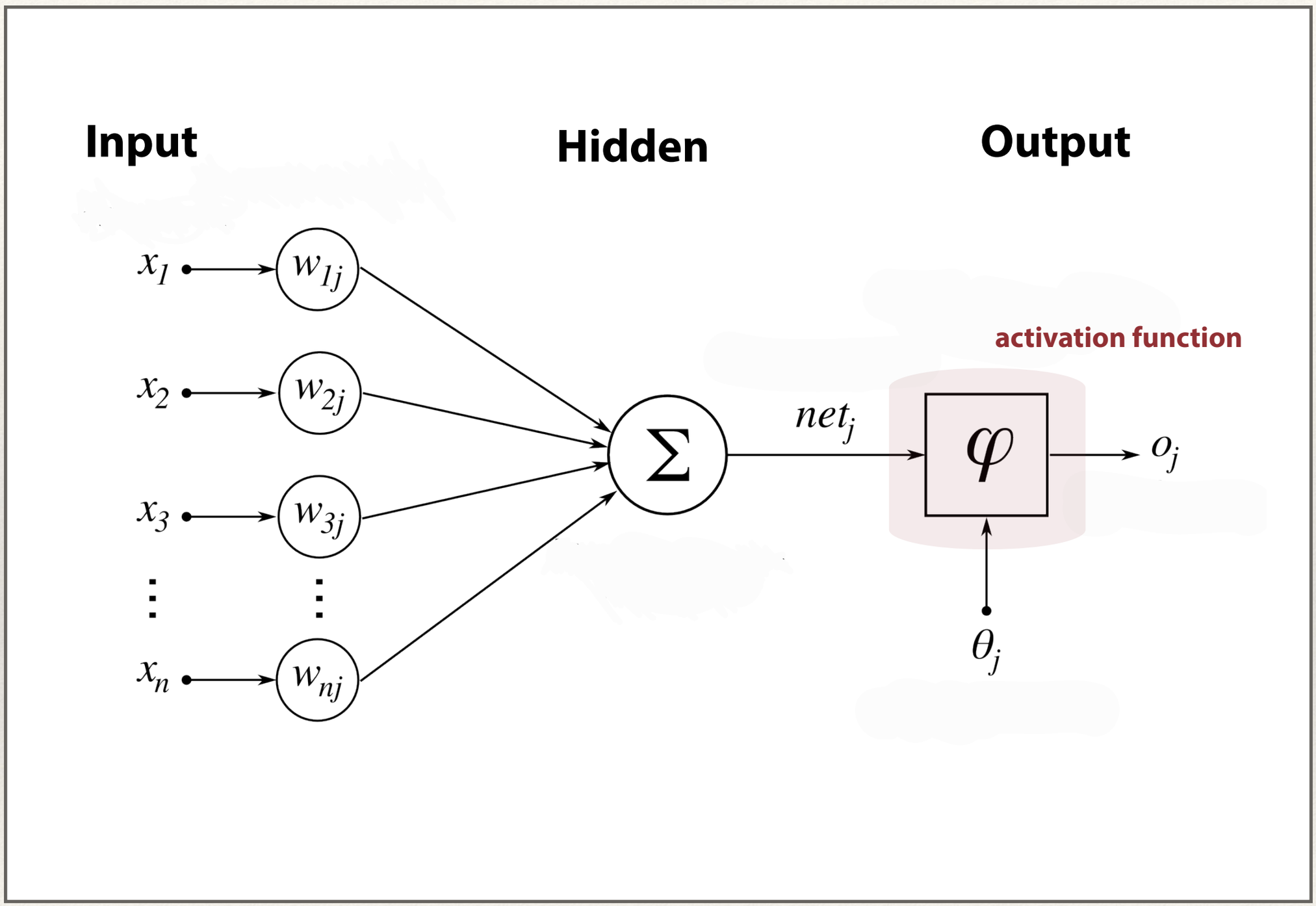
- Introduction
- Matlab's Neural Networks Toolbox
- How to build a Neural Network from scratch
  - Hopfield Networks and Hebbian Learning
  - Implementation
  - Biomedical applications

Introduction: Neural Networks


Input
Hidden
Output
input variables
x_1
x_2
x_3
x_n
w_{1j}
w_{2j}
w_{3j}
w_{nj}
Σ
net_j
φ
o_j
θ_j


Input
Hidden
Output
weights
x_1
x_2
x_3
x_n
w_{1j}
w_{2j}
w_{3j}
w_{nj}
Σ
net_j
φ
o_j
θ_j


Input
Hidden
Output
update network states
x_1
x_2
x_3
x_n
w_{1j}
w_{2j}
w_{3j}
w_{nj}
Σ
net_j
φ
o_j
θ_j


Input
Hidden
Output
activation function
x_1
x_2
x_3
x_n
w_{1j}
w_{2j}
w_{3j}
w_{nj}
Σ
net_j
φ
o_j
θ_j

Matlab's Neural Networks Toolbox

Neural Networks Toolbox
Network Architectures

Supervised

Feedforward Networks
- Perceptrons
- Backpropagation
- Nonlinear Feedforward
* Prediction
* Pattern Recognition
* Fitting nonlinear functions

Dynamic Networks
- Nonlinear Autoregression(NARX)
- Recurrent Feedback Models
- Hopfield Networks
* Spatial-temporal Patterns
* Learning & Control

Learning Vector Quantification (LVQ)

Classification of not linearly separable patterns

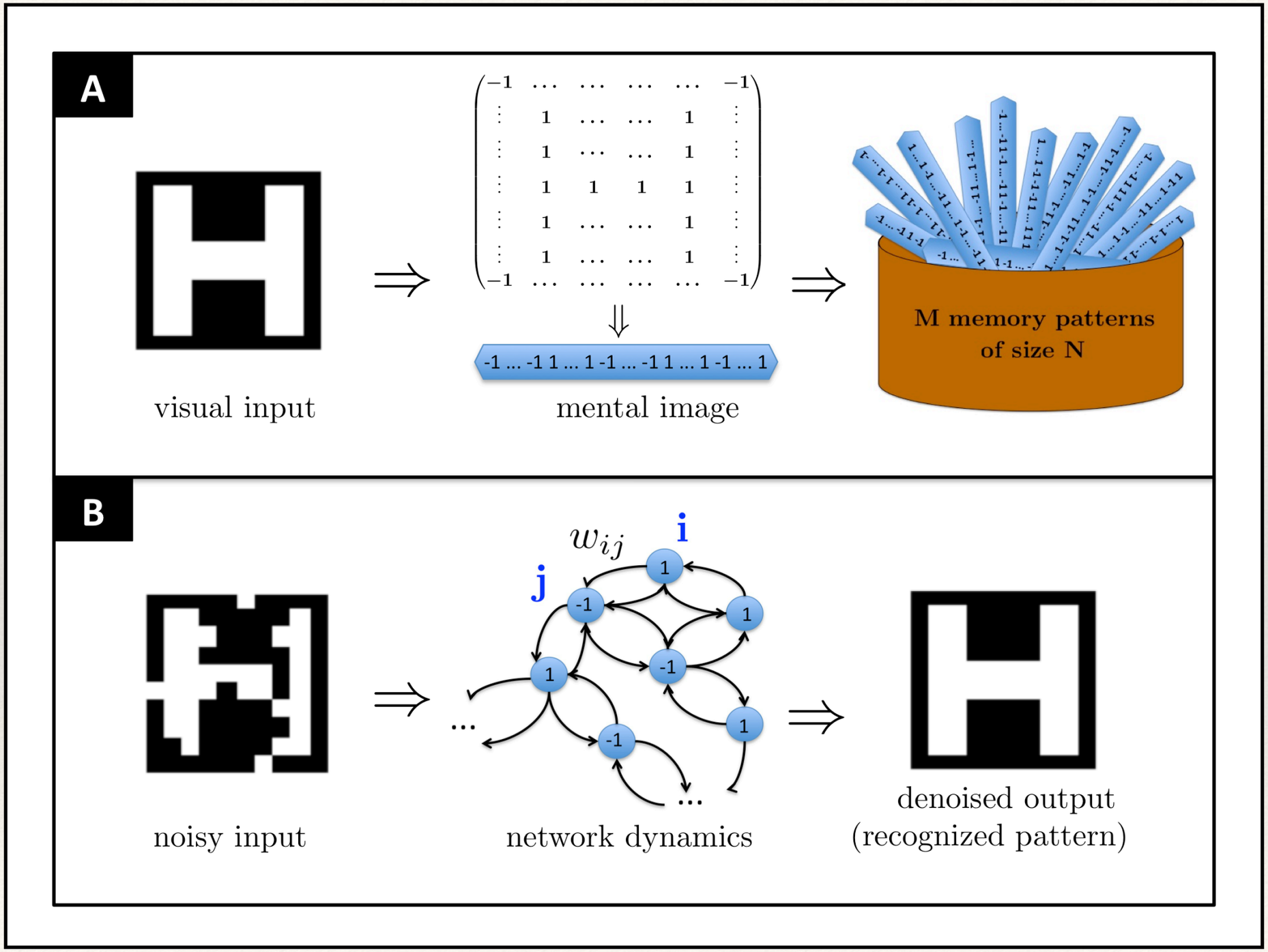
Unsupervised

Competitive Layers
Categorization
* Classification tasks
* Pattern recognition

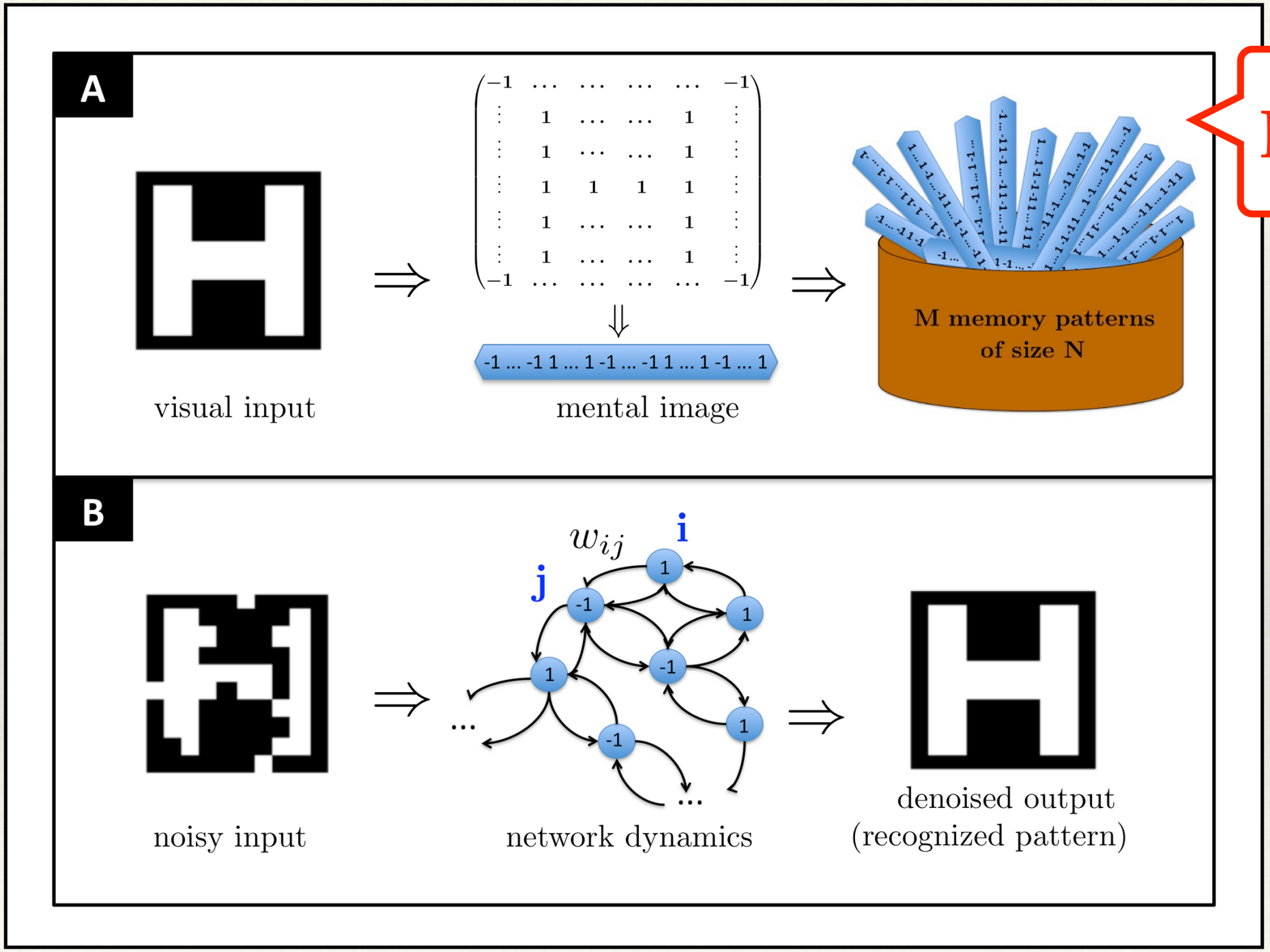
Self-organizing Maps
topology-preserving categorization
* Classification tasks
* Pattern recignition

How to build a Neural Network from scratch

Hopfield Networks (Hebbian Learning)



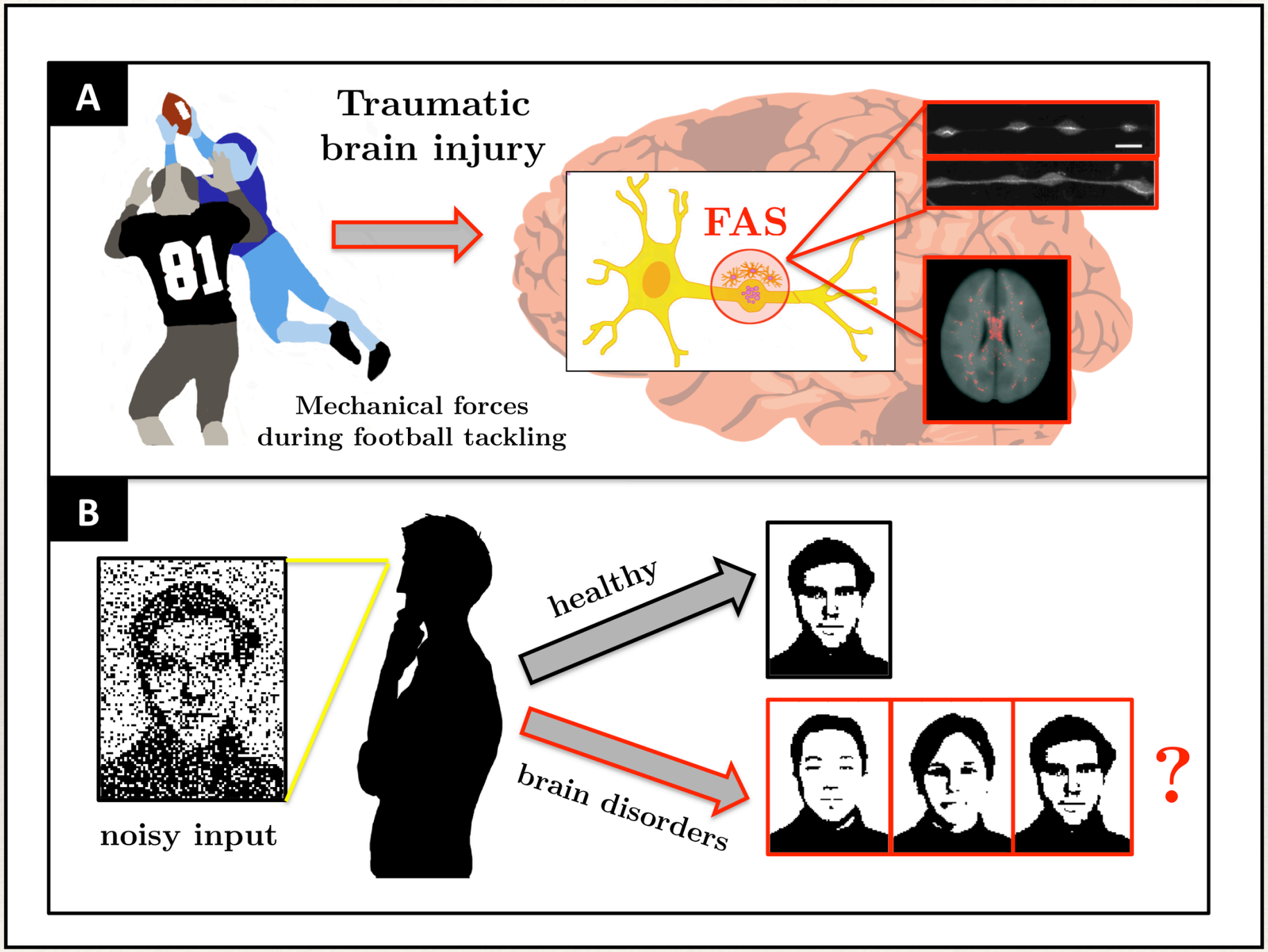
Hopfield Networks (Hebbian Learning)



Biomedical Application

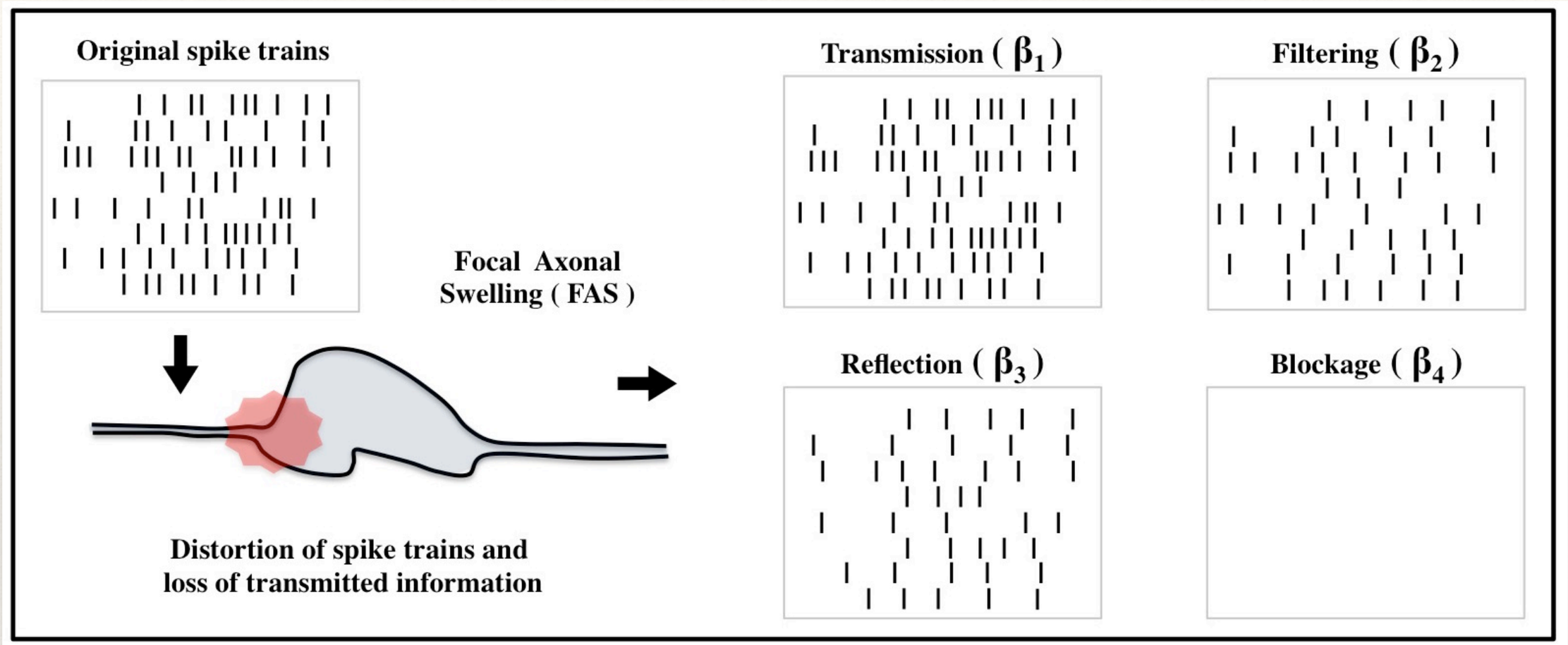
Modeling brain disorders with Hopfield Networks

Focal Axonal Swellings as cause of Brain disorders



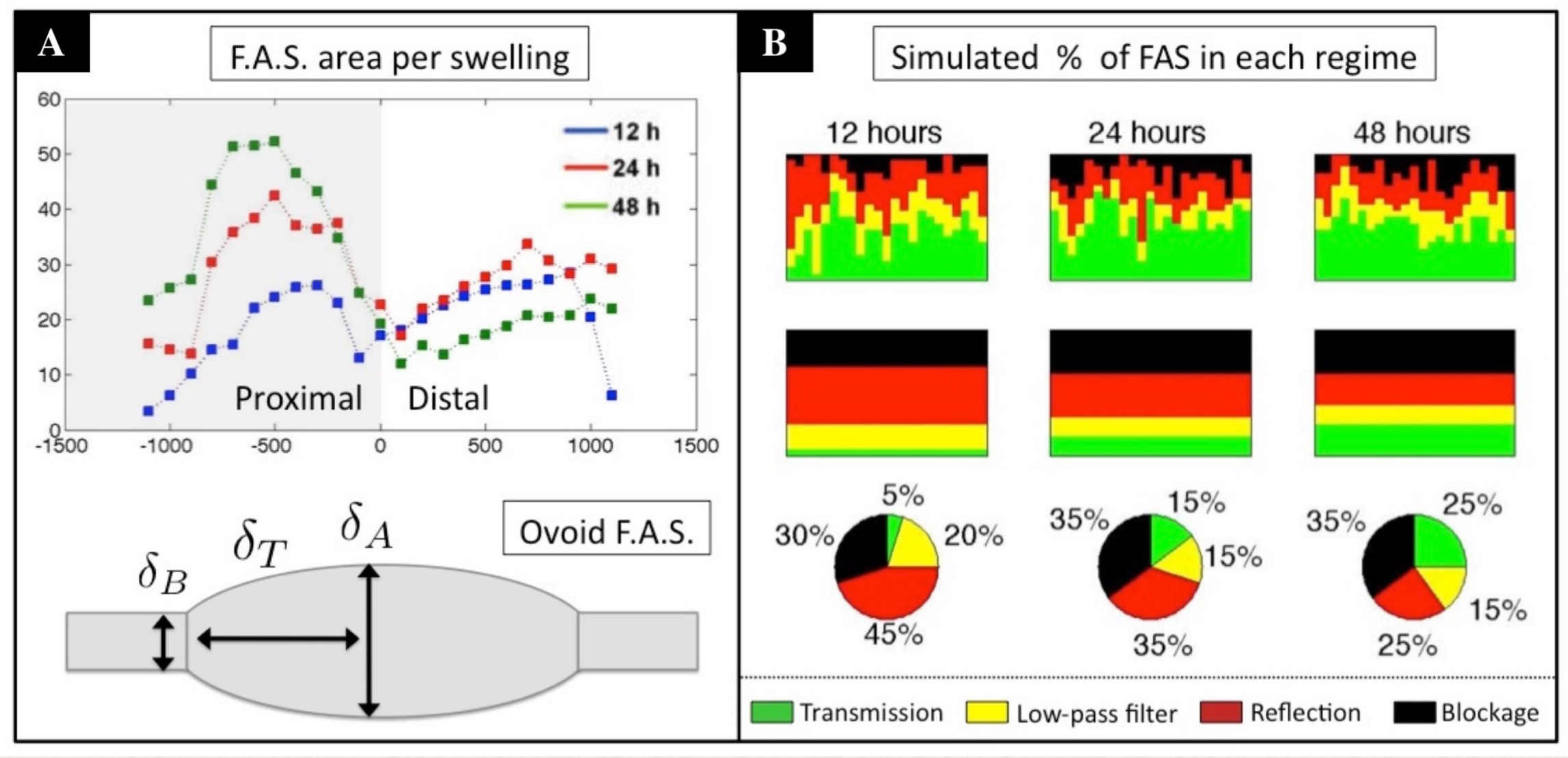
[Weber, Maia, Kutz (2016); submitted]

Modelling FAS



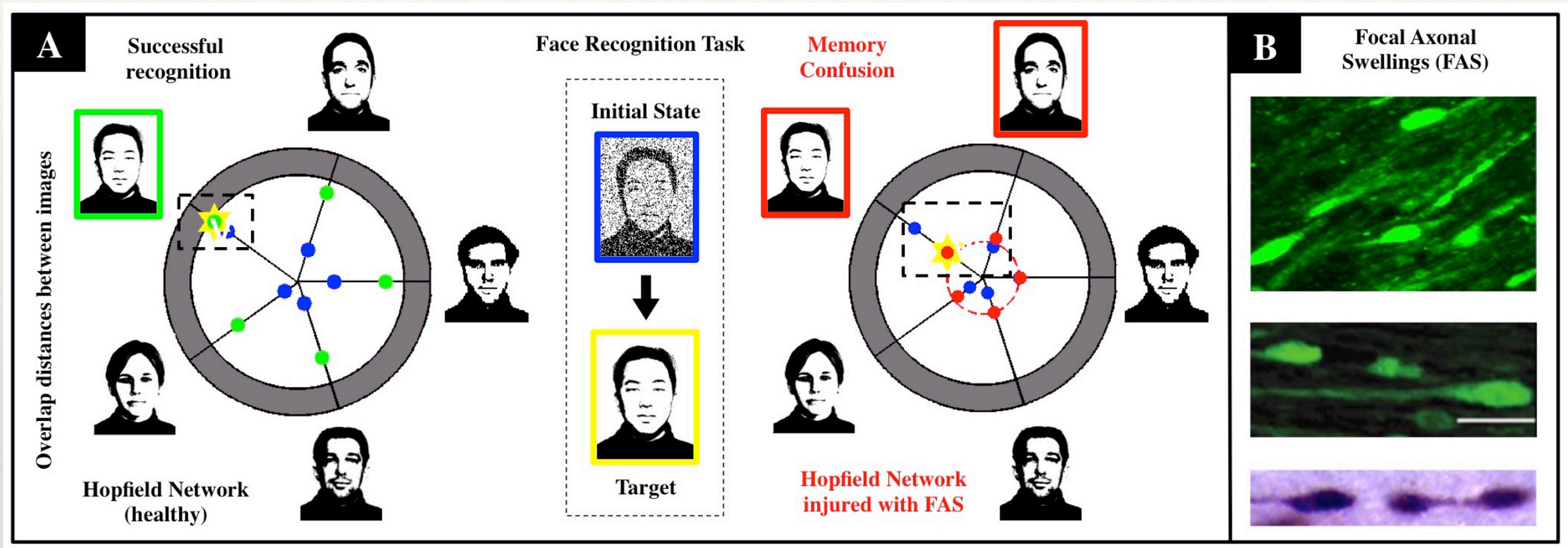
[Weber, Maia, Kutz (2016); submitted]

Distribution of FAS mechanisms



[Weber, Maia, Kutz (2016); submitted]

Implementation with Hopfield Networks



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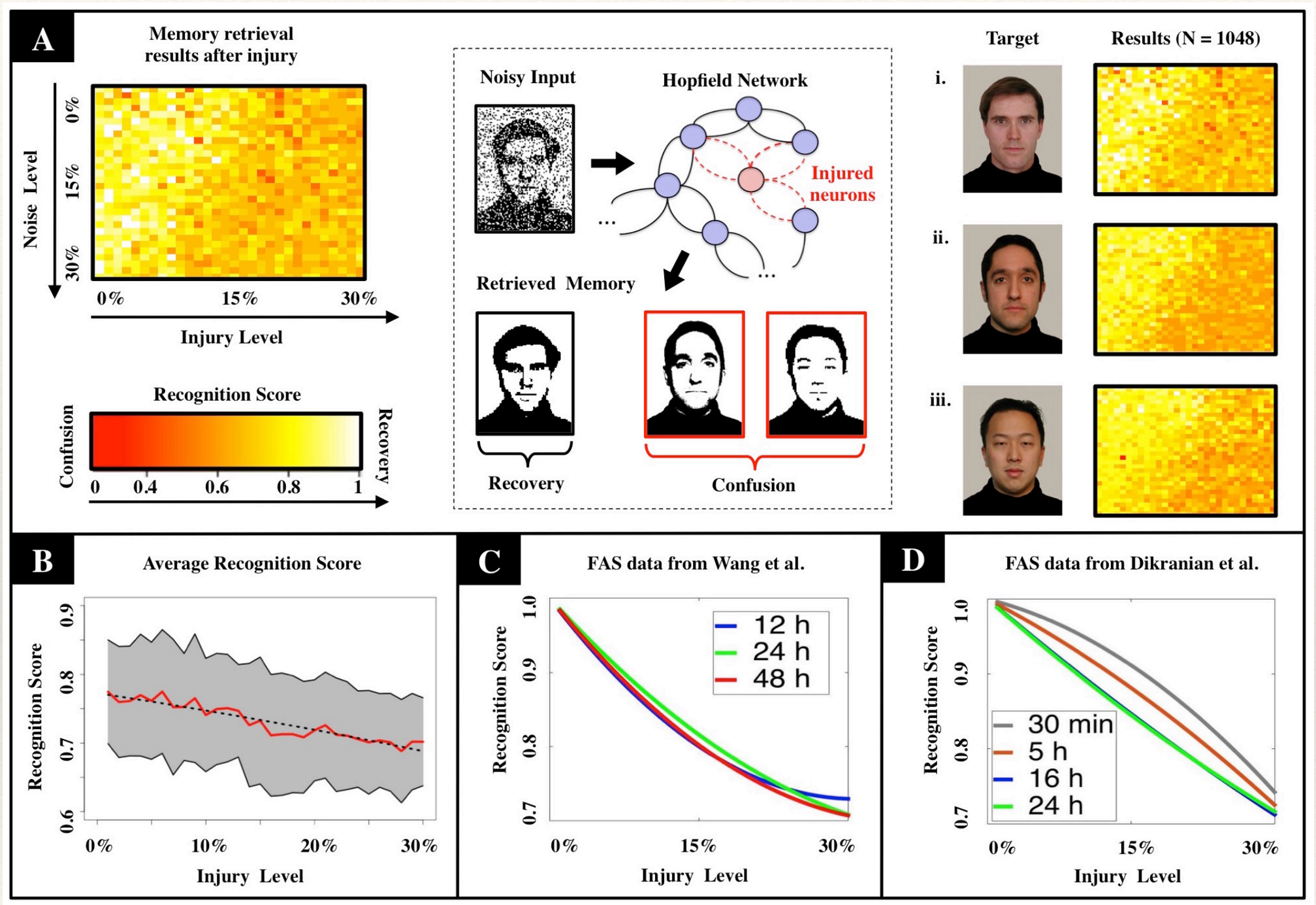
Implementation with Hopfield Networks



[Weber, Maia, Kutz (2016); submitted]

Thank you for your attention!

– Questions?