

Applicating the concept of synergistic movement to upper extremity movement training programs in post-stroke patients
运用协同动作原理在中风后个案的上肢动作训练

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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

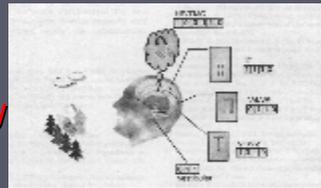
- ▶ Prerequisites for activities in space
 - Ø Balance - essence of posture and movement
 - Ø **Space orientation** -
 - the ability to maintain an **appropriate relationship** for a task
 - between the body segments
 - between the body and the environment
(维持肢体之间或身体与环境间的相对关系)

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, schemeas, 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

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

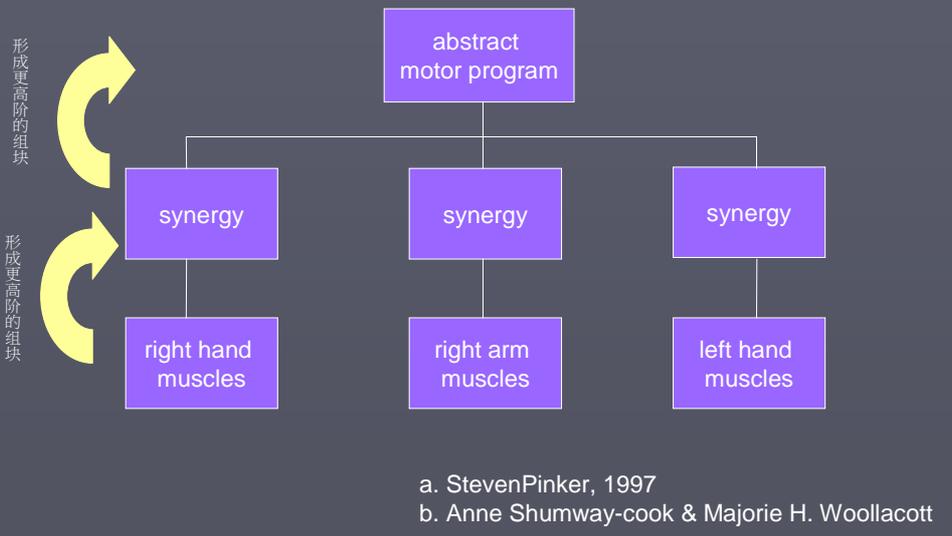
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- **movement hierarchy (动作阶层)**

motor element → synergy → movement → activity

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graph LR; A[motor element] --> B[synergy]; B --> C[movement]; C --> D[activity]; A --- E[ ]; E --> B; E --> C; E --> D;
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Hierarchical Structure 阶层架构



Synergy
协同动作

Synergy (1)

协同动作

- ▶ 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

Synergy (2)

协同动作

- ▶ 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) 协同动作

- ▶ **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

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 behaviors. 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 Brunnstrom 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 ± 4.31) as compared to BRS-H (2.47 ± 1.45) and FMA wrist and hand (11.50 ± 5.88), respectively. Very high correlation ($r = 0.9$ to 1.0 ; $P < .05$) was found between the 2 components of FMA (wrist circumduction and spherical grasp). 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 paretic 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:** Brunnstrom recovery stage, Fugl-Meyer assessment, hemiparesis, motor recovery, stroke rehabilitation, synergy, upper extremity

Relationship between synergies 协同动作相关性

Key movement	Goal			
Shoulder 90° abduction with forearm pronation and elbow at neutral position	Pronation-supination of the forearm with elbow 90° flexion and shoulder at neutral position	Wrist movement with shoulder 30° flexion and elbow at neutral position	Finger flexion	
Pronation-supination of the forearm with elbow 90° flexion and shoulder at neutral position	Pronation-supination with shoulder 30-90° flexion and elbow at neutral position	Wrist movement with shoulder 30° flexion and elbow at neutral position	Finger flexion-extension	Cylindrical grasp

Relationship between synergies

协同动作相关性

Wrist stability with elbow at 90° flexion and shoulder at neutral position	Wrist movement with shoulder 30° flexion and elbow at neutral position			
Wrist movement with elbow at 90° flexion and shoulder at neutral position	Wrist stability and movement with shoulder 30° flexion and elbow at neutral position			
Wrist stability with shoulder 30° flexion and elbow at neutral position	Wrist movement with shoulder 30° flexion and elbow at neutral position	Cylindrical grasp		
Wrist movement with shoulder 30° flexion and elbow at neutral position	Wrist circumduction	Finger flexion-extension	Cylindrical grasp	
Wrist	Finger flexion-	Thumb opposition		

Relationship between synergies

Thumb opposition	Cylindrical grasp	Spherical grasp		
Finger extension	Cylindrical grasp	Lateral prehension of thumb	Thumb opposition	
Finger flexion	Cylindrical grasp	Lateral prehension of thumb	Thumb opposition	

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**.

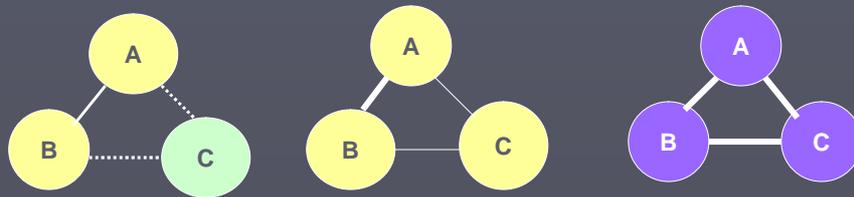
神经可塑性是动作学习的机制

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

Ø Hebbian rule (海伯法则)

— fired together, wired together

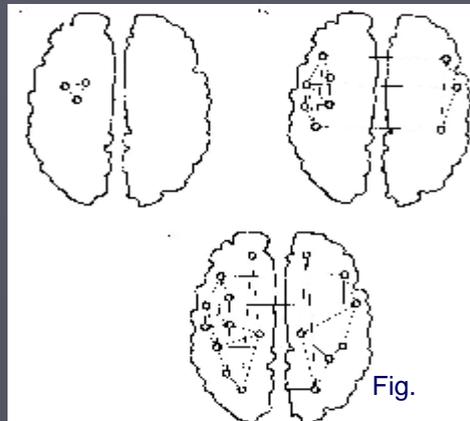
Hebb's postulate on synaptic plasticity emphasized that **changes in synaptic efficacy would take place when a pre-synaptic cell participated in firing a post-synaptic cell**.



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

Ø Functional link-in between neurons

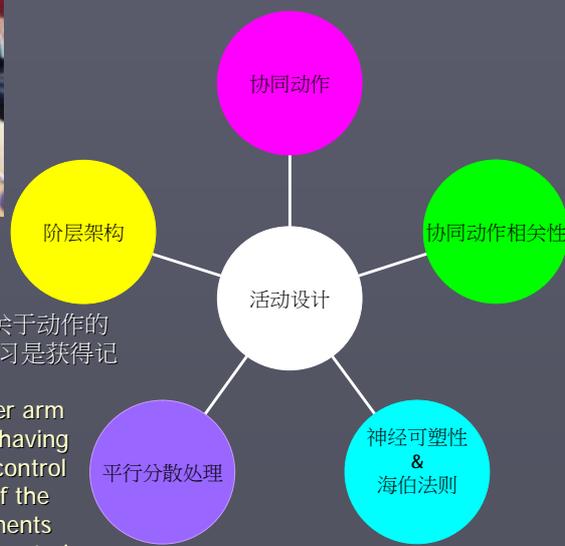
- neuronal assembly
- module
- neural circuit
- **neural network**
(**engram**)
- information is stored
in population of
neurons and their
pattern of activity.



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 informations 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

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**Thank you for your
attention**