Acquisition and Retention of Basic Components of Skill

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### MURI task taxons and IMPRINT taxons

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Research Topics

I. Transfer of perceptual-motor learning
   - **Visual, linguistic, auditory processing**
   - **Visual/Symbolic representation**
   - **Motor planning (discrete)**

II. Mixed mappings and tasks
    - **Executive control/monitoring**
    - **Visual representation**
    - **Motor planning (discrete/continuous)**

III. Performance of multiple tasks
     - **Executive control/monitoring**
     - **Visual/Symbolic representation**
     - **Motor planning (discrete)**
Research Topics

I. Transfer of perceptual-motor learning
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I. Transfer of Perceptual-Motor Learning

• Paradigm:

![Diagram showing practice and transfer paradigms]

• In the transfer task, responses are typically faster when stimulus and response locations correspond than when they do not (the Simon effect).

• Transfer of learning is implied if the Simon effect is reduced after practice with a spatially incompatible mapping.
I. Transfer of Perceptual-Motor Learning

• Training specificity:

  - The degree of transfer depends on
    (a) Similarity between learning and test contexts, and
    (b) Associative strength between a learned event and contextual
         features present during learning.

  - Similarity between the learning and text contexts is a function of
    feature overlap.

  - Associative strength depends on the amount of practice.
I. Transfer of Perceptual-Motor Learning

- Training specificity:

\[
U_N(E_1|C_T) = \sum_{Y \in C_T} \frac{\sum_{X \in C_P} f_N[E_1, S(X, Y)]}{\sum_{Y \in C_T} \sum_{X \in C_P} f_N[E_k, S(X, Y)]}
\]

- \( E \) : Learned event
- \( C_P \) : Practice context
- \( C_T \) : Test context
- \( S \) : Similarity function
- \( f \) : Associative strength
- \( N \) : \# of trials
Amount of Practice

- The strength of learned associations between stimulus and response depends on the amount of practice

**Strengthening of Association**

**e.g.,**

\[ f_N(E_i, X) = \sum_{r=1}^{N} \alpha r^{-\beta(X)} \]

- \( \alpha \): initial strength
- \( \beta(X) \): learning rate
- \( N \): # of practice trials

Anderson (1982)
Amount of Practice (Linguistic Stimuli)

- Proctor, Yamaguchi, Zhang, & Vu (2008)
Feature Overlap

- Feature overlap between the learning and testing contexts depends on similarity of contextual features.

**Similarity**

\[ S(X, Y) = \beta'(X) \exp\{-d(X, Y)\} \]

\(d(X, Y)\): psychological distance between \(X\) and \(Y\)

\(\beta'\): ‘transfer coefficient’ related to \(\beta\)

The ‘transfer coefficient’ is such that:

\[ X \neq Y \Rightarrow \beta(X) > \beta'(X) \]
Feature Overlap – Stimulus Modality

Feature Overlap – Stimulus Modality

- Proctor, Yamaguchi, & Vu (2007)
Feature Overlap – Stimulus Modality

- Proctor, Yamaguchi, & Vu (2007)

![Visual to Auditory Simulation Effect](image)
Feature Overlap – Stimulus Type
(Physical-location, symbol, linguistic stimuli)

- Proctor, Yamaguchi, Zhang, & Vu (2008)
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**Word ↔ Arrow**

**Word ↔ Location**
Feature Overlap – Spatial Dimensions (Auditory Task)

- Proctor, Yamaguchi, & Vu (2007)
Feature Overlap – Response Mode


![Graph showing Simon effect (ms) for Joystick Simon and Keyboard Simon with different practice modes: Control, Joystick Practice, Keyboard Practice. The graph compares the response times across different conditions.]
Principle of Training Specificity

• The principle of training specificity is applicable to perceptual-motor learning.

• Specificity of transfer is confirmed for:
  (a) Stimulus modality          (b) Stimulus type
  (c) Spatial dimension          (d) Response mode

• Specificity can be attributed at least in part to feature overlap of learning and training contexts.

• Specificity can be overcome with extended practice in some conditions (e.g., word ↔ arrow)
  – This may be due to strengthening of associations between response and abstract representations of task features, or learning of an abstract ‘rule’.
Influence of Intervening Task (with different target items)

- Another line of research looks at influences of an intervening task for previously learned associations.
Influence of Intervening Task (with different target items)

- Two separate practice sessions with different stimuli
Influence of Intervening Task (with different target items)

- Two separate practice sessions with different stimuli

![Graph showing Simon Effect](image)
Influence of Intervening Task  
(with different target items)

- A previously learned association is offset by learning of a new association.

Practice with the stimulus $X$ for $n$ trials $\rightarrow f_N(E,X)$

Practice with another stimulus $Y$ for $m$ trials $\rightarrow f_M(E,X)$

The associative strength for $X$ after practicing with $Y$ may be:

$$f_{N+M}(E,X) = f_N(E,X) - f_M(E,Y)$$

Or

$$f_{N+M}(E,X) = \frac{f_N(E,X)}{f_N(E,X) + f_M(E,Y)}$$
Practice with Mixed Target Items

- Two different types of target items can occur in a practice block

```
Practice (Mixed)

or

RIGHT

Transfer

RIGHT

```
Practice with Mixed Target Items

- # of word trials were equal for the two practice conditions
- Predict equally strong associations if # of trials is the only relevant factor.

![Graph showing Simon Effect for Word Only and Arrow & Word conditions. The graph indicates a significant difference in Simon Effect between the two practice conditions.]
Practice with Mixed Target Items

• Learning of an association is interfered with in the mixed target condition.

• This result is consistent with an offset of a learned association.
Further issues

1. Variable practice hypothesis
   - Immediate test performance may be poor, but retention is better when practice contexts are variable.

2. Factors affecting the degree of interference
   e.g., Similarity between mixed stimuli
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II. Mixed Mappings and Tasks

• Paradigm:

**Location-irrelevant**

![Diagram showing location-irrelevant paradigm with colored stimuli and Simon task]

**Location-relevant**

![Diagram showing location-relevant paradigm with white stimuli and SRC task, horizontal line as compatible mapping, and vertical line as incompatible mapping]

Colored stimuli \(\rightarrow\) Simon task

White stimuli \(\rightarrow\) SRC task; horizontal line – compatible mapping

Vertical line – incompatible mapping
Mixed Mappings and Tasks

• Dissociation of the compatibility effects for the location-relevant (SRC) and location-irrelevant (Simon) trials.

• The influences of payoffs appeared in both SRC and Simon trials.

• ACT-R models of the tasks are in progress.
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III. Performance of Multiple Tasks

- Executive control/monitoring
  - Coordinating performance of 4 tasks in a synthetic work environment
  - Practice and transfer with payoffs for 3 tasks held constant and only one changed
  - Sensitivity of strategies to relative payoff changes

- Symbolic representation
  - Can two “ideomotor” compatible tasks be performed together with no cost?
    - Always find some dual-task cost
    - Little change across relatively small amounts of practice

- Motor planning (discrete)
  - Benefits of consistent mappings for relative positions in dual-task studies for which responses are made with fingers on each hand