Quantifying training principles: Performance shaping functions

Bill Raymond

University of Colorado, Boulder

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Approach

- *Project goal:*

  Identify the effects on performance of different training methods for complex military tasks.

- *Feature decomposition:*

  1. Task type
  2. Training method
  3. Performance assessment (context & measures)
  4. Training principles

- *Quantify principles:*

  - Principles are qualitative, derived from empirical studies.
  - Define performance shaping functions using empirical data.
  - Generalized functions can be used in IMPRINT.

Example: RADAR

- *RADAR task - scanning visual stimuli for targets*

Sub-task	Imprint taxon
- Visual scan of moving stimuli	Visual
- Comparison to pre-assigned target(s)	Information processing
- Manual response on detection	Fine motor - discrete

- *Training methods*
  - Repeated practice
  - Variability of task difficulty (target set size, mapping consistency)
  - Manipulation of concurrent or subsequent secondary tasks
  - Consistency of training and testing contexts
- *Performance assessments* - speed and accuracy
  - Speed of response to targets
  - Accuracy of response (hits and false alarms)
- *Principles*
  - Repeated practice improves performance
  - Performance declines with delay
  - Training difficulty aids retention
  - Contextual reinstatement aids subsequent performance

Some principles with empirical data

- *Practice*

  Repeated practice improves performance (of knowledge and skills)
  Spaced practice is superior to massed practice
  Periodic testing during practice improves performance
  Contextual interference during practice retards learning
  Deep processing during practice improves knowledge acquisition

- *Retention*

  After practice, performance ability decays
  Refresher practice retards decay of performance
  Spacing during practice retards decay of performance
  Testing during practice retards forgetting of declarative knowledge
  Contextual interference during practice improves retention
  Reinstatement of training procedures facilitates performance on previously acquired skills and knowledge

- *Transfer and Generalization*

  Contextual interference during training improves transfer
  Generalization improves with task similarity

Preliminary functions for some principles

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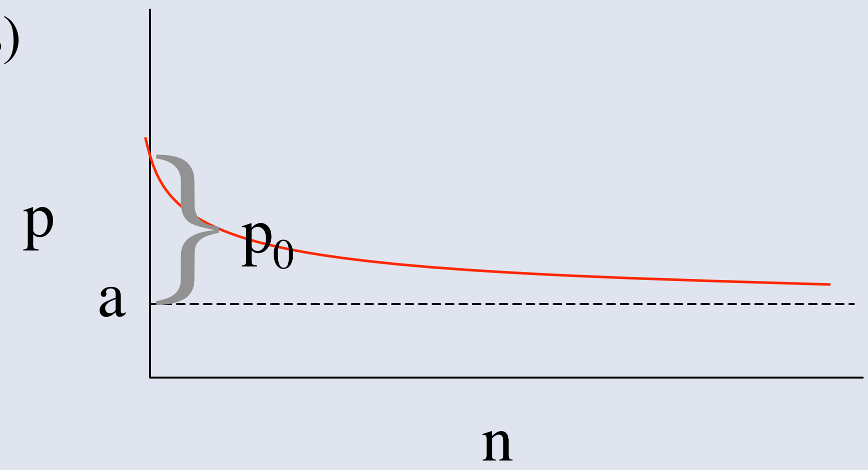
Repeated practice improves performance: *Power law of learning*

$$p = a + p_0(1+ bn)^{-c}$$

- p is a measure of performance (RT or errors)
- a is asymptotic performance
- p_0 is initial performance above asymptote
- $b > 0$ is a scaling parameter
- n is the number of practice trials
- $c > 0$ is rate of learning



IMPRINT task taxons affected: numerical analysis, information processing, fine motor discrete, fine motor continuous, gross motor – light

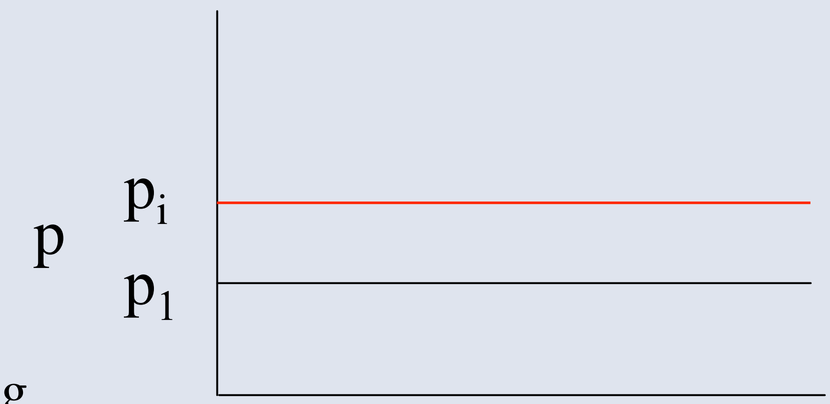
Parameters may differ for different taxons

[Data entry: cognitive learning, c = .045; motoric learning, c = .015]

Deep processing during practice improves declarative knowledge

$$p_i = c_i p_1$$

- p_i is performance (RT or errors) after training following a deep processing condition *i* during training
- p_1 is performance after training following the most shallow processing requirement during training
- $c_i < 1$ is the benefit from a deep processing condition *i* (e.g., semantic processing)

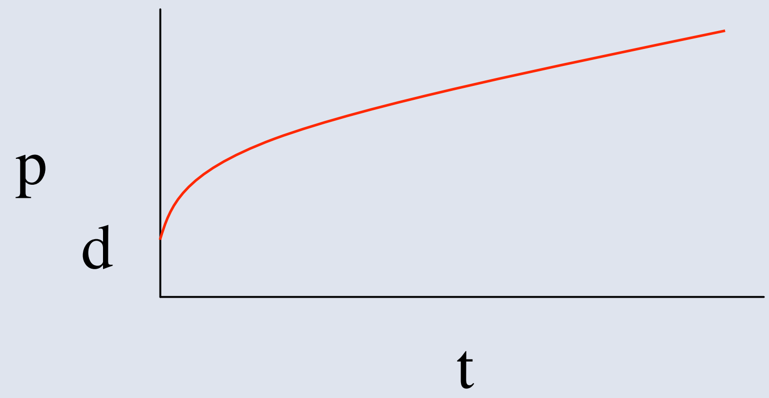


IMPRINT task taxons affected : numerical analysis, information processing

After practice performance ability decays: *Power law of forgetting*

$$p = d + et^{-f}$$

- p is performance (RT or errors)
- d is performance after learning
- e > 0 is a scaling parameter
- *t* is time since practice stopped
- -1 < f < 0 is the rate of forgetting

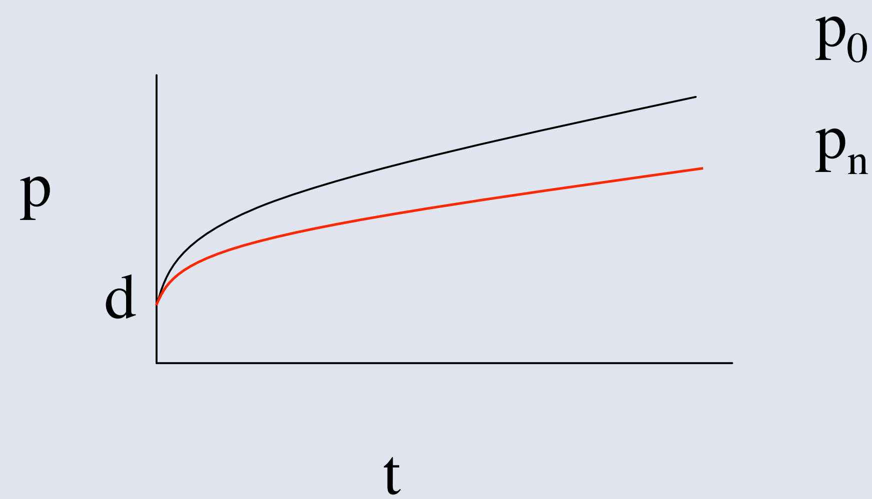


IMPRINT task taxons affected: numerical analysis, information processing, fine motor discrete, fine motor continuous, gross motor - light

Testing during practice retards forgetting of declarative knowledge

$$p_n = d + et^{-fg(n)}$$

- p_n is performance after n tests
- d is performance level after practice
- $e > 0$ is a scaling parameter.
- t is time since learning
- $-1 < f < 0$ is the rate of forgetting
- $0 < g < 1$ is the rate change attributable to repeated testing (a function of the number of tests administered)



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Future work

- *Verify, refine, and expand our current set of performance shaping functions.*
  - Test functions using data from other tasks.
  - Define ranges of application in terms of taxons.
  - Quantify additional principles.
- *Transition work could help determine forms and parameter values for these functions to be used in IMPRINT.*
  - It would be possible to find values for other cells in the taxonomic planning matrix with further research, including meta-analysis.
  - Development of performance-shaping functions and the taxonomic analysis feed into each other.

End

Contextual interference

- ***Contextual interference retards learning…***

$$p_c = ap_t$$

  - p_c is performance during training under contextual interference
  - $a > 1$ is the magnitude of the interference effect at training
  - p_t is performance during training under no interference conditions

- ***but improves long-term retention***

$$p_{c'} = bp_{t'}$$

  - $p_{c'}$ is delayed performance following contextual interference during training
  - $b < 1$ is the magnitude of the interference effect after a delay
  - $p_{t'}$ is delayed performance following no interference conditions during training

Applicable to the following IMPRINT task taxons: numerical analysis, information processing, fine motor discrete, fine motor continuous