Using big data to understand theories of rehabilitation

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Disclosure

Has significant financial interest

- Scientific Advisor for Constant Therapy
- Ownership stock in Constant Therapy
Post stroke aphasia

Achieve functional communication independence
Post stroke aphasia

Learning and experience results in plasticity

More intensive training increases plasticity

Cortical plasticity depends on undamaged tissue

Achieve functional communication independence

Kleim, 2011; Kleim & Jones, 2008
Post stroke aphasia

Learning and experience results in plasticity

More intensive training increases plasticity

Cortical plasticity depends on undamaged tissue

Identify the optimal rehabilitation

Predict the degree of impairment

Predict the degree of improvement

How much therapy is enough?

Achieve functional communication independence

Age
Lesion location
Lesion size/volume
Months post stroke
Education
Severity of impairment
Duration of treatment
Type of treatment

AoA 2015
Figure 1. (a) Naming accuracy on typical, intermediate, and atypical items for the category birds and (b) naming accuracy on atypical, intermediate, and typical items for the category vegetables across baseline, treatment, and follow-up phases for Participant 1.

Kiran & Thompson, 2003, JSLHR
Individual patient analysis

Small cohort analysis

Population analysis
Population analysis

Small cohort analysis

Individual patient analysis
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What do we know about severity?

Initial aphasia severity associated with poorer outcomes; patients with milder aphasia show greater recovery (Laska et al., 2001; Pederson et al., 2004; Plowman et al., 2011)

Initial severity has a negative effect on outcome of stroke rehabilitation (van Bragt, 2014)
Using technology to improve treatment delivery

- Recent studies have examined the efficacy of rehabilitation techniques, such as videoconferencing, for individuals with hearing, stuttering and motor speech issues (Georgeadis et al., 2004; Hill et al., 2006).

- Other studies have provided aphasia therapy over the internet to individual patients (Goral et al., 2010; 2011).

- Virtual Therapy programs: Sentactics (Thompson, Choy, Cole & Holland, 2010); ORLA-VT; (Cole, Chemey et al).

- Computerized rehabilitation programs:
  - Multicue (Doesborgh, van de Sandt-Koenderman, 2004).
  - MossTalk (Fink et al, 2002).
  - Other computerized methods (Palmer et al., 2012; Rambserger & Marie, 2007).
  - Software platforms such as Constant Therapy (Des Roches et al., 2015).
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  - Software platforms such as Constant Therapy (Des Roches et al., 2015).
Effectiveness of an impairment-based individualized rehabilitation program using an iPad-based software platform

Carrie A. Des Roches, Isabel Balachandran, Elsa M. Ascenso, Yorgos Tripodis and Swathi Kiran

The delivery of tablet-based rehabilitation for individuals with post-stroke aphasia is relatively new, therefore, this study examined the effectiveness of an iPad-based therapy to demonstrate improvement in specific therapy tasks and how the tasks affect overall language and cognitive skills. Fifty-one individuals with aphasia due to a stroke or traumatic brain injury (TBI) were recruited to use an iPad-based software platform, Constant Therapy, for a 10 week therapy program. Participants were split into an experimental (N=41) and control (N=9) group. Both experimental and control participants received a 1 h clinic session with a clinician once a week, the experimental participants additionally practiced the therapy at home. Participants did not differ in the duration of the therapy and both groups of participants showed improvement over time in the tasks used for
• 51 patients with stroke or TBI
• 42 experimental patients and 9 control patients
• Both groups matched for WAB AQ, CLQT composite severity and age
• Both groups practiced Constant Therapy on their ipads.
Assess baseline performance

• Language and cognitive skills

Assign individualized set of tasks

Task assigned if accuracy less than 80% on first session

Des Roches et al., 2015
Assess baseline performance

- Language and cognitive skills

Assign individualized set of tasks

Patient performs tasks

Experimental patients in clinic and home
Control patients in clinic only

Des Roches et al., 2015
Assess baseline performance

Assign individualized set of tasks

Patient performs tasks

Clinician monitors progress and alters plan

- Language and cognitive skills
- Experimental patients in clinic and home
- Control patients in clinic only

Des Roches et al., 2015
Weekly clinic sessions

- Keep the task or modify the task
- If the participant achieved 95% or higher accuracy two times in succession,
  - The clinician would either progress the next level of difficulty or different task.
- If a participant was not improving on a task over time,
  - Either a lower level of that task was assigned in addition to or in replacement of the original task,
  - A different task examining the same skill,
  - No change.

Des Roches et al., 2015
Individual patient level analysis

Des Roches et al., 2015
Overall, experimental participants show beneficial and significant change.

Overall, experimental participants show non-beneficial but significant change.
light blue: participants with a lower score than average show more improvement in the task.

Participants with a higher than average WAB AQ score show more improvement in accuracy.

dark blue: participants with a higher score than average show more improvement in the task.
<table>
<thead>
<tr>
<th>Domain</th>
<th>Task</th>
<th>Accuracy</th>
<th>Latency</th>
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<td>Passive Sentence Completion</td>
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Des Roches et al., 2015
Experimental patients show more significant changes on standardized tests than control patients.

Patients with lower initial scores showed more improvements on the standardized tests than patients with higher initial scores.

Des Roches et al., 2015
What can we understand about severity?

The more severely language-impaired participants tended to benefit from the simpler tasks (e.g., category matching) that were assigned.

The less severely language-impaired participants benefit from more difficult tasks and those that combined language and cognitive skills.

Patients with lower initial scores showed more improvements than patients with higher initial scores.

Possible to better tailor treatment based on starting level severity of impairment across a group of patients.
Not only can examine quantitative measures that we are used to looking such as accuracy and latency.

We can even begin to look at more qualitative metrics such as scaffolds.

Quantify the way patients interact with therapy.
Follow up- Study #2

- Examined individual differences in the way patients used cues to solve the tasks.
- 51 individuals with aphasia,
- 10 week therapy program using the Constant Therapy software platform,
- Participants could self-administer hints (available in 28 of the 37 tasks).

Des Roches et al., in preparation
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What is the relationship between accuracy and hint use?

- First, a simple regression of the count of all hints self-administered within a session and average accuracy within the session for all participants
  - Hint use had a significant negative predictive relationship with accuracy.
  - K-means cluster analysis for sample participants.

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Des Roches et al., in preparation
What is the relationship between accuracy and hint use?

Patients form five subgroups in terms of whether increased hint use is associated with increased accuracy.

Des Roches et al., in preparation
Are participants’ severity profiles related to frequency of self-administered hint use?

- Pearson correlation of frequency of hint use with all standardized test scores and demographic information,
- All severity measures negatively correlated with frequency of hint use,
- The more severe the participant, the more frequently they used hints.

Des Roches et al., in preparation
Combining severity and frequency of hint use

Overall accuracy on task ranged between 75%-85%

These participants used hints infrequently and had the highest scores on most of the standardized measures.

Des Roches et al., in preparation
Combining severity and frequency of hint use

Low but beneficial hint use

Des Roches et al., in preparation
Combining severity and frequency of hint use

High but non-beneficial hint use

Des Roches et al., in preparation
Des Roches et al., in preparation
What does this tell us about severity?

The more severe patients (based on the standardized tests) also used hints more frequently, but this higher hint use was not beneficial.

The less severe patients (based on the standardized tests) used hints less frequently, but this hint use was beneficial for them.

Has implications for the way self-administered hints or clinician-generated cues may help or hinder patients during rehabilitation.
How can big data inform clinical decision making?

**Scientific Advisor and Ownership stock for Constant Therapy**
Approach for CT data

- Patients download the app and sign up for an account.
- Based on an initial baseline assessment, a given task is assigned as long as its performance is between 40% and 90% accuracy and average latency.
- For the analysis, for given task type and level:
  - Compared post-tx performance (Average of the last 10 items for each patient) - pre-treatment performance (average of the first 10 items for each patient).
  - Drop the first three items of a given task.
- Paired t-test (two tailed) per task; Only consider $p < .05$ as statistically significant changes.
- Same analysis for accuracy and latency.
Less than 90% accuracy
Less than 80% accuracy
Latency gain in percentage

Less than 70% accuracy
Less than 60% accuracy
Less than 50% accuracy
Latency gain in percentage

Less than 40% accuracy
What does this tell us about severity?
What does this tell us about severity?

Worse starting performance does not indicate poorer outcomes.

Moderate-severely impaired patients can make strong gains in treatment.

Implications for providing therapy services for the more severe-impaired patients.
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Therapy

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Therapy Outcomes
Population analysis

Small cohort analysis

Individual patient analysis
Future Direction

- We are really only at the beginning of accessing big data.
- Lot more work needs to be done.
- But we have the tools to examine and understand the factors that contribute to rehabilitation outcomes.
- Future work examine different types of control conditions.
- Relationship between symptomatology and treatment gains.
Thank you

- Research papers were funded by the Coulter Foundation for Translational Research.
- Thanks to Elsa Ascenzo, Isabel Balachandran, Stephanie Keffer, Sahil Luthra, and Anna Kasdan for their contributions to the project and for their assistance in data collection.
- Everyone in the APHASIA LAB
- Mahendra Advani - Constant Therapy
Individualized treatment assignment and analysis

Des Roches et al., 2015, Frontiers in Human Neuroscience