First Course "Basics in Motion analysis"

TRAMA Project

September 10 -12 th 2007

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MOTOR CONTROL

I. is the control and organization
of processes underlying motor behavior

Understanding motor control implies
an understanding of what is controlled and how
that process is organised.

II. The term motor control "refers to the study of postures and movements And also to the functions of mind and body that govern posture and Movement. (V. B. Brooks 1986)

Formal field opening: Int. Symposium org. by Ragnar Granit in Stockholm 1965 followed by his monograph "The Basis of Motor Control" 1970.

MOTOR CONTROL

Is the scientific field that investigates

☞ how the CNS controls movement

☞ how sensory information is used to control movement

☞ how these informations provide selection of movement

MOTOR CONTROL

Contemporary knowledge in motor control suggests:

Movements are organized around behavioral goals

Strategies for moving emerge from interactions between the individual and the environment to accomplish the task

The environment presents a powerful tool for movement

Movement is linked to sensory input in two distinct ways feedback control and feedforward control

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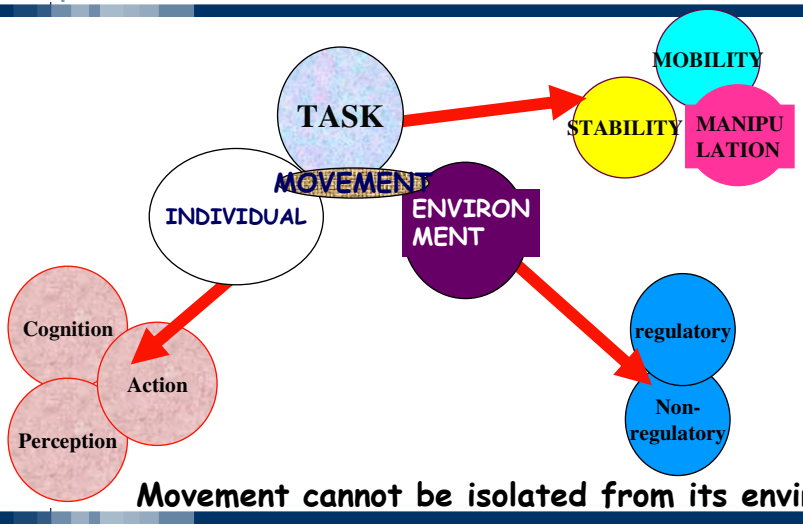
MOTOR CONTROL



Movement cannot be isolated from its environment

MOTOR CONTROL

Motor Control theory provides

- A framework for interpreting behavior
- A guide for clinical action
- Working hypothesis for examination and intervention
- New ideas for treatment

MOTOR CONTROL

- Criteria for assessment is based on underlying theoretical framework

- Treatment planning mirrors assessment tools

MOTOR CONTROL today

Transition from a
Task Orientation to a Process Orientation

TO: focus on effect of variables on completion of motor task
PO: focus on underlying neural events that support or produce movements.

THEORY:

- group of abstract ideas about the nature and cause of something
- a philosophical point of view

HYPOTHESIS

- a theoretical approach leading to testable predictions

MODEL A representation, a simplified version odf the real thing

Control models (modif. after Hirschfeld 1995)

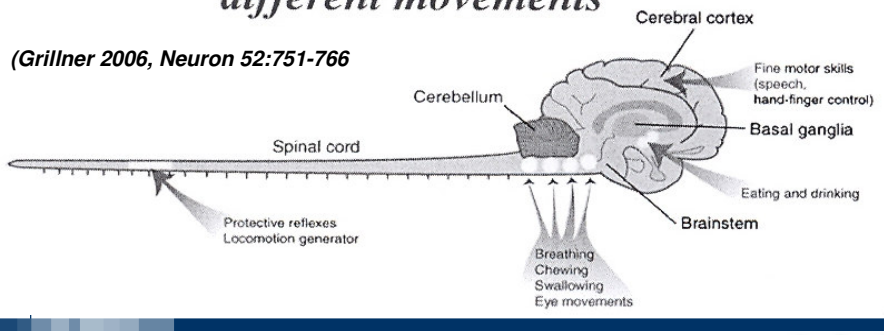
	Hierarchical	Heterarchical,(Systems model)
CNS	Controls muscles and movement patterns	Problem solving, organizes movement to reach the goal
Functional **unit**	Reflex	Motor program
CNS works	as reactor, activator	as evaluator, predictor, creator
Movement trigger	Sensory input	Intention, motor program, sensory input
Voluntary movement	Summation of reflexes	Innate, acquired motor programs
Treatment Concepts P.T.	Facilitation of "normal movement" inhibition of abnormal muscle tone	Teach to accomplish goals problem solving approach
Org.	Higher centers control lowers (Sherrington 1912, Jackson 1943)	Modular approach, network of subsystems, dynamic interaction among subsystems (Bernstein 1967)

MOTOR CONTROL

MOTOR INFRASTRUCTURE

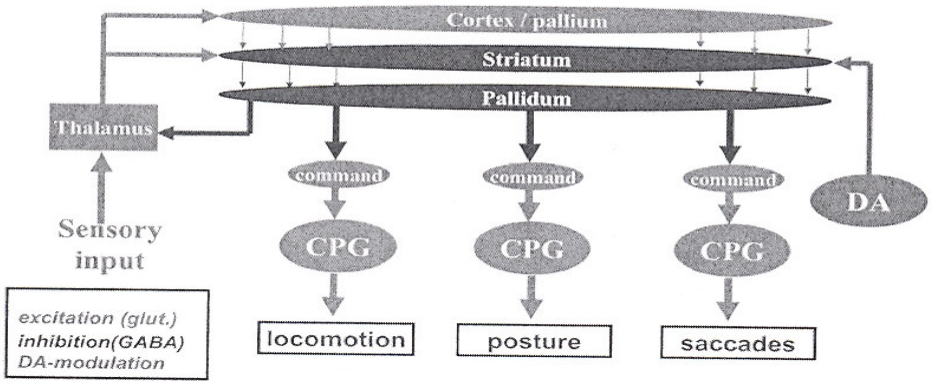
Neuronal networks that co-ordinate different movements

(Grillner 2006, Neuron 52:751-766



Selection of behaviour

(Grillner 2006, Neuron 52:751-766



MOTOR PROGRAM

Is a set of motor commands that is pre-structured at the executive level and that defines the essential details of a skilled action;
Analogous to a central pattern generator.

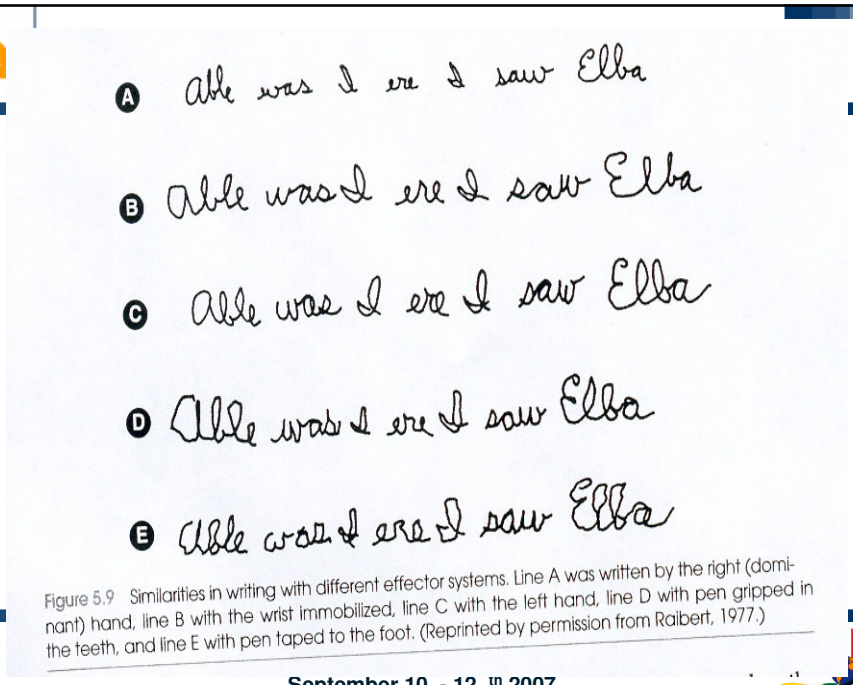


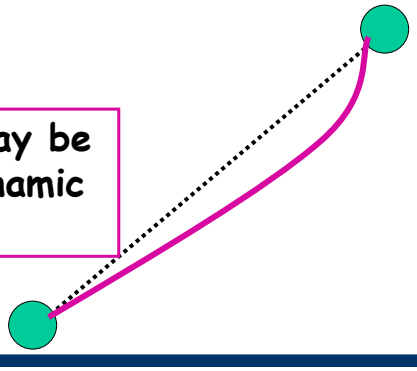
Figure 5.9 Similarities in writing with different effector systems. Line A was written by the right (dominant) hand, line B with the wrist immobilized, line C with the left hand, line D with pen gripped in the teeth, and line E with pen taped to the foot. (Reprinted by permission from Raibert, 1977.)

MOTOR CONTROL

EQUILIBRIUM TRAJECTORY HYPOTHESIS

CNS plans a virtual trajectory of the working point

Actual trajectory may be different due to dynamic factors.



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Movement must be matched to specific conditions in environment

Solution: sensory input is used to guide movement

- two general ways: feedback control and feedforward control
- Adaptive mechanisms

MOTOR CONTROL

CLOSED LOOP CONTROL

- **feedback**
  - sensory input provides information about the movement
  - is information about the consequences of the movement
  - correct errors
  - involves error-correcting mechanisms

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MOTOR CONTROL

OPEN LOOP CONTROL

- **feedforward**
- sensory input used to guide movement, but input not about movement itself
- sensory information used to update the commands to the muscle

» e.g. reaching for an object, catching a boll

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MOTOR CONTROL

SKILL ACQUISITION

Skills consist in ability performing the task with maximum certainty and minimum of time and energy

- **shift from reliance on feedback to greater use of feedforward**
- **we "learn" to predict disturbances in advance**

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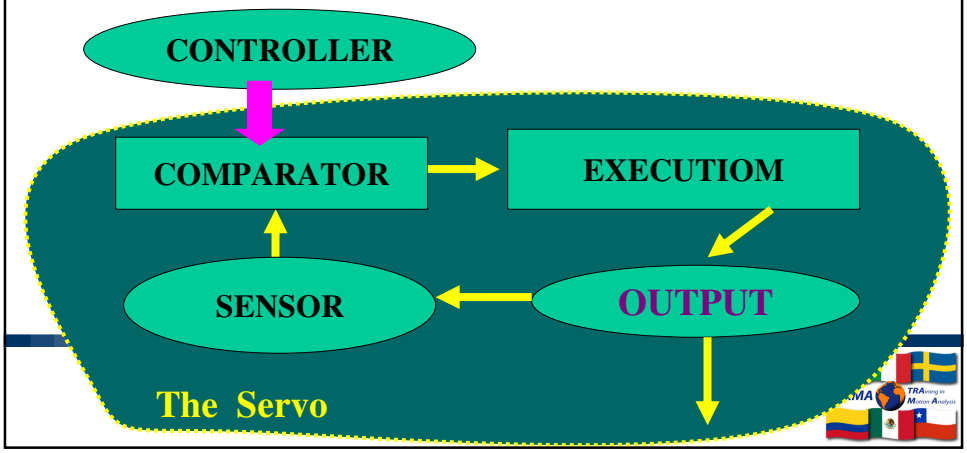
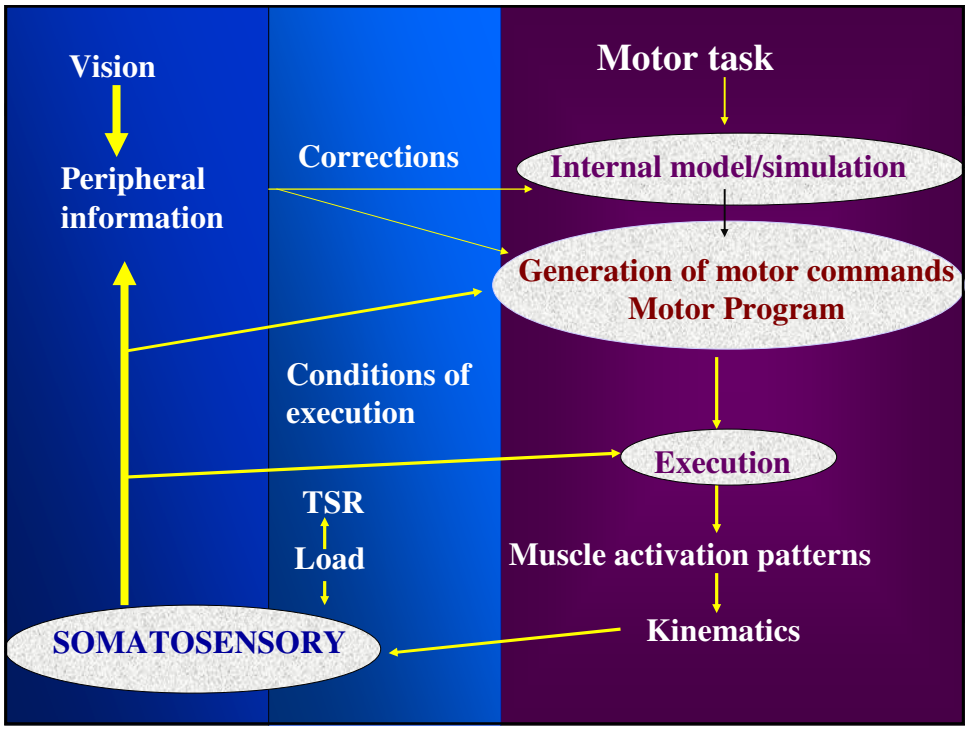
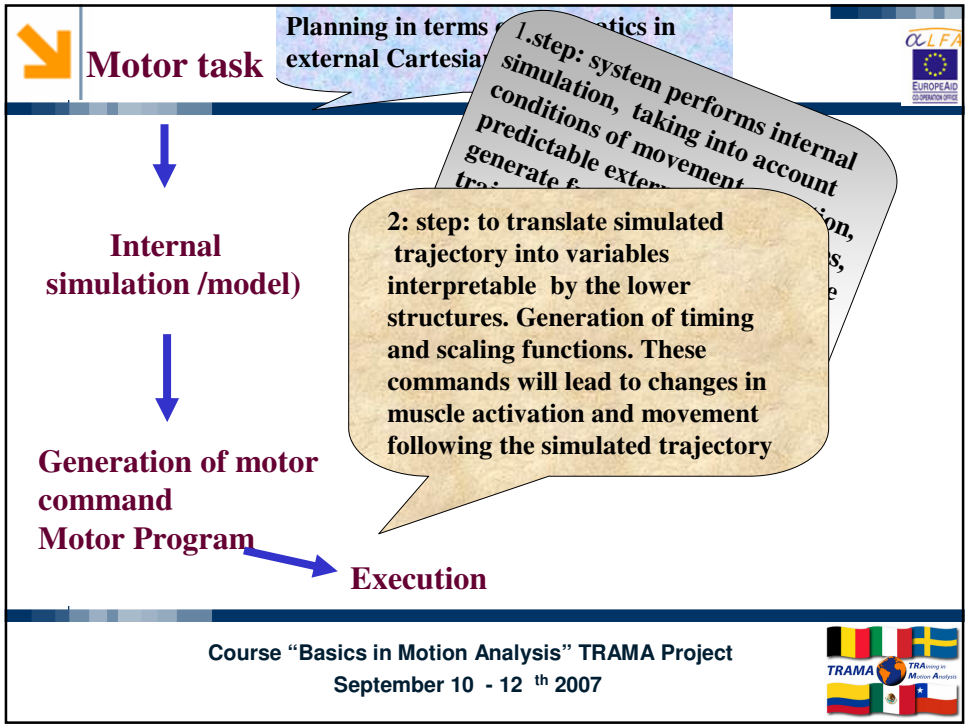
Adaptive Control

Control scheme generating command signals
in a feedforward manner and correcting the signals
(if different to desired outcome) using feedback control.






Motor task
Planning in terms
external Cartesia
tics in
1.step: system performs internal simulation, taking into account conditions of movement
predictable
generate
2: step: to translate simulated trajectory into variables interpretable by the lower structures. Generation of timing and scaling functions. These commands will lead to changes in muscle activation and movement following the simulated trajectory
Internal simulation /model)
Generation of motor command
Motor Program
Execution
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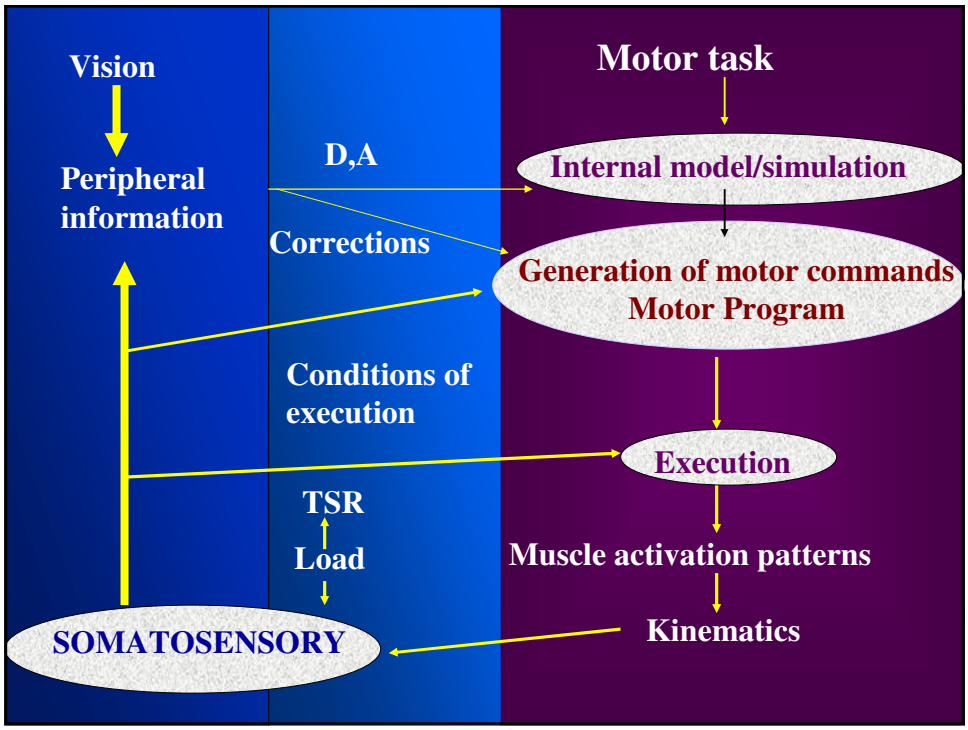
Vision
Peripheral information
D,A
Corrections
Conditions of execution
TSR
Load
SOMATOSENSORY
Motor task
Internal model/simulation
Generation of motor commands
Motor Program
Execution
Muscle activation patterns
Kinematics

INITIATION OF MOTOR TASKS

Central information transforming processes during the interval between the stimulus and the actual start of the movement

INTENTION Activates a stored repertoire of motor program

SENSORY INPUT SELECTION selection of essential information from the environment and body

STIMULUS RECOGNITION AND MEMORY MECHANISMS interplay between knowledge base and motor processes

RESPONSE SELECTION flexibility (i.e. dependent on context and momentary position of the body relative to the object)

INITIATION OF MOTOR TASKS

PROGRAMMING

planning (temporal order of the operation)
parameter specification (adding context and task dependent eg force, direction to the motor program)

(Parkinson inability to specify correct force parameters)

INITIATION

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CNS PLASTICITY

ADAPTIVE CHANGES IN MOTOR PATTERNS OF INDIVIDUALS med movement disorders

Play important roles in shaping the patient's behavior (motor pattern)

Take advantage of adaptive abilities - identify, goals, provide tools, allow the CNS to find solutions (don't practice movement patterns!!!)

Find procedures, stimulating learning processes

Correcting the primary cause is first priority - however, not always possible.

MOTOR CONTROL

Requirements for catching a balloon

Control of multijoint movement

Trajectory planning

Postural control including:

- **Postural orientation (Alignment)**
- **Equilibrium**

(anticipatory and compensatory postural adjustments)

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Control 4 y | CP indep. 4 y | CP shell

MOTOR CONTROL

Hand trajectory (five trials)

Non-Disabled (10 y) | **CP indep. (10 y)** | **CP shell**

MOTOR CONTROL

Task parameters

(what is required from the subject)

movement time , movement amplitude,
external load,
accuracy requirements
other instructions to the subject

(many clinical tests have focus on task parameters)

MOTOR CONTROL

Performance parameters

(what the subject is doing)

Kinematic variables :

linear, angular displacement, velocity, acceleration.

Kinetic variables:

joint torque and its' derivative,GRFs, EMG, CoM-CoP interaction, accuracy indexes)

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Clinicians have continually to keep abreast of current research findings and operational theories!