A Review of Errorless Learning Strategies in Rehabilitation

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Neuroplasticity:
- Potential of the nervous system to be modified in response to stimulation and activation
- Experience-dependent
- Cortical reorganization

Evidence of Neuroplasticity in Humans

- Cortical reorganization following:
  - Exposure to sensory stimulation (somatosensory)
  - Practice (musicians; London Taxi drivers)
  - Missing or altered sensory input
  - Central lesions
    - Evidence of increased right hemisphere activity in rehabilitation (Crosson et al., Brier et al., 2006)

Recovery in Aphasia still difficult to predict

1. The literature on aphasia recovery and rehabilitation is replete with variability in findings regarding its neural substrates and characterized by disagreements regarding their underlying nature.
2. The variability is real, we need to understand it.


Neuroplasticity: Survivors of brain damage will engage in behaviors

- Rehabilitation or otherwise
- Adaptive or maladaptive
- Identify principles that will maximize the adaptive and compensatory, and minimize the maladaptive

Examine errorless learning strategies

- Language deficits in aphasia thought to benefit from errorless learning because of:
  - Hebbian based learning mechanism
  - Gains in language retrieval (face-name associations) demonstrated in memory impaired population
Errorless Learning Takes Flight

- Errorless learning was first described by Terrace (1963) in a study of animal behavior.
- Terrace taught pigeons to discriminate between a red and a green key using errorless and errorful approaches.

Errorless Learning Takes Flight

- The pigeons that received errorless learning discriminated between the keys more accurately than those that received errorful learning.

Errorless strategies


Errorless strategies


Errorless strategies


Errorless strategies

- Spaced Retrieval: increasing delay intervals between trials (Brush & Camp (1998b). Using spaced retrieval as an intervention during speech-language therapy. Clinical Gerontologist. 16(1), 51-64.).
Errorless learning strategies have been applied to a variety of fields with success, including:
- Learning
- Memory
- Aphasia

Learning
- Errorless learning has been found to produce greater learning outcomes than errorful learning in a variety of learning domains, including:

Memory
- Errorless learning strategies have been shown to be effective with individuals with memory impairments
- Through errorless learning, individuals with severe memory impairments have:
  - Acquired new information
  - Learned new skills
  - Formed new associations
- Etiologies of memory impairments studied included:
  - Encephalitis
  - Korsakoff’s syndrome
  - TBI
  - Stroke
  - Dementia
  - Hypoxic brain disease
  - Hydrocephalus
  - Alzheimer’s disease

Errorless learning strategies have been shown to be effective with individuals with memory impairments
- Acquired new information
- Learned new skills
- Formed new associations
**Memory**

- Errorless strategies have been used to instruct individuals with memory impairments in:
  - Word list learning
  - Face-name associations
  - Technological instruction
  - Novel information & associations

**Word List Learning**

- Observed errorless advantage for word list learning in individuals with memory impairments

- Word list learning: learning and recalling lists of 5 words, such as “fly, story, house, bird, give”

**Word List Learning**

- Wilson et al. (1994) was first to study errorless learning in this population

- Errorless procedure of word list learning with cued recall:
  - Participants told NOT to guess
  - “I am thinking of a five letter word beginning with ST and the word is STORY. Write that down.”

- Wilson et al. (1994)
- Errorful procedure of word list learning:
  - “I am thinking of a five letter word beginning with ST. Guess what that might be.”
  - Correct answer revealed after 25 seconds or 4 incorrect answers
  - If target word guessed, substitute word used to ensure at least one error

**Word List Learning**

- Wilson et al. (1994)
- Conclusions:
  - Participants benefited significantly more from errorless learning than errorful learning
  - Demonstrated in cued recall of word lists
    - Cued recall: recall task where cues are given
  - Errorless Advantage for word list learning in individuals with severe memory impairments

- Hunkin, Squires, Parkin & Tidy (1998) confirmed Wilson et al.’s findings
  - Both Wilson et al. (1994) and Hunkin and colleagues reported an errorless advantage for cued recall (with cues) of learned word lists
  - Hunkin et al. also reported an errorless advantage for free recall (without cues)
<table>
<thead>
<tr>
<th>Word List Learning</th>
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<tr>
<td>Hunkin Squires, Parkin &amp; Tidy (1998) also extended Wilson et al’s (1994) findings by testing delayed recall</td>
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<tr>
<td>Hunkin et al. found that the errorless advantage was maintained across a 48 hour delay</td>
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<td>However, there was a significant decrease in errorless performance accuracy</td>
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<thead>
<tr>
<th>Face Name Associations</th>
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<tr>
<td>Reported errorless advantage for face name association learning in individuals with memory impairments</td>
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<td>Individual results vary</td>
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<td>A very functional task for individuals with memory impairments</td>
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<tr>
<td>Some reported errorless advantage for Cued Recall</td>
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<td>Reported by Kalla, Downes, &amp; van den Broek (2001). The pre-exposure technique: enhancing the effects of errorless learning</td>
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<tr>
<td>Some reported errorless advantage for Free Recall</td>
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<tr>
<td>Some reported conflicting results—2 cases with errorless advantage and 1 case without errorless advantage</td>
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<tr>
<th>Face Name Associations</th>
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<tr>
<td>Possible methods to enhance errorless learning of face name associations:</td>
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<tr>
<td>Pre-Exposure technique: intervention in which one factor of a targeted association is presented in advance of the second factor</td>
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<td>Used in combination with errorless learning strategy</td>
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<th>Technological Instruction</th>
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<tr>
<td>Observed errorless advantage in instruction of technology-based skills to individuals with memory impairments</td>
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<tr>
<td>Individual results vary</td>
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<tr>
<td>Technology-based skills include:</td>
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<tr>
<td>Word processing (Hunkin et al., 1998)</td>
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<tr>
<td>Programming electronic memory aid (Evans et al., 2000; Wilson et al., 1994)</td>
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</table>
Technological Instruction


Errorless Learning and the acquisition of word processing skills

Technological Instruction

Hunkin, Squires, Aldrich, & Parkin (1998)

Reported improvement in both instructed and alternative word processing skills following errorless type intervention

Novel Information & Associations


- Errorless Learning was beneficial for learning novel word associations. (Wilson et al., 1994)

- Errorless Learning was beneficial for learning novel information. (Wilson et al., 1994)

- Errorless Learning was beneficial for learning novel word associations. (Squires et al., 1997)

Remote word associations: "salad-cold"

Errorless advantage observed for cued recall not free recall

Conflicting evidence regarding delayed recall

Squires et al. (1997)

Memory Conclusions

Errorless learning strategies facilitated new learning in individuals with memory impairments.

Errorless strategies were beneficial for:

- Word list learning
- Face-name associations
- Technological instruction
- Novel information & associations

Factors that may affect errorless outcomes:

- Type of recall task: cued vs. free recall
- Type of instructional task
- Severity of participant’s memory impairments

(Evans et al., 2000; Wilson et al., 1994)
Aphasia

Researchers have begun to examine errorless learning in individuals with aphasia.

Word Finding

- Most anomia treatments are errorful in nature.
- Some are error reducing in nature.
  - Provision of orthographic or phonologic cues (Fillingham, Sage, & Lambon Ralph, 2005a-c).
  - Semantic Therapy: semantic analysis, not explicit retrieval (Miceli et al., 1996; Nickels & Best, 1996).
- Few anomia treatments are errorless in nature (error eliminating).
- Errorful and errorless strategies had equal likelihood to produce positive outcomes.

Most reported positive outcome using errorless learning for word finding:


Contrasting errorless and errorful strategies:

- Equivalent treatment gains of treatment effects for errorless and errorful strategies (Fillingham, Sage, & Lambon Ralph, 2005a-c; McKissack & Ward, 2007).
- Equivalent maintenance for errorless and errorful strategies (Fillingham, Sage, Lambon Ralph, 2005a-c).
Word Finding

- Influence of feedback:
  - Errorless learning equivalent to errorful learning with or without feedback (Fillingham et al., 2005)
  - Errorless learning equivalent to errorful learning with feedback (McKissock & Ward, 2007)

- Potential Advantages of errorless learning
  - Some participants preferred errorless learning over errorful (Fillingham, Sage, & Lambon Ralph, 2005a-c)
  - Some errorless methods could be used for home practice (McKissock & Ward, 2007)

Word List Learning

- Spaced retrieval: error reducing technique
- Recall of learned information over progressively longer periods of time

- Spaced retrieval produced better outcomes than traditional cueing hierarchy (Fridriksson et al, 2005)
- Better recall accuracy across sessions
- Fewer sessions required to master objectives
- Pattern of acquisition of information was inconsistent

Treatment of Aphasia and Related Disorders: Subproject 3: Contrasting Treatment for Sentence Production Deficits

- Lynn M. Maher, PI
- Leslie J. Gonzalez Rothi, Co-PI
- NIH: NIDCD P05

Compare errorless learning procedures to errorful learning procedures in treatment of sentence production

- Response to TX
- Differences in learning between the errorless and errorful learning
- Impact of each approach on measures of sentence production
Within Subject Experimental Design

- Each subject serves as own control
- Multiple baselines pre-TX and throughout TX
- Control measure also probed with same frequency as TX probes
- Untreated sentences to measure generalization
- C-statistic to measure change in slope of line over variability of baseline performance
- Group comparisons on treatment response measure
- Group effect sizes

Impact of Error on Treatment of Sentence Production in Non-Fluent aphasia. (Maher et al., in preparation)

- Compared two types of treatment for agrammatism: Mapping TX (Byng, 1988; Schwartz, 1994) to “Traditional” (Shewan and Bandur, 1986) under two delivery methods: Errorless (constant time delay) versus errorful (trial and error with cueing hierarchy) in 2 X 2 crossover design
- 25 participants; all single L CVA with chronic nonfluent aphasia and difficulty with comprehension and production of reversible sentences
- No difference between groups for age, education and MPO
- Crossover design: each subject received two versions of the treatment

Baseline and Probe measures

- 3 sets of 5 pictured reversible verbs: both directions and in both active and passive syntax
  - 1 set TX 1
  - 1set TX 2
  - 1 set untreated
- Daily probes: total 60 sentences (treatment response measure)
- Control task (individualized)
- TX:
  - 8 sessions active sentences
  - 8 sessions passive sentences
  - 4 sessions “Mixed”

Results:

<table>
<thead>
<tr>
<th>TX Order</th>
<th>% gain in accuracy</th>
<th>Treatment Type</th>
<th>% gain in accuracy</th>
<th>Effect size</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>33.42</td>
<td>Errorless</td>
<td>40.11</td>
<td>1.42</td>
</tr>
<tr>
<td>2</td>
<td>20.18</td>
<td>Errorless</td>
<td>31.05</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>20.07</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mapping</td>
<td>20.24</td>
<td>.90</td>
</tr>
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Significant order effect: p = .03
Trend (p = .09) for significant difference between groups

Impact of Error on Treatment of Sentence Production in Non-Fluent aphasia. (Maher et al., in preparation)

In this case, the errorless strategy did seem to have an advantage for generating active and passive reversible sentences, although all groups demonstrated progress

Individual differences: individual preferences
Summary

- Errorless strategies were advantageous for learning across a variety of fields
- Errorless strategies were advantageous for memory rehabilitation
- Benefit of errorless strategies for aphasia rehabilitation is not yet well defined

Summary

- Errorless word finding strategies produced results equivalent to errorful strategies
- Some pragmatic advantages of errorless strategies
- Error reducing (spaced retrieval) word list learning strategy produced better results than errorful

Summary

- Errorless sentence production strategies produced larger effect sizes than errorful sentence production strategies

Summary

- Further research is needed to clarify the effects of errorless learning in aphasia rehabilitation
- Errorless learning strategies are a viable alternative to more commonly used errorful techniques
- Consider implementing errorless techniques in rehabilitation practice