GENERAL OUTLINE

Understanding models of language processing and verbal short-term memory, as well as mechanisms of generalization so as to maximize anomia treatment outcomes.

> Part A
  – Language Models
  – Mechanisms Of Generalization

> Part B
  – Verbal Short Term Memory
  – Application To Language Assessment And Treatment

Part A: OUTLINE

> Language Recovery after Stroke
> Ultimate Goal of Aphasia Therapy
> Language Models
> Engaging Mechanisms of Generalization
  – Semantic Feature Analysis
  – Verb Network Strengthening Treatment
  – Phonomotor Treatment
Anomia therapy: The “Bigger” Picture
Wisenburn & Mahoney (2009)

Trained items:
– Large gains across different treatment types
– Similar at 3 months post

Untrained items:
– Minimal gain immediately post-treatment
– Limited to semantically related words
– Sharp decline after 3 months
– Semantic therapy appeared to be more likely to show generalization (Nickels & Best, 1996a)

Ultimate Goal of Anomia Therapy

> Rehabilitative success = Ability to flexibly communicate regardless of context
  – Generalization to untreated words
  – Generalization to daily verbal communicative contexts

How do we achieve broad generalization?
OUTLINE

> Language Recovery after Stroke
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Two considerations:

1) REPRESENTATIONS
   – Storage

2) PROCESSES
   – Access/Activation

Wernicke-Lichtheim (WL) model

“Box and arrow” or “Localist” model

> Representations -- stored in specific places
> Processes -- ??
Distributed models of language and aphasia

“Connectionist” or “Network” models

> Units are connected in interactive networks
> Processing -- spreading or simultaneous activation
> Learning involves modifying connection weights

Neural support for distributed models

> Unique and overlapping networks for sentence/syntactic, semantic, phonological processing.

Distributed models

2 basic types of connectionist models:

> Interactive activation
> Parallel distributed processing (PDP)
Interactive activation model (Dell, 1986 & 1997)

Nodes

Features

"dog"

Words

Sounds
Dell's Interactive Activation Model

- **Representation** – "Nodes"
- **Process** – Interactive spreading activation
- Processing is cascading and interactive
- Aphasia results from deficits
  - in representation integrity
  - activation transmission
- Learning = changes in the strength of connections

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Parallel Distributed Processing Model (PDP)

(Nadeau, 2001 & 2012)

- **Representation** – Emergent from network processing
- **Process** – Co-activation of massively interconnected networks
- Aphasia – Due to impaired co-activation of networks
- Neurons are processing units
- Processing is massively parallel
OUTLINE

> Language Recovery after Stroke
> Ultimate Goal of Aphasia Therapy
> Language Models
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Types of Generalization

Generalization to untreated words
- Substrate Mediated
  - Intrinsic
  - Extrinsic

Generalization to social situations
- Contextual
  - Cross Function

(Nadeau, 2014)
1. Substrate Mediated Generalization

Developing residual language skills to a critical level in order for generalization to occur from therapy

- Necessary for intrinsic generalization
- Methods:
  - Directly and exhaustively
  - Training of *atypical exemplars* (Thompson, Shapiro, Kiran & Sobecks, 2003)

---

**Penguin**
- Lives in a nest
- Has feathers
- Lays eggs
- Flies
- Sings
- Hangs out in trees

**Sparrow**
- Lives in a nest
- Has feathers
- Lays eggs
- Flies
- Sings
- Hangs out in trees

**Canary**
- Lives in a nest
- Has feathers
- Lays eggs
- Flies
- Sings
- Hangs out in trees

**Blue Jay**
- Lives in a nest
- Has feathers
- Lays eggs
- Flies
- Sings
- Hangs out in trees

**Zoo**
- Swims
- Eats fish

**Tuxedo**
- Swims
- Eats fish

---

**Antarctic**
- Tuxedo
- Penguin
- Eats fish

---

**Zoo**
- Penguin
- Eats fish

---

**Swims**
- Tuxedo
- Penguin
- Eats fish

---

**Lives in a nest**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Hangs out in trees**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Has feathers**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Lays eggs**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Flies**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Sings**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Hangs out in trees**
- Penguin
- Sparrow
- Canary
- Blue Jay

---

**Eats fish**
- Tuxedo
- Zoo

---

**Tuxedo**
- Swims
- Eats fish
- Zoo

---

**Swims**
- Tuxedo
- Zoo
2. Intrinsic Generalization

Taps into inherent regularities in language – train the underlying components that support all aspects of language processing

> Re-train regularities encoded in language networks
  – Semantic feature knowledge → shared across words
  – Phonologic sequence knowledge → shared across all words
  – NOT relationship between word meaning and form → largely arbitrary
> REFINE network knowledge, not re-establish

3. Extrinsic Generalization

> Achieved through learning a *technique* to be used during and outside therapy
> Not the content but the acquisition of a therapeutic technique!
  – Continued practice to REBUILD language function

Types of Generalization

Generalization to *untreated words*
- Substrate Mediated
  - Intrinsic
  - Extrinsic

Generalization to *social situations*
- Contextual
- Cross Function

(Nadeau, 2014)
A. Contextual Generalization

- Achieved by applying knowledge learned in therapy to contexts outside of therapy
- Specificity and Salience
- The greater the resemblance, the higher the likelihood of success
  - Spacing effect; distributed practice
  - More opportunities for matching contexts
  - Greater time for consolidation of memory

B. Cross Function Generalization

- Achieved when knowledge is applied to multiple tasks and/or domains

Summary: Types of Generalization

<table>
<thead>
<tr>
<th>Generalization to untreated words</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substrate</strong> Mediated</td>
</tr>
<tr>
<td><strong>Intrinsic</strong></td>
</tr>
<tr>
<td><strong>Extrinsic</strong></td>
</tr>
<tr>
<td>Generalization to social situations</td>
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<tr>
<td><strong>Contextual</strong></td>
</tr>
<tr>
<td><strong>Cross Function</strong></td>
</tr>
</tbody>
</table>
OUTLINE

> Language Recovery after Stroke
> Ultimate Goal of Aphasia Therapy
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  – Semantic Feature Analysis
  – Verb Network Strengthening Treatment
  – Phonomotor Treatment

Semantic approaches

> Word-picture matching
> Semantic sorting
> Semantic cuing
> Systematic training of semantic features:
  – Semantic Feature Analysis (SFA)
  – Verb Network Strengthening Treatment (VNeST)

Semantic Feature Analysis (SFA)

<table>
<thead>
<tr>
<th>Group</th>
<th>Use</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Properties</th>
<th>Location</th>
<th>Association</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Coelho, Mckigh & Boyle, 2000)
Language Model?

- Wernicke-Lichtheim model (Box-and-Arrow)
- Dell's Interactive Activation model
- Parallel Distributed Processing model

Semantic Feature Analysis

SFA predictions

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDIATED</td>
<td>+/- (if atypical exemplars used)</td>
</tr>
<tr>
<td>INTRINSIC</td>
<td>+ but limited</td>
</tr>
<tr>
<td>EXTRINSIC</td>
<td>+/- (if self-cueing taught)</td>
</tr>
<tr>
<td>CONTEXTUAL</td>
<td>Varies widely</td>
</tr>
<tr>
<td>CROSS FUNCTION</td>
<td>+/- (if reading/writing done)</td>
</tr>
</tbody>
</table>
SFA findings

- Intrinsically generalizes for untrained items that share some of the featural relationships and within-category (Hashimoto & Frome, 2011; Wambaugh et al., 2013).
- Generalization: Inconsistent measures and wide range.
- Review of SFA studies by Boyle (2010):
  - 16/17 improved on trained nouns.
  - 6/17 showed generalization.
- Repeated exposure or true generalization? (Howard, 2000; Nickels, 2002a & 2002b).

Verb Network Strengthening Treatment (VNeST)

- Step 1: Generate agents & patients.
- Step 2: Read responses aloud.
  - "Dad drive boat.
  - Chauffeur drive limousine.
  - Paramedic drive ambulance.
  - Taxi driver drive taxi.
- Step 3: Expand one schema with ad-questions.
- Step 4: Make semantic judgments about sentences that the clinician reads aloud (N=12).
- Step 5: Produce target verbs independently.
- Step 6: Repeat Step 1 (without clinician cues).

Language Model?

- Wernicke-Lichtheim model (Box-and-Arrow).
- Dell's Interactive Activation model.
- Parallel Distributed Processing model.
Verb Network Strengthening Treatment (VNeST)

VNeST predictions

<table>
<thead>
<tr>
<th>SUBSTRATE</th>
<th>+/- (if atypical exemplars used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDIATED</td>
<td></td>
</tr>
<tr>
<td>INTRINSIC</td>
<td>+</td>
</tr>
<tr>
<td>EXTRINSIC</td>
<td>+</td>
</tr>
</tbody>
</table>

| CONTEXTUAL | ++ Specificity, Salience, Repetition |
| CROSS FUNCTION | +/- (if reading/writing done) |

VNeST findings

> Verb = engages large network of schemas and semantic relationships
> – Broad range of possible subjects/objects
> Edmonds, Mammino, & Ojeda (2014)
> 11 PWA

<table>
<thead>
<tr>
<th>Effect Size</th>
<th>Immediately post (# of PWA)</th>
<th>3 months post (# of PWA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Large</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Phonomotor Treatment (PMT) (Kendall et al., 2008)

Multi-modal articulatory-kinematic approach

> Training phonological sequence knowledge
> Verbal production of all words involve translation of semantic to phonologic
> Parallels language development

---

Phonomotor Treatment (PMT)

Based on the Lindamood Phoneme Sequencing Program (LIPS)

> Stage 1: Oral Awareness Training
  - How articulators move to produce phonemes
  - Use line drawings of mouth and articulators
  - Multisensory approach
    - visual, auditory, oral tactile-kinesthetic
    - provides in-depth perception of phonemes

---

[Image of mouth and articulator movements]
Phonomotor Treatment (PMT)

> Stage 2
  - Simple nonword training
  - train phonological awareness of V, CV, VC, CVC
  - determine the number, order, sameness/differences of phonemes
  - If this says “ep” show me “ef”

> Stage 3
  - Letters

Phonomotor Treatment Manual

Free access from this website:
https://canvas.uw.edu/courses/1166215

or

Access from the UW Aphasia Research Lab website – “For Professionals”:
https://sphsc.washington.edu/research-labs/aphasia-research-lab/professionals

Language model?

W-L IA PDP

Types of generalization?

- Substrate Mediated (Critical Mass)
- Intrinsic (Underlying components)
- Extrinsic (Technique)
- Contextual (Beyond clinic)
- Cross Function (Multiple tasks)
- Extrinsic (Technique)
Parallel Distributed Processing Model (PDP) (Nadeau, 2001 & 2012)

PMT predictions

<table>
<thead>
<tr>
<th>SUBSTRATE MEDIATED</th>
<th>+ Exhaustive (Sounds), Atypical sequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRINSIC</td>
<td>+ Broad</td>
</tr>
<tr>
<td>EXTRINSIC</td>
<td>+</td>
</tr>
<tr>
<td>CONTEXTUAL</td>
<td>+ Repetition</td>
</tr>
<tr>
<td>CROSS FUNCTION</td>
<td>+</td>
</tr>
</tbody>
</table>

PMT findings

> Enabling better use of residual knowledge
> With repertoire of phonologic sequences – continue to learn outside of therapy
  > With both direct and indirect pathways and widespread activation — Hebbian learning
> Kendall, Oelke, Brookshire, & Nadeau (2015)
  > Generalization to untrained items: 23/26
    > Overall effect size small
  > At 3 months post: 13/26 showed further increase
    > Overall effect size remained the same
SUMMARY

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>SFA</th>
<th>VNeST</th>
<th>PMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Mediated</td>
<td>+/-</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>+ (limited)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Extrinsic</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Contextual</td>
<td>Varies</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Cross Function</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
</tr>
</tbody>
</table>

GENERAL OUTLINE

Understanding models of language processing and verbal short-term memory, as well as mechanisms generalization so as to maximize anomaia treatment outcomes.

- Part A
  - Language Models
  - Mechanisms Of Generalization

- Part B
  - Verbal Short Term Memory
  - Application To Language Assessment And Treatment

Using Verbal Short-Term Memory to Maximize Treatment Gains
Where we’re going today
Verbal Short Term Memory
  > Background
  > Models
  > Assessment
  > Treatment

Evidence of Cognitive Deficits
Among stroke survivors assessed in the…
  > Acute phase: 78% of 200 patients had at least one cognitive deficit
  > Sub-Acute phase: 81% of 80 patients
  > Chronic: 72.5% of 80 patients

(Lesniak et al., 2008)
What about aphasia+?

> Increasing evidence for **attentional issues** in aphasia (Hula, McNeil, & Sung, 2007; Crosson, et al 2007)
> Increasing evidence for **executive dysfunction** in aphasia (Chiou & Kennedy, 2009; Mikola, 2010)
> Increasing evidence for **verbal short-term memory impairment** in aphasia (Martin & Reilly, 2012)

**What is Short-Term Memory?**

The ability to maintain representations over short periods of time in the…

> Visual domain
> Spatial Domain
> Linguistic Domain

(Baddeley & Hitch, 1974; Cowan, 1996)

**What is Verbal Short-Term Memory?**

The ability to maintain a linguistic representations over time at the…

> Phonemic level
> Word level
> Phrase level
> Sentence level
Verbal Short-Term Memory vs. Verbal Working Memory

<table>
<thead>
<tr>
<th>Verbal Short-Term Memory</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Maintenance of linguistic representations during processing</td>
<td>&gt; Active manipulation of linguistic representations during processing</td>
</tr>
<tr>
<td>&gt; Example: forward span</td>
<td>&gt; Example: backward span</td>
</tr>
</tbody>
</table>

**Verbal Working**

(Baddeley & Hitch, 1974; Cowan, 1996; Salis, Kelly, & Code, 2015)

“...[T]he content of verbal short-term memory and working memory is language.”

(p. 726, Salis, Kelly, & Code, 2015)

Verbal Short-Term Memory in Aphasia

Evidence for VSTM impairment in...

> Spoken language comprehension
> Spoken language production
> Reading comprehension
What we know so far…

- High prevalence of ≥1 cognitive impairments in stroke survivors (Lesniak et al., 2008)
- Increasing evidence of attentional, executive function, and short-term memory deficits co-occurring with aphasia
- Verbal short-term memory (VSTM) increasingly evident in aphasia (Martin & Reilly, 2012)
- VSTM distinct from visuospatial short-term memory and verbal working memory (Cowan, 1996)

Model Review

Dell’s (Interactive Activation) Model

(Dell, 1986)
Problems with Dell’s Model

Some areas are open to speculation, but specifically,…

… how are representations maintained over time?

Applying VSTM to Dell’s Model

Multi-Representation Storage Hypothesis

In a broken system, …

… connection strength may be weak.
Applying VSTM to Dell’s Model

In a broken system, …

… activation may decay too rapidly.

VSTM in a Broken System

Impairment at the semantic level means…

… over-reliance on phonology to maintain representations

VSTM in a Broken System

Impairment at the phonological level means…

… over-reliance on semantics to maintain representations
What we know so far...

> We know VSTM is impaired in aphasia
> The multi-representation storage hypothesis (MSH) modified Dell’s model to help us think about VSTM in the language system
> According to MSH, anomia is due to...
  > Weak connections between representations
  > Overly rapid decay of activation
> When one level (i.e., semantics, phonology) of the system is impaired, linguistic processing will rely heavily on the unaffected level

Assessment

Assessment of VSTM in Aphasia

Span Tasks
> Recall of increasingly longer strings
> Most popular memory assessment tool
> Process: Forward (VSTM), Backward (VWM)
> Stimuli: Digit, Word, Non-word, Sentence
> Response: Verbal, Pointing, Matching

> Not all span tasks are created equal

Martin & Ayala, 2004; Salis et al., 2015
### Span Tasks
**Memory Processes**

<table>
<thead>
<tr>
<th></th>
<th>Forward</th>
<th>Backward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory</td>
<td>Provides insight into serial order processing, semantic and phonological deficits</td>
<td>Provides insight on ability to manipulate linguistic units</td>
</tr>
</tbody>
</table>

Martin & Ayala, 2004

### Span Tasks
**Stimuli**

<table>
<thead>
<tr>
<th></th>
<th>Digit</th>
<th>Word</th>
<th>Nonword</th>
<th>Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory</td>
<td>Most common span task</td>
<td>More semantic than digits</td>
<td>More phonological than words</td>
<td>Long but meaningful strings</td>
</tr>
</tbody>
</table>

Martin & Ayala, 2004

### Span Tasks
**Responses**

<table>
<thead>
<tr>
<th></th>
<th>Verbal</th>
<th>Pointing</th>
<th>Matching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory</td>
<td>Most common modality</td>
<td>No motor speech confound</td>
<td>No motor speech confound</td>
</tr>
</tbody>
</table>

Martin & Ayala, 2004
Span Tasks
What do span tasks tell us?
> Locus of impairment in moderate-mild cases
  – Semantic vs. Phonologic

<table>
<thead>
<tr>
<th>Effect</th>
<th>Semantic Impairment</th>
<th>Phonologic Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient will recall last words in a string</td>
<td>Patient will recall first words in a string</td>
<td></td>
</tr>
</tbody>
</table>

Example
Stimuli: shoe – ball
Response: ... ball
Stimuli: shoe – ball
Response: shoe...

Span Tasks
What do span tasks tell us?
> Locus of impairment in moderate-mild cases
  – Semantic vs. Phonologic
  – Connection Strength vs. Decay Rate
> Insight into interactions between memory and language
  – Is there evidence of asymmetry between VSTM impairment and language impairment?
  – Influence our choice of cues and strategies
Span Tasks
What’s a clinician to do?
> Use spans that have been standardized:
  – Comprehensive Aphasia Test (CAT)
  – Wechsler Adult Intelligence Scale VI (WAIS-VI)
  – Wechsler Memory Scale VI (WMS-VI)
  – Repeatable Battery for Assessment of Neuropsychological Status (RBANS)
  – Test of Memory and Learning (TOMAL-2)
  – Arizona Battery for Communication Disorders of Dementia (ABCD)

Salis et al., 2015

Span Tasks
What’s a clinician to do?
> Interpret scores on non-aphasia tests with caution
> Spans tasks may not be appropriate for severely aphasic patients
> Select a span task appropriate to:
  – The information you’re trying to gather
  – The skills and impairments of your patient

Martin & Ayala, 2004

Naming and Repetition Tasks
Weak connection strength means a higher proportion of…
> Unrelated semantic paraphasias
  – Target: lion → Response: table
> Neologisms
  – Target: lion → Response: fras
> Omissions or no response
Naming and Repetition Tasks

Overly rapid decay means a higher proportion of...
- Related semantic paraphasias
  - Target: lion → Response: tiger
- Formal (phonological) paraphasias
  - Target: lion → Response: scion

What we know so far...
- We know VSTM is impaired in aphasia
- Anomia is due to...
  - Weak connections between representations
  - Overly rapid decay of activation
- Impaired language system relies on unaffected linguistic level
- Span tasks commonly used to assess memory
  - Use a task that matches patient’s skills and impairments
- Language behaviors can suggest locus of impairment

Application to Treatment
Treatment of VSTM in Aphasia

Evidence to date:
> Mayer & Murray (2002)
> Francis et al. (2003)
> Majerus et al. (2005)
> Vallat et al. (2005)
> Koenig-Bruhin & Studer-Eichenberger (2007)
> Kalinyak-Fliszar et al. (2011)
> Salis (2012)
> Harris et al. (2014)
> Berthier et al. (2014)

VSTM Treatment Paradigms

Treatments that tax VSTM
> Repetition-based
> Focus on maintenance rather than manipulation
  – Delay intervals of 1s, 5s
> Stimuli:
  - Sounds
  - Phrases
  - Sentences
  - Words
  - Nonwords

Treatment Protocols

> Phonomotor Treatment (Kendall et al., 2015)
> Sentence Production Treatment (formerly HELPSS; Helms-Estabrooks & Nicholas, 2000)
> Treatment of Underlying Forms (TUF; Thompson, 2001)
**Treatment Considerations**

What about that semantic/phonological impairment stuff?

> Suspected semantic impairment:
  - Semantic Feature Analysis
  - Verb Network Strengthening Treatment
  - Semantic cueing hierarchy

> Suspected phonologic impairment:
  - Phonomotor Treatment
  - Phonological Component Analysis
  - Phonological cueing hierarchy

---

**Remember!**

Evidence-Based Practice has three components:

Use your judgment and do what makes sense for your patient!

---

**What we know now**

> We know VSTM is impaired in aphasia
> Anomia is due to…
  - Weak connections between representations
  - Overly rapid decay of activation
> Span tasks commonly used to assess memory
  - Use a task that matches patient’s skills and impairments
> Language behaviors can suggest locus of impairment
> Use assessment results to inform treatment
> To tax VSTM, use treatments that:
  - Are repetition-based
  - Focus on maintenance – not manipulation – of stimuli
References


References
Thank You!