

APA 2120

Review: Motor Control

Motor Performance Measurement

Scientific Method

- Terminology
 - *Independent Variable* – researcher manipulates (has control over)
 - *Dependent Variable* – affected by independent variable (no control over)
 - *Hypothesis* – statement proposing tentative relationship between dependent & independent variables

How Do We Measure Motor Behaviour/Performance?

- Performance Outcome Measures
 - How well movement achieved environmental goal
 - i.e. trying to hit target
- Performance Process Measures
 - Measures something of the movement that led to the outcome
 - Describe characteristics of the movement

Statistical Terms

- When determining outcome measures, we typically measure multiple times and are interested in two aspects of the measurement:

1. Central Tendency

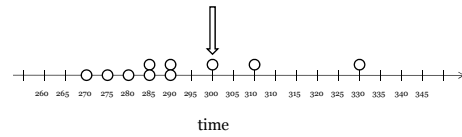
- ⌘ measure of the location of the middle or center of a distribution (i.e. "typical" score) A.K.A. "Average"

2. Variability

- ⌘ Measure of how homogeneous scores are (i.e. consistency)

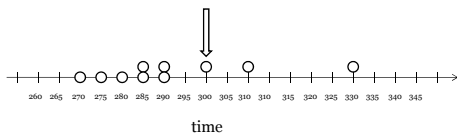
Performance Accuracy & Bias - Constant Error (CE)

- Measure of how far away from the target and in which direction (signed deviation)
 - Measures accuracy and **bias** (amount & direction)
 - CE = trial score - criterion goal



Performance Accuracy - Absolute Error (AE)

- Measure of how far away you were from the goal
 - Absolute value of error score (no sign)
 - AE = | trial score - criterion goal |
 - Represents overall accuracy of subject

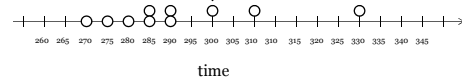


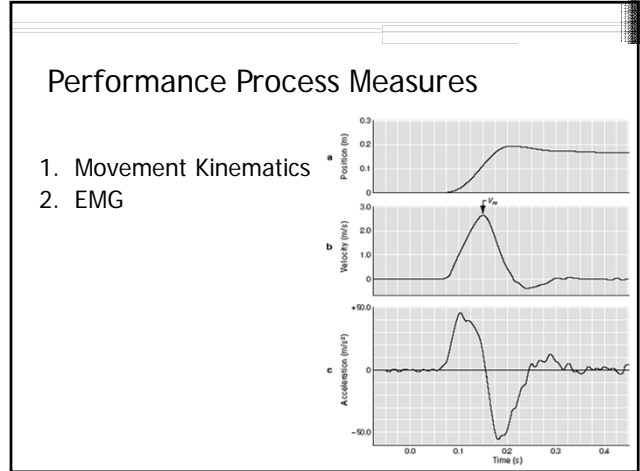
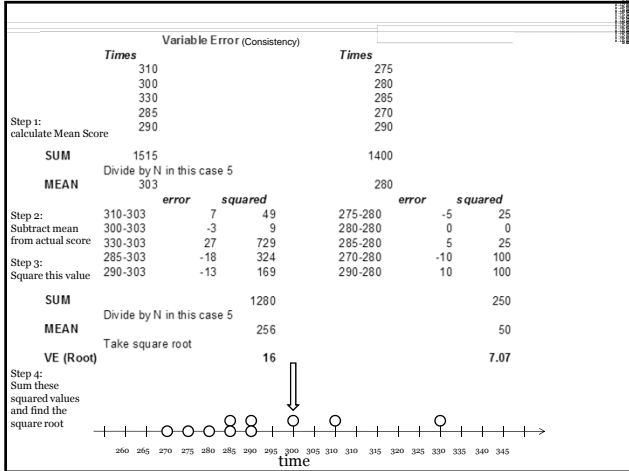
Criterion Time of 300ms

Group A	Group B
310	275
300	280
330	285
285	270
290	290

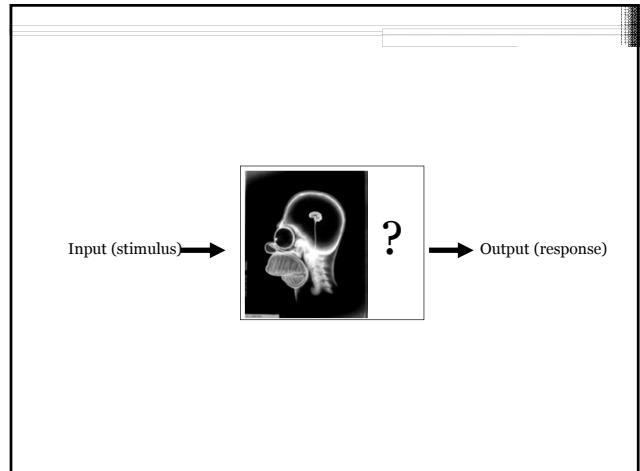
Constant Error (performance bias)	
310 - 300 =	10
300 - 300 =	0
330 - 300 =	30
285 - 300 =	-15
290 - 300 =	-10
SUM	15
Divide by N in this case 5	3
CE	-20

Absolute Error (General indicator of average error)	
310 - 300 =	10
300 - 300 =	0
330 - 300 =	30
285 - 300 =	15
290 - 300 =	10
SUM	65
Divide by N in this case 5	13
AE	20



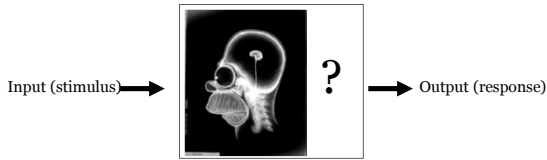


Information Processing

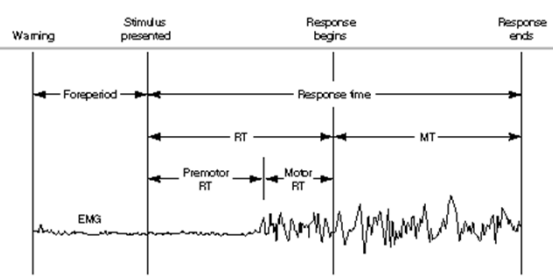
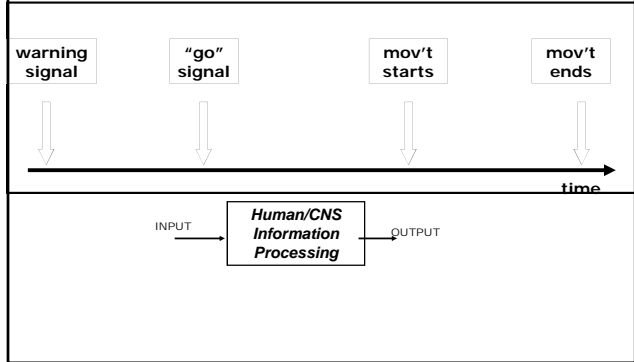


The BIG question

- How do we figure out what is going on inside the black box????

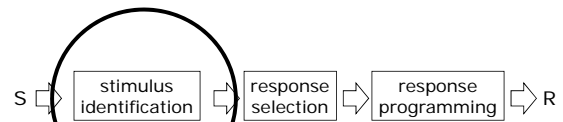


Time Course for Reactions



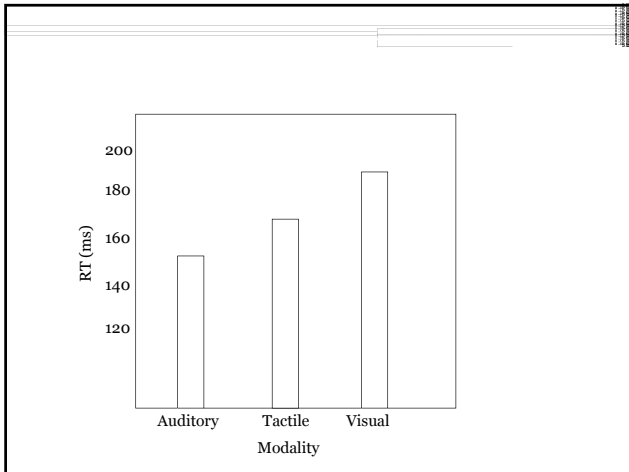
From Motor Control and Learning: A Behavioral Emphasis, Fourth Edition by Richard A. Schmidt and Timothy D. Lee, 2005, Champaign, IL: Human Kinetics.

Factors Affecting Stimulus Identification



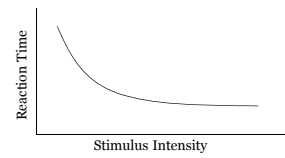
Factors related to stimulus identification

- performer alertness – foreperiod
- Stimulus modality
- Stimulus intensity

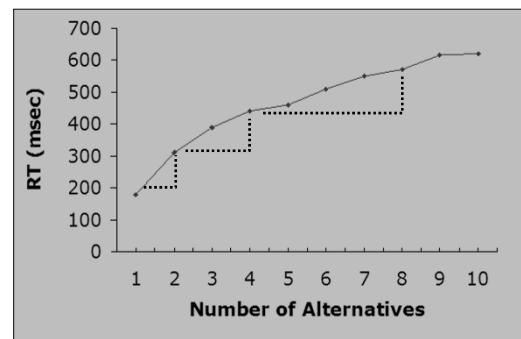
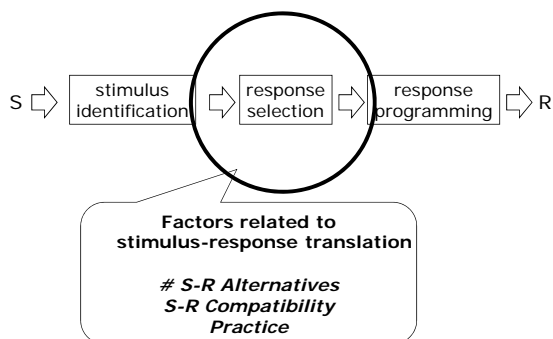


Stimulus intensity effect

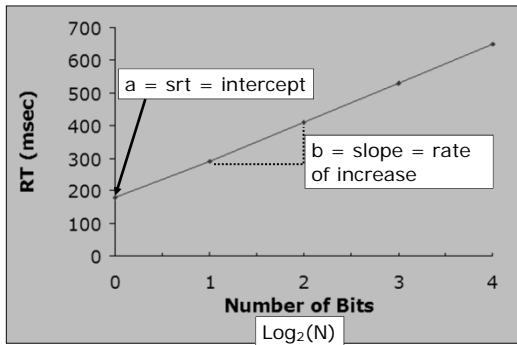
- as stimulus intensity increases, RT decreases
 - Piéron (1920) and Luce (1986).
- Seen across different modalities (e.g. Auditory, Visual, etc.)



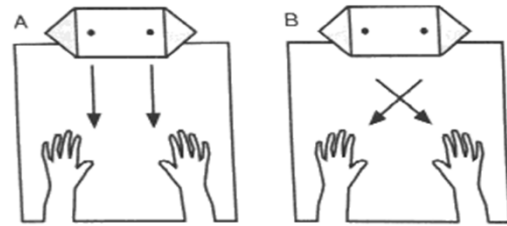
Factors Affecting Response Selection



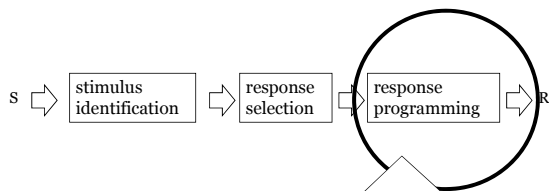
Hick's Law: $RT = a + b * \text{Log}_2(N)$



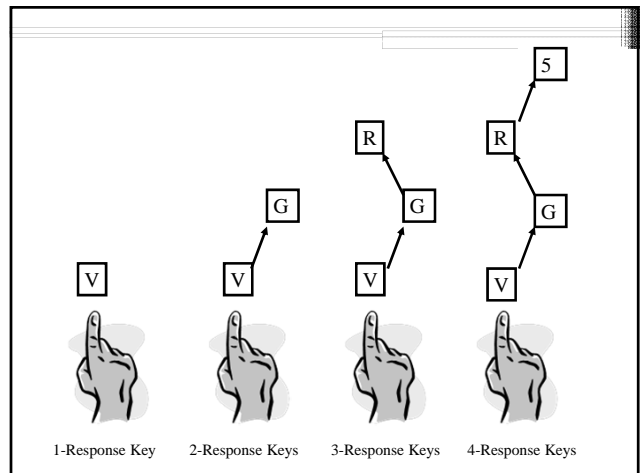
S-R Compatibility: Spatial mapping

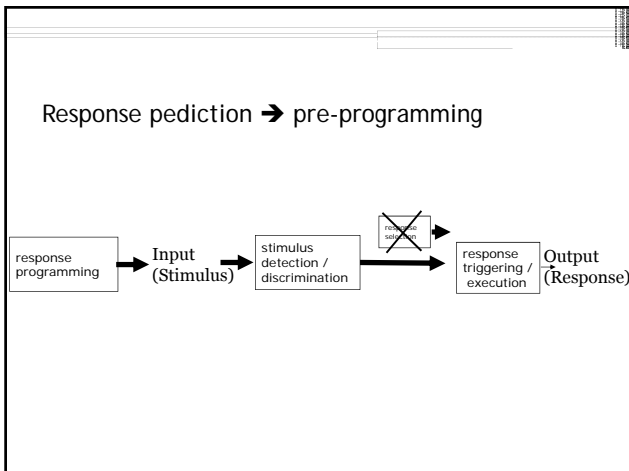
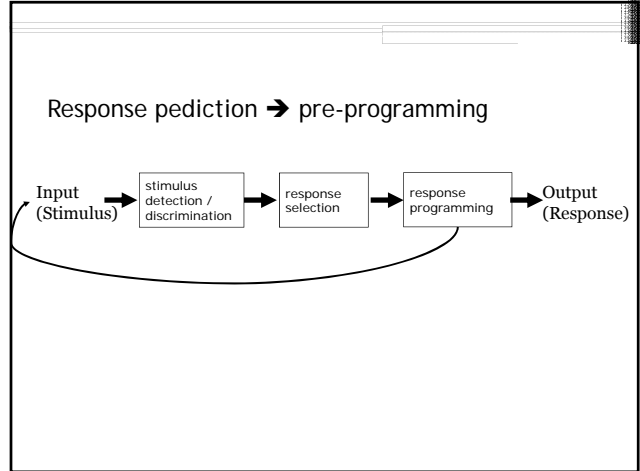
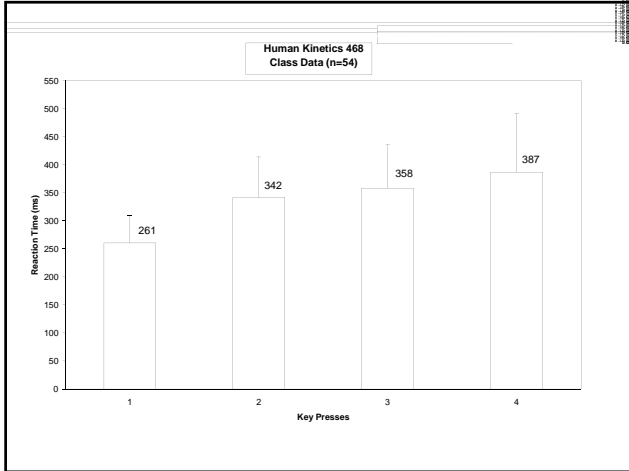


Factors Affecting Response Programming



Factors related to programming the response:
Complexity
Predictability / Anticipation





Nervous System & Sensory Feedback

Where does the Information Processing occur?

CNS

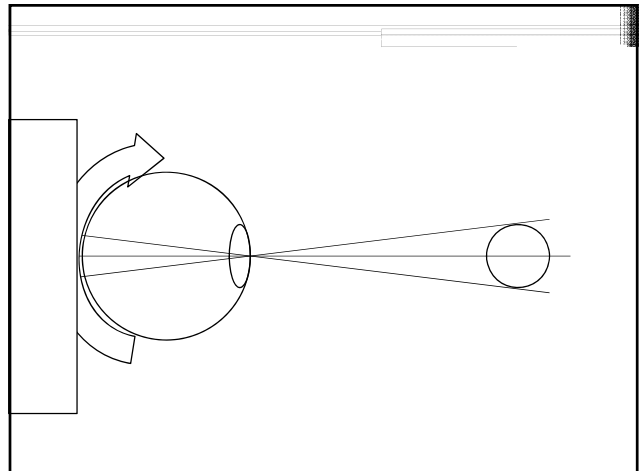
- Major components
 - Where they are
 - What they do
- CNS
 - Brain – 4 lobes
 - Subcortical structures
 - Spinal cord
- PNS
 - Afferent & Efferent nerves

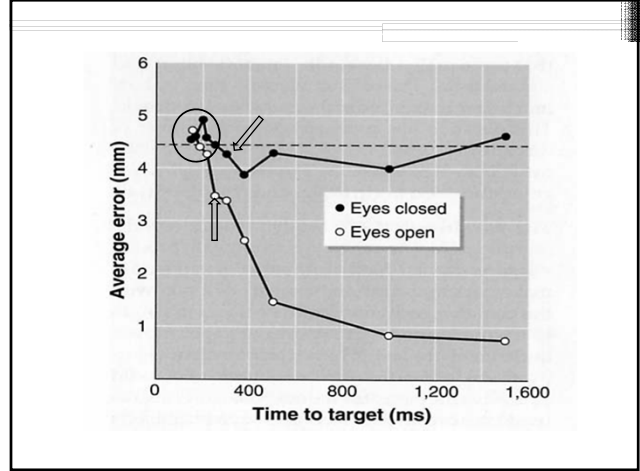
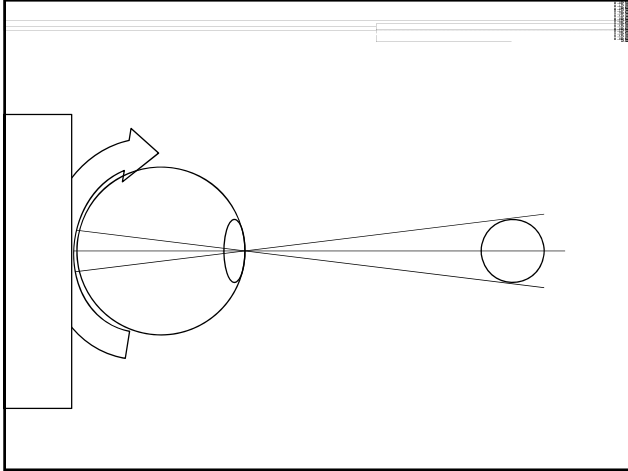
Visual Feedback

1. What is Vision?
2. Processing Dynamic Visual Information
3. Time to Process Visual Feedback
4. How Vision provides information
 - Two Visual Systems

Processing Visual Information

- Time to Contact (T_c) or Tau (τ)





Results

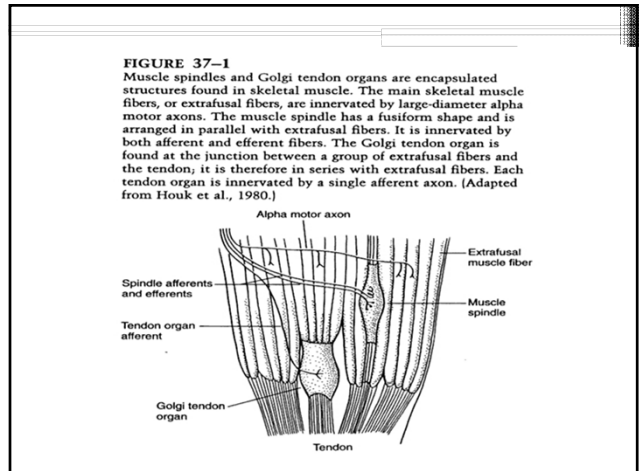
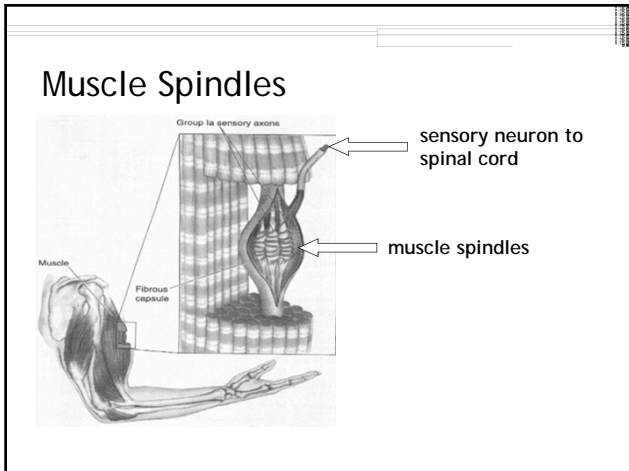
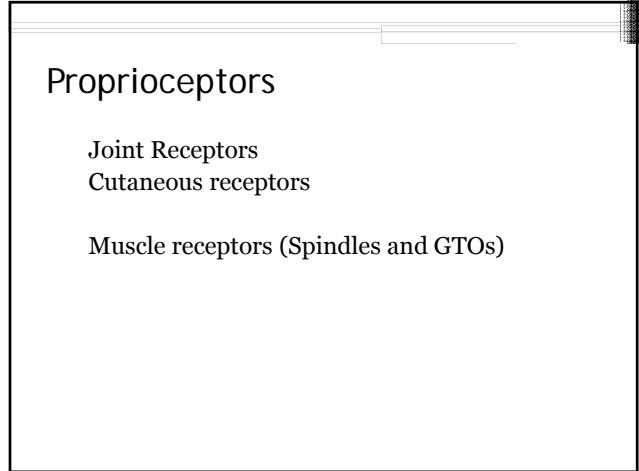
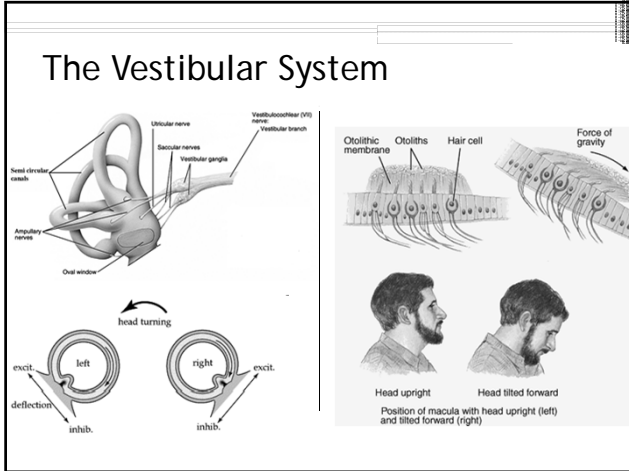
- Time to Process Visual Information = **215 TO 250 ms**
- AIMING MOVEMENT COMPRISED OF 2-STAGES
 1. Initial-impulse phase
 2. Current-control phase

Two Cortical Visual Systems

A lateral view of a human brain with two dashed arrows indicating visual pathways. One arrow points from the back of the brain towards the front, labeled 'Dorsal route'. The other arrow points from the back of the brain towards the bottom of the brain, labeled 'Ventral route'.

Dorsal route
 Milner and Goodale: "Where?"
ACTION
 Possibly immune to the effects of visual illusions
 - It is thought to 'ignore' context, and process only the action target

Ventral route
 Milner and Goodale: "What?"
PERCEPTION
 Thought to be responsible for many illusion effects
 - Processes the target and its context



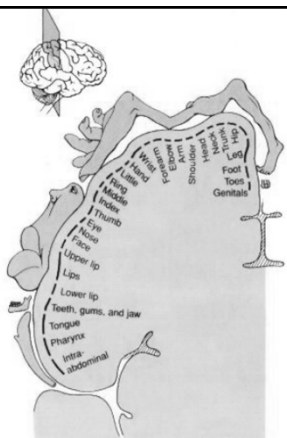
Sensory Feedback

Where does it go? What does it do? How do we use it?
 i.e. Closed-Loop Control

- Visual, auditory, smell, etc. take more direct routes to their respective sensory areas.
 - Visual information → primary visual cortex (V1) (occipital lobe)
 - Auditory info → primary auditory cortex (A1) (temporal lobe)

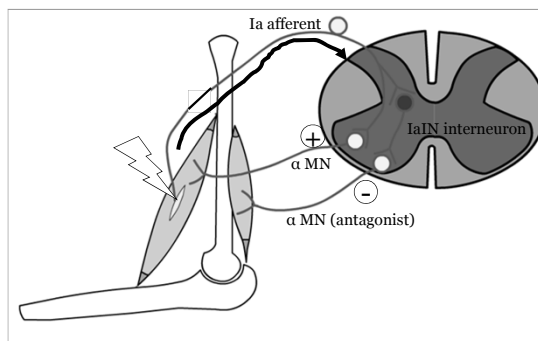
Primary Somatosensory Cortex

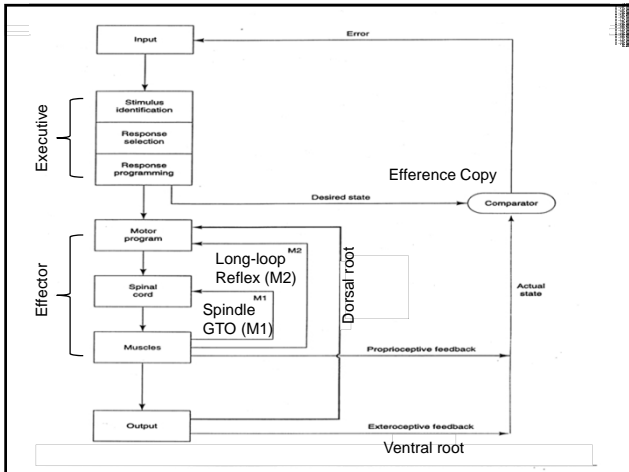
- Somatosensory cortex - area where proprioceptive sensory information is received



(a) Somatosensory cortex in right cerebral hemisphere

M1 reflex circuit





Sensory Feedback

No time for sensory feedback? Deafferented?
i.e. Open-Loop Control

Do Motor Programs Exist?

Support for Motor Programs:

1. *Movements can be produced in the absence of feedback*

e.g. *Deafferentation or Fast Movements (Boxing jab)*

Do Motor Programs Exist?

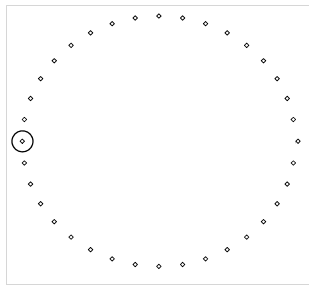
- *Support for Motor Programs:*

2. *Reaction time increases with the complexity of movements*

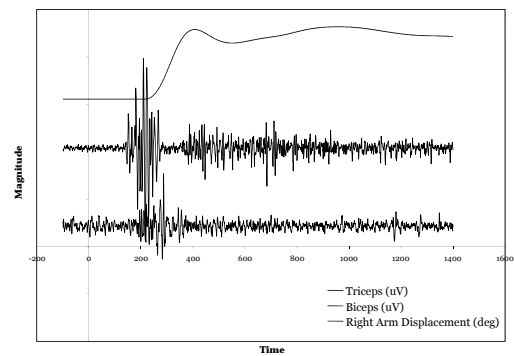
Movement Complexity	RT (ms)
finger lift	~160
reach/ht	~200
reach/ht/reverse/ht	~225

Henry & Rogers, 1960

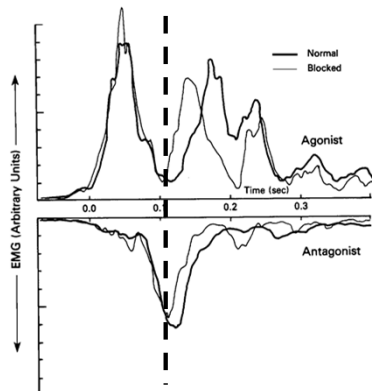
Stopping



tri-phasic EMG



Movement Blocking



GMP's

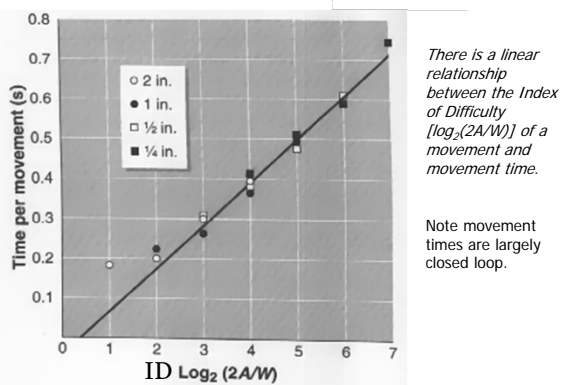
- GMP's are thought to have invariants & parameters
 - Invariants - "deep structures"
 - Components that remain constant - ("signature" of the program)
 - Fundamental features of the GMP that do not change from one execution to the next
 - Parameters - "surface features"
 - The modifiable features of a GMP
 - Input specifications for the GMP that define how it is executed

Principles of Movement

Fitts' Law

Fitts' Law

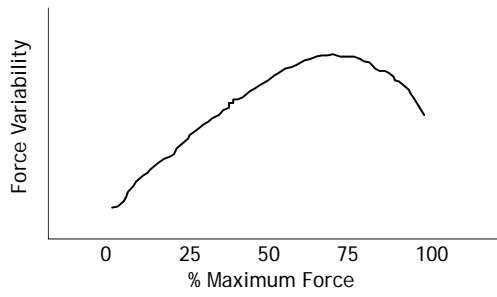
- Paul Fitts' Task
 - tap between 2 targets as rapidly as possible for 20 seconds, maintaining 95% accuracy
 - examine relation between:
 - movement time (MT) = 20s/# taps
 - movement amplitude (A)
 - target width (W)



Explanations of Speed Accuracy Trade-Off

- Why do more accurate movements take longer to complete?
 - MT represents the time required to process information and achieve the movement goal
 - Longer MT allows processing time to detect errors and make corrections
- How do we control these movements?
 1. Impulse-Variability Theories
 2. Two-Phase Movement Theories

Relation Between Force and Force Variability



Optimized submovement correction model

