ASHI691:

Why We Fall Apart: The Neuroscience and Neurophysiology of Aging

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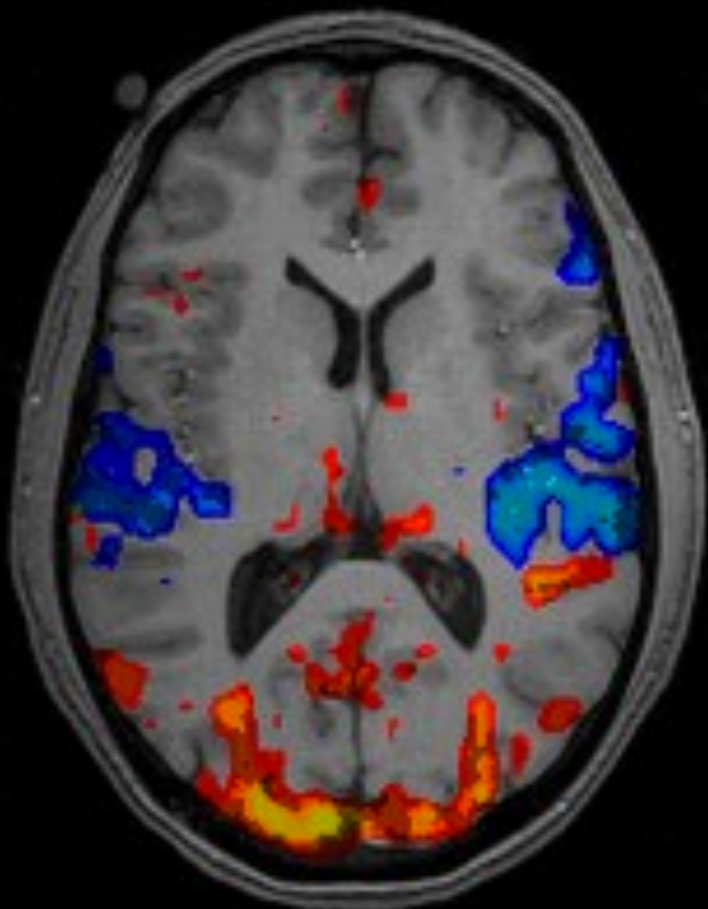
Lecture 3:
MOTOR DEFICITS



Part I: What research is good research?

1. Examine the author
    - Do they hold a faculty appointment as a Tier I or Tier II university?
    - Is it their primary appointment?
    - Faculty rank: Adjunct, Sessional, Assistant, Associate, Full, Emeritus?
    - Are they writing with their area of expertise?
    - Check out their H-Index and i-Index, Google Scholar, Research Gate

Part I: What research is good research?

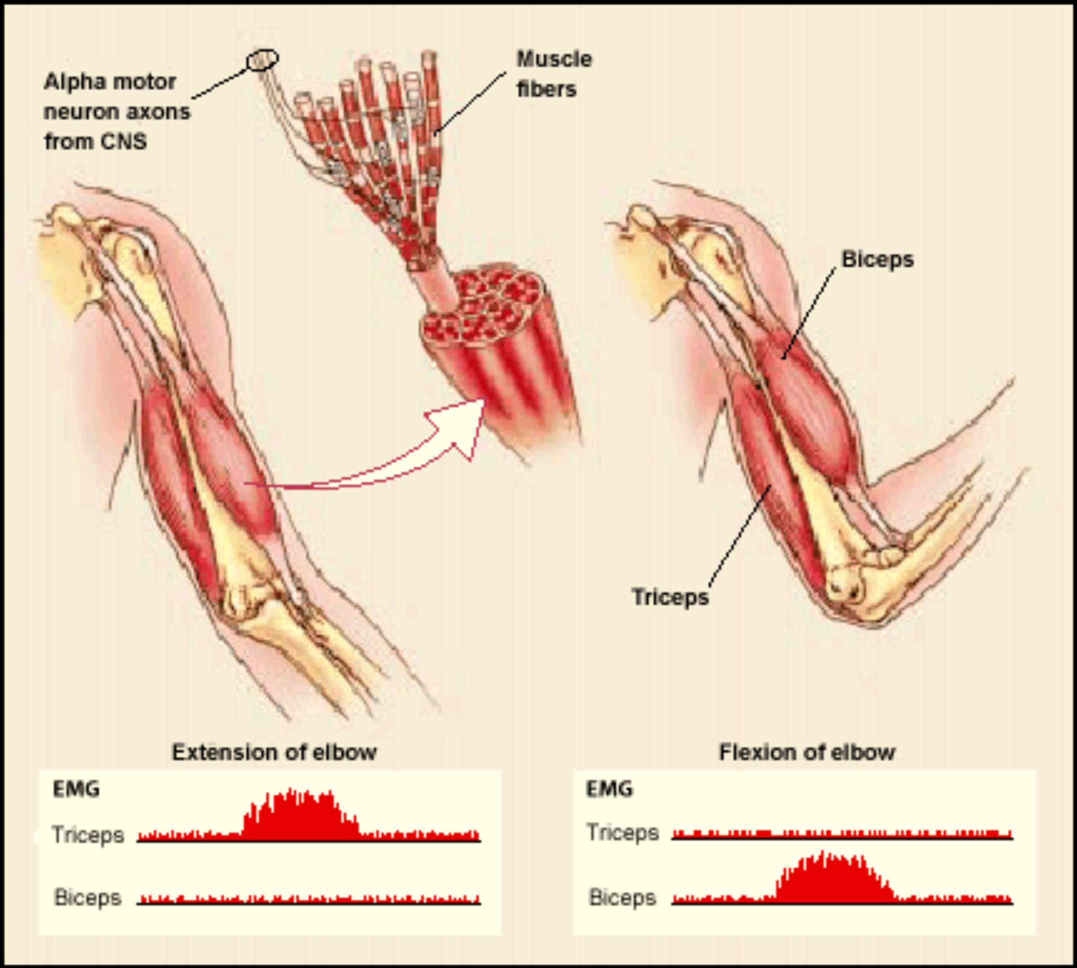
2. Examine the source
    - Is it a peer reviewed journal?
    - Is it a predatory journal?
        - Lists, Google, Submission Cost
    - Do other academics publish in the journal?
    - What is the impact factor of the journal?
    - What is the citation count of the article?

Part I: What research is good research?

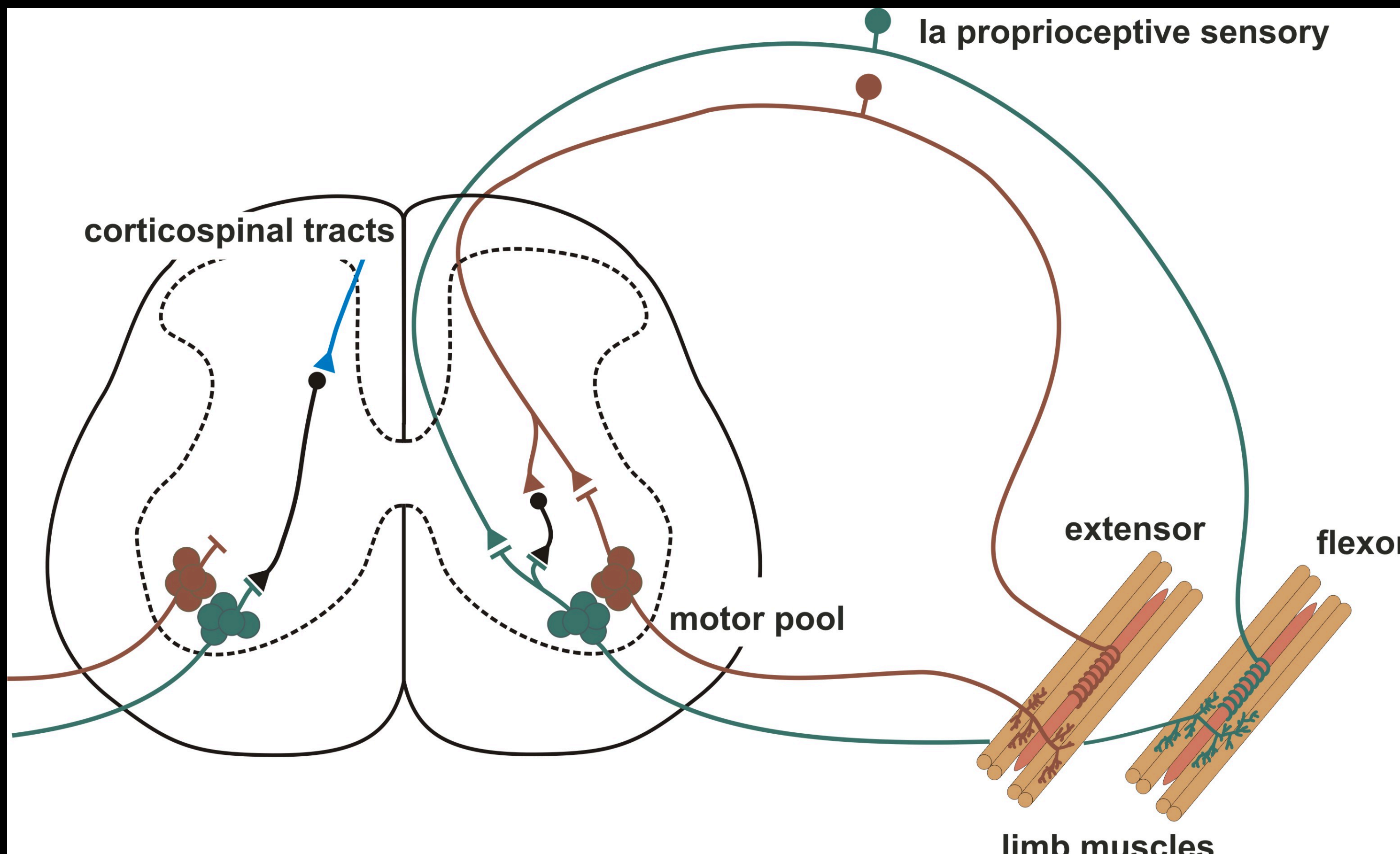
3. Non academic offerings
   - Do they cite primary research articles?
   - Read the articles the work is based on?
   - Again, check the researcher(s) behind the article?
   - Look for quotations versus transcription
   - Remember everything may be out of context
   - Extreme versus average effects

Part II: How We Move

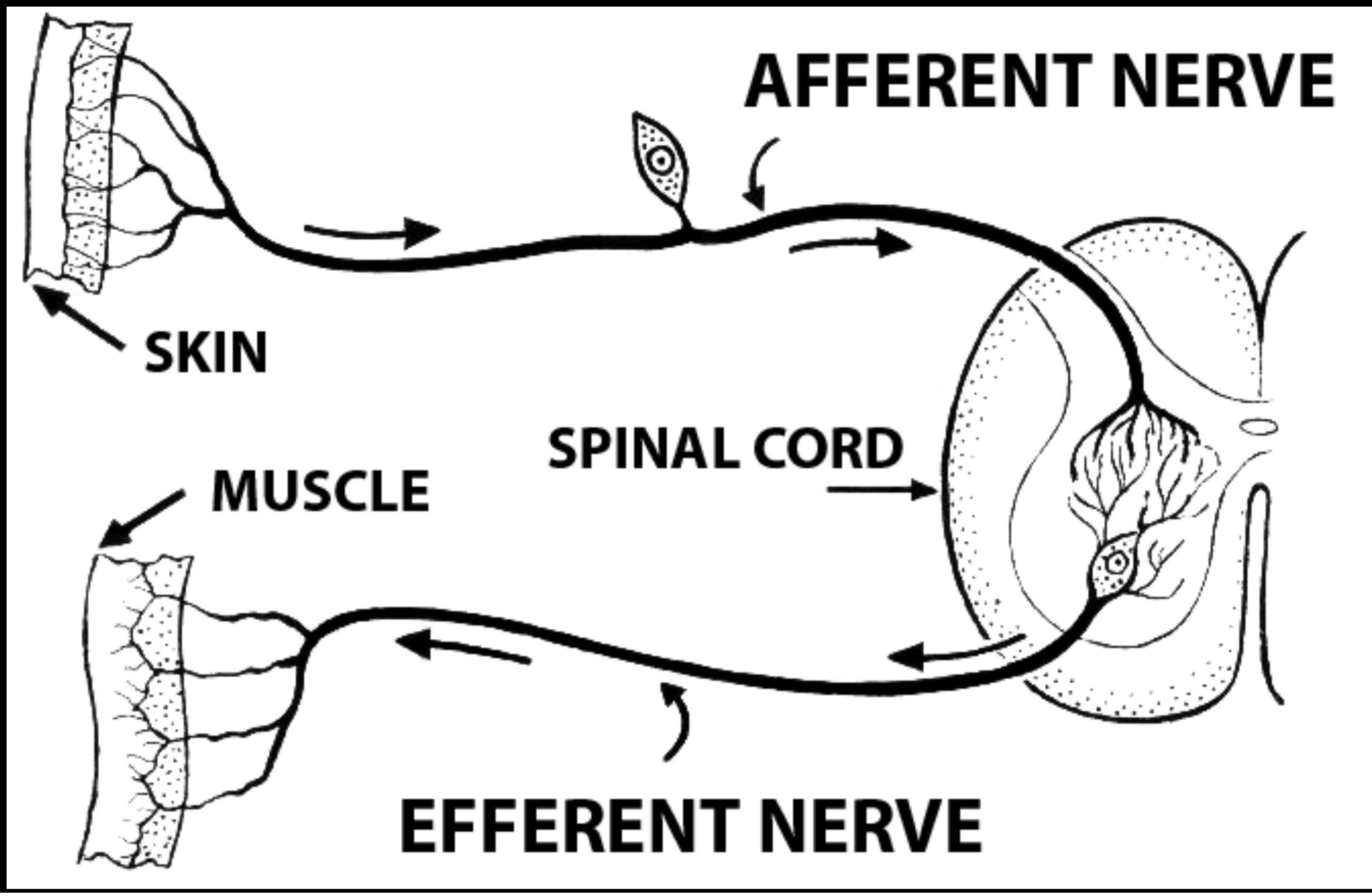
Muscles are activated by alpha motor neurons

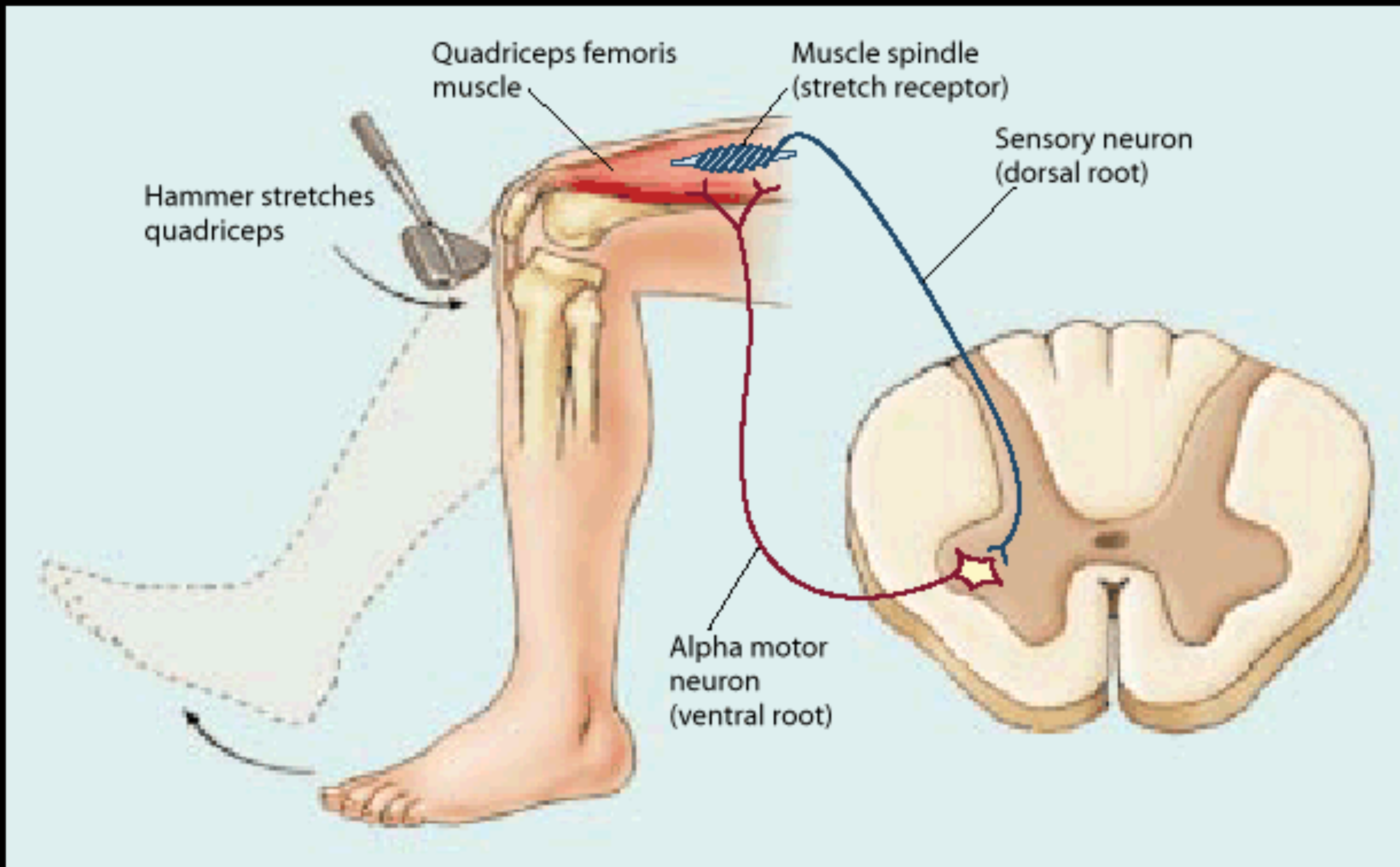


1a Sensory Neurons

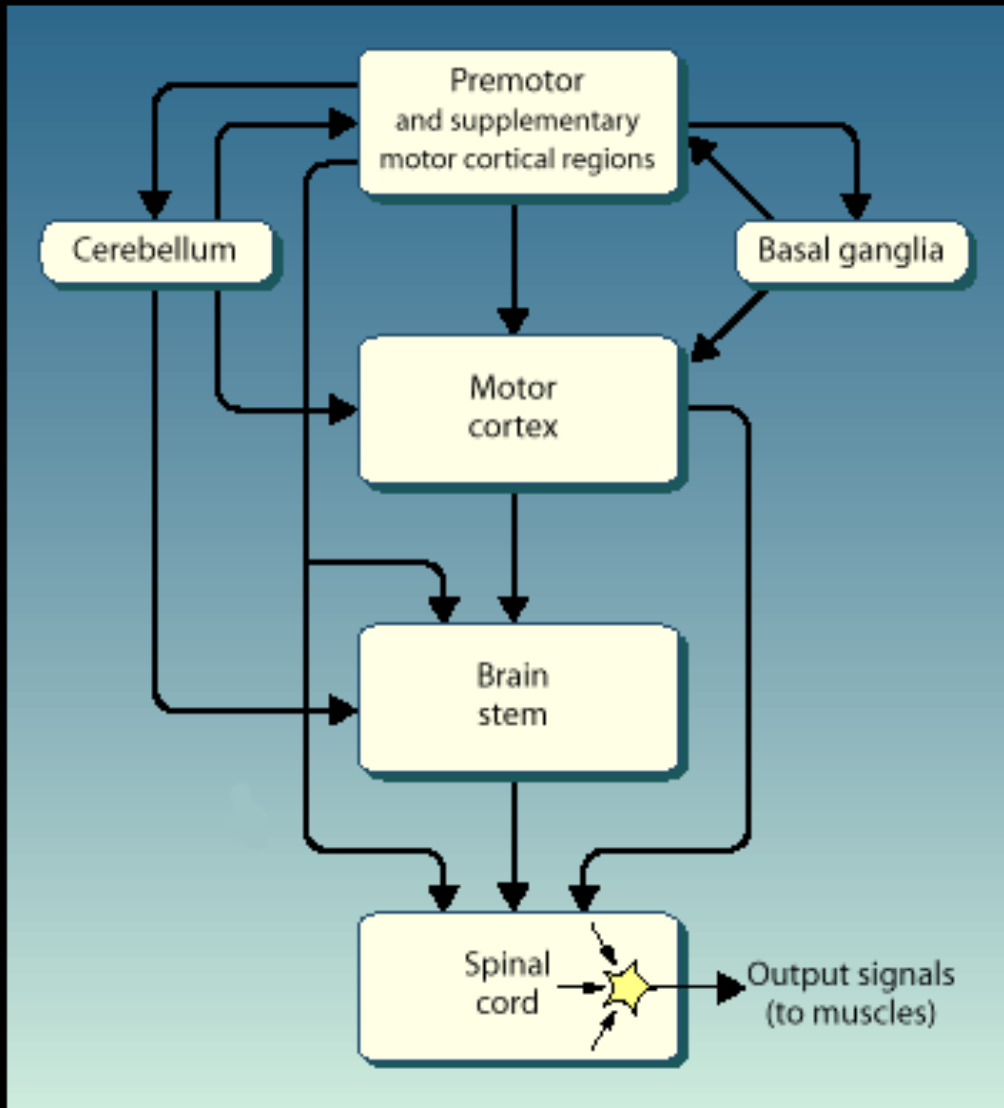


Afferent and Efferent Pathways

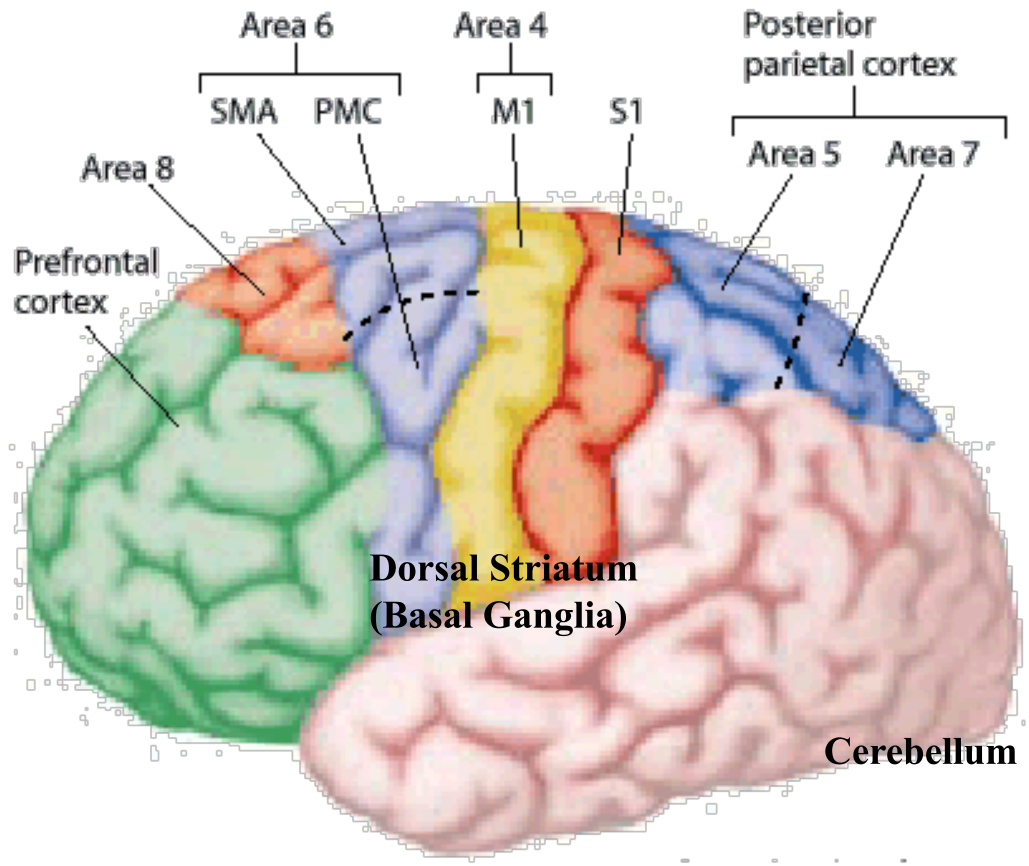



Quadriceps femoris muscle
Muscle spindle (stretch receptor)
Sensory neuron (dorsal root)
Hammer stretches quadriceps
Alpha motor neuron (ventral root)

Schematic overview of the motor system



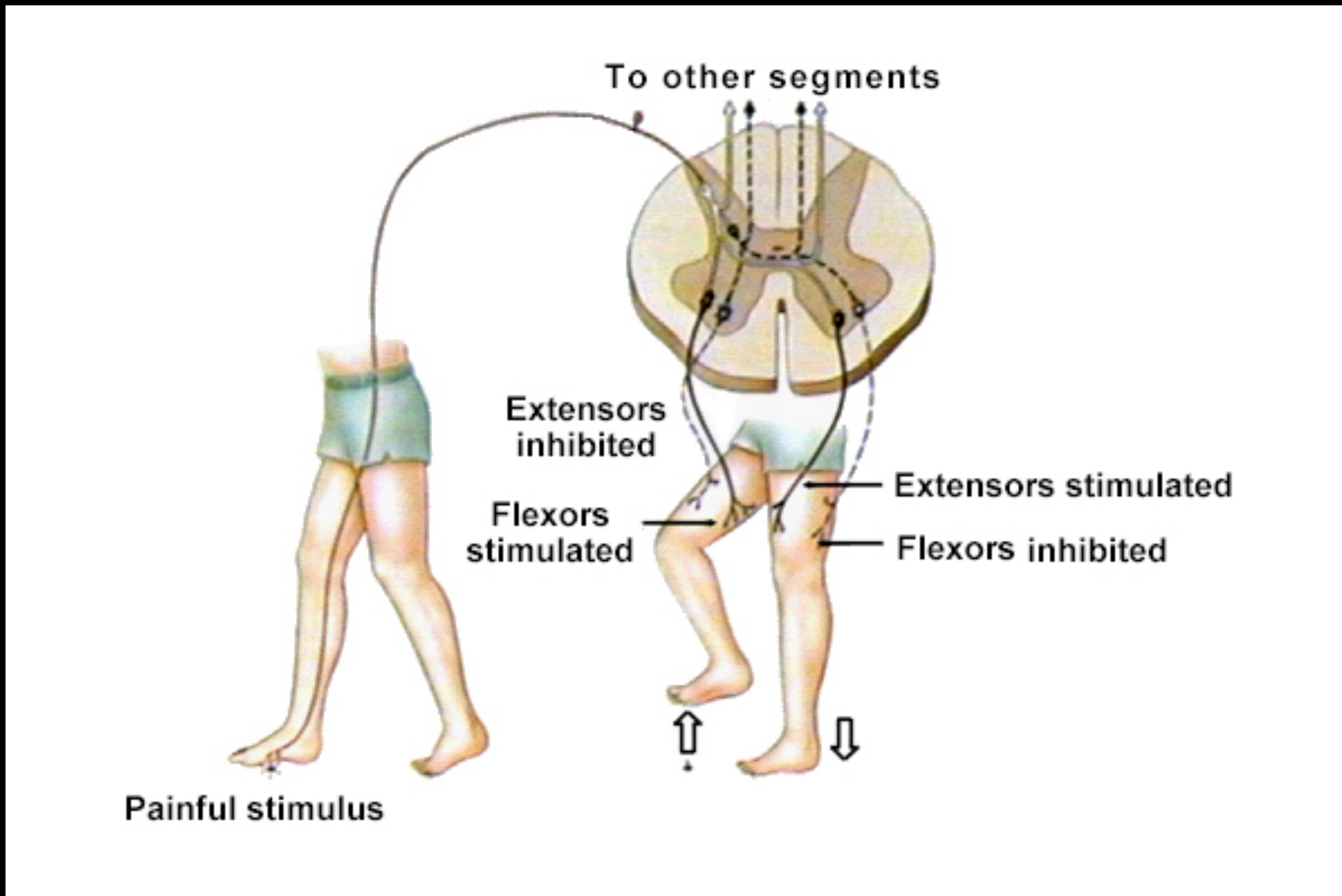
The Motor System



Levels of Movement

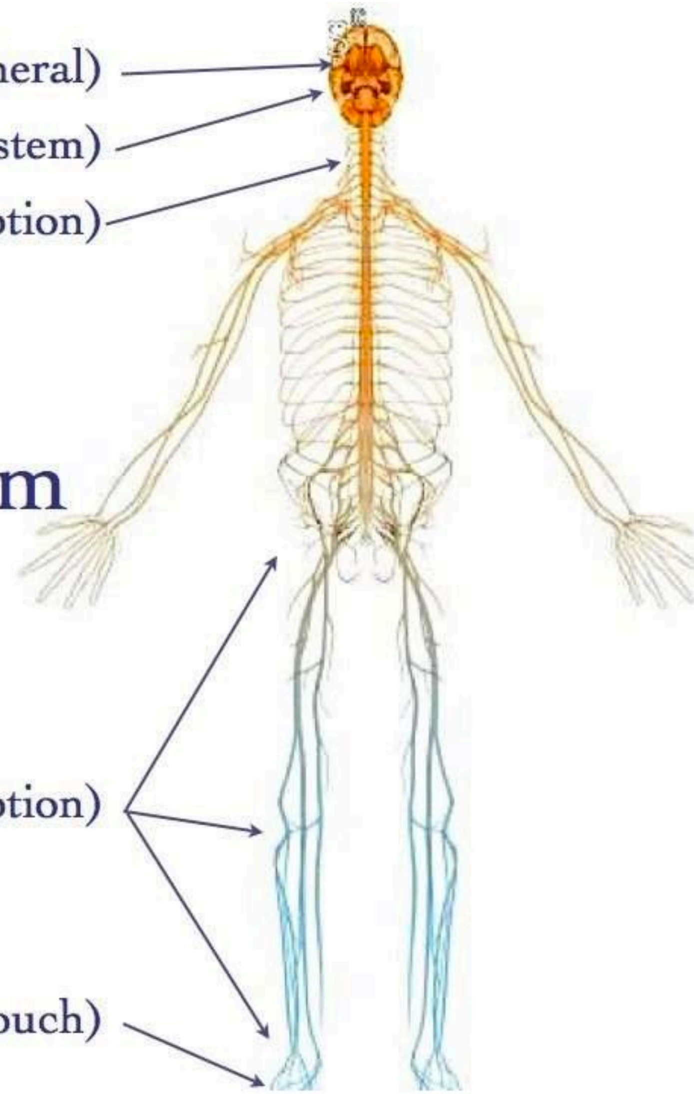
Reflexes

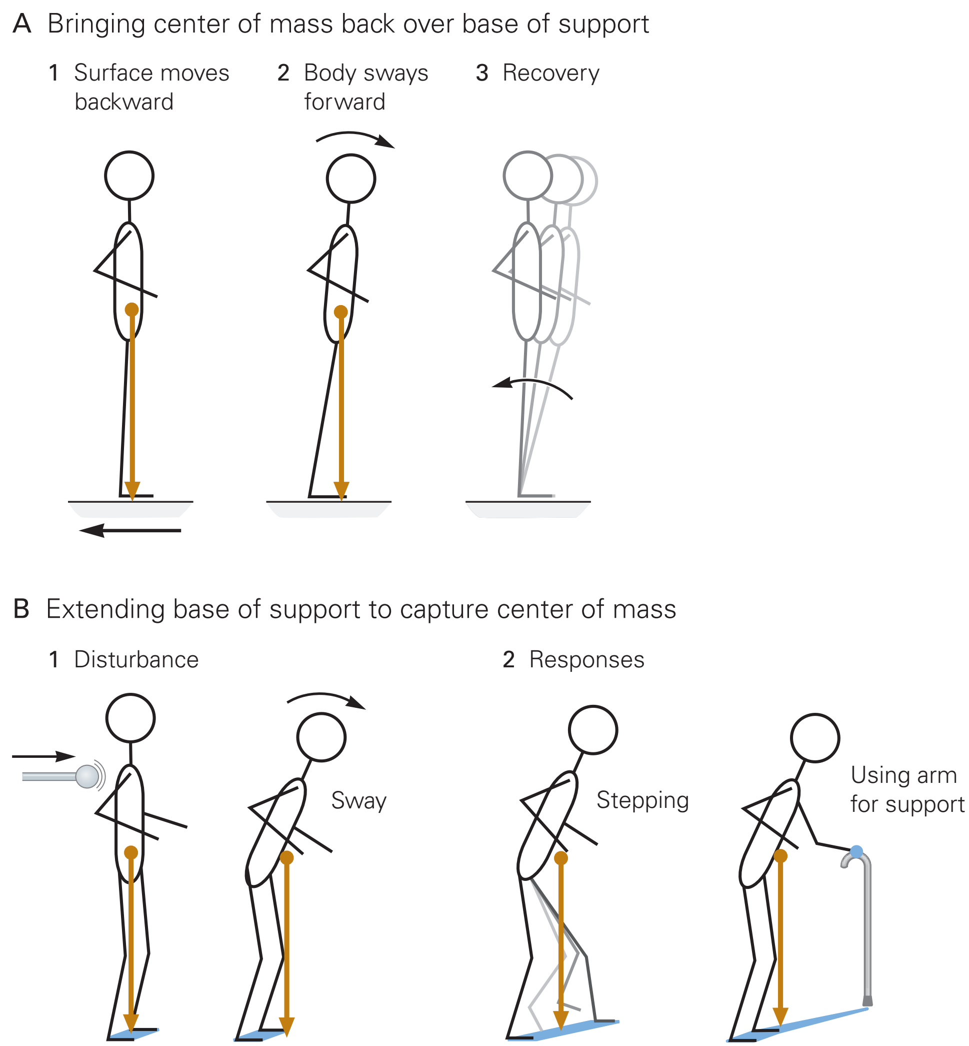
Flexion Withdrawal Reflex…



Postural Control

Equilibrium system



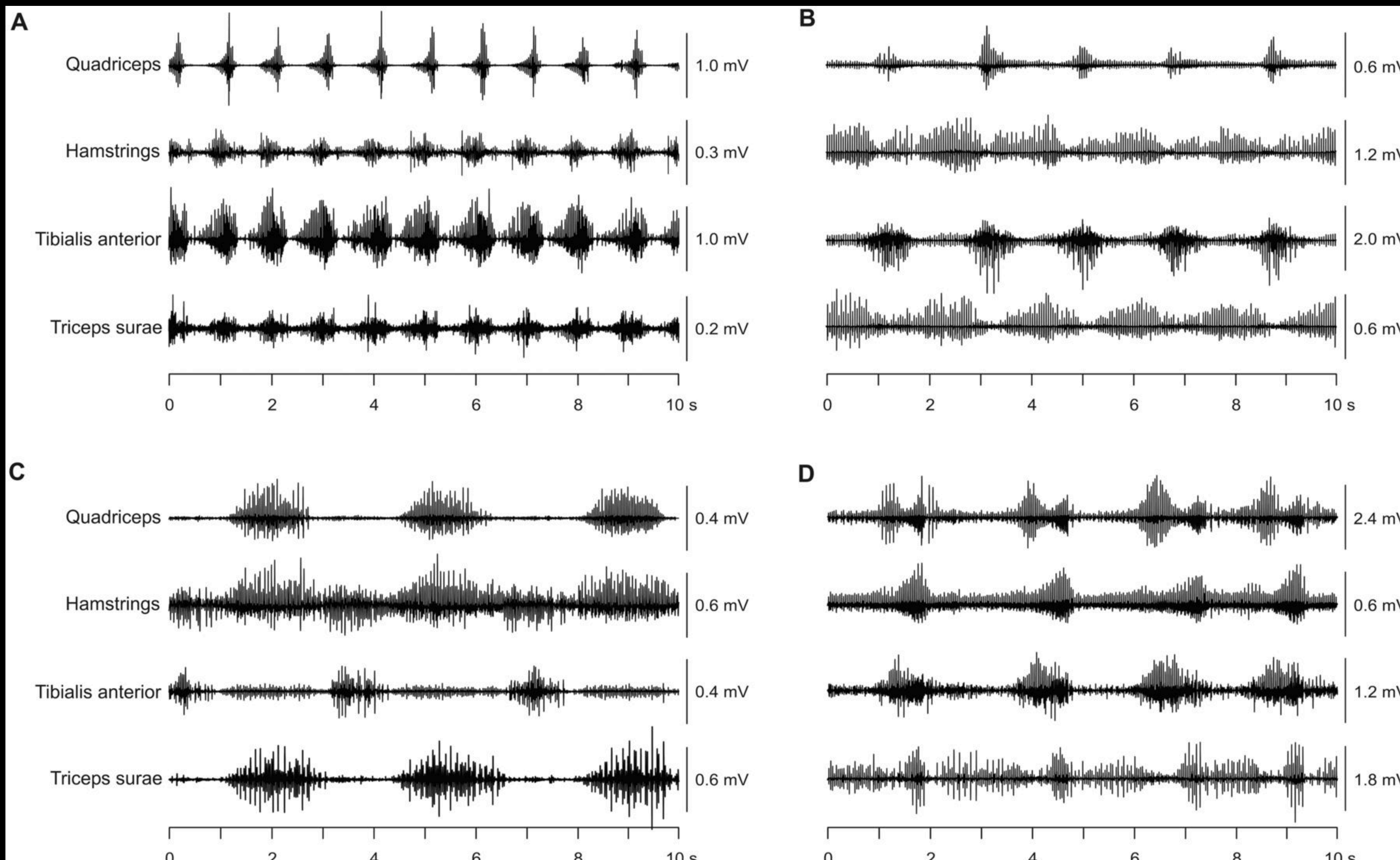


A Bringing center of mass back over base of support
1 Surface moves backward
2 Body sways forward
3 Recovery
B Extending base of support to capture center of mass
1 Disturbance
Sway
2 Responses
Stepping
Using arm for support

Posture: Lines of Defense

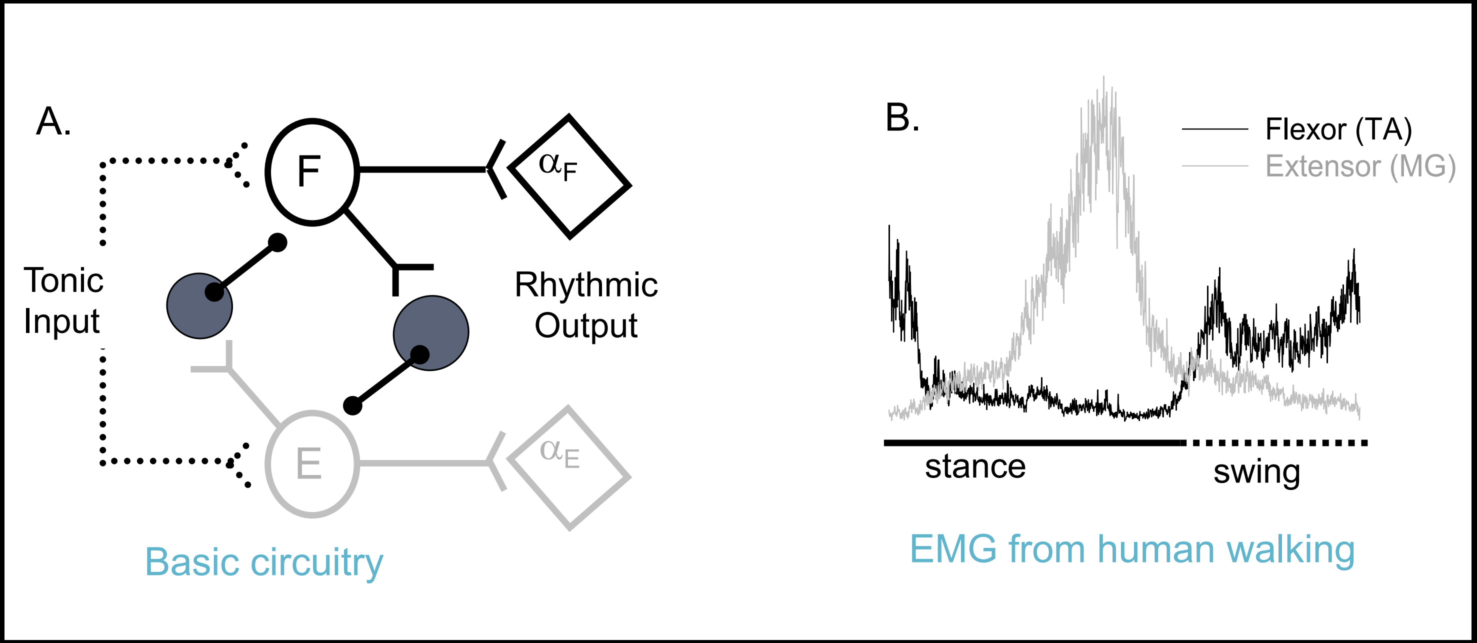
Mechanism	Typical Time Delay	Important Features
1. Anticipatory Postural Actions	-600 ms - 0 ms	Based on predicting a perturbation
2. Muscle and tendon elasticity	0 ms	Can be modulated (pre-flexes)
3. Equilibrial triad (vision, vestibular, proprioception)	20 ms -70 ms	Poorly controlled, low gain
4. Pre-programmed reactions	80 ms	Approximate correction
5. Voluntary actions	150 ms	Too late!

Gait


A
Quadriceps
Hamstrings
Tibialis anterior
Triceps surae
1.0 mV
0.3 mV
1.0 mV
0.2 mV
0 2 4 6 8 10 s
B
0.6 mV
1.2 mV
2.0 mV
0.6 mV
0 2 4 6 8 10 s
C
Quadriceps
Hamstrings
Tibialis anterior
Triceps surae
0.4 mV
0.6 mV
0.4 mV
0.6 mV
0 2 4 6 8 10 s
D
2.4 mV
0.6 mV
1.2 mV
1.8 mV
0 2 4 6 8 10 s

CPGs: Half-Centre Model

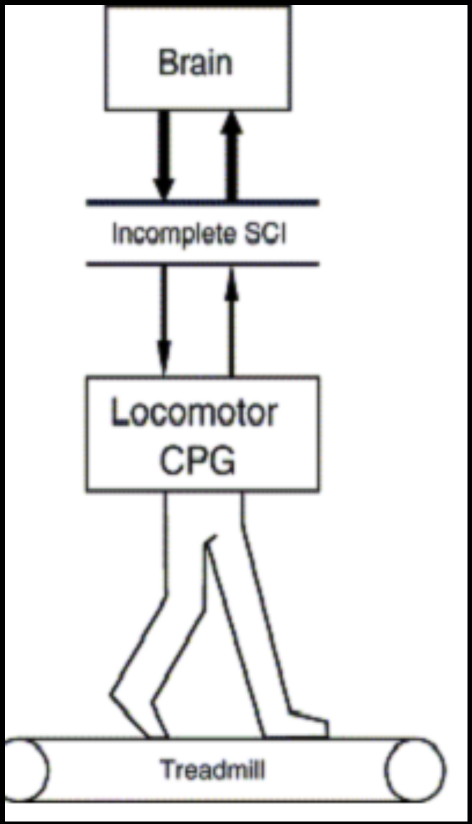
- generates rhythmic output from tonic input
- interneurons controlling flexor and extensor motor neurons have reciprocal inhibitory connections
  - also Left-Right control in swimming (e.g. Lamprey)



Evidence for a human CPG

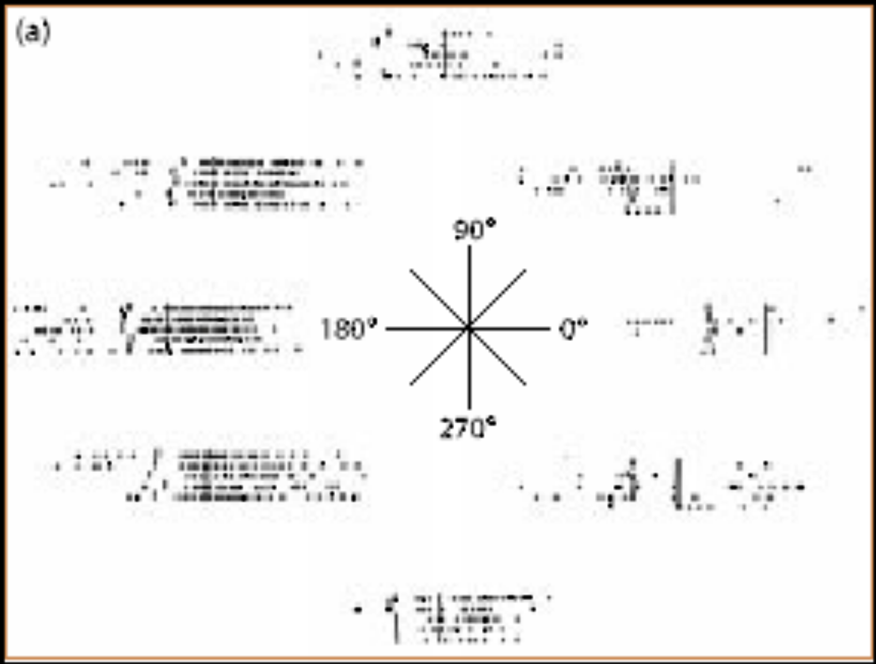
Rhythmic leg movements in SCI patients

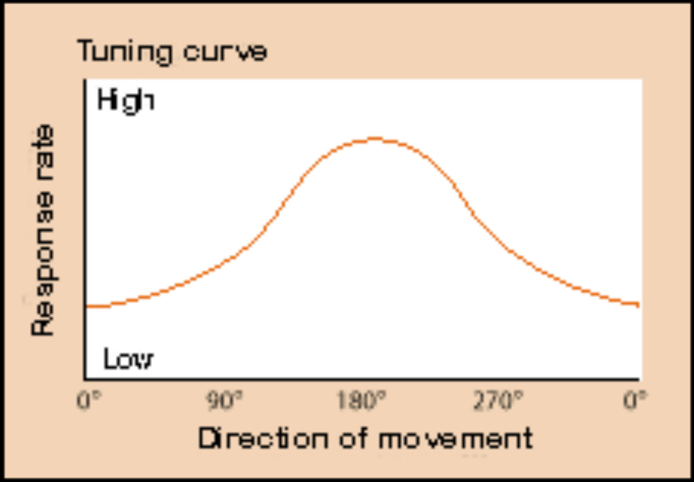
- hip and knee flexion-extension movements at about 1 Hz
- placed over treadmill…
  - occurs more often in incomplete than complete injuries
  - most compelling evidence is a 37 year old patient with history of an incomplete cervical neck injury



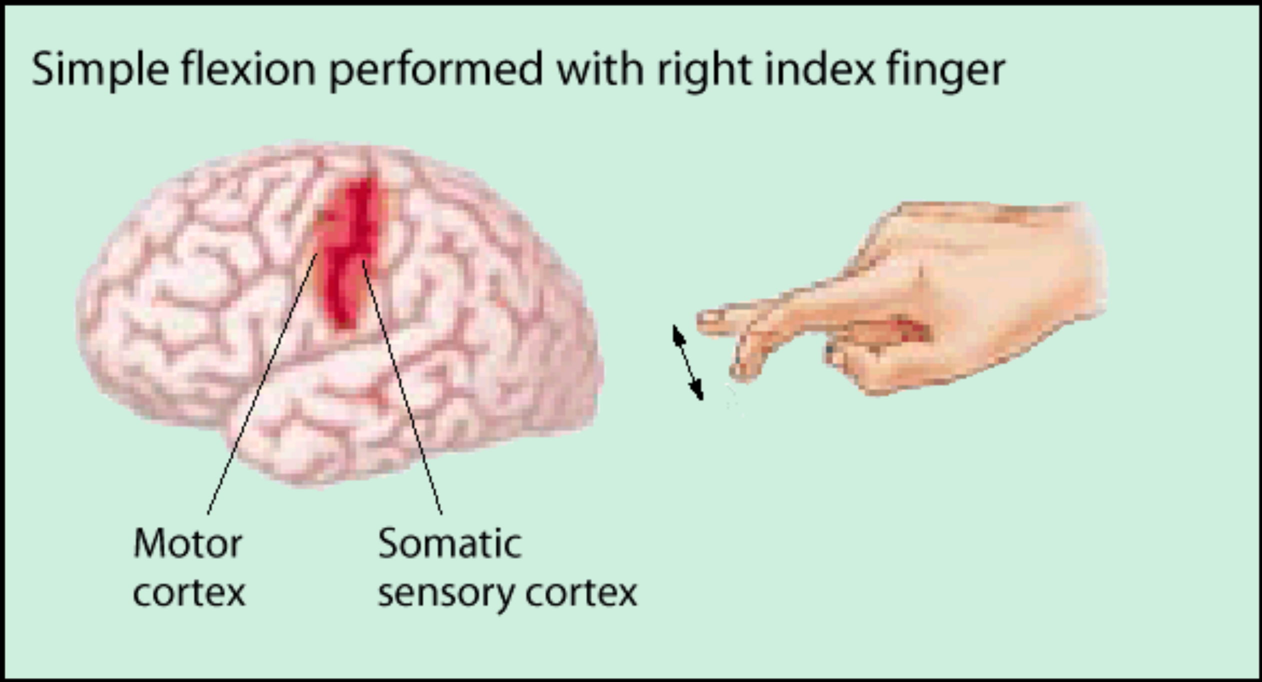
Goal Directed Actions

Georgopoulos shows that movement is coded in population vectors

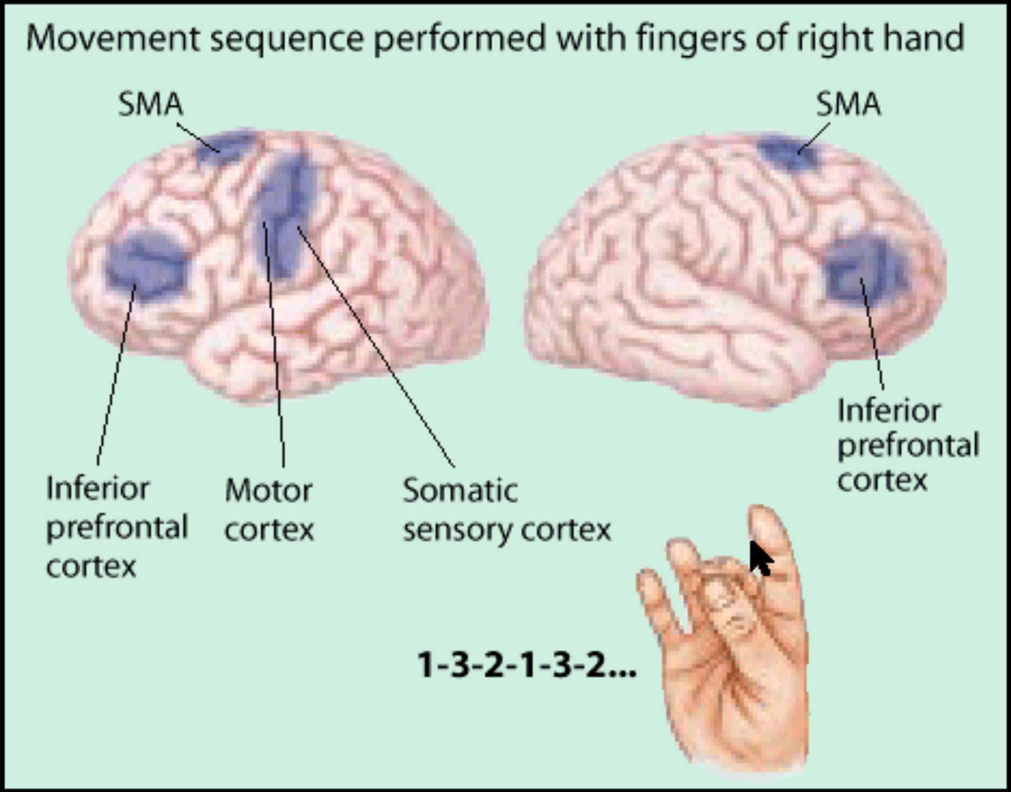




Simple movement activations motor cortex and somatosensory cortex

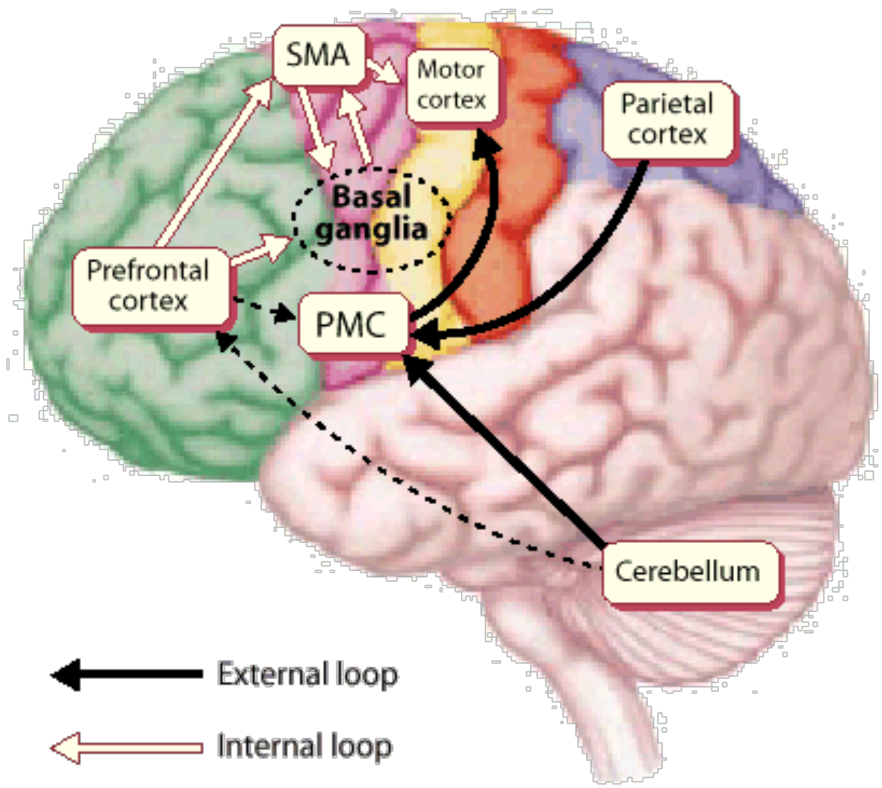


More complicated sequences involve other areas



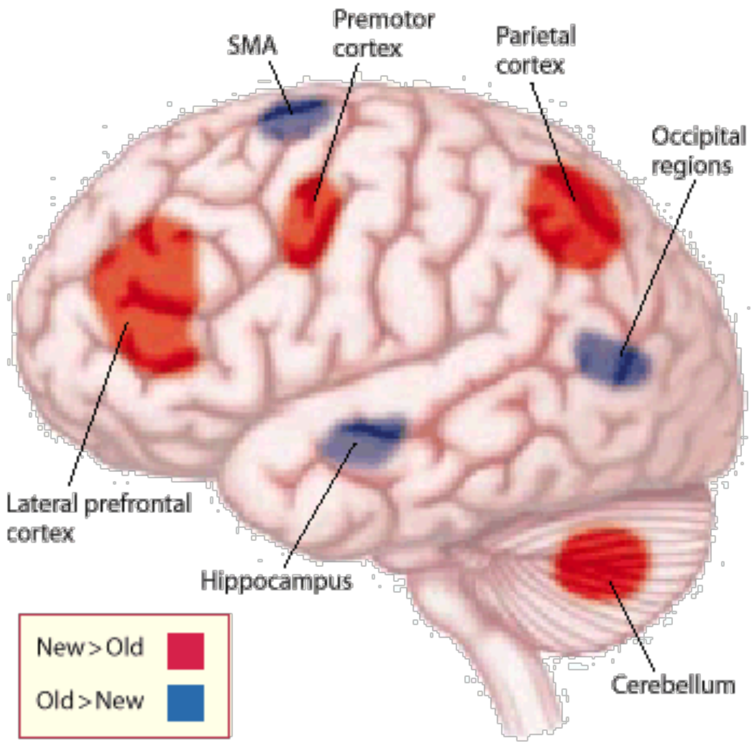
SMA = supplementary motor area (part of area 6)

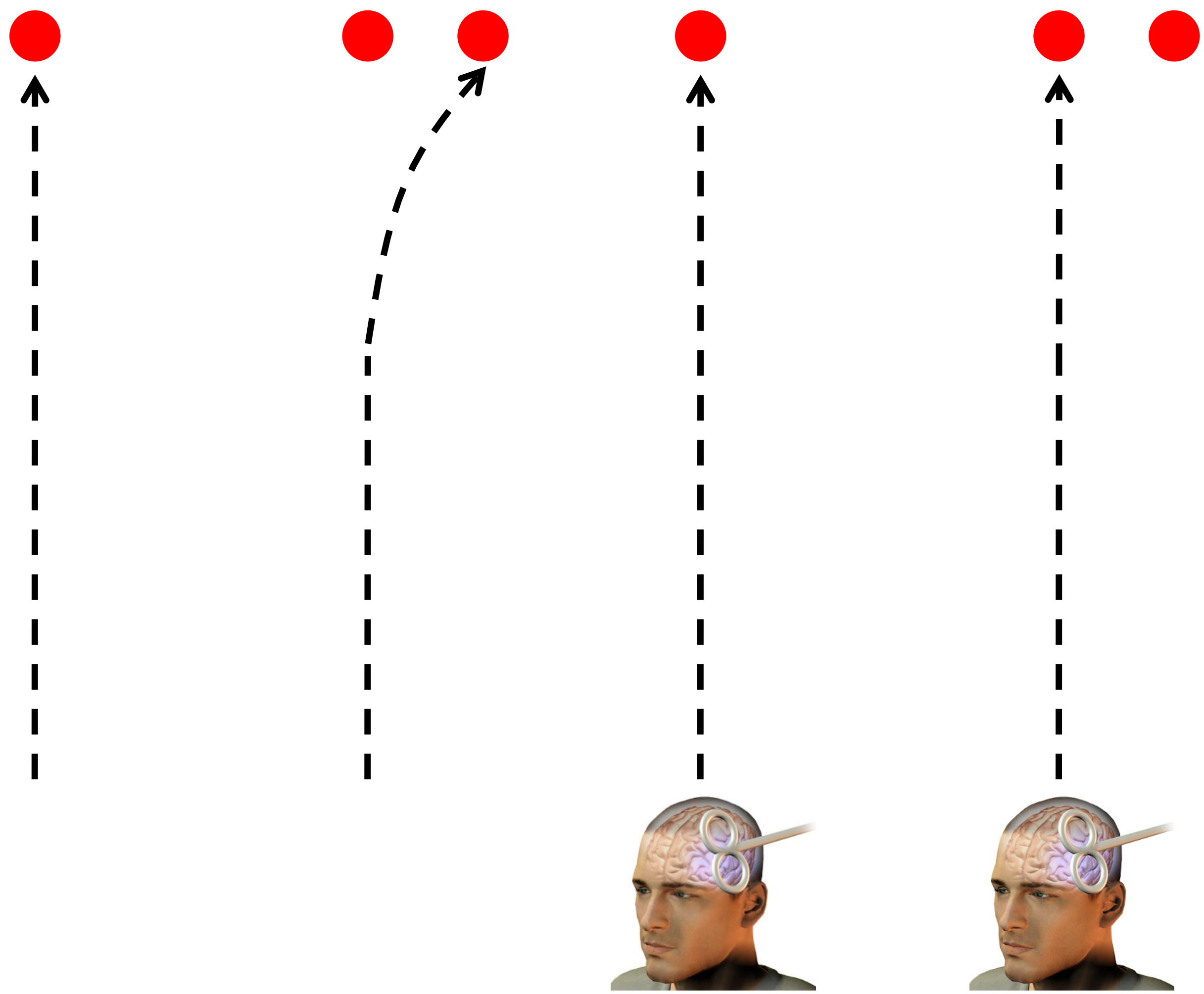
Internally and externally generated movements



PMC = premotor cortex (also part of area 6)

Skilled (Old) versus new motor movements





Part III: How Aging Impacts How We Move

Incidence of Falls

- >1/3 of ambulatory elderly fall each year
  - For patients with no risk factors, fall risk is 8%
  - For patients with 4 or more risk factors, fall risk is 78%
- In 2005 1.8 million older adults fell
  - Approximately 15,800 died from their injuries
- In South Carolina, over a 6 year period (1996 – 2002)
  - 26,298 hip fractures
    - ~ 4400 per year

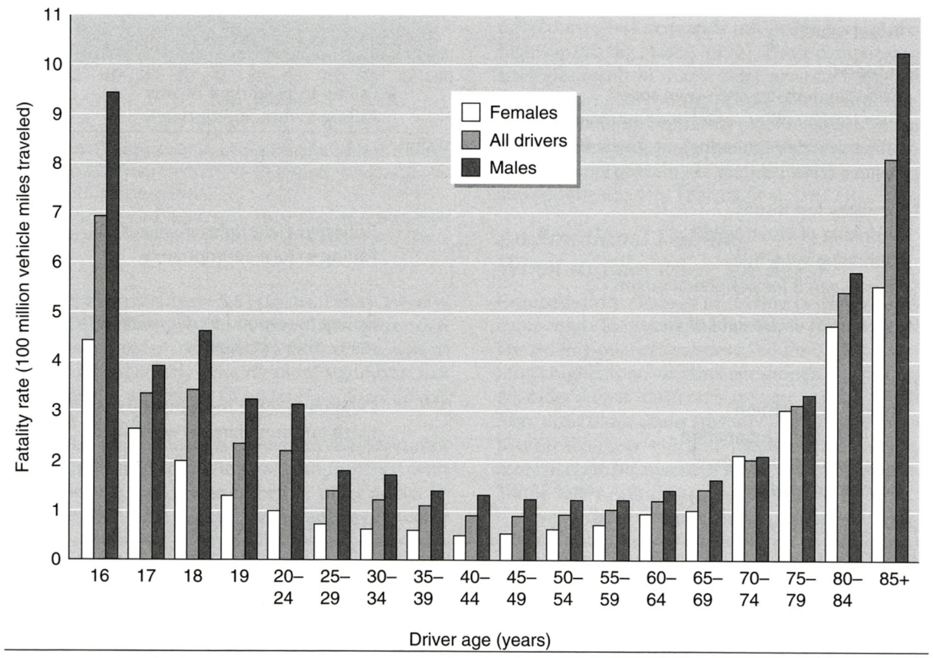


Figure 8.8 Driver fatality rates by age and gender, 1996. Fatality rate per 100 million vehicle miles traveled.
Data from National Center for Statistics.

As people age they become more field dependent, which means they are less likely to detect signs and symbols in the "background" field of vision while driving (Panek et al., 1978). Old drivers tend to neglect some of the information from road signs, traffic lights, and traffic, particularly if it is overwhelming (McFarland et al., 1964). It has been fairly well established that it is not a loss of muscular strength or simple reaction time that causes old people to have accidents, but rather the slowness with which they make decisions and their inability to rapidly discriminate relevant information from irrelevant information (Birren, 1974).

Table 8.1 **Reliability and Decline in Function in Coordination and Functional Tasks**

Test name[a]	Reliability coefficient (r)	Decline in function from age 20 to 80 years (%)
Rising from chair with support	.55	31
Putting on shirt	.63	40
Managing large button	.65	27
Managing small button	.70	22
Manipulating safety pins	.47	21
Zipping garment	.54	34
Tying bow	.66	24
Rotating large peg	.78	27
Speed of handwriting	.84	30
Cutting with knife	.62	43

General changes in the neuromotor system:

- Strength decline
- Longer delays of reactions
- Impaired control of posture/gait
- Impaired accurate control of force/movement
- Unintended force production

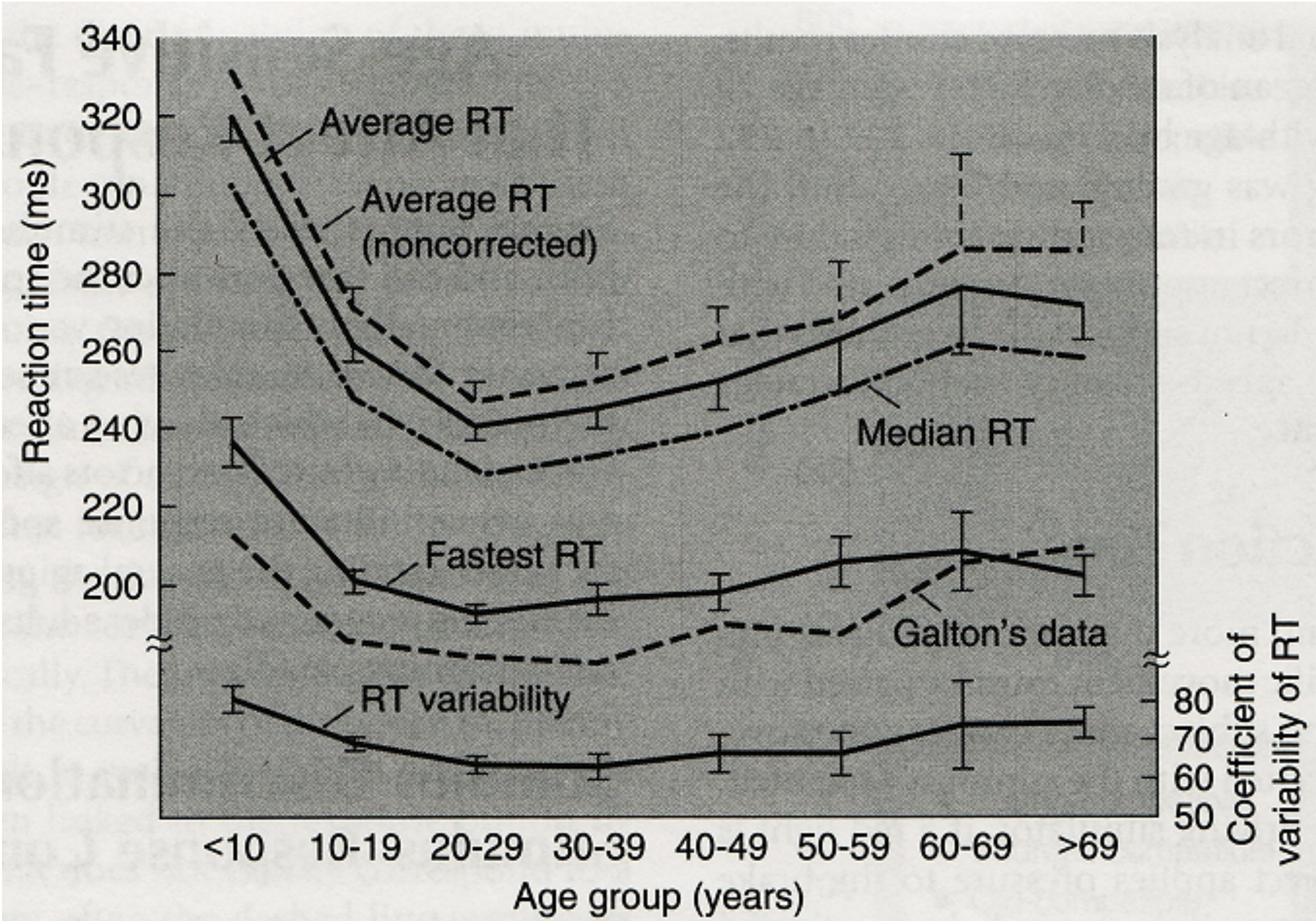
Behavioral Changes With Aging

- Weakness
- Slowness
- Higher variability
- Larger postural sway; delayed anticipatory postural adjustments

Movements and Aging

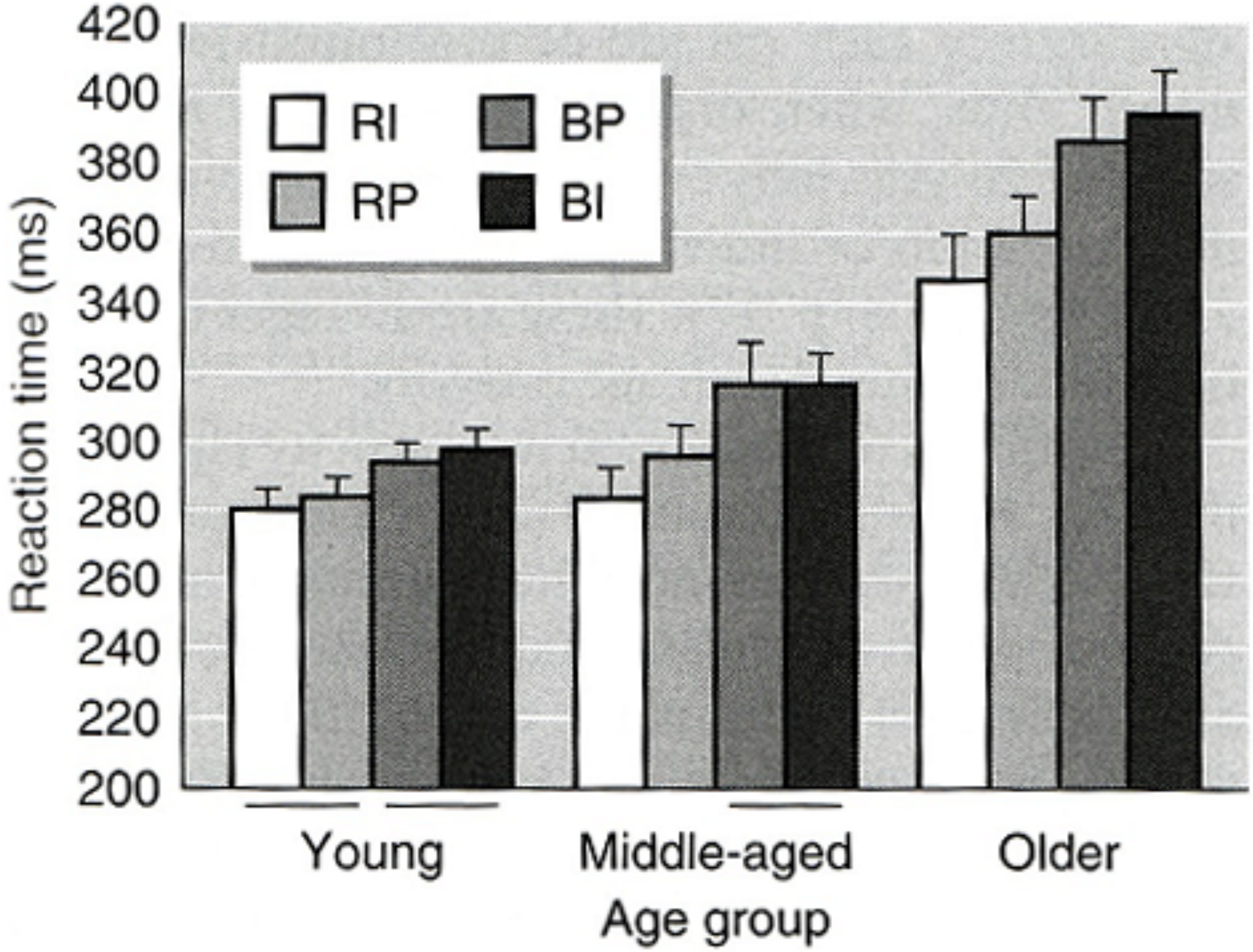
Central changes:

- Longer RT
- Slower movements
- Higher antagonist cocontraction
- Higher safety margins
- Changed synergies



340
320
300
280
260
240
220
200
Reaction time (ms)
Average RT
Average RT
(noncorrected)
Median RT
Fastest RT
Galton's data
RT variability
80
70
60
50
Coefficient of
variability of RT
<10
10-19
20-29
30-39
40-49
50-59
60-69
>69
Age group (years)

Response Complexity



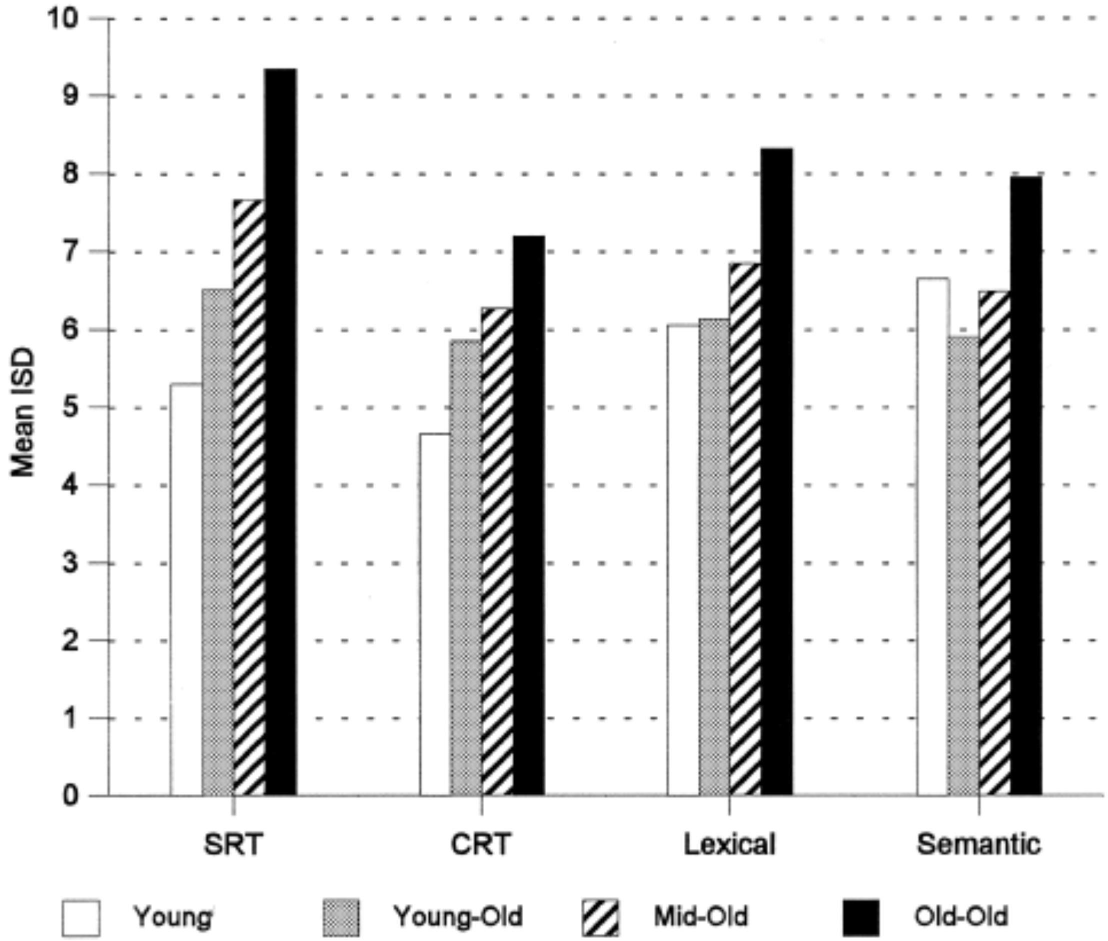


Figure 3. Mean latency intraindividual standard deviation (ISD) scores by age group for four reaction time tasks. SRT = simple reaction time; CRT = choice reaction time.

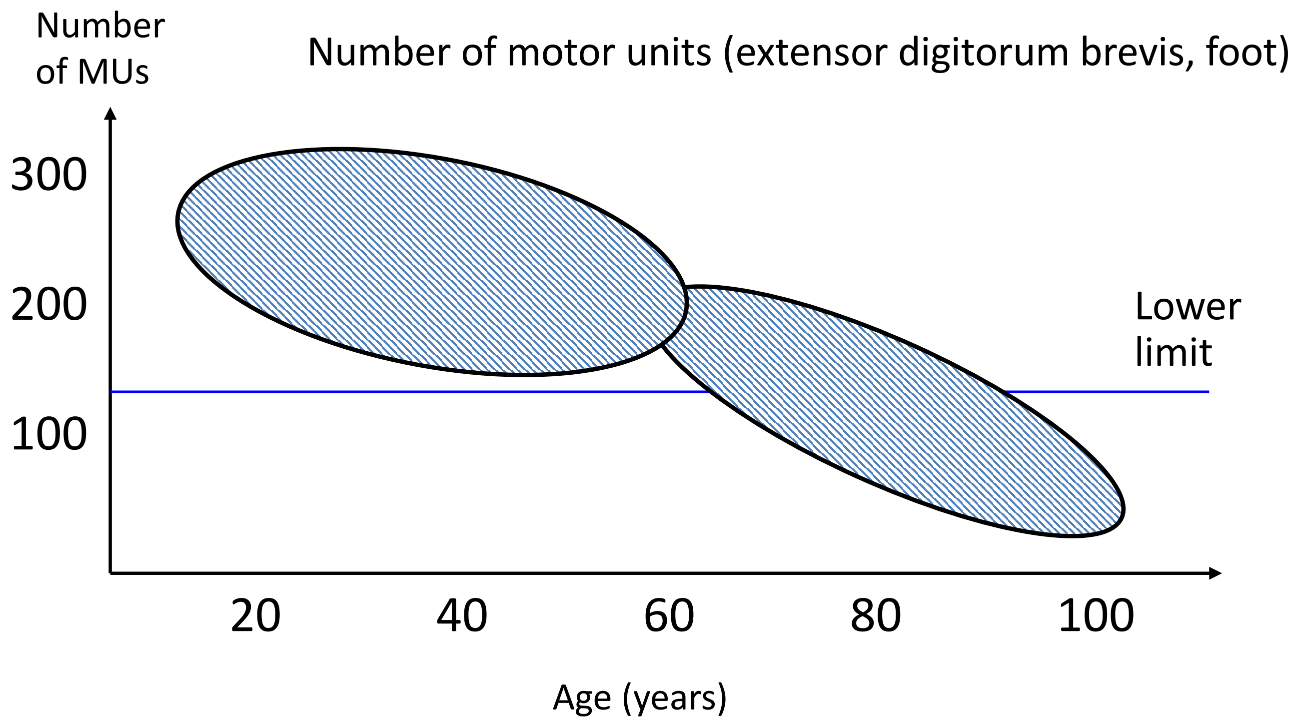
Changes in Motor Units With Age

- Decline in the number of alpha-motoneurons
- Muscle fiber denervation and atrophy
- Reinnervation by surviving motoneurons
- Higher innervation ratio
- Preferential degeneration of larger motoneurons
- Consequence: fewer motoneurons (on average, larger in size and slower)

Consequences of Changes in Motor Units With Age

- Smaller MUs are absent; poor control of low forces
- Poor smoothness of force production
- Inability to develop force quickly (larger twitch contraction time, from 100–150 ms to 125–200 ms)

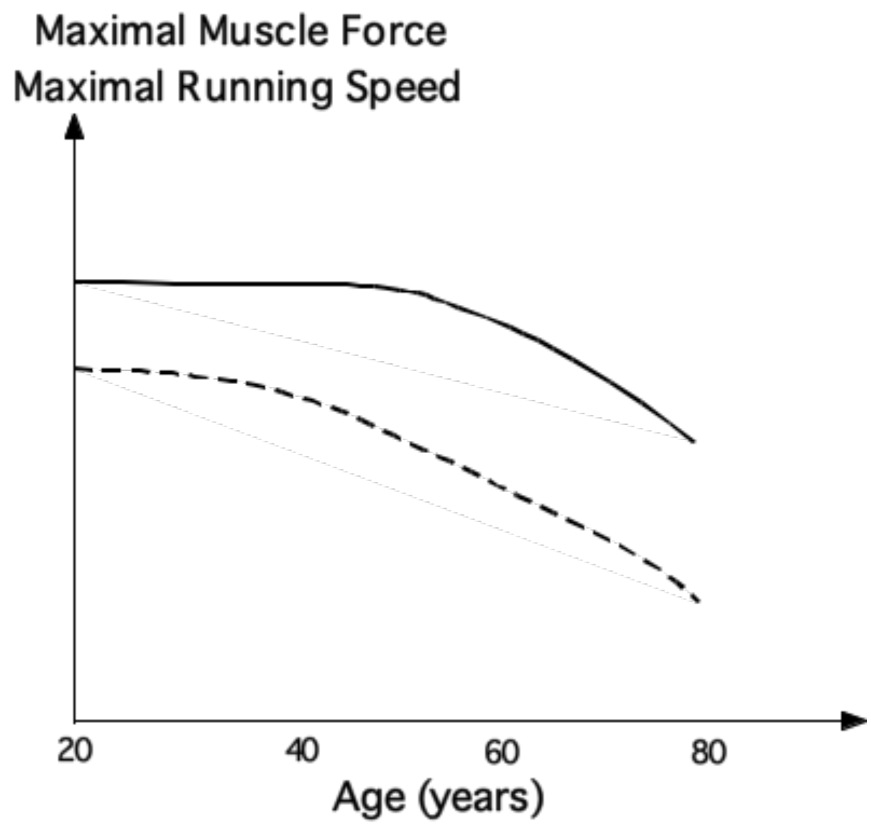
Changes in Motor Units With Age



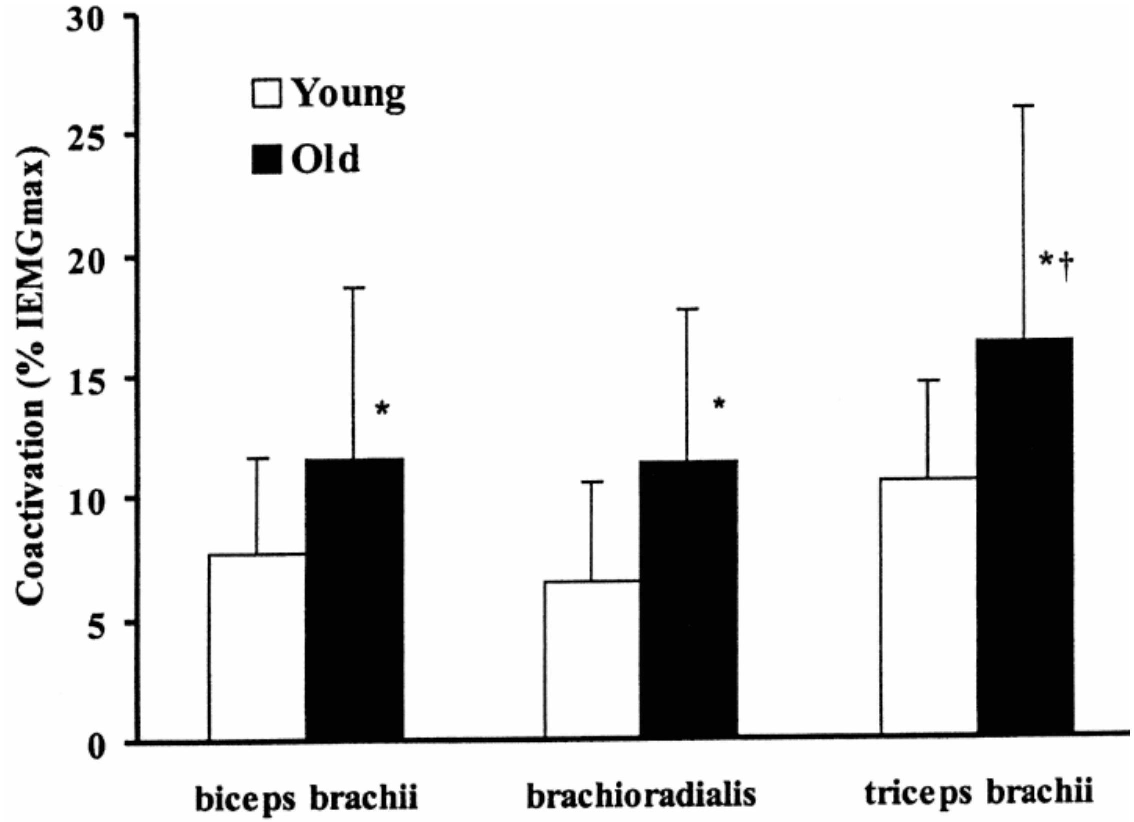
Changes in Strength With Age

- Muscle mass: reduced (partly replaced by fat/connective tissue)
- Cross-sectional area: reduced
- Normalized force (MVC/cross-sectional area): reduced
- Neural activation: depends on the muscle
- Coactivation of antagonist muscles: increased by 30%
- Not all muscle show similar force losses; typically, more distal muscles are more affected
- Consequences for multimuscle synergies

Aging: Parallel Changes in Force and Speed



Aging: Higher Muscle Coactivation



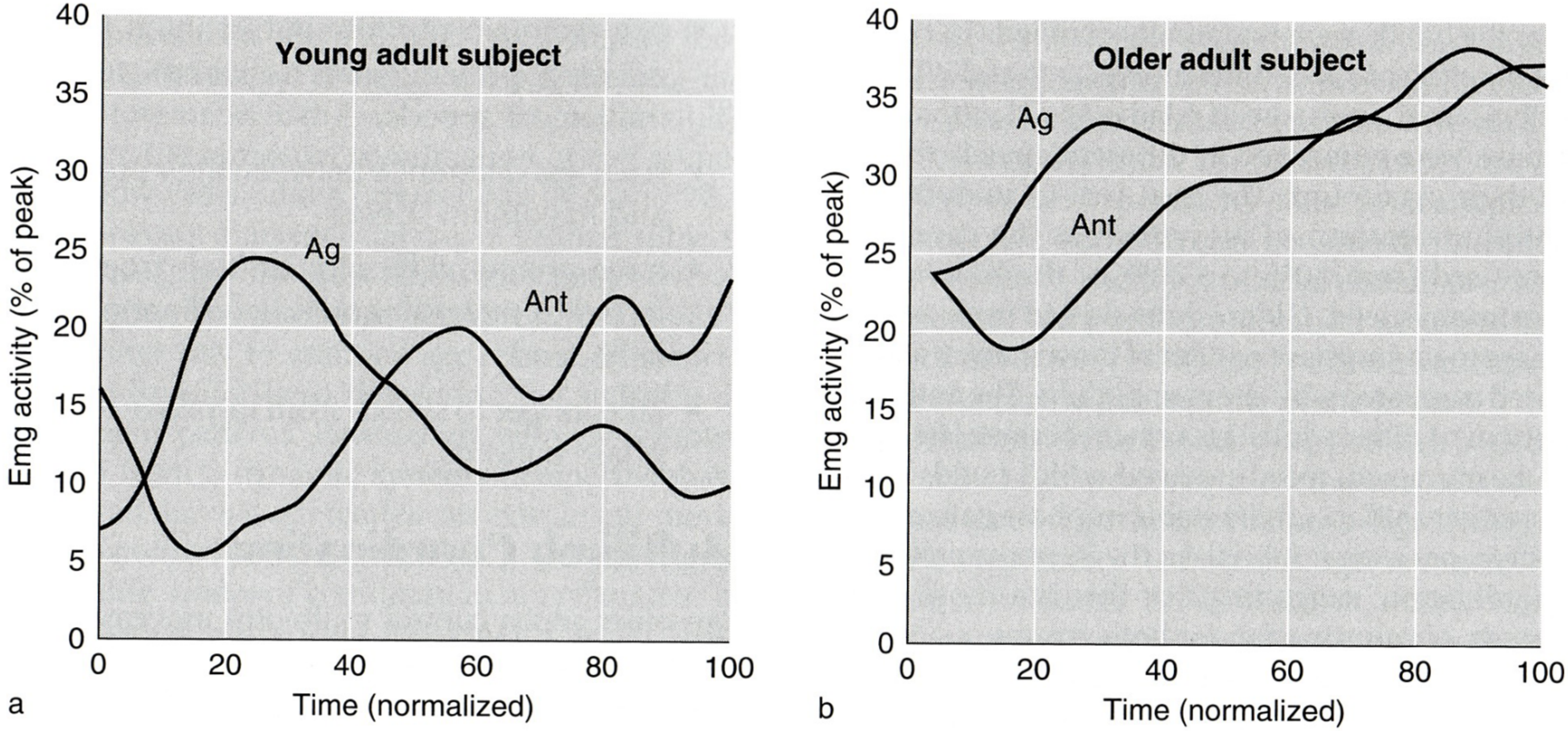
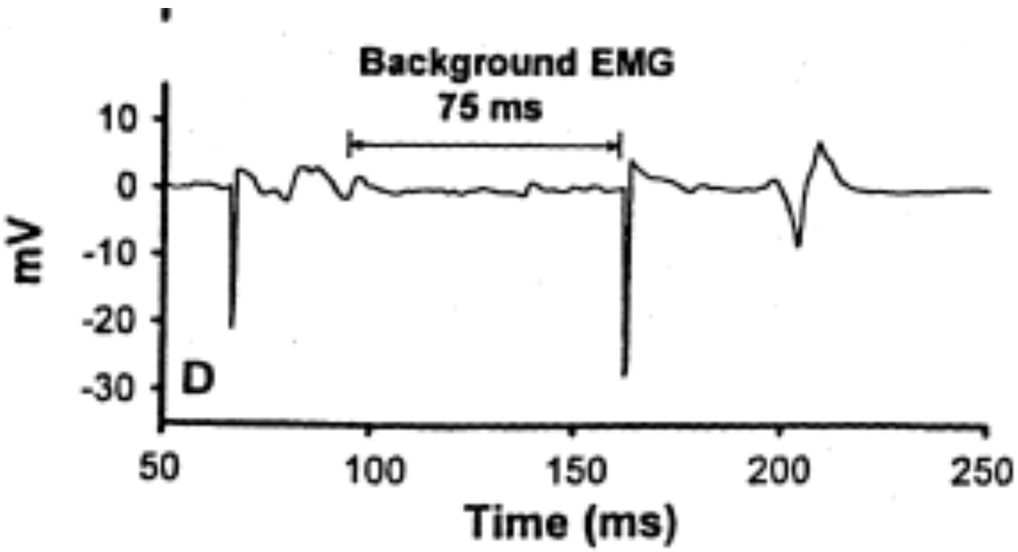


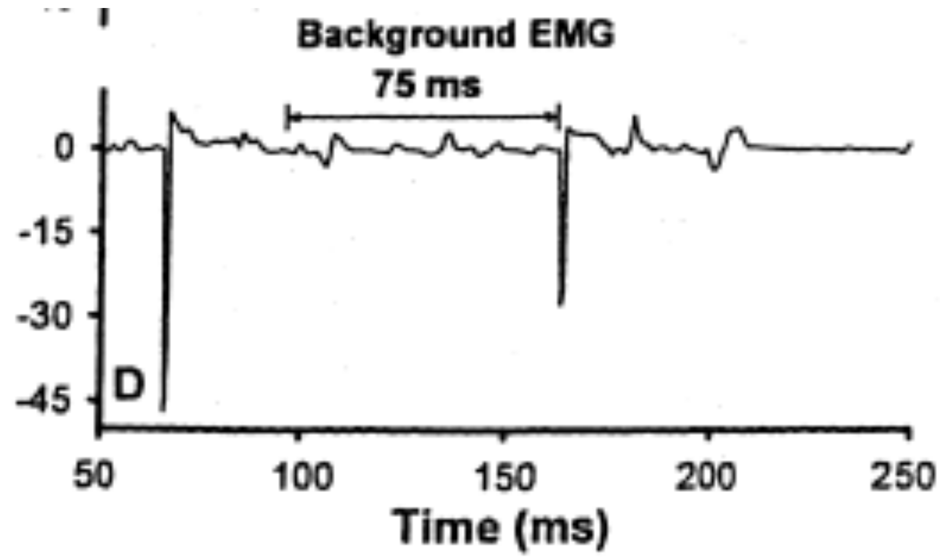
Figure 8.7 Electromyographic (EMG) activity expressed as a percentage of peak for a young and older subject. AG = agonist; ANT = antagonist. The older adult demonstrates a different activation pattern (greater coactivation) than the young.

Changes in Reflexes/Reactions With Age

- H-reflex amplitude: slightly reduced (may show a delay)
- Tendon tap reflex: slightly reduced (may show a delay)
- Polysynaptic reflexes: reduced
- Simple reaction time: increased



young

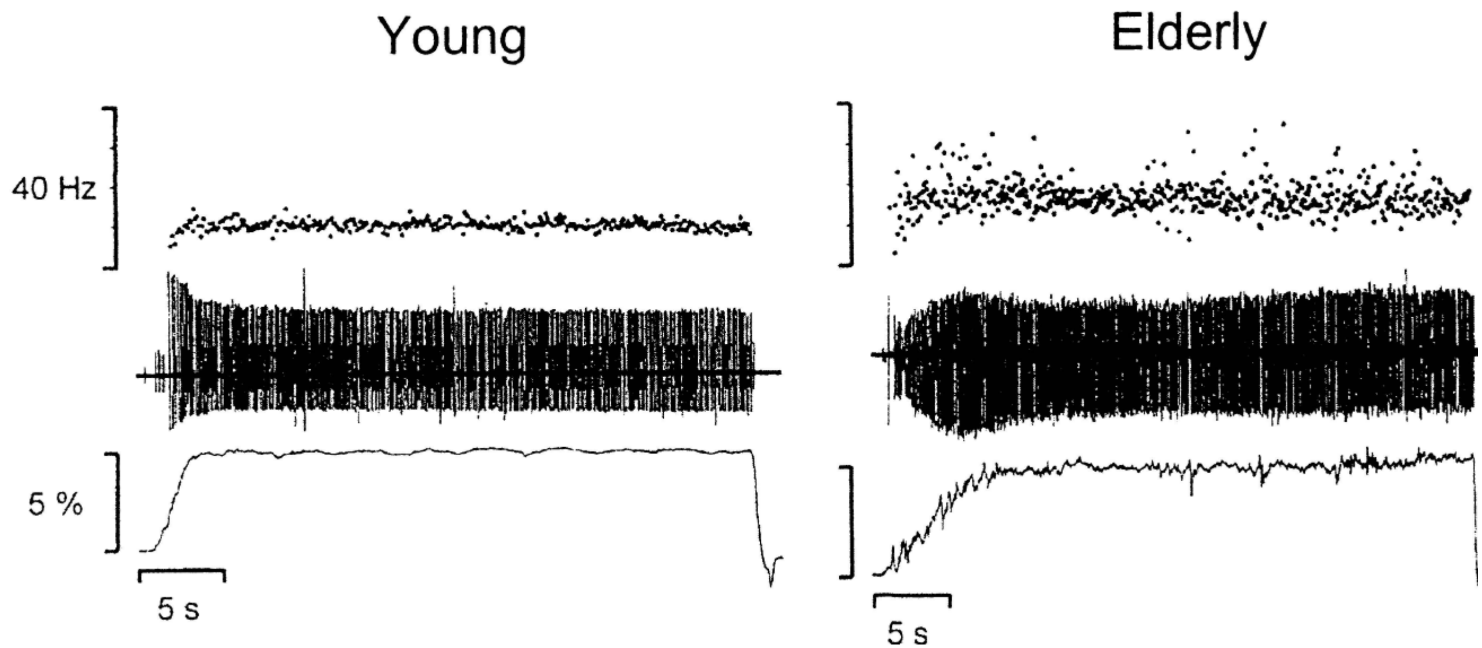


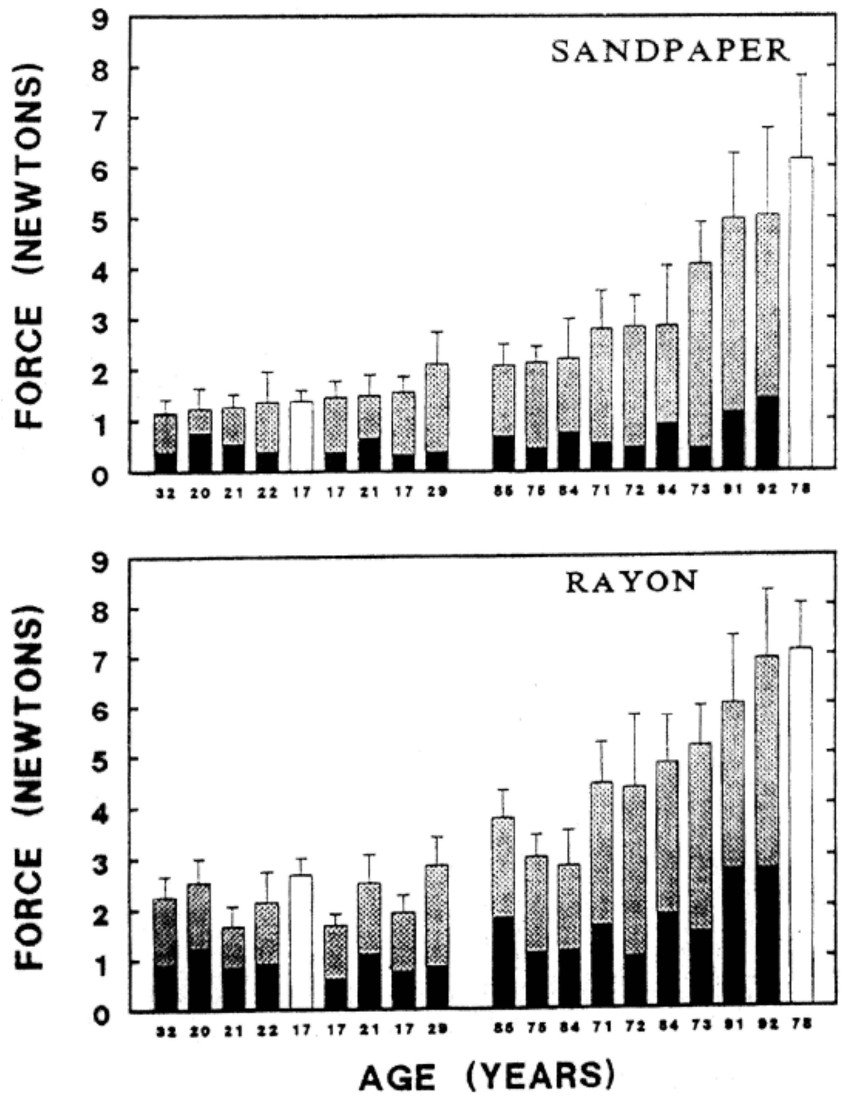
elderly

Accurate Force/Movement Production

- Higher variability; larger errors
- Large force fluctuations during F = const.
- Excessive forces
- Excessive grip; larger safety margin

Aging: Increased Variability in Force and MU Firing Rate

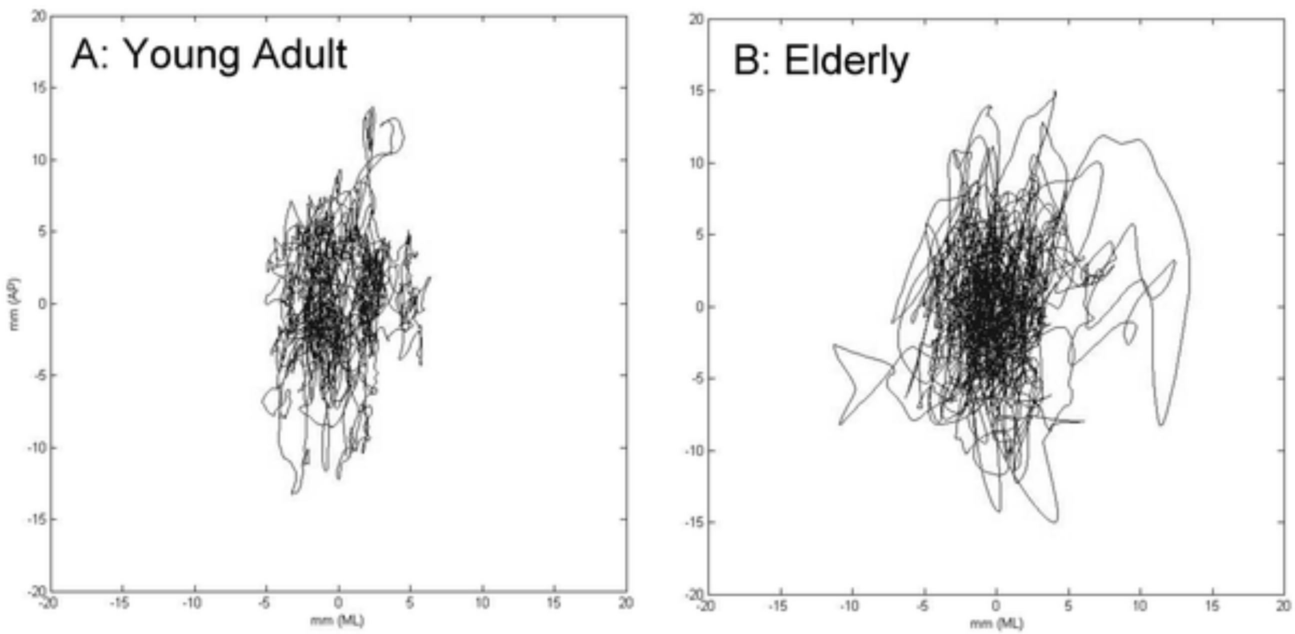




Aging: Larger Safety Margin

Changes in Posture/Gait With Age

- Postural sway: increased
- Anticipatory postural adjustments delayed
- Preprogrammed reactions: decreased and delayed; switch from ankle to hip strategy
- Greater coactivation of antagonist muscles
- Higher variability (stride to stride)

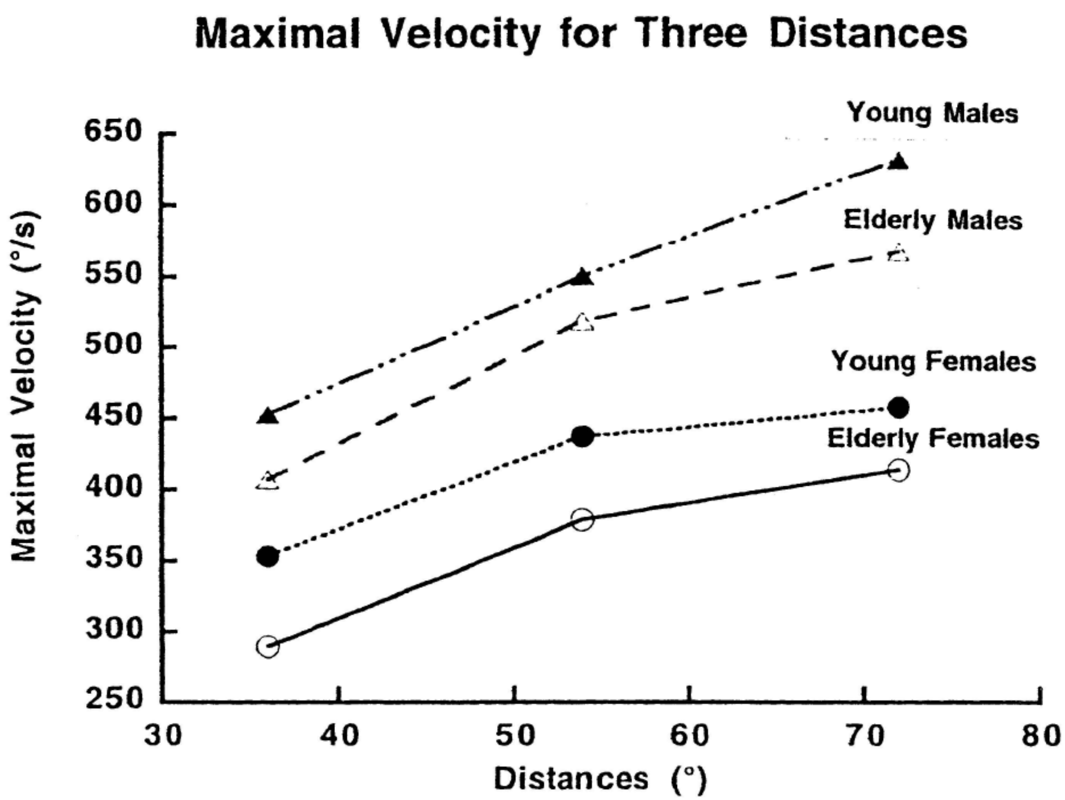


A: Young Adult
B: Elderly
mm (AP)
mm (ML)

Changes in Fast Movement Production

- Slowness in initiation and execution
- Longer deceleration
- Higher reliance on visual feedback
- Higher muscle cocontraction

Aging: Slower Single-Joint Movements



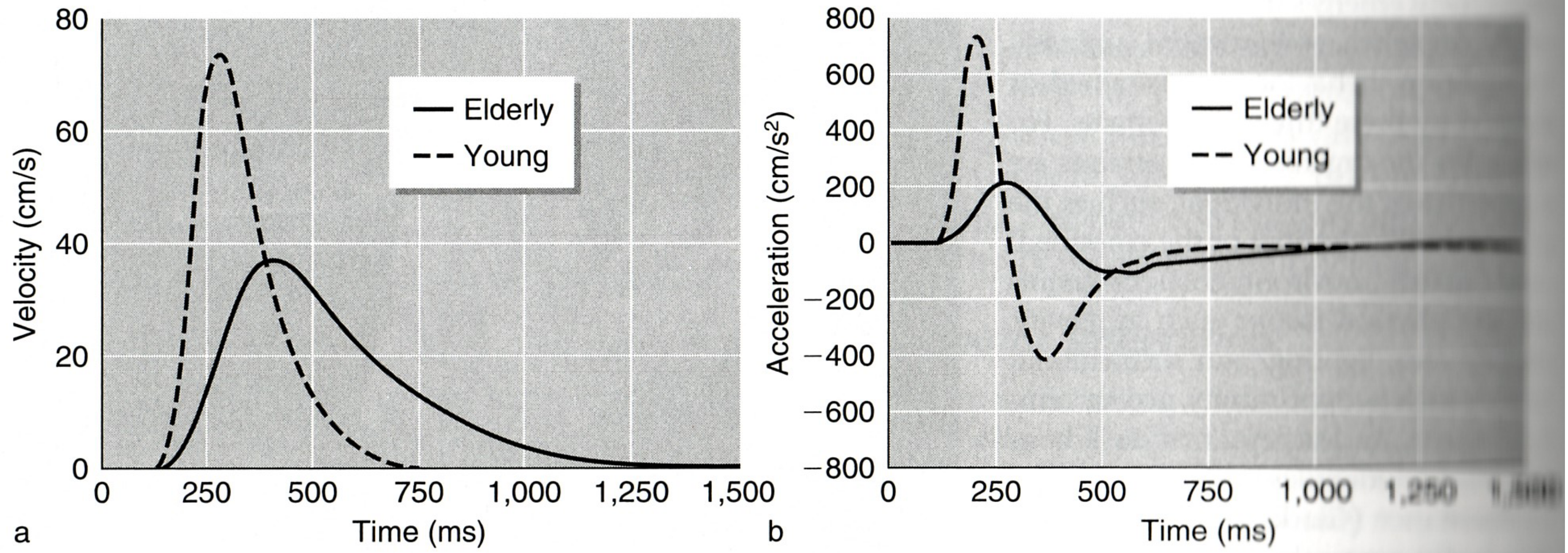
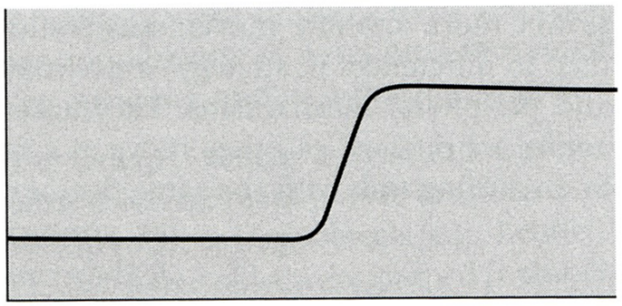
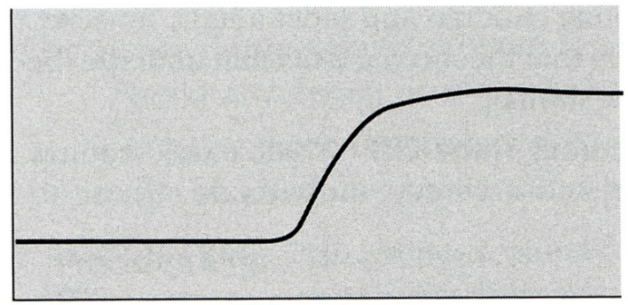


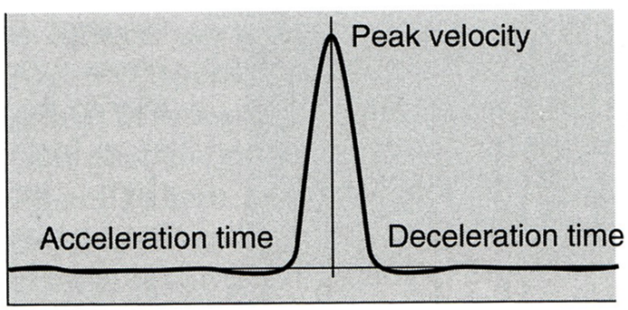
Figure 8.1 *(a)* Velocity and *(b)* acceleration profiles of young and older adults.



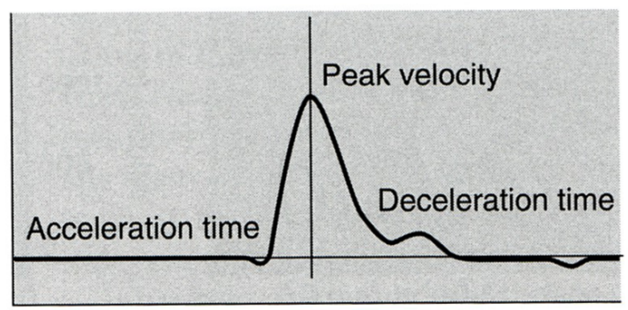
Young adult positional profile



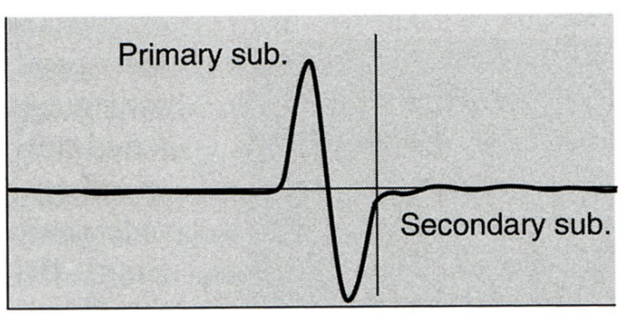
Older adult positional profile



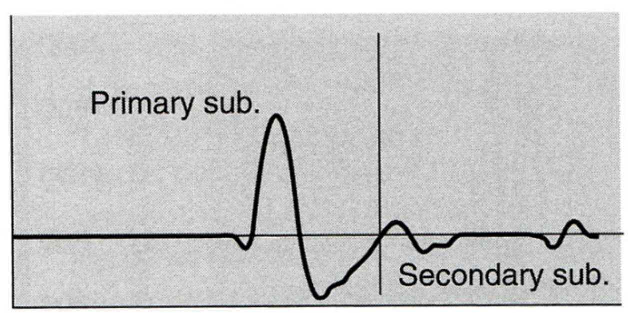
Young adult velocity profile



Older adult velocity profile



Young adult acceleration profile



Older adult acceleration profile

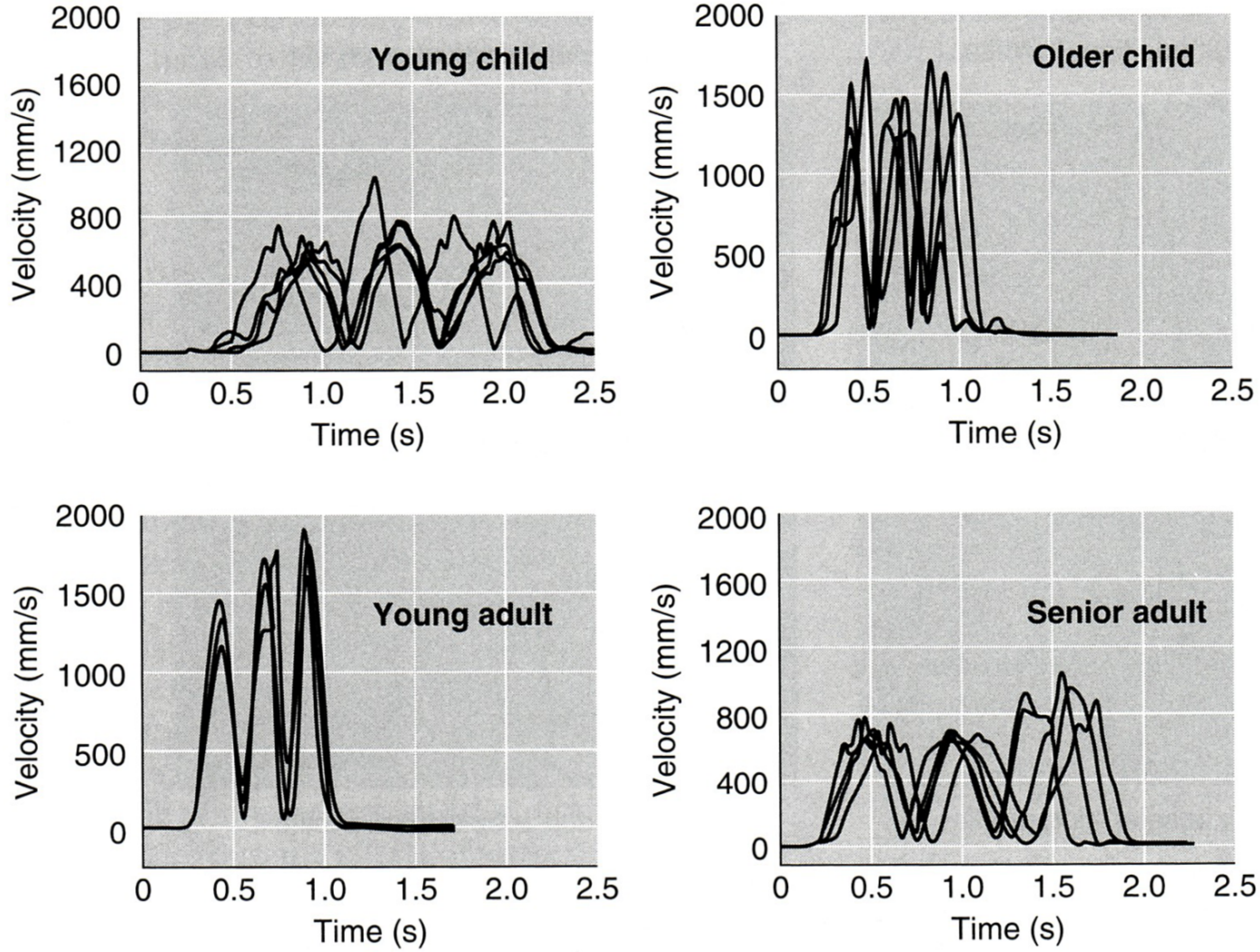
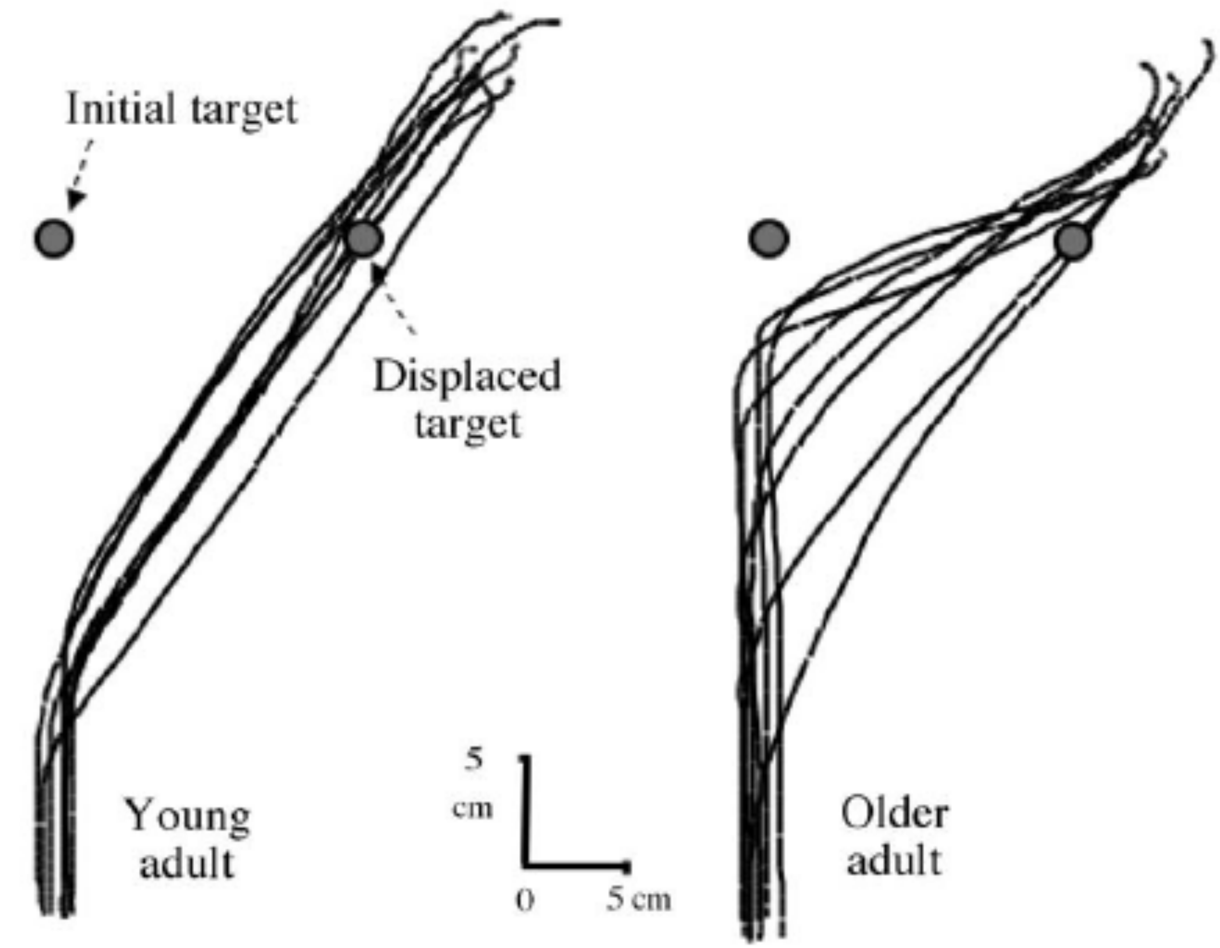


Figure 8.4 Movement velocity profiles for a young child (6 years), older child (9 years), young adult (24 years), and older adult (74 years).


Initial target
Displaced target
Young adult
5 cm
0
5 cm
Older adult
(B)

Changes in Hand Function

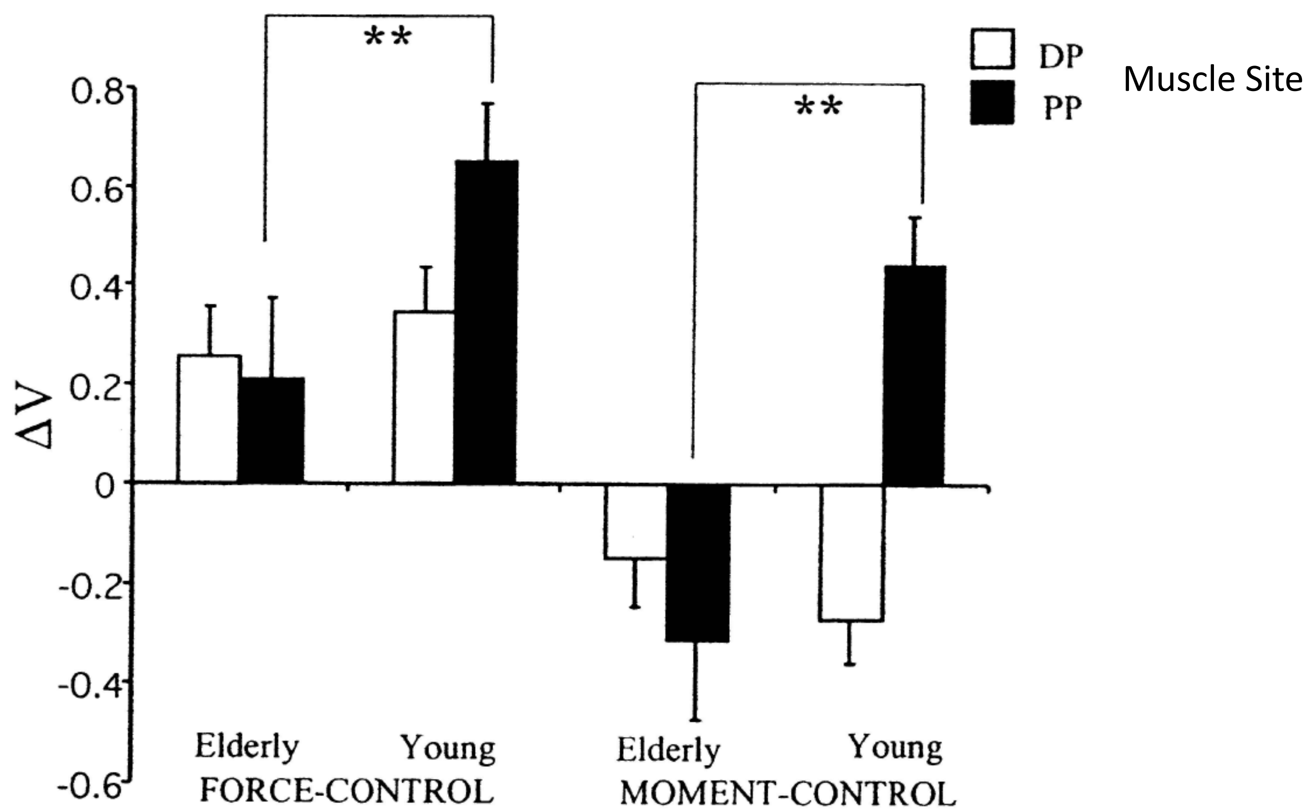
Motor:

- Loss of force
- Poor multidigit synergies in force and moment of force production

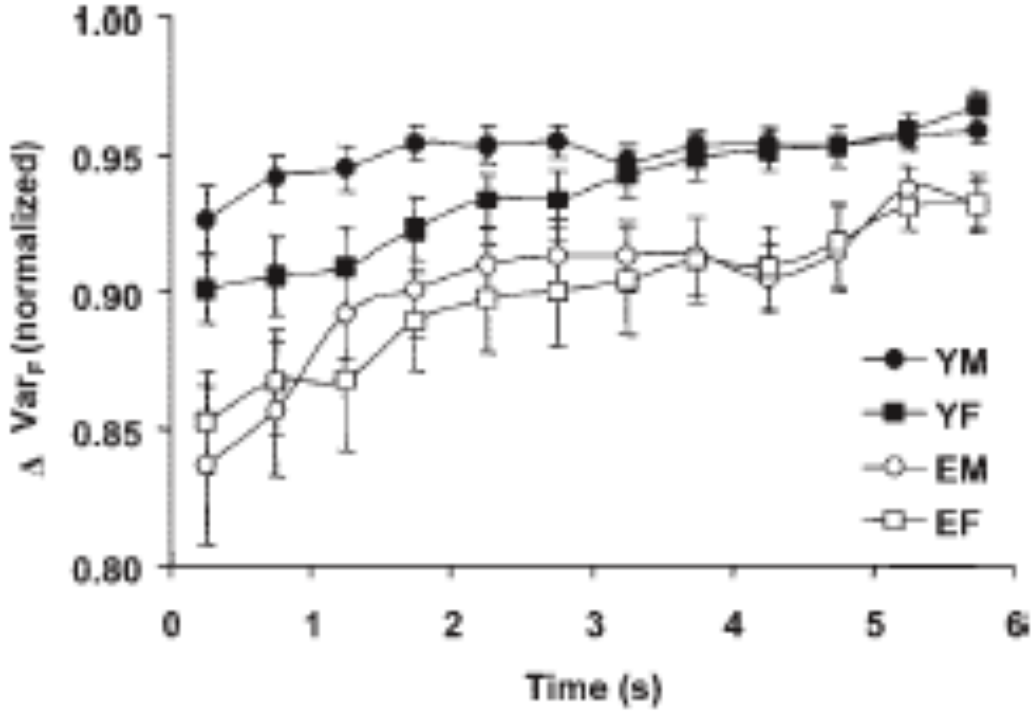
Sensory:

- A decline in the number of receptors
- Poor touch discrimination

Aging: Changes Multi-Finger Synergies (Pressing)



Aging: Changes Multi-Finger Synergies (Grasping)



General Problems

Impairments in Posture and Gait

Posture and postural reflexes:

- flexed in neck and trunk, extended in knees and elbows
- spontaneous and induced sway are exaggerated
- recovery after perturbation is impaired
- postural reflexes are impaired in 70% of elderly over 80 years of age

Gait abnormality, gait apraxia:

- short, slow strides; wide base
- 15% of those over 60 have gait problems, reduced arm swing, stiff turns, tendency to fall

Common Subclinical Movement Signs

- Bradykinesia (slowness of movement)
- Tone changes (absent in normal aging; paratonia, or a progressive resistance to passive movement)
- Cogwheeling phenomenon (rhythmic interruption of attempted passive movement)
- Hyperkineses (tremor, in over 25%)
- Ophthalmoplegia, particularly limitation of vertical gaze

Disorders Prevalent in the Elderly

- Parkinson’s disease
- Drug-induced parkinsonism (neuroleptics)
- Tremor
- Stroke
- Dyskinesia (involuntary movement)

Osteoarthritis

- Leading cause of disability in US

- Damage to articular cartilage causes tissue break down
- Gliding surface of joint becomes rough
- Articular surface continues to wear out and can disappear altogether

- Can be caused by immobilization (as the synovial fluid does not circulate)

Osteoarthritis

- Occurs primarily in women over 40, men over 50
- Risk can be increased by repeated strenuous activity
- Risk factors also include
  - Muscle weakness
  - Reduced joint proprioception

Osteoarthritis

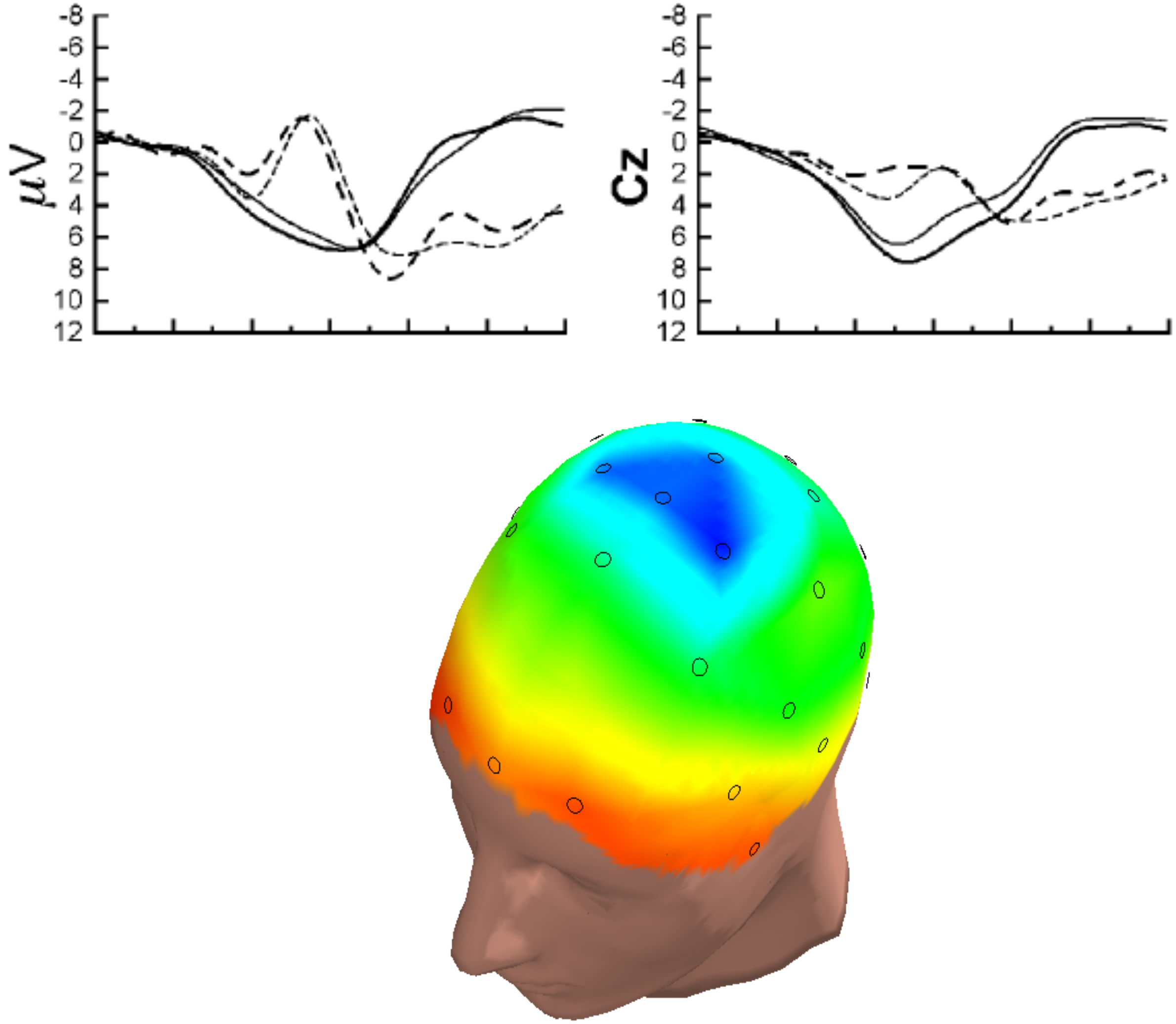
- Exercise is beneficial although it does not offset OA

- Can decrease pain and improve function and well being

It’s Not All Bad

Motor Learning

1. You can learn novel motor skills – differences in force, smoothness, speed
2. Learn at a slower rate (?)
3. Depend more on feedback
4. Learn better when they have a cogntive strategy


-8
-6
-4
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0
2
4
6
8
10
12
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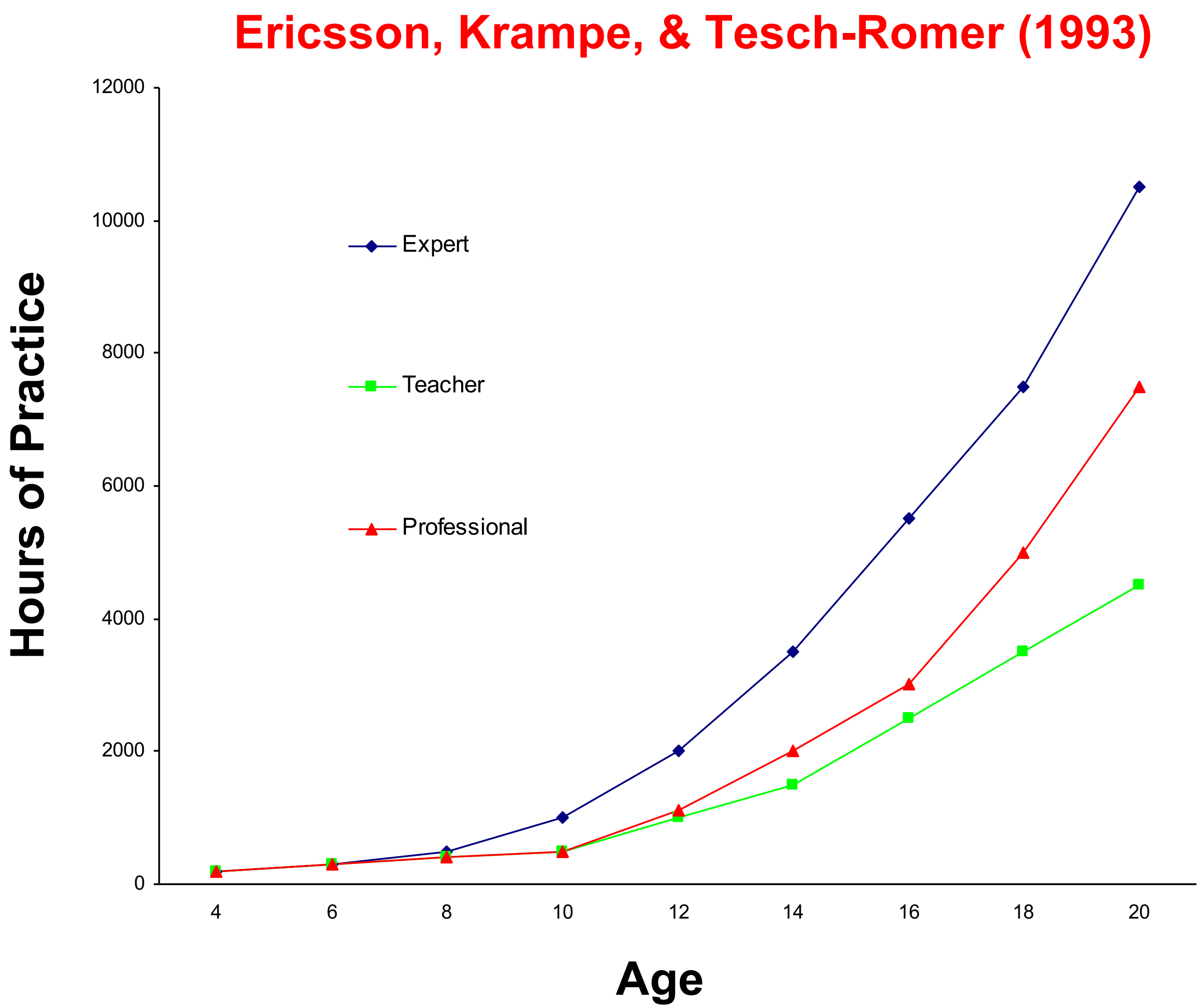
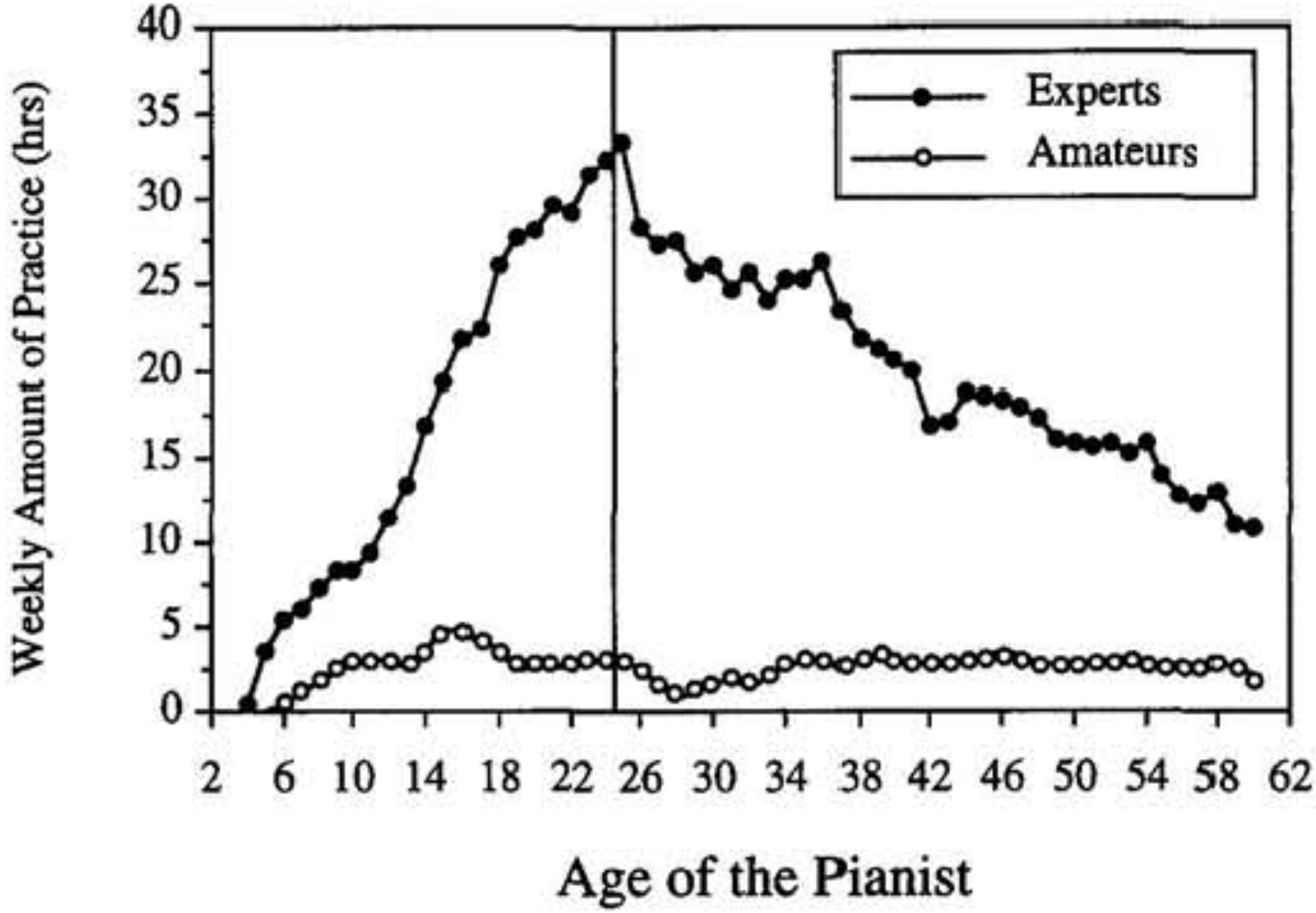
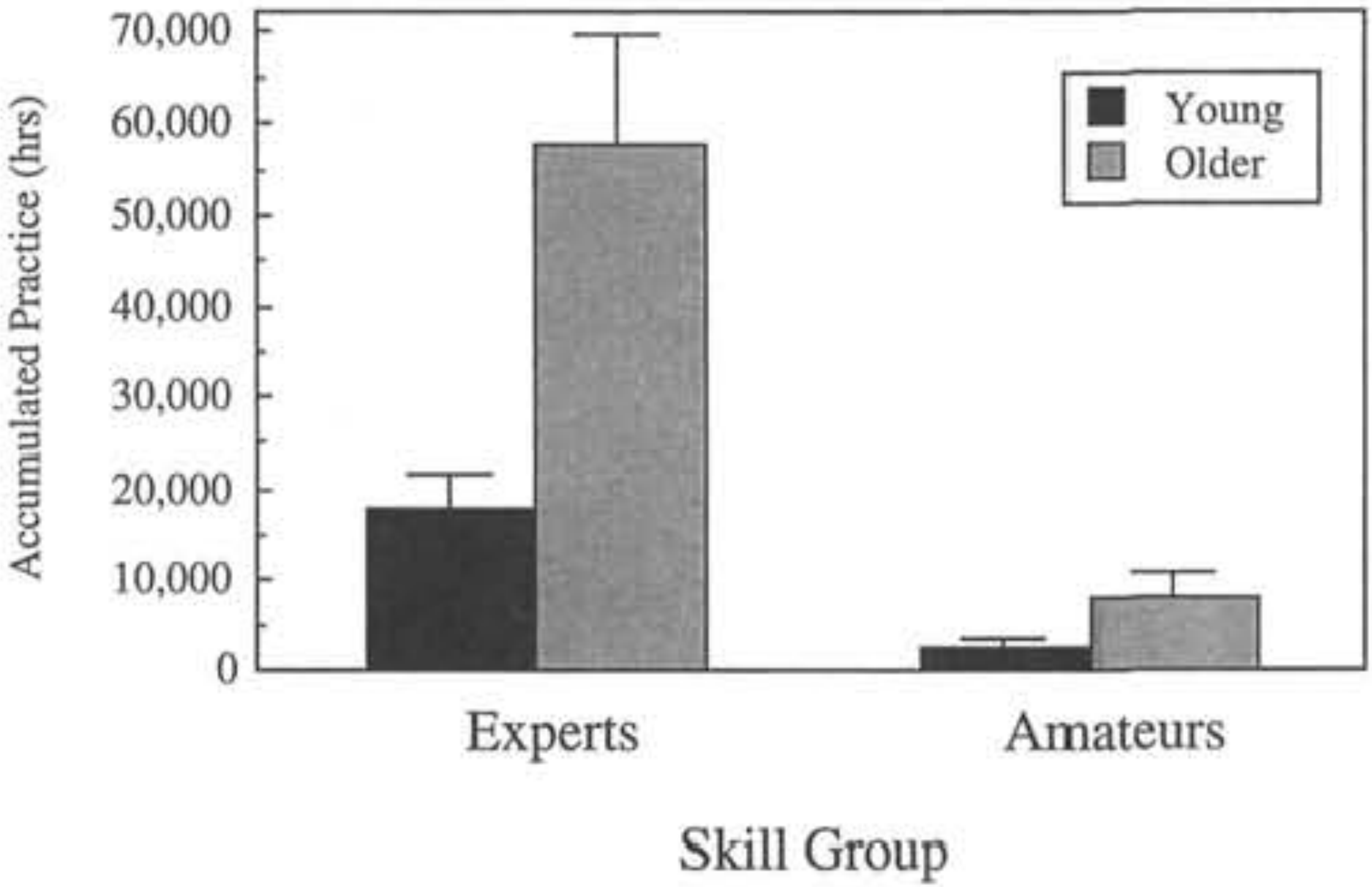
Cz

Aging and Expertise

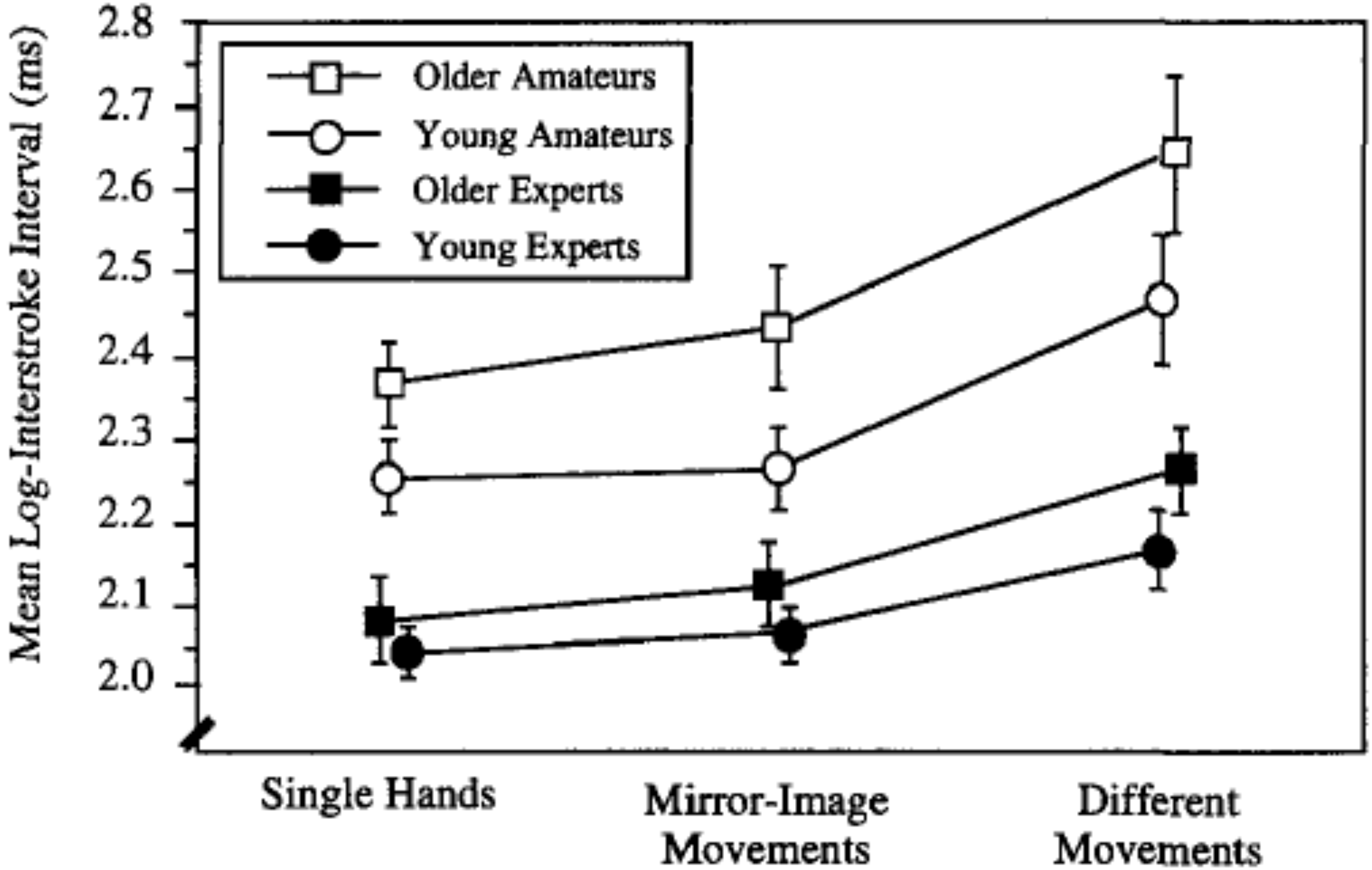

Ericsson, Krampe, & Tesch-Romer (1993)
Hours of Practice
12000
10000
8000
6000
4000
2000
0
Expert
Teacher
Professional
4
6
8
10
12
14
16
18
20
Age



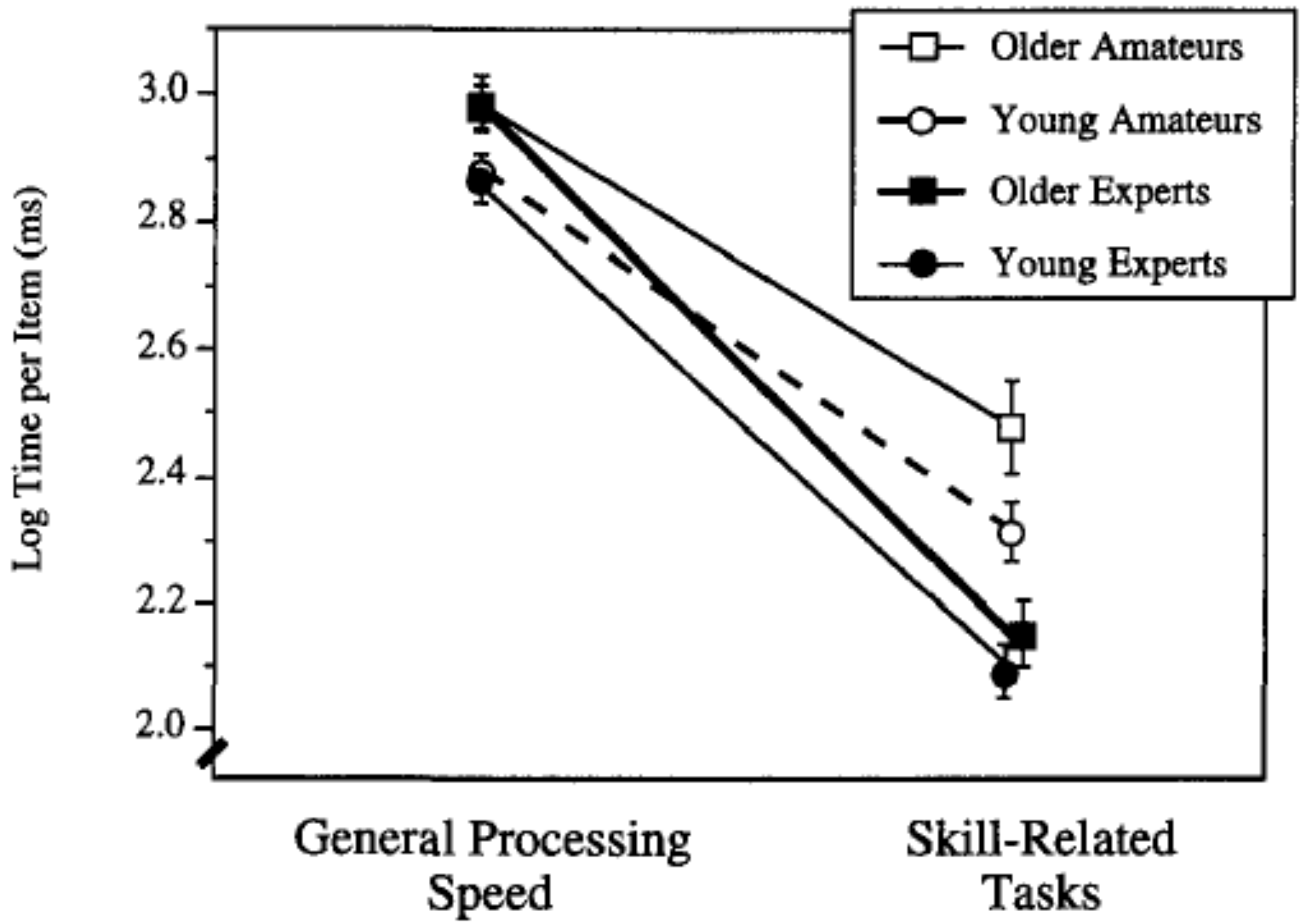
Weekly Amount of Practice (hrs)
40
35
30
25
20
15
10
5
0
Experts
Amateurs
2 6 10 14 18 22 26 30 34 38 42 46 50 54 58 62
Age of the Pianist



Accumulated Practice (hrs)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Young
Older
Experts
Amateurs
Skill Group



Mean Log-Interstroke Interval (ms)
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
Older Amateurs
Young Amateurs
Older Experts
Young Experts
Single Hands
Mirror-Image Movements
Different Movements


Older Amateurs
Young Amateurs
Older Experts
Young Experts
Log Time per Item (ms)
3.0
2.8
2.6
2.4
2.2
2.0
General Processing Speed
Skill-Related Tasks

Effects of Training

- Higher forces
- Lower antagonist cocontraction
- Changes in cross-sectional area
- Increased aerobic fitness (brain function)
- Increased strength (brain function)