Motor Learning in Parkinson’s disease: Clinical Practice
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http://research.ncl.ac.uk/hmst/

Aims
- Definition
- Neural substrates
- Implications for PD
- Evidence
- Clinical Application (assessment and principles)

Motor learning: definition and stages

“A set of processes associated with practice or experience, leading to relatively permanent changes in the capability for movement” (Schmidt 1999)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
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<tbody>
<tr>
<td>Cognitive</td>
<td>Novel task&lt;br&gt;Receive instruction and feedback&lt;br&gt;Problem solving - what to do and how to do it&lt;br&gt;Error prone - variability of performance</td>
</tr>
<tr>
<td>Associative</td>
<td>Environmental cues associated to movements&lt;br&gt;Goal or skill attainment&lt;br&gt;↓ error and ↑ consistency</td>
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<tr>
<td>Autonomous</td>
<td>↑ conscious control&lt;br&gt;↑ dual task (eg talking and driving)</td>
</tr>
</tbody>
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Fitts & Posner, 1967

Fitts & Posner, 1967
Neural substrates of motor learning

- Early acquisition involves - striatum, cerebellum, motor cortical regions, prefrontal cortex, parietal cortex, hippocampus
- Reduction in brain activity
- Shift from cortical (prefrontal-parietal) to subcortical (striatum and cerebellum)
- Brain changes dependent upon type of motor learning
  - Motor sequence learning = striatum
  - Motor adaptation = cerebellum
- Could hypothesise that PD have difficulty in motor learning?

Doyon et al., 2009

Motor sequence learning process whereby elements of movement sequence become a single entity with repetitive practice

Motor adaptation process requiring adaptation to environmental (contextual) changes

Neural substrates in PD

- PD recruited larger brain volume but similar areas compared to controls
- Greater bilateral recruitment
- Areas involved - cerebellum, premotor areas, parietal cortex, precuneus and DLPFC
- Reduced efficiency

Mentis et al., 2003

Significant declines in learning-related activity in cortical areas with prominent Lewy body formation
Behavioural evidence for motor learning in PD

- Novel goal-directed skills
- Possible – acquisition and retention
- Attenuated compared to controls
- Facilitated with augmented feedback
- Effects on automatic tasks predominantly affected in PD?

ADDRESSING MOTOR DEFICITS IN PD THROUGH MOTOR RELEARNING

12 weeks: lab/home/lab
3 x week – lab; 5 x week – home
Balance: Anticipatory postural adjustment and external perturbation – computer exergames + equiTest + treadmill or over-ground walking
Control: strength and endurance training programme

Balance training with augmented feedback more effective
Training effects: 
Cueing therapy
De Novo
7 studies: 58 PD; 56 controls

- Motor learning in upper limb occurs in PD with repetitive practice of tasks designed to reduce movement time
- Effect sustained over time

- Evidence limited to small pre-post designs
- Unknown if cues improve performance on line or are consolidated into motor programme with sustained effect
- Long-term training and retention studies needed

Summary

- Relearning complex skills feasible in PD
- PD benefit from external cues and augmented feedback
- Consolidates motor programme reinforced through compensatory brain networks
- Facilitates skill acquisition and retention
- Too much feedback/continual cueing can lead to dependency and reduce retention/transfer
- Emphasis therefore on faded practice and manipulation of context/predictability
Contemporary approaches could enhance motor learning

- Novel and engaging training regimes
- Augmented feedback
- Knowledge of results available
- Repetition and intensity facilitated
- Possibility for transfer practice
- Encouraging explicit and implicit learning
How can we evaluate motor learning in the clinic?

Automaticity  ➔ Dual-task
Complex tasks

Retention  ➔ Effect retained at follow-up appointment

Transfer  ➔ Other skills
Different contexts
Motor learning in a model of physiotherapy

Ingredients for successful learning

Applying principles

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Learning strategy</th>
<th>Intervention</th>
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<tbody>
<tr>
<td>Single task</td>
<td>Explicit</td>
<td>Repetitive task practice e.g.</td>
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<tr>
<td></td>
<td></td>
<td>- Functional (ADL)</td>
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<tr>
<td></td>
<td></td>
<td>- Gait</td>
</tr>
<tr>
<td>Dual-task</td>
<td>Implicit</td>
<td>Repetitive task practice under single, dual-task, multi-task conditions</td>
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<tr>
<td>Strategies to augment/optimise learning</td>
<td>Explicit/implicit</td>
<td>Task practice using external sensory information - cues (visual or auditory feedback)</td>
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<tr>
<td>Cued</td>
<td>Explicit/implicit</td>
<td>Imagine movement first then practice</td>
</tr>
<tr>
<td>Mental/motor imagery</td>
<td>Explicit/implicit</td>
<td>Imagine movement first then practice</td>
</tr>
<tr>
<td>Movement observation</td>
<td>Explicit/implicit</td>
<td>Observe movement first then practice</td>
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Provide strategic feedback - Knowledge of results/performance indicators – but limit this. Vary context for enhanced transfer.
Training complex tasks

Cueing complex tasks

Applying principles across disease severity

- Complex exercise (task and context)
  - Augmented feedback
  - Attentional
  - Motor imagery/observation
  - Faded practice

- H&Y I
  - + optimal medication
  - + high intensity
  - + feedback on performance

- H&Y II
  - + Permative cues & faded practice

- H&Y III
  - + Permanent cueing devices
Practice points

• Motor learning is possible in PD
• Include motor learning as part of therapy programme
• Select patients based on knowledge of potential limitations (disease severity and cognitive impairment)
• Feedback augments learning and may help consolidate motor skills for enhanced retention
• Faded practice may facilitate generalisation and transfer
• Evaluate the effect of therapy (ART)

Acknowledgements

UK NIHR Biomedical Research Unit for Lewy Body Dementias award to the Newcastle upon Tyne Hospitals NHS Foundation Trust