


BOSTON UNIVERSITY ISHA 2016 

Using Big-Data to Drive Effective Clinical Decision Making in Aphasia

Swathi Kiran, PhD, CCC-SLP
 Professor, Speech Language and Hearing Sciences
 Boston University

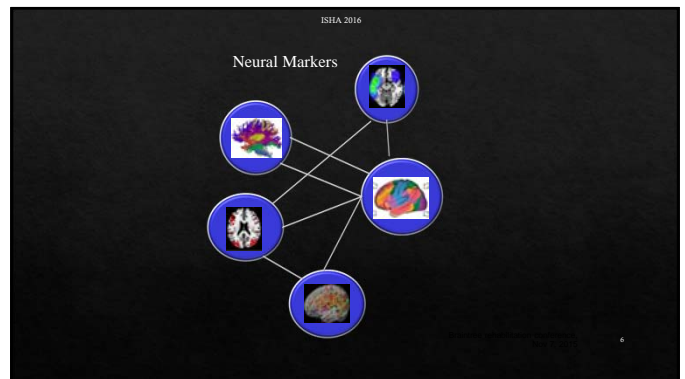
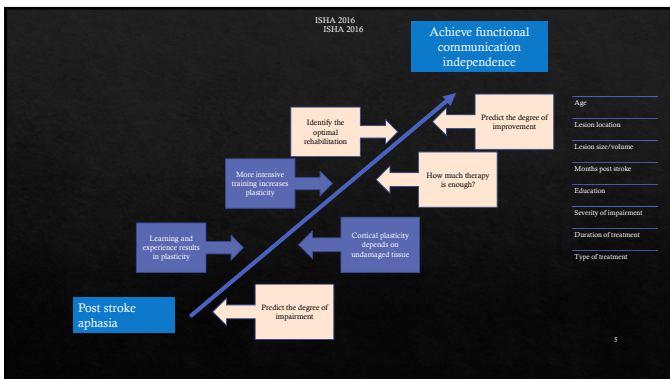
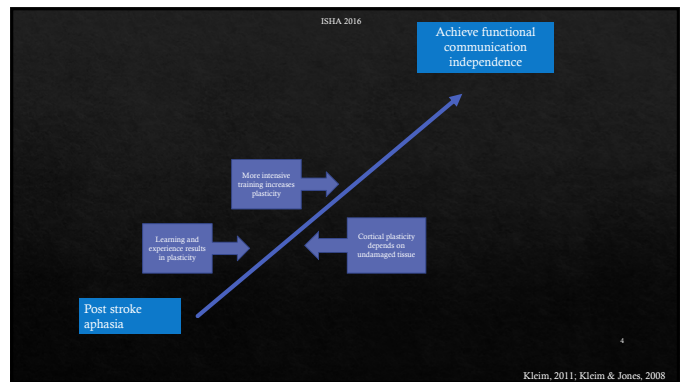
* Kiran (2016). How does severity of aphasia influence individual responsiveness to rehabilitation: Using big data to understand theories of aphasia rehabilitation, *Seminars in Speech and Language*, 37; 1-14

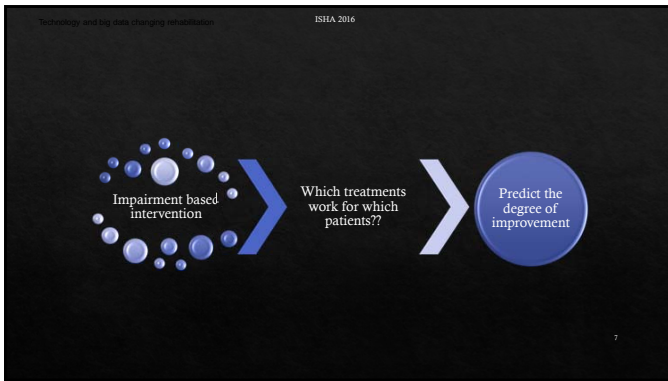
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Disclosure

- Has significant financial interest
 - Scientific Advisor for Constant Therapy
 - Ownership stock in Constant Therapy

2





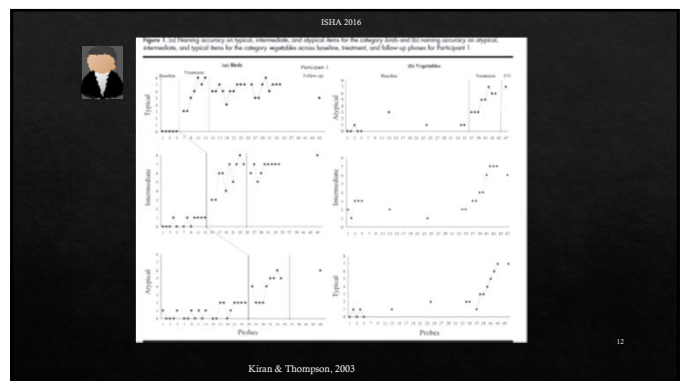
- ISHA 2016
- Review studies of rehabilitation outcomes in individuals with chronic aphasia report that therapy is indeed effective for these individuals
 - Allen L, Mutha S, McCune JA, Teasell R. Therapeutic interventions for aphasia initiated more than six months post stroke: a review of the evidence. *Top Stroke Rehabil*. 2012;19(6):529-535. Teasell R, Mutha S, Peters S, et al. Time to rethink long-term rehabilitation management of stroke patients. *Top Stroke Rehabil*. 2012;19(6):457-462.
 - More intense therapy for patients results in greater outcomes in acute and chronic aphasic patients
 - ICAP aphasia
 - Perad, C., Wronick, L., & Kostopoulos, E. (2013). Retrospective analysis of outcomes from two intensive comprehensive aphasia programs. *Topics in Stroke Rehabilitation*, 20(5), 385-397. doi:10.1177/1078200213505289
 - Very early aphasia therapy in acute aphasia
 - Galetzki, B., Rai, T., Ciccone, N., Amthang, S., Granger, A., & Henley, G. J. (2013). Amount of therapy matters in very early aphasia rehabilitation after stroke: a clinical prognostic model. *Semin Speech Lang*, 34(3), 129-141. doi:10.1055/s-0033-1308369
 - Systematic review of constrained induced aphasia therapy
 - Cherney LR, Patterson JP, Roymer A, Frymark T, Schooling T. Evidence-based systematic review effects of intensity of treatment and constraint reduce language therapy for individuals with stroke-induced aphasia. *J Speech Lang Hear Res* 2008;51(5):1282-1299
 - Systematic review of aphasia therapy studies
 - Bhogal SK, Teasell R, Speechley M. Intensity of aphasia therapy: impact on recovery. *Stroke* 2003; 34(4):987-993.

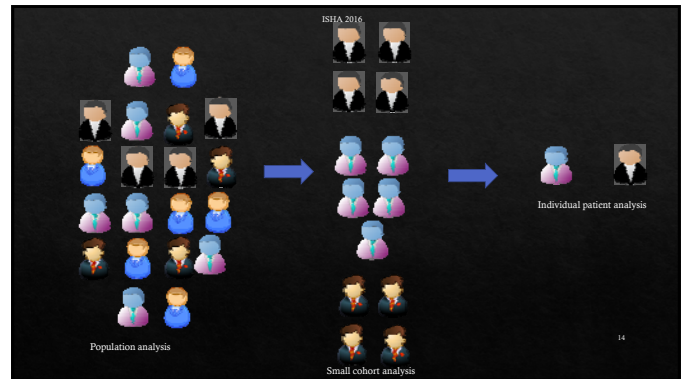
- ISHA 2016
- A recent influential study (ACTNOW) suggested that rehabilitation was no more effective in promoting change on the measured outcomes than everyday communication with hospital volunteers in acute stroke survivors
 - A best-practice, flexible intervention by NHS SL therapists, up to three contacts per week for up to 16 weeks compared with a similar number of AC contacts by employed visitors
 - There was no evidence, on any measure, of added benefit of early communication therapy beyond that from AC.
 - Functional communication improved for both groups
 - Bowen, A., Hesketh, A., Patchick, E., Young, A., Davies, L., Vall, A., ... Tyrrell, P. (2012). Clinical effectiveness, cost-effectiveness and service users' perceptions of early, well-resourced communication therapy following a stroke: a randomised controlled trial (the ACT Now Study). *Health technology assessment*, 14(26), 1-160. doi:10.3310/hta14260
 - A Cochrane review of randomized control trials in aphasia have been less favorable. Some promising evidence but not strong outcomes.
 - Brady, M. C., Kelly, H., Godwin, J., & Enderby, P. (2012). Speech and language therapy for aphasia following stroke. *The Cochrane database of systematic reviews*, 5, CD000425. doi:10.1002/14618583.CD000425.pub3

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Question # 1: What do you think about the effectiveness of aphasia rehabilitation

- Always effective
- Mostly effective but depends on intensity
- May be effective with intense therapy
- Not convinced its effective





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Using technology to improve treatment delivery

- Main advantage is to provide therapy to people who cannot travel to obtain rehabilitation services.
- Speech language pathology services are particularly suited to telerehabilitation due to the emphasis on auditory/visual interaction
- Thus far, videoconferencing services between client and clinician for audiology, stuttering, and motor speech have been reported (Georgeadis et al., 2004; Hill et al., 2006)
- Several centers set up for providing aphasia therapy over the internet (City University, London, University of North Carolina, Greensboro).

15

ISHA 2016

- ◆ Computer programs also provide an opportunity for patients to practice more intensely and consistently than what is typical in weekly/biweekly visits to a clinical location.
- ◆ Swales QJ 4 MA, Hill AJ, Finch E. Feature rich, but user-friendly: speech pathologists' preferences for computer-based aphasia therapy. *Int J Speech Lang Pathol* 2015;1-14
- ◆ "As more and better software programs for the delivery of therapy are developed, there is the possibility to achieve the intensive levels of stimulation and practice necessary to trigger reorganization of neuronal assemblies."
- ◆ "In particular, if programs can be devised that allow users under the guidance of clinicians to self-administer the therapy, then limitations of therapists and therapy time can be circumvented."

Varley R. Rethinking aphasia therapy: a neuroscience perspective. *Int J Speech-Language Pathol* 2011;13(1):1-20

16

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- ◆ "The role of the clinician will then shift to one of an advisor and orchestrator of the rehabilitation process.
- ◆ Based on careful diagnostics at all three levels of aphasia rehabilitation, the clinician can choose which treatment approach is needed and offer relevant treatment programs that enable the client to work on his or her own rehabilitation, independently and at his or her own pace."
- ◆ Niekke E. Van de Sandt-Koenderman. Aphasia rehabilitation and the role of computer technology: Can we keep up with modern times? *International Journal of Speech-Language Pathology*, February 2011, Vol. 13, No. 1 - Pages 2-7

17

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Question #2: What are the advantages and disadvantages of technological applications in aphasia therapy

Advantages??

Disadvantages?

18

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Current technological applications

Virtual therapists

Single function computer programs

Multifunctional programs

19

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Sentaci cs: Virtual Therapist

Sentaci cs is a computer-automated program that trains patients in comprehension and production of complex sentences based on TUF

"Sabrina," an automated clinician, presents the patient with stimuli and gives feedback about the patient's performance

Thompson CK, Chay JJ, Holland A, Cole R. Sentaci(R): Computer-Automated Treatment of Underlying Forms. *Aphasiology*. 2010;24(10):1242-1266.

20

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ORLA with Virtual Therapist (ORLA-VT)

(a) Treatment: Sentence practice.

(b) Treatment: User data log.

(c) Authoring: Sentence design.

(d) Authoring: Sentence recording.

Cherny LR. Oral reading for language in aphasia (ORLA): evaluating the efficacy of computer-delivered therapy in chronic nonfluent aphasia. *Top Stroke Rehabil*. 2010; 17(6):423-431.

21

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Computerized Brain Rehabilitation Software

- ◆ **Multicue software**
 - ◆ Makes different types of cues (semantic, phonemic, general information) available to patients as they practice word retrieval. Results from 18 patients with aphasia who received Multicue therapist improved on the Boston Naming Test (BNT), but the changes were not significant when compared with the control group. A similar
- ◆ **MossTalk**
 - ◆ Also provides patient initiated cues during word retrieval. This program was shown to be effective in increasing patients' comprehension and lessening word retrieval deficits in aphasic individuals and those who had semantic dementia.

Doesborgh S, van de Sandt-Koenderman M, Dippel D, van Harskamp F, Koudstaal P, Visch-Brink E. Cues on request: The efficacy of Multicue, a computer program for word-retrieval therapy. *Aphasiology*. 2004;18(3):219-222.

Vanmourik M, Vandesandkeenderman WWC. Multicue. *Aphasiology*. 1992;24(2):177-183.

Pink RA, Brecher A, Schwartz M, Robey RR. A computer-implemented protocol for treatment of naming disorders: Evaluation of clinician-guided and partially self-guided instruction. *Aphasiology*. 2002;16(10):1106-1086.

Pink R, Brecher A, Sobel P, Schwartz M. Computer-assisted treatment of word retrieval deficits in aphasia. *Aphasiology*. 2005;19(10):943-954.

Raymer AM, Cohen RP, Staffell D. Computerised training for impairments of word comprehension and retrieval in aphasia. *Aphasiology*. 2005;20(2-4):527-548.

Siebell R, Racion E, Anderson ND. Evidenced learning of computer-generated words in a patient with semantic dementia. *Neuropsychological Rehabilitation*. 2010;20(1):16-41.

22

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Computerized Brain Rehabilitation Software

- ◆ **StepByStep**
 - ◆ Palmer et al found the 15 patients assigned to a computer treatment group showed more improvement on their naming ability than did 13 patients who practiced everyday language activities, including conversation and support groups and reading and writing activities.
- ◆ **Lingraphica**
 - ◆ Structured language therapy to 50 patients in community settings showed improvements on standardized tests such as the WAB and CEIT.
- ◆ **Constant Therapy**
 - ◆ Standardized and individualized treatment for 51 patients using the software showed significant changes on WAB, CLQT, BNT etc

Palmer R, Brantley P, Cooper C, et al. Computer therapy compared with usual care for people with long-standing aphasia poststroke: a pilot randomised controlled trial. *Stroke*. 2012;43(7):1906-1911.

Afonimos L B, Appelbaum J S, & Steele R D. (1999). Improving outcomes for persons with aphasia in advanced community-based treatment programs. *Stroke*, 30(7), 1370-1374.

Des Roches CA, Balachandran I, Ascenso EM, Tripodi Y, Kran S. Effectiveness of an impairment-based individualized rehabilitation program using an iPad-based software platform. *Frontiers in Human Neuroscience*. 2015;8.

23

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Age

Lesion location

Lesion size/volume

Months post stroke

Education

Severity of impairment

Duration of treatment

Type of treatment

Therapy Outcomes

24

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Question #3: What do you think about the influence of severity of aphasia in outcomes

- The more severe, the poorer the outcomes
- The more severe, the better the outcomes
- Severity does not influence outcomes
- I don't know!

25

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- ◆ In patients with acute aphasia, one randomized control trial showed that patients with mild aphasia improved more than patients with severe aphasia.
 - ◆ Laska AC, Kahn J, Hellison A, Murray V, von Aban M. A randomized controlled trial on very early speech and language therapy in acute stroke patients with aphasia. *Cerebrovasc Dis Suppl* 2011; 11(1):6-7.
- ◆ However, Pedersen and colleagues showed that initial aphasia severity predicted language impairment in the chronic stage and was associated with poorer outcomes in the long term.
 - ◆ Pedersen PM, Vinter K, Olsen TS. Aphasia after stroke: type, severity and prognosis. The Copenhagen aphasia study. *Cerebrovasc Dis* 2004;17(1):35-43
- ◆ One large-scale study examined overall stroke outcomes (not specifically language) and found that greater severity predicted a poorer outcome after rehabilitation.
 - ◆ von Bragt PJ, van Gmelen BT, Westendorp I, Hejenbroek-Kol MH, Wijffels MP, Ribbens GM. Predicting outcome in a poststroke stroke rehabilitation programme. *Int J Rehabil Res*. 2014;37(1):11-17.

26

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- ◆ However, another study showed that at even severe patients with aphasia benefited from very early language therapy.
 - Godecke E, Hird K, Lohr EE, Rai T, Phillips MR. Very early post stroke aphasia therapy: a pilot randomized controlled efficacy trial. *Int J Stroke* 2012;7(8):633-44
- ◆ In a meta-analysis, Robey showed that acute patients with severe aphasia show substantial gains after treatment but chronic patients with moderate and severe aphasia also show substantial gains after rehabilitation.
 - Robey RR. A meta-analysis of clinical outcomes in the treatment of aphasia. *Journal of Speech, Language and Hearing Research*. 1998;41(1):172-187.
- ◆ In chronic aphasia, Persad and colleagues reviewed outcomes from rehabilitation centers that provide intensive comprehensive aphasia treatment and found both mild and severe chronic patients with aphasia to benefit from such treatment
 - Persad C, Wazniak L, Katsopoulos E. Retrospective analysis of outcomes from two intensive comprehensive aphasia programs. *Topics in Stroke Rehabilitation*. 2013;20(5):388-397.

27

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Severity??

Population analysis → Small cohort analysis → Individual patient analysis

28

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Study #1

frontiers in Human Neuroscience

Effectiveness of an impairment-based individualized rehabilitation program using an iPad-based software platform

5,079

29

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- 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.

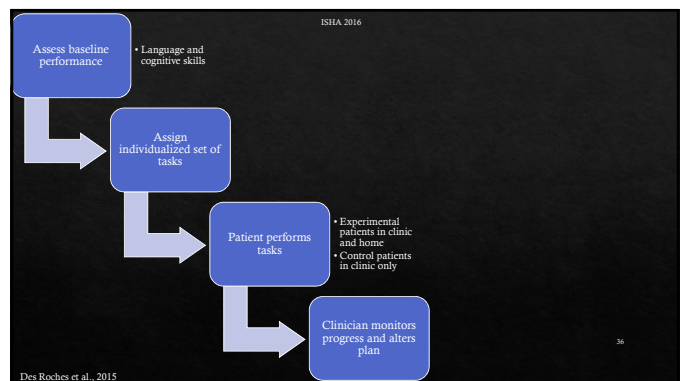
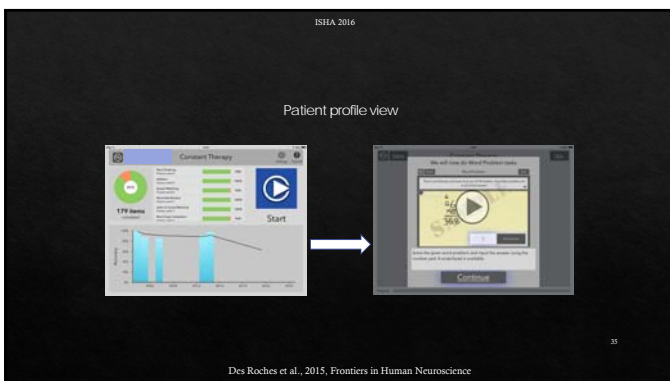
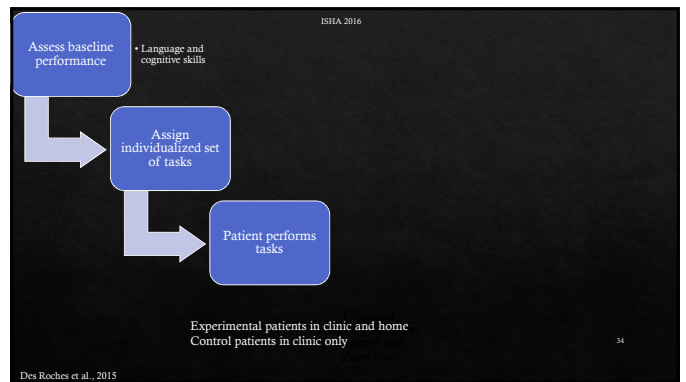
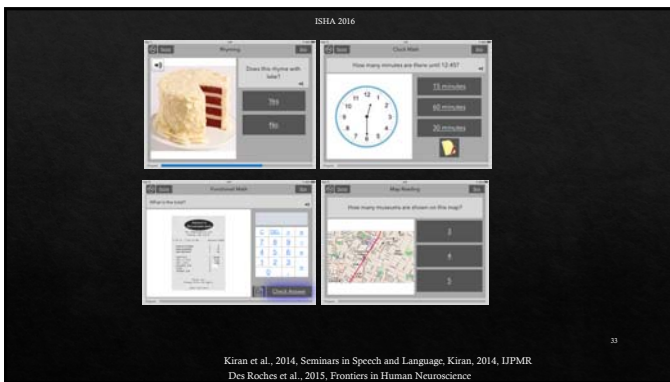
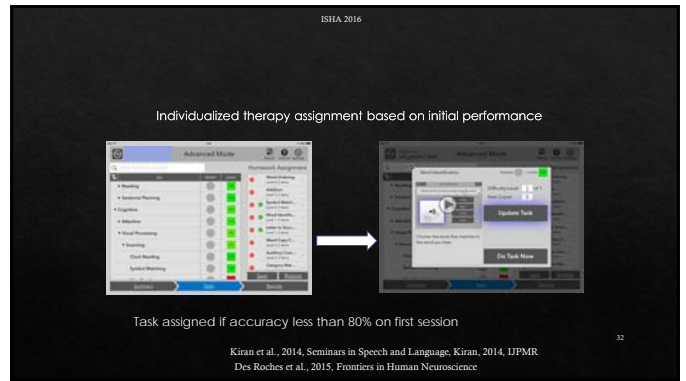
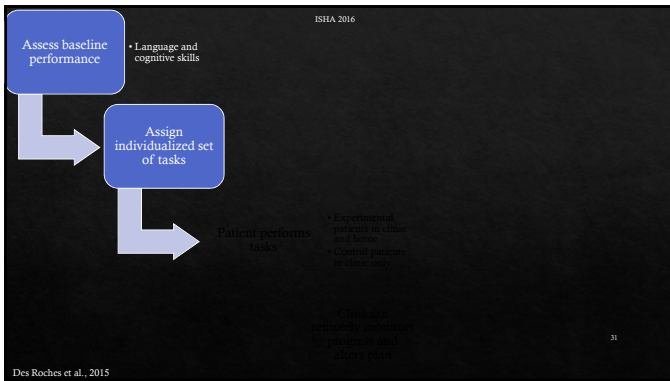
FIGURE 2 | Scatter plot of low vs. high difficulty in B-WAB AQ (x-axis) and CLQT Composite Severity (y-axis) for patients. The dotted lines denote the average B-WAB AQ and average CLQT Composite Severity scores for experimental participants to provide more information for Table 3B.

EXPERIMENTAL PATIENTS (N = 42)

CONTROL PATIENTS (N = 9)

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

30



ISHA 2016

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.

37

Des Roches et al., 2015

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Individual patient level analysis

38

Des Roches et al., 2015

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Domain	Task	DF	Accuracy		Lemons
			Calibrated Improvement	Effect of CLOQ	
Threading	Category Matching	1018			
	Pattern Matching	788			
	Choosing Picture	392			
	Phrasing	1041			
	To-Do List Identification	849			
Reading	Category Identification	771			
	Letter to Sound Matching	293			
	Sound to Letter Matching	896			
	Reading Passage	771			
	Long Reading Comprehension	146			
Writing	Word Identification	842			
	Word Copy	861			
	Word Copy Completion	703			
	Word Spelling	348			
	Picture Spelling	113			
Business Planning	Active Business Completion				
	Passive Business Completion				
Auditory Memory	Visual List	118			
	Sound Matching	403			
Visual Spatial Memory	Pattern Matching	728			
	Word Matching	811			

overall, experimental participants show beneficial and significant change

overall, experimental participants show non-beneficial but significant change

39

Des Roches et al., 2015

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Domain	Task	DF	Accuracy		Lemons
			Calibrated Improvement	Effect of CLOQ	
Threading	Category Matching	1018			
	Pattern Matching	788			
	Choosing Picture	392			
	Phrasing	1041			
	To-Do List Identification	849			
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Business Planning	Active Business Completion				
	Passive Business Completion				
Auditory Memory	Visual List	118			
	Sound Matching	403			
Visual Spatial Memory	Pattern Matching	728			
	Word Matching	811			

participants with a lower score than average show more improvement in the task

participants with a higher score than average show more improvement in the task

participants with a lower than average WAB AD score show more improvement in accuracy

Participants with a higher than average CLOQ score show more improvement in accuracy

40

Des Roches et al., 2015

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Domain	Task	DF	Accuracy		Lemons
			Calibrated Improvement	Effect of CLOQ	
Threading	Category Matching	1018			
	Pattern Matching	788			
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	Passive Business Completion				
Auditory Memory	Visual List	118			
	Sound Matching	403			
Visual Spatial Memory	Pattern Matching	728			
	Word Matching	811			

Experimental patients show more significant changes on standardized tests than control patients.

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

41

Des Roches et al., 2015

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Subtest	Experimental Group (N=41)	Control Group (N=9)
WAB-AD	7.13 (s = 2.05, p < .05)	6.92 (ns)
WAB-CO	2.10 (s = 2.05, p < .05)	1.83 (ns)
WAB-AN	3.18 (s = 2.05, p < .01)	2.89 (ns)
CLOQ-comprehension	3.20 (s = 2.02, p < .01)	4.06 (ns)
CLOQ-fluency	10.9 % (s = 11.83, p < .05)	12.94 (ns)
CLOQ-Phrasing	1.80 (ns)	1.95 (ns)
CLOQ-Business Planning	5.95 (s = 2.71, p < .01)	1.88 (ns)
CLOQ-Language	1.80 (ns)	1.88 (ns)
CLOQ-Visual Spatial	8.80 (s = 3.15, p < .001)	2.88 (ns)

Experimental patients show more significant changes on standardized tests than control patients.

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

42

Des Roches et al., 2015

ISHA 2016

What can we understand about severity?

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

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

Participants with lower language skills and participants with higher cognitive skills had more to gain in accuracy on specific tasks.

Possible to better tailor treatment based on starting level severity of impairment across a group of patients.

43

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Question #4: What do you think about the influence of severity of aphasia in outcomes

- The result is what I expected
- Makes sense, more severe patients have to gain more, but do they need more therapy?
- I really don't think it about severity
- I don't know!

44

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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.

45

ISHA 2016

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

46

ISHA 2016

Hint use and accuracy

- ▶ 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

47

ISHA 2016

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.

Participant ID	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Average Accuracy	41%	43%	41%	100%	44%
Average Hint Use	42	42	14	25	12
Number of Tasks	200	200	0	0	0

Participant ID	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Average Accuracy	67%	65%	70%	71%	72%
Average Hint Use	42	14	25	25	12
Number of Tasks	200	200	0	0	0

Des Roches et al., in preparation

48

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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.

Subgroup	Percentage of Participants
Upward	~24%
Constantly stable upward	~14%
Unchanged	~18%
Constantly stable downward	~24%
Unstable/Downward	~10%

Des Roches et al., in preparation

ISHA 2016

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

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- ▶ Combining severity and frequency of hint use
- ▶ Overall accuracy on task ranges between 75%-85%

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

Test	Accuracy (%)
Average frequency of hint use	~10%
Average WAB (S)	~95%
Average CLQT (S) Comprehension Severity %	~95%
Average BNT %	~85%
Average ASHA FACS CI % (Communication Sub-domain)	~95%

Des Roches et al., in preparation

ISHA 2016

- ▶ Combining severity and frequency of hint use

Low but beneficial hint use

Test	Accuracy (%)
Average frequency of hint use	~15%
Average WAB (S)	~95%
Average CLQT (S) Comprehension Severity %	~95%
Average BNT %	~85%
Average ASHA FACS CI % (Communication Sub-domain)	~95%

Des Roches et al., in preparation

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- ▶ Combining severity and frequency of hint use

High but non-beneficial hint use

Test	Accuracy (%)
Average frequency of hint use	~45%
Average WAB (S)	~95%
Average CLQT (S) Comprehension Severity %	~95%
Average BNT %	~85%
Average ASHA FACS CI % (Communication Sub-domain)	~95%

Des Roches et al., in preparation

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Test	Accuracy (%)
Average frequency of hint use	~45%
Average WAB (S)	~95%
Average CLQT (S) Comprehension Severity %	~95%
Average BNT %	~85%
Average ASHA FACS CI % (Communication Sub-domain)	~95%

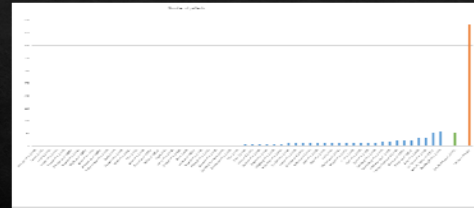
Des Roches et al., in preparation

ISHA 2016
Question #5: What do you think about the influence of self-administered cues on aphasia in outcomes

- Don't cue patients
- Check whether cues help before you allow cues
- Without cues, treatment can be very frustrating!
- I don't know!

55

ISHA 2016
How can big data inform clinical decision making?



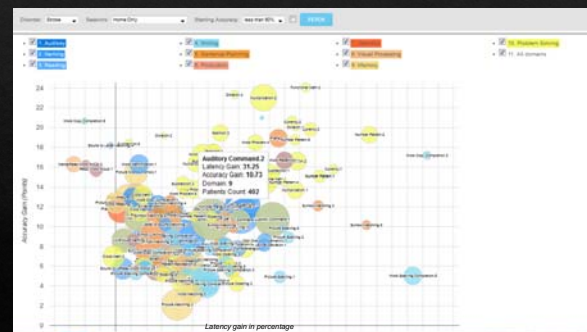
Case-studies, SED → Large data sets

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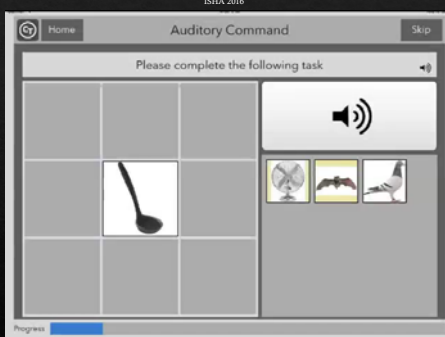
ISHA 2016
Methods & Analysis

- ◆ 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, compared post (Average of the last 10 items of the given task type and level) – pre (average of the first 10 items of the given task type and level).
- ◆ Drop the first three items of a given task.
- ◆ Paired t-test, two tailed; Only consider $p < .05$ as statistically significant changes.
- ◆ Same analysis for accuracy and latency.

57



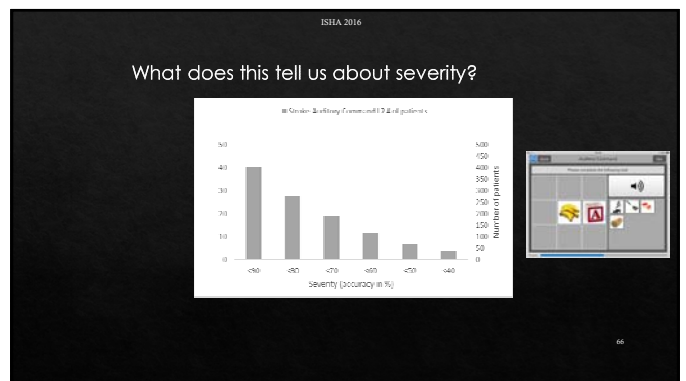
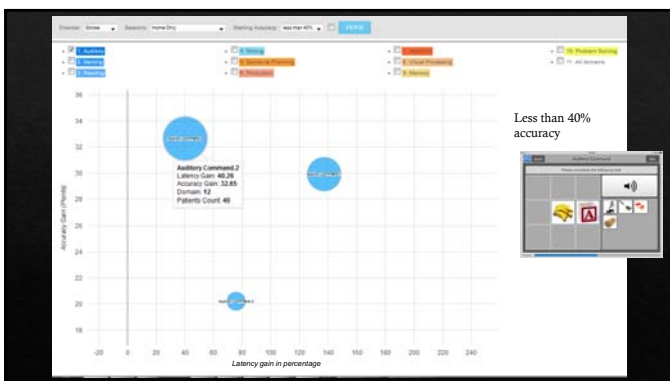
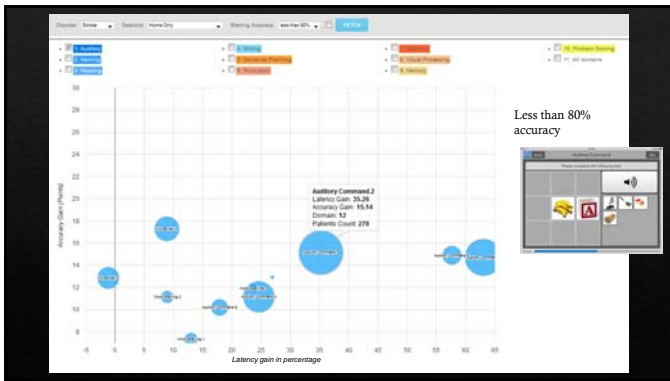
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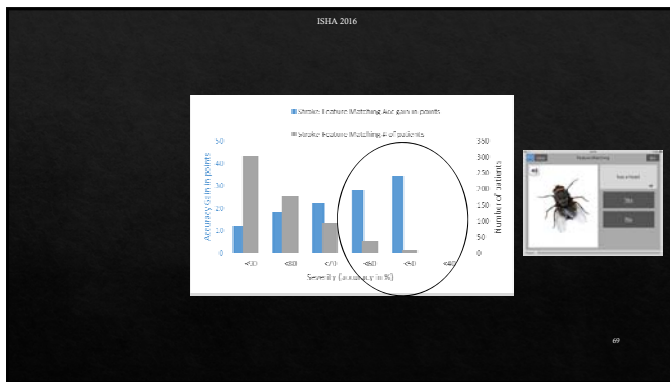
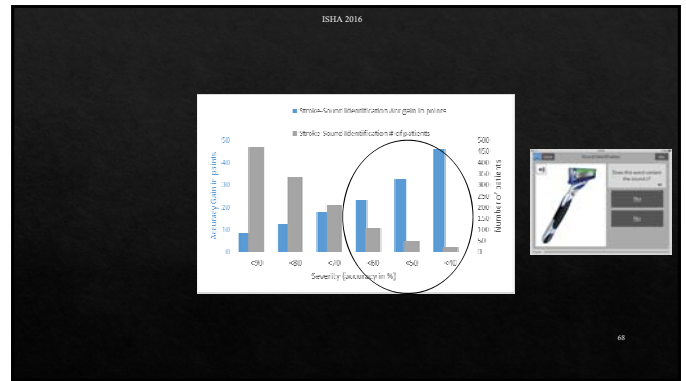
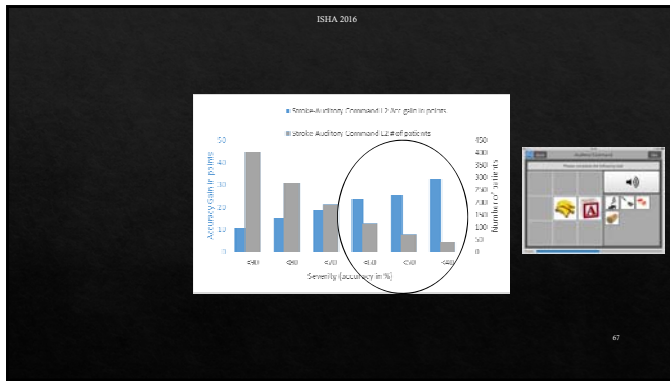


59



Less than 90% accuracy





ISHA 2016

What does this tell us about severity?

Severely impaired patients make strong gains in treatment.

Implications for providing therapy services for severe-impaired patients.

Prognosis is good not just for mildly impaired patients

70

ISHA 2016

Question #6: How does this impact your clinical decision making?

- Don't cue patients
- Check whether cues help before you allow cues
- Without cues, treatment can be very frustrating!
- I don't know!

71



ISHA 2016

Predict treatment outcomes before treatment even begins

ISHA 2016

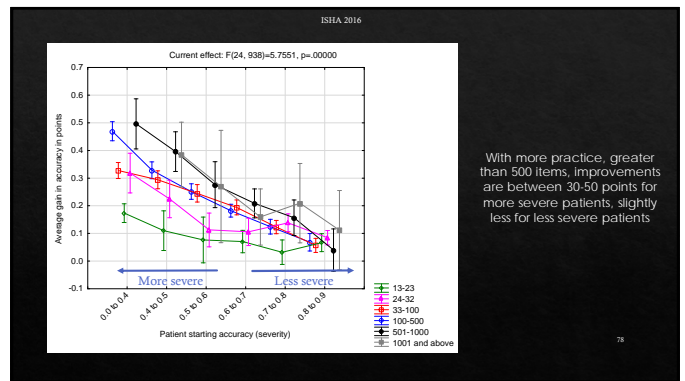
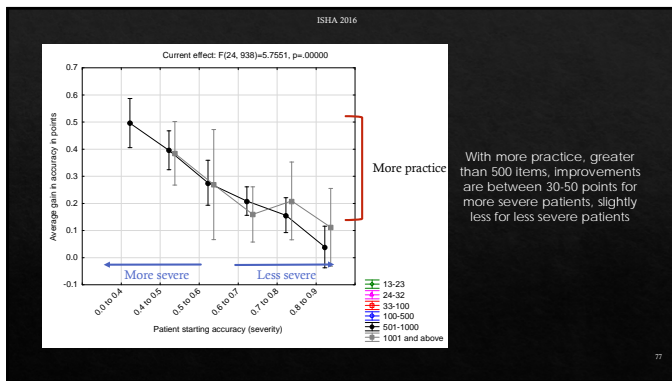
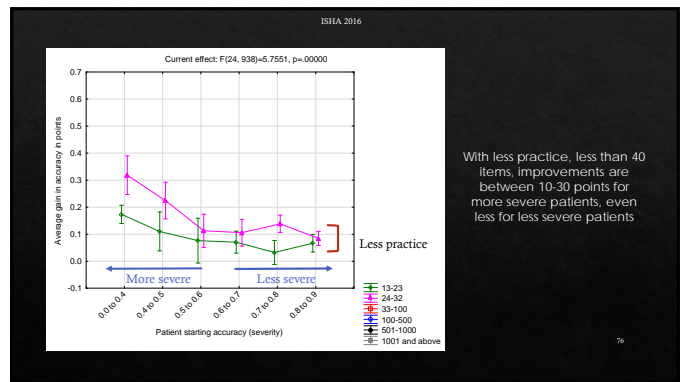
- Age
- Lesion location
- Lesion size/volume
- Months post stroke
- Education
- Severity of impairment
- Duration of treatment
- Type of treatment

→ Therapy Outcomes

ISHA 2016

- Age
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→ Therapy Outcomes



ISHA 2016

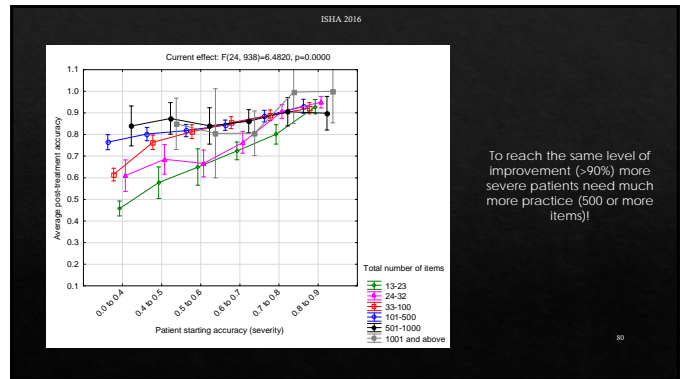
What does this tell us about severity?

The less severely impaired patients show minimal gains with less practice, but more severely impaired patients show some gains with less practice

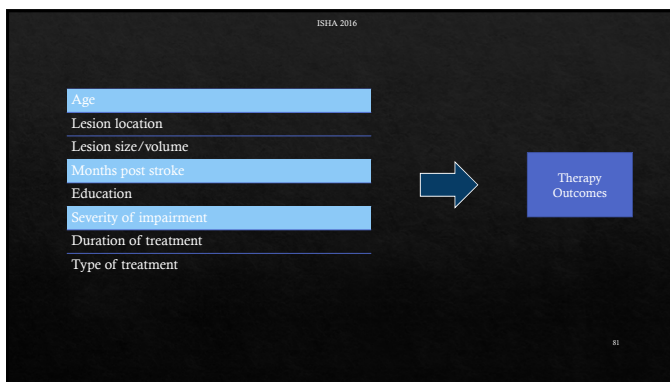
The less severely impaired patients show 10-20 point gains with more practice whereas the more severely impaired patients show 30-50 points gains

More practice is needed for more severe patients to achieve gains

79



To reach the same level of improvement (>90%) more severe patients need much more practice (500 or more items)!



ISHA 2016

~~One size fits all~~ → Standardize and individualize treatment

~~More severe prognosis~~ → More severe patients show more improvements in language therapy

More practice, more improvements → More practice results in 20-50 point gains in trained tasks

→ More severe patients need more practice to reach the same level of improvement as less severe patients

ISHA 2016

So what does this mean clinically?

- ◆ The more we understand about population data, the more we can individualize patient treatment
 - ◆ Based on the study results, an individualized, evidence-based-practice approach results in significant patient gains
- ◆ How could data like this change your clinical decision making?
 - ◆ Development of technology = more data and more scientific clinical decisions

83

ISHA 2016

Thank you

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84