Applying the concept of synergistic movement to upper extremity movement training programs in post-stroke patients

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Outline

► Internal Representation 内在表征
► Hierarchical Structure 动作阶层架构
► Synergy 协同动作
► Relationship between synergies 协同动作相关性
► Mechanism of motor learning 动作学习机制
  - Neural plasticity & Hebb’s rule & engram 神经可塑性与海伯法则
  - Parallel Distributed Processing 平行分散处理
► Application 临床应用
Territories of motor control
动作控制范畴

► Adaptive behavior
- behaviors that responds appropriately
  and effectively to environmental stimuli
  and demand

► An area of study dealing with the understanding
  of the neural, physical, and behavior aspects of
  movement.

Prerequisites for activities in space
在空间中活动的前辈技巧

► Prerequisites for activities in space
  ◆ Balance - essence of posture and movement
  ◆ Space orientation -
    - the ability to maintain an appropriate
      relationship for a task
    - between the body segments
    - between the body and the environment
      (维持肢体之间或身体与环境间的相对关系)
Space Types
空间种类

► interaction between body and environment
  (1) physical space
  (2) internal representation of space (空间的内在表征)

Spatial internal representation
内在表征

► concept of internal representation
  - the internal representation of posture
    reflects the physical reference of body
    and external world

► know as the knowledge and structure in memory, as
  propositions, productions, schematas, neural network, or
  other forms.

► The information in internal representation has to be retrieved
  from memory by cognition process, although the cue in
  external representation can sometimes trigger the retrieval
  process.
Hierarchical Structure
阶层架构

- capacity limitation of CNS
  - chunking mechanism (组块机制) for hierarchical organization
    eg. 0-9-3-7-1-2-3-1-2-3

- movement hierarchy (动作阶层)
  motor element ➔ synergy ➔ movement ➔ activity
Hierarchical Structure

abstract motor program

synergy

right hand muscles

right arm muscles

left hand muscles

Synergy

a. Steven Pinker, 1997
b. Anne Shumway-coll & Majorie H. Woollacott
Muscle synergies may therefore represent the bottom of a hierarchal neural control structure. 2 or more things working in a coordinated fashion for an outcome. Functional linkage of muscles during voluntary motor action. From which complex muscle activation patterns are constructed. One muscle can be part of many muscle synergies, and one synergy can activate many muscles.

Nervous system:
- Uses muscle synergies as a set of heuristic solutions to transform task-level goals into detailed spatiotemporal patterns of muscle.
- Uses flexible combinations of just a few muscle synergies to produce a wide range of motor behaviors.
Synergy (3)

► innate (some degree) & shaped by adaptive processes (vary depending on context)

► difference between some conditions of motor deficit and motor skill
  - the number of available muscle synergies
  - the appropriateness of those muscle synergies

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Relationship between synergies

协同动作相关性
**Relation between the Upper Extremity Synergistic Movement Components and Its Implication for Motor Recovery in Poststroke Hemiparesis**

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**Background:** Synergy is a functional linkage of muscles during voluntary motor action. In poststroke hemiparesis, synergistic movements get disorganized in the form of stereotyped behavior. Furthermore, there is a linkage between the movement components of the synergies, which should be understood for focused motor rehabilitation. **Objective:** To find the relationship between the synergistic motor behavior and recovery of the individual movement in chronic poststroke hemiparetic subjects. **Method:** A prospective, cross-sectional, observational study was conducted at an outpatient occupational therapy unit of a rehabilitation institute. A convenience sample of 30 chronic poststroke hemiparetic subjects (25 male and 5 female, 16 left sided and 14 right sided) was assessed using the Fugl-Meyer assessment (FMA) and Tinetti recovery stages of arm (BRS-A) and hand (BRS-H). **Results:** The mean poststroke duration of the subjects was 40.9 months. There were significantly higher scores (P < .001) for BRS-A (4.13 ± 1.07) and FMA upper arm (29.03 ± 6.31) as compared to BRS-H (2.47 ± 1.45) and FMA wrist and hand (11.50 ± 5.85), respectively. Very high correlation (r = 0.9 to 1.0; P < .05) was found between the 2 components of FMA (corticodorsal and anterolateral) and Tinetti recovery stages of arm. Moderate (r = 0.5 to 0.69; P < .05) to high (r = 0.7 to 0.89; P < .05) correlation was found between many components of FMA (flexor synergy, extensor synergy, movement combining synergies, movement out of synergy, upper arm, and wrist-hand components). **Conclusion:** Many upper extremity movement components of the parietic side were related to one another. The components may be used for motor rehabilitation in order of their strength of association. The concept of synergistic linkage may be applied for motor training of the upper limb at a particular stage of the recovery. **Key words:** Tinetti recovery stage, Fugl-Meyer assessment, hemiparesis, motor recovery, stroke rehabilitation, synergy, upper extremity

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### Key movement

<table>
<thead>
<tr>
<th>Goal</th>
<th>Shoulder 90° abduction with forearm pronation and elbow at neutral position</th>
<th>Pronation-supination of the forearm with elbow 90° flexion and shoulder at neutral position</th>
<th>Wrist movement with shoulder 30° flexion and elbow at neutral position</th>
<th>Finger flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>Pronation-supination with shoulder 30-90° flexion and elbow at neutral position</td>
<td>Wrist movement with shoulder 30° flexion and elbow at neutral position</td>
<td>Finger flexion-extension</td>
<td>Cylindrical grasp</td>
</tr>
</tbody>
</table>
### Relationship between synergies

<table>
<thead>
<tr>
<th>Wrist stability with elbow at 90° flexion and shoulder at neutral position</th>
<th>Wrist movement with shoulder 30° flexion and elbow at neutral position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist movement with elbow at 90° flexion and shoulder at neutral position</td>
<td>Wrist stability and movement with shoulder 30° flexion and elbow at neutral position</td>
</tr>
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<td>Wrist stability with shoulder 30° flexion and elbow at neutral position</td>
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</tr>
<tr>
<td>Finger flexion</td>
<td>Thumb opposition</td>
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<tr>
<td>Cylindrical grasp</td>
<td>Spherical grasp</td>
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<td>Thumb opposition</td>
<td>Cylindrical grasp</td>
</tr>
<tr>
<td>Finger flexion</td>
<td>Cylindrical grasp</td>
</tr>
<tr>
<td>Lateral prehension of thumb</td>
<td>Thumb opposition</td>
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Mechanism of motor learning
动作学习机制

Neural plasticity & Hebb's rule
神经可塑性与海伯法则

► Neural plasticity
- The term "plasticity" refer, in general, to the capacity of the central nervous system to adapt to functional demand and therefore to the system's capacity to reorganize.
Neural plasticity & Hebb’s rule
神经可塑性与海伯法则

- **Hebbian rule** (海伯法则)
  - fired together, wired together
  Hebb’s postulate on synaptic plasticity emphasized that **changes in synaptic efficacy** would take place when a pre-synaptic cell participated in firing a post-synaptic cell.

A → B → C → module → neural circuit → neural network (engram)
- information is stored in population of neurons and their pattern of activity.

Friedemann Pulvermuller & Bettina Mohr, 1996
Parallel Distributed Processing
平行分散处理

► Brain: a parallel processor

► It processes information through parallel neural circuits, that is, processing information through multiple pathways that process the same information simultaneously in different ways.

► through integration, intact neural circuitry can enhance the function of impaired neural circuitry.

Application
临床应用

1. 动作控制是关于动作的记忆，动作学习是获得记忆的历程
2. use the upper arm components having good motor control for training of the hand components having poor control.
Reference


Reference

Thank you for your attention