Deep Brain Stimulation – New Frontier

Neuromodulation for visual perception & action

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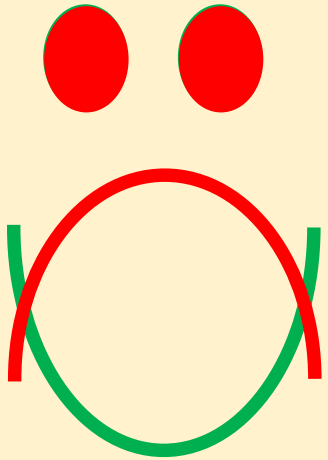
Action
(motor domain)



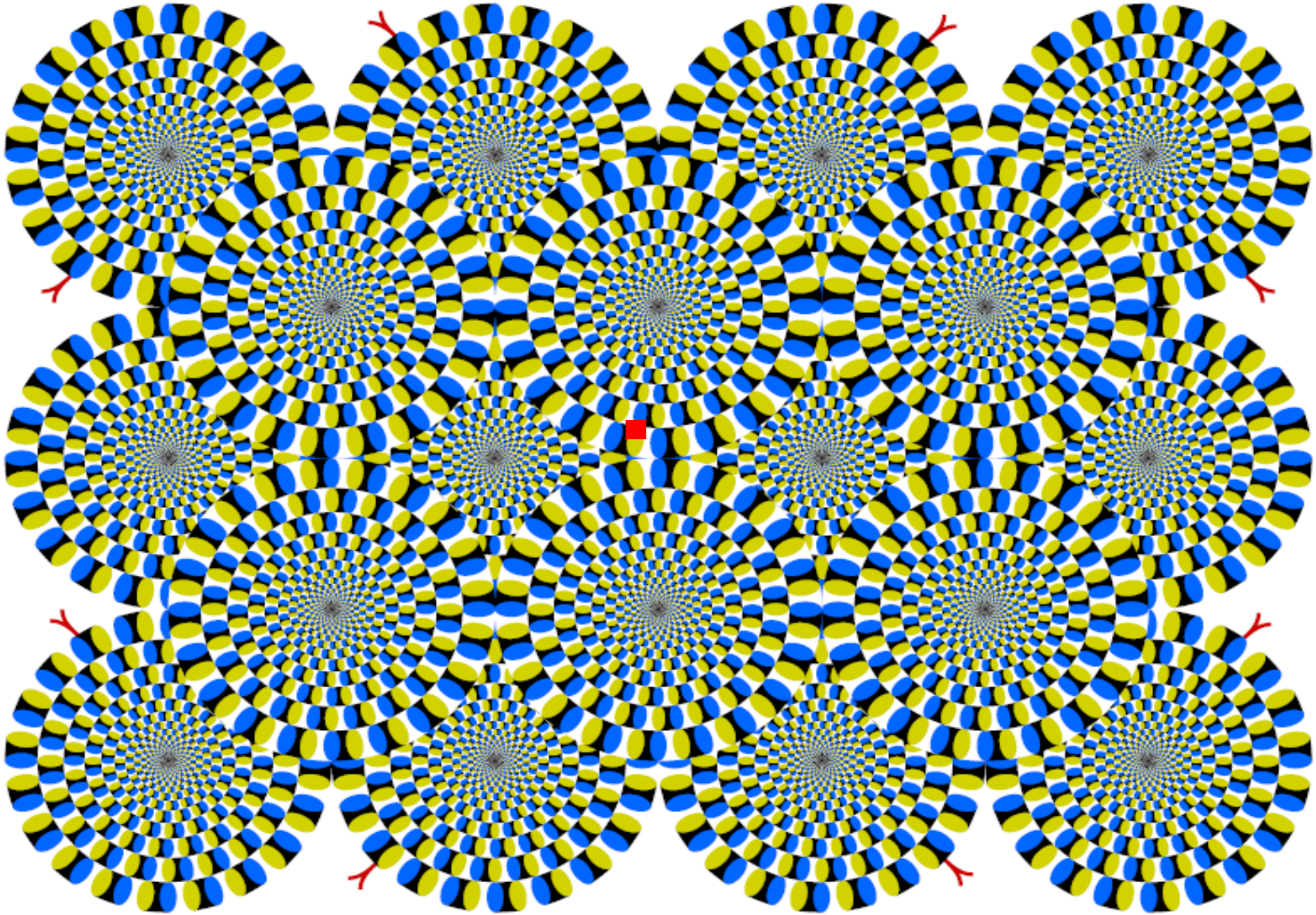
Perception
(cognitive domain)

Visual **perception & action**

Perception of **details**


University Hospitals
University Hospitals Case Medical Center
ONE WAY
DO NOT ENTER

Perception of **illusion**

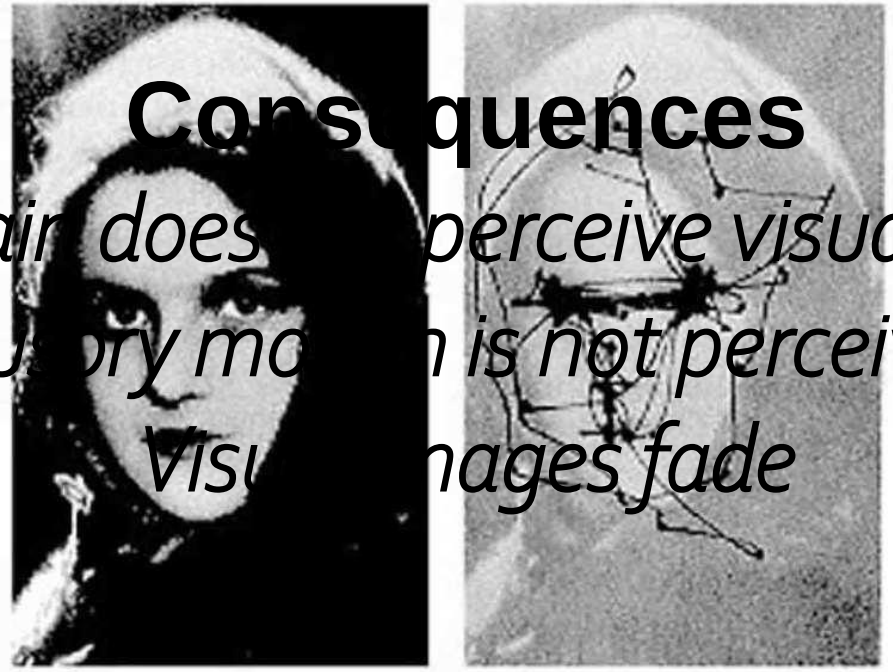


Perception of **fading**

What happens when we focus on the red dot?

The brain spontaneously generates miniatures eye movements (microsaccades) to keep up with visual perception.

Focusing on the red dot suppresses the microsaccades.

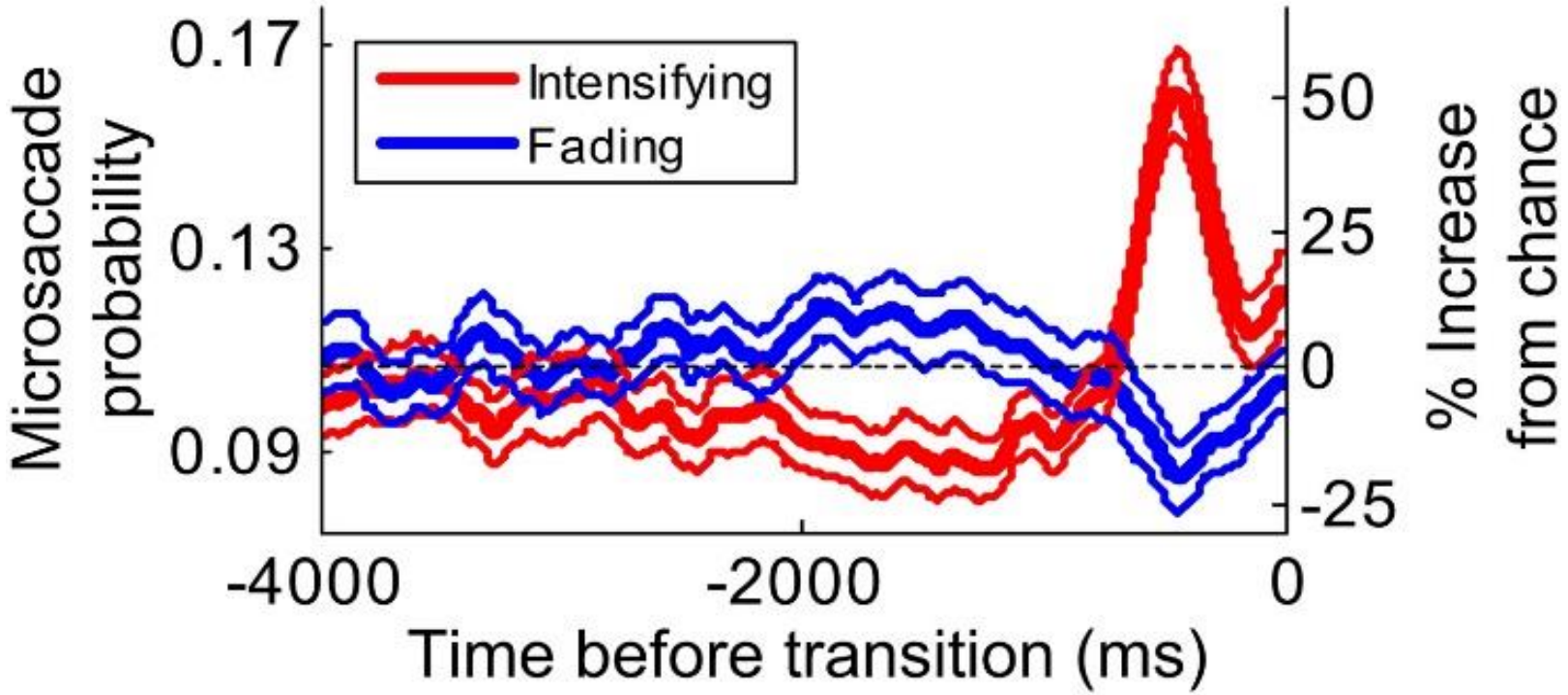


Consequences

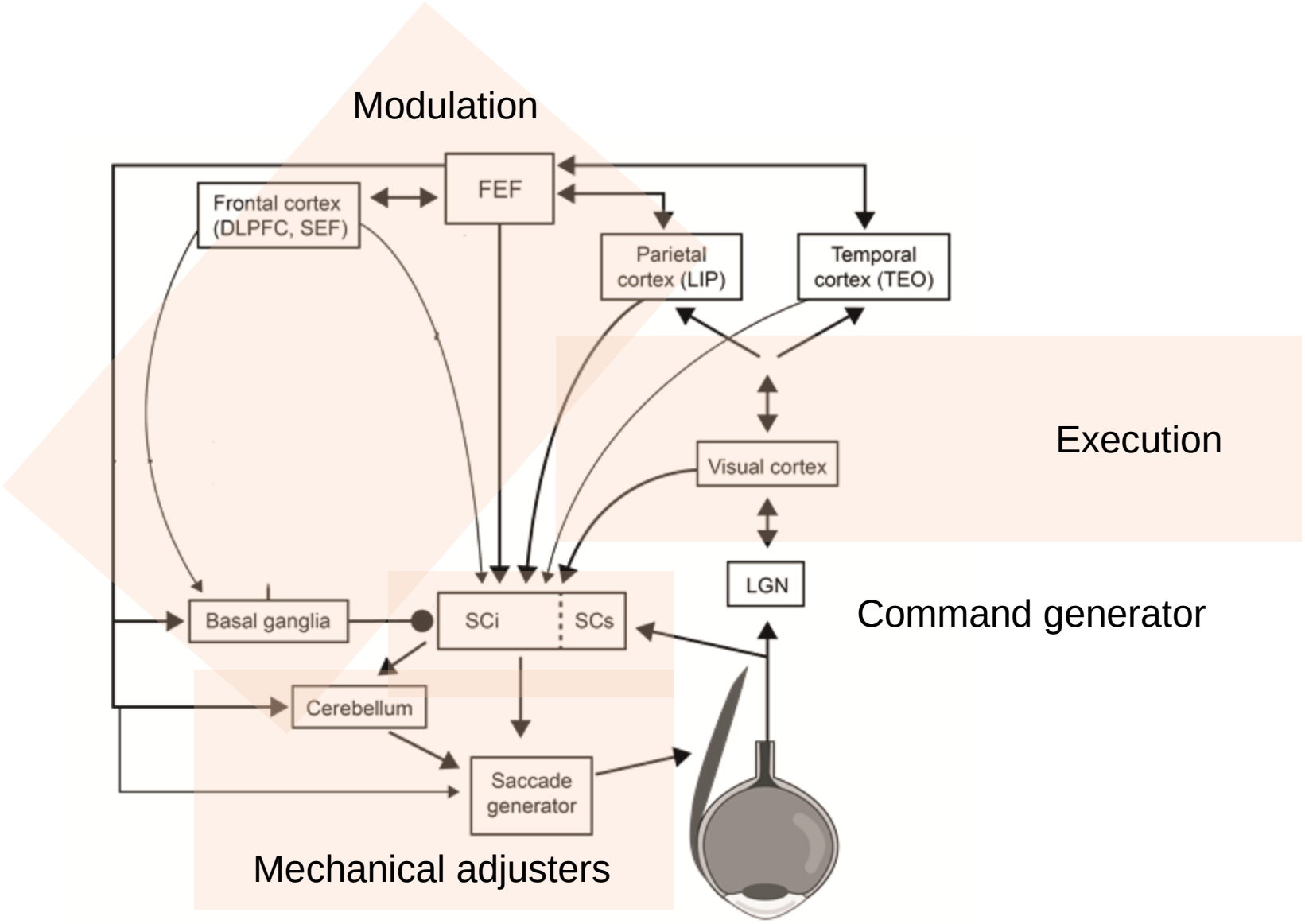
The brain does not perceive visual details

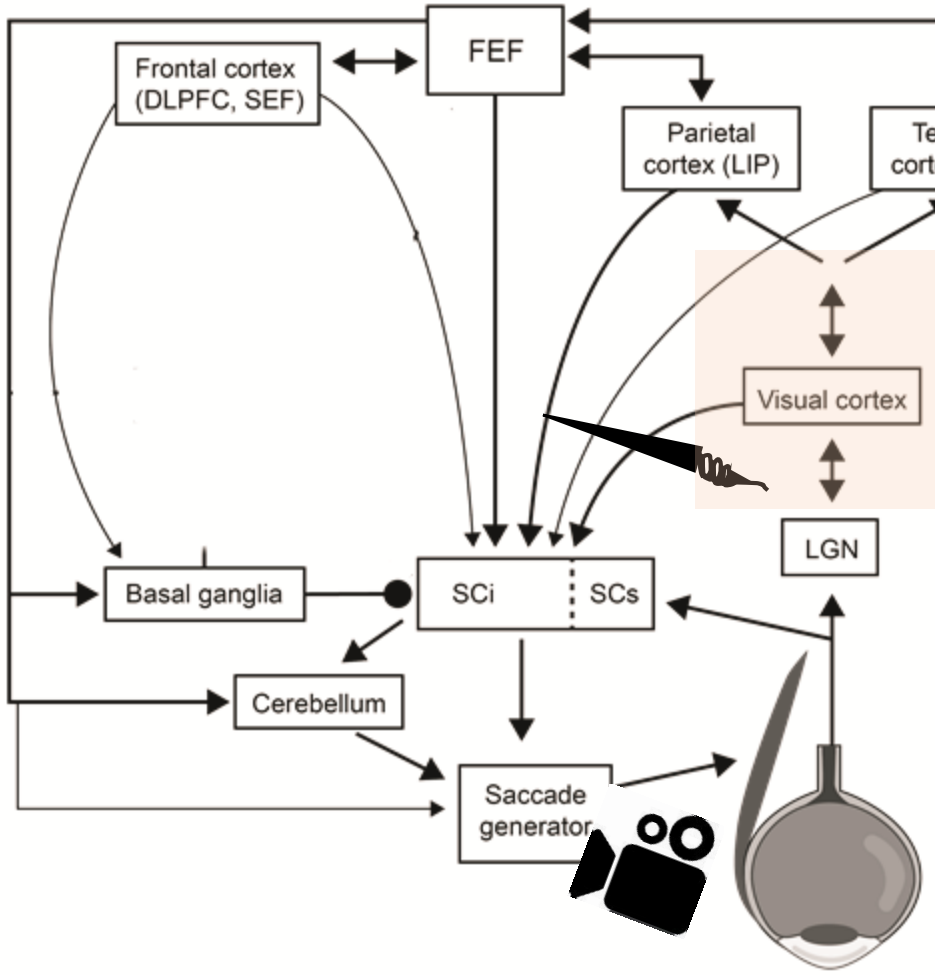
Illusory motion is not perceived

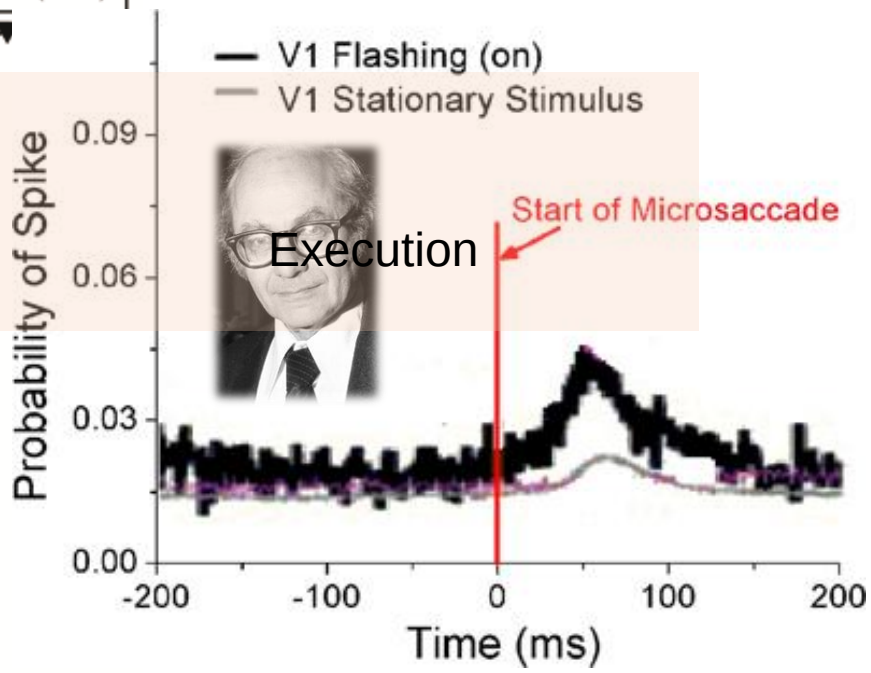
Visual images fade



Martinez-Conde, et al., Neuron 2006


Modulation
FEF
Frontal cortex (DLPFC, SEF)
Parietal cortex (LIP)
Temporal cortex (TEO)
Visual cortex
Execution
LGN
Basal ganglia
SCi
SCs
Command generator
Cerebellum
Saccade generator
Mechanical adjusters



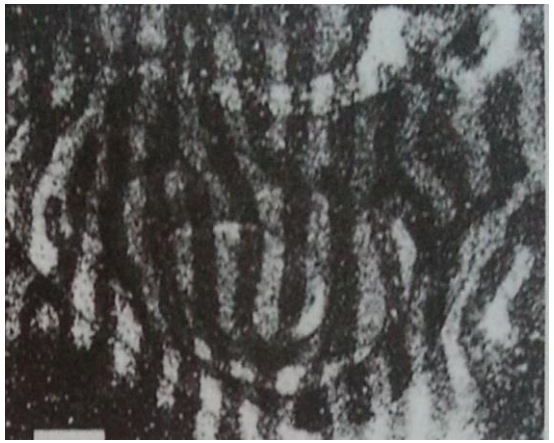


(Martinez-conde, Macknik and David Hubel 2004)

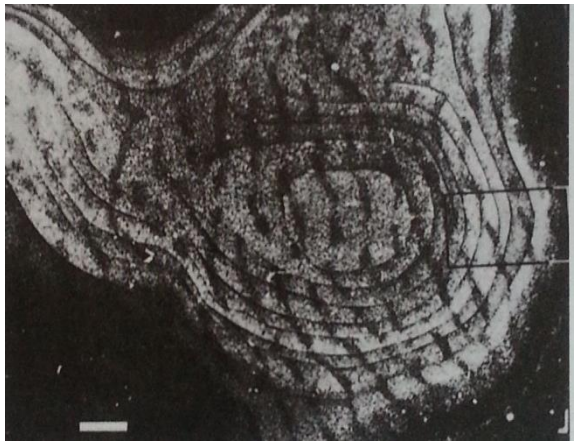
MICROSACCADES IN DISORDER OF VISUAL CORTEX: **AMBLYOPIA**

The "lazy eye": most common cause of blindness in children

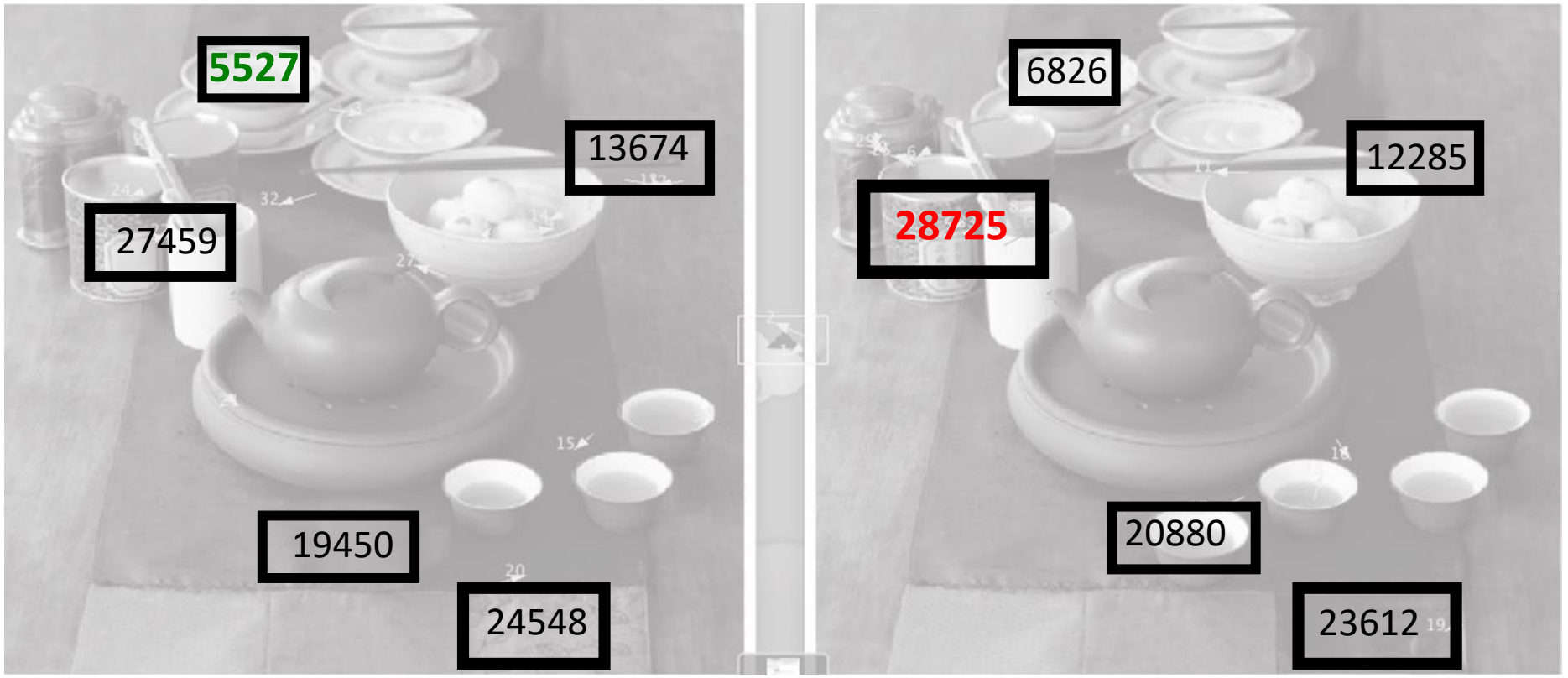
Normal striate cortex



Striate cortex in
animal model of amblyopia



Healthy controls



Picture differences identified= 5

Reaction time/difference = 4.6 sec

Number of microsaccades = 35

Severe amblyopia

Picture differences identified= 0

Number of microsaccades = 7

Amblyopic are unable to generate microsaccades.

Cannot **prime** the cerebral cortex to perceive visual image.

Blindness

PLOS ONE

RESEARCH ARTICLE

Abnormal Fixational Eye Movements in Amblyopia

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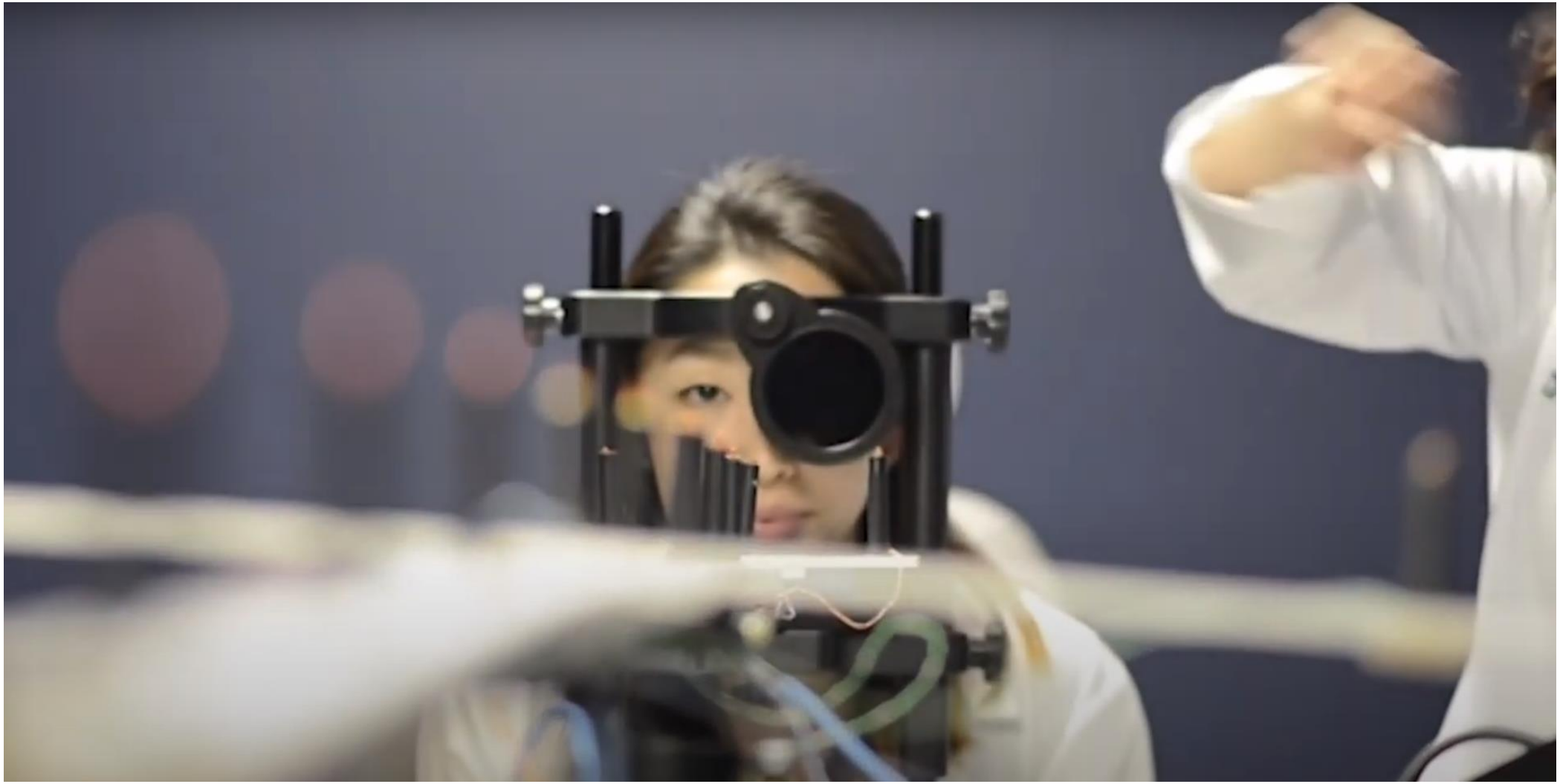
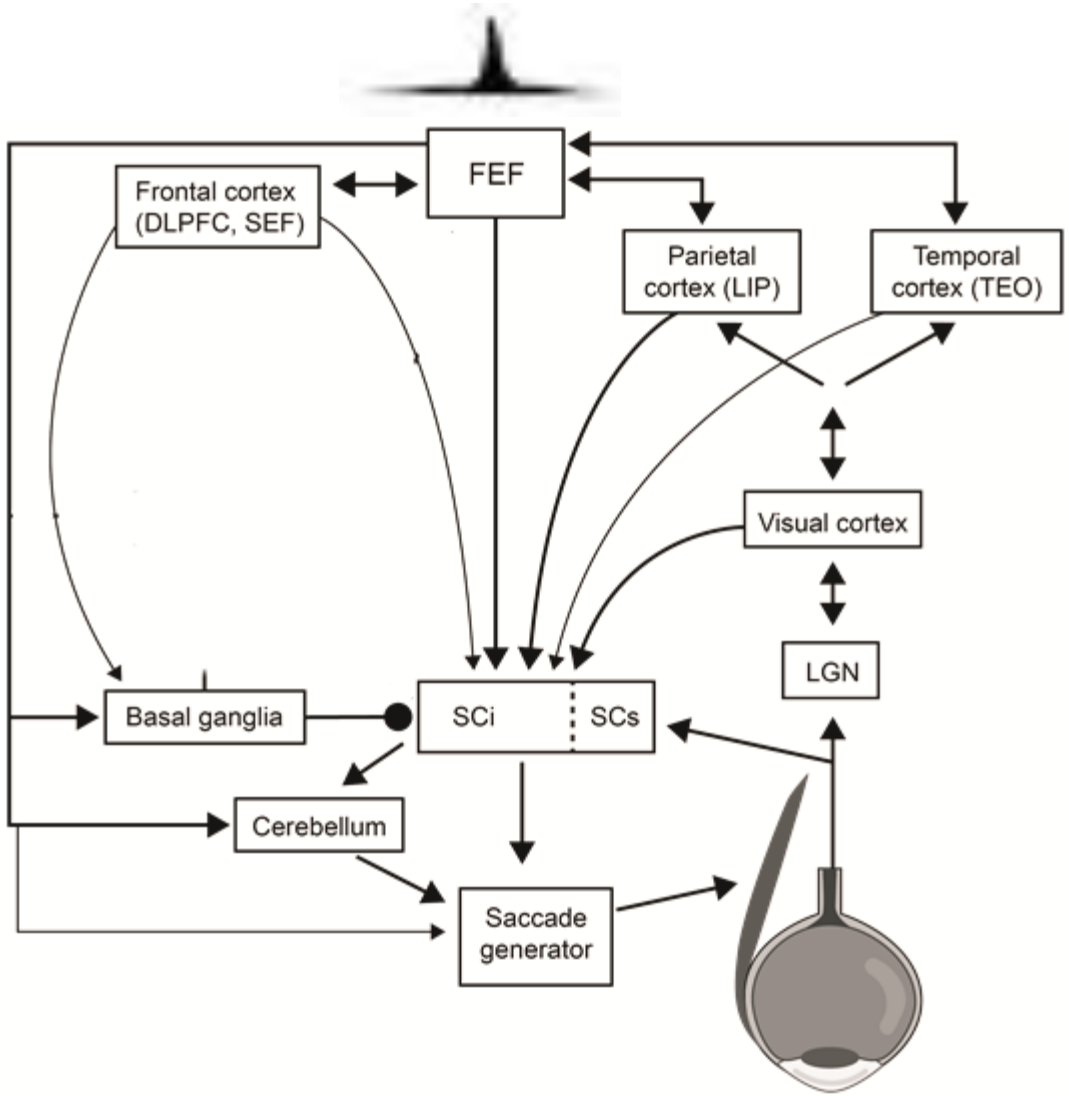
MICROSACCADES IN DISORDER OF BASAL GANGLIA: **PARKINSON'S DISEASE**

Study of visual perception and eye movement function



Deep brain stimulation

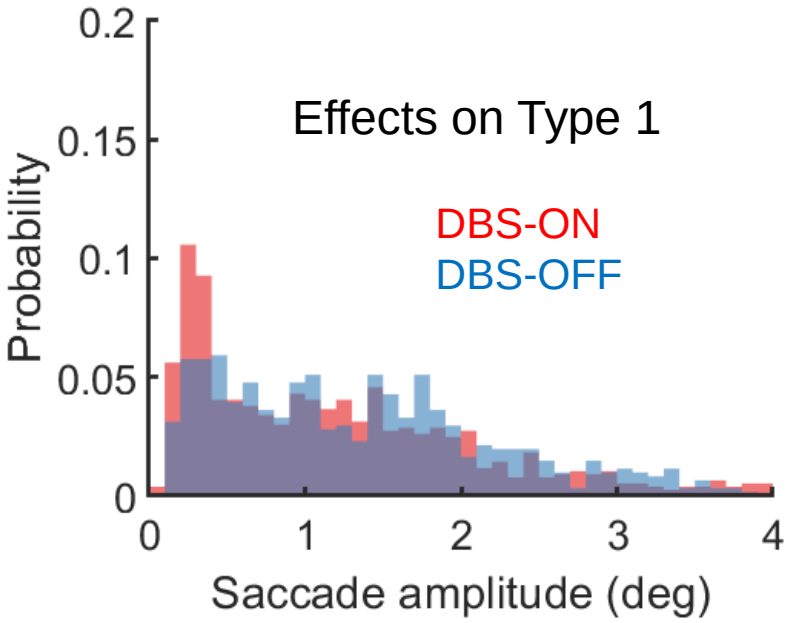
Noise

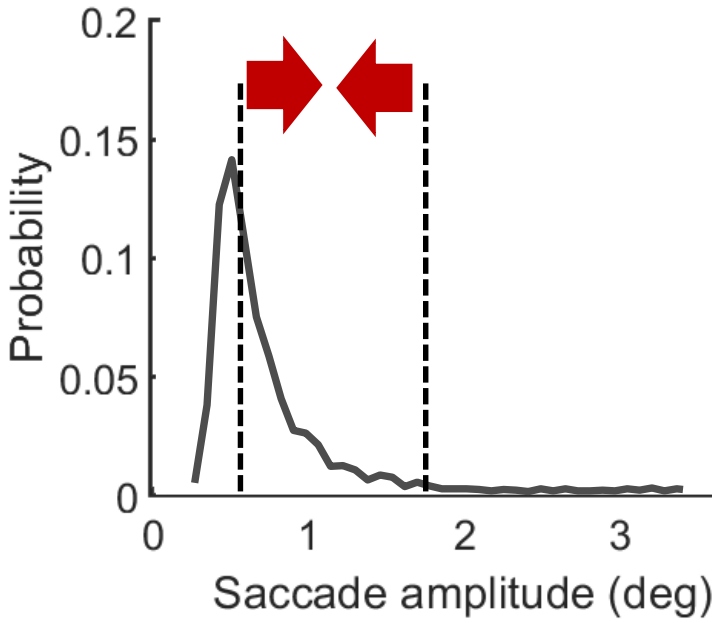


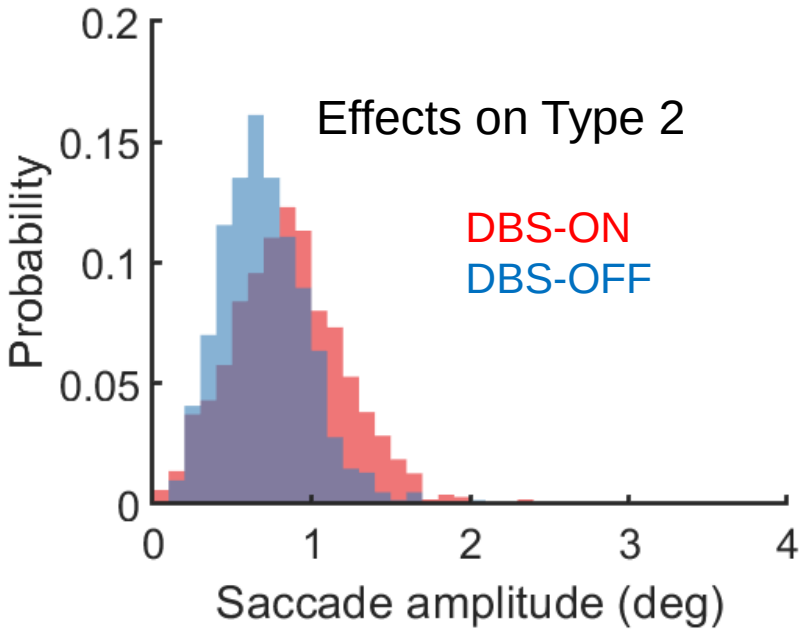
What are the effects of excessive noise on microsaccade generation?

What happens to microsaccades if we “modulate” the noise?

Microsaccade **size**







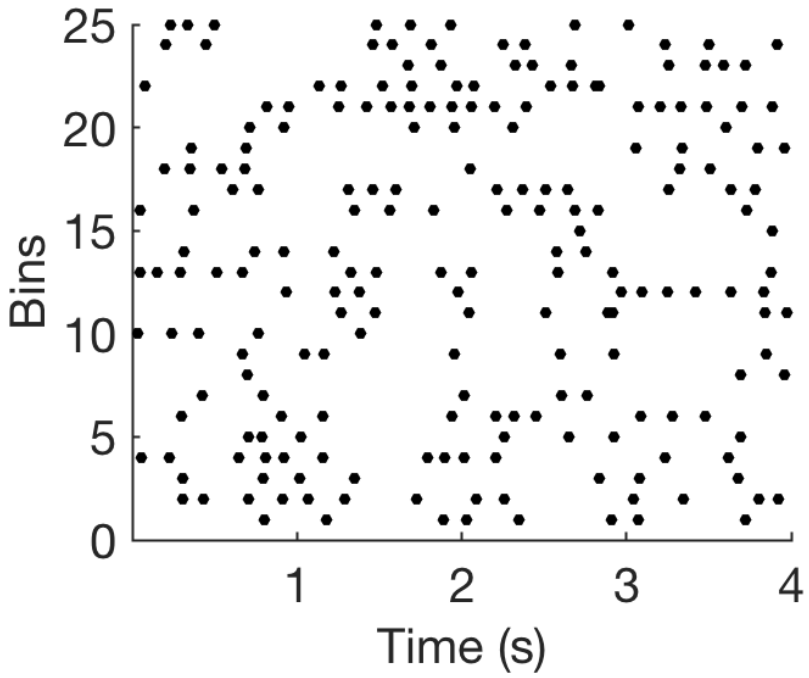
Normal state → **Pathological state**

THIRD state: *Treated state*

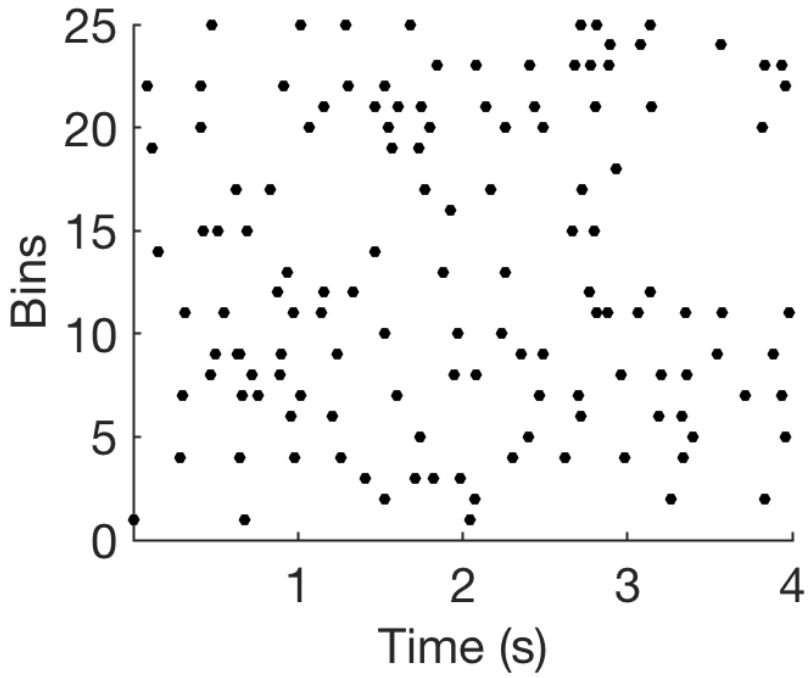
The same phenomenon seen in **microsaccade frequency**

Microsaccade **temporal pattern**

DBS off: **clustered**



DBS on: **random**



VISUAL SCANNING PATTERN:
PARKINSON'S DISEASE

Healthy control

Parkinson's disease (DBS OFF)

Healthy control

Parkinson's disease (DBS ON)

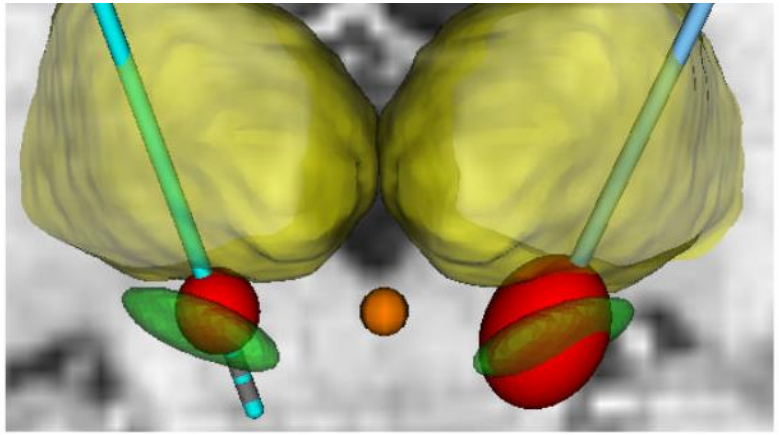
The eye sees only what the mind is prepared to comprehend.

Henry Bergson

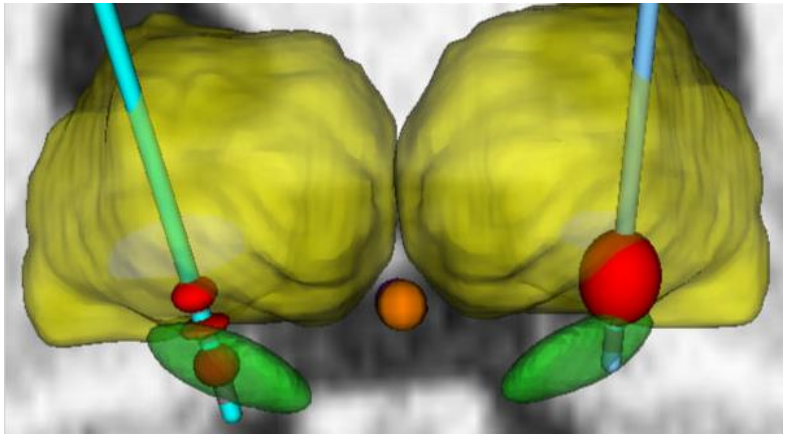
Determinants of deep brain stimulation on **visual perception and microsaccades**

1. The size of electrically activated volume of brain tissue
2. The location of such activated tissue in relation to the subthalamic nucleus

When deep brain stimulation **CHANGED** visual perception and microsaccades



When deep brain stimulation **DID NOT CHANGE** visual perception and microsaccades



Summary

- Microsaccades, the miniature eye movements
  → marker for perception and action
- Generated by cerebral cortex
- Modulated by the basal ganglia
- Artificial modulation of cortico-striatal circuit with deep brain stimulation can modulate microsaccades.
  → Can we modulate action perception relationship?
  → Does this reflect change in the human behavior and executive function?

Thank you

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