Motor Disorders

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• Sensory versus Motor Systems

• Reason we have a brain

• Breakdown of motor control following failure of sensory or motor systems
  • Deafferentation [peripheral]
  • Parkinson’s disease [central]
MUHAMMAD ALI, who suffers from parkinsonism, lit the Olympic flame at the 1996 Summer Games in Atlanta. The unsteadiness of this once indomitable athlete served as a stark reminder of the pressing need for more effective therapies.
Cortical Motor Areas

Basal Ganglia

Cerebellum

Thalamus

Brain Stem

Spinal Cord

Final Common Path

Muscle Contraction & Movement

Sensory Receptors

Muscle Contraction & Movement

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Sensory Receptors
BRAIN REGIONS affected physically or functionally by Parkinson’s disease are highlighted. The pars compacta region of the substantia nigra (dark area in detail) loses neurons that normally issue motion-controlling signals (arrows) to the striatum in the form of the naturally occurring chemical dopamine. Striatal neurons relay the messages to higher motor centers (gray).

Death of the nigral neurons lowers dopamine levels and thereby disrupts the circuit and, in turn, a patient’s motor control. Dopamine-producing neurons outside the substantia nigra are not harmed much, but areas that lose other kinds of neurons, such as the raphe nuclei and locus ceruleus, contribute to depression and to additional nonmotor manifestations of the disorder.
Parkinson’s Disease

- Reliance on external cues
- Basal Ganglia are important for the internal guidance of movement
  - Point to remembered 3D locations without vision

Sensorimotor Mapping Problem

- How to control joint angles of arm given knowledge of coordinates of target in external space
SUBJECTS

- 11 PD Patients (mild to moderate)
- Studied OFF medication
- 8 Age-Matched Controls
- Right handed, right hand used
PD Patients (N=11)
Conclusions for Experiment 1

• With vision only of the initial hand position and target, mild to moderate PD patients have normal 3D pointing accuracy

• Thus, PD patients are able to construct spatial maps of the target and of their moving limb and coordinate the two

• Certain dimensions of performance are impaired

• Challenging integration of vision and proprioception may induce large spatial errors
Modes of Target Presentation

1. No-Vision
2. Finger-Vision
3. Target-Vision

- No required transformations across sensory modalities: Finger-Vision
- Required transformations across modalities: No-Vision Target-Vision

Hypothesis: Deficits in Conditions 1 & 3, but not in 2.
SUBJECTS

• 9 PD Patients (mild to moderate)

• Studied OFF Medication

• 9 Age-Matched Controls
Conclusions

• PD patients show large 3D reaching errors when forced to extract critical information from proprioception to map onto a spatial target

• This deficit may in part underlie PD patients’ reliance on external cues

• Turn to learning new sensorimotor mappings
Immersive 3D Virtual Reality Environment

- Head-Mounted Display by Virtual Technologies
- 3D electromagnetic tracking by Ascension Technology
Visuomotor multistage learning task

**Task phases**

1. Baseline (B)
2. Initial discordance (ID)
   \[ x + 10 \text{ cm} \& y + 10 \text{ cm} \]
3. Reverse discordance (RD)
   \[ x - 10 \text{ cm} \& y - 10 \text{ cm} \]
4. AfterEffect (A)

\[ x + 10 \text{ cm} \& y + 10 \text{ cm} \]

* Biaxial Distortion

- Virtual targets
- Real target
SUBJECTS

• 8 PD Patients (mild to moderate)
• Studied OFF Medication
• Minimal or No Tremor or Dyskinesias
• 10 Age-Matched Controls
• 10 Young Adult Controls
Horizontal Errors

Vertical Errors

B  -  Baseline
IL  -  Initial Learning
RL  -  Reversal Learning
A  -  AfterEffect

Young
Elderly
Parkinson
PD Subjects are impaired in reversal learning

Subjects are impaired in reversal learning.
CONCLUSIONS

• PD subjects show an endpoint elevation depression at baseline

• The ability to adapt to a sudden biaxial visuomotor distortion applied in 3D space declines in normal aging and Parkinson disease

• The Basal ganglia contribute to visuomotor learning, particularly when the task requires a rapid reconfiguration of newly learned visuomotor coordinations
Deafferented Subjects