# Learning ability as a predictor of language therapy outcomes

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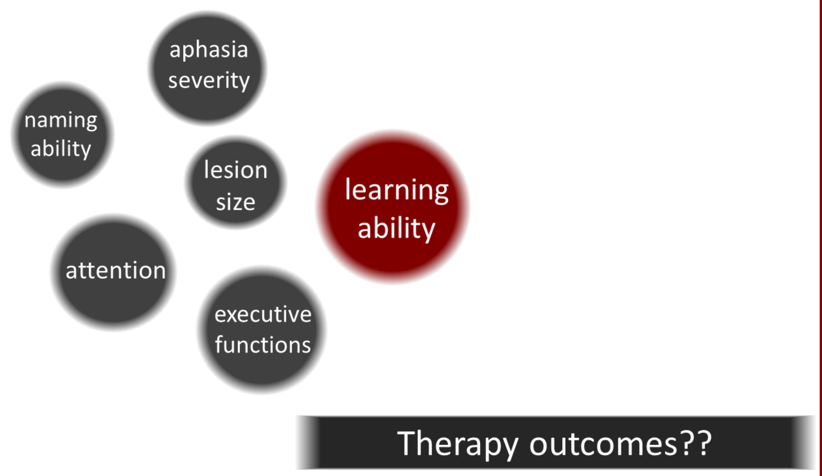
## Introduction




Severity of language impairment and lesion size present important predictors of *spontaneous* recovery in aphasia (Plowman et al., 2012 for review). In the phases of *rehabilitation* however, patients with similar degrees of language impairment show variable responses to treatment (Lambon-Ralph et al., 2010).

**Can a new measure, learning ability, help predict therapy outcomes?**

## Background

For many years the general rehabilitation literature has pointed to cognitive factors as important factors in patient progress with therapy.

- Attentional systems have been identified as important in the top-down processing and gating of incoming information (Robertson & Murray, 1999)
- Skills of abstract reasoning, thinking, verbal memory, comprehension and orientation have been implicated as important skills for learning and functional carry-over of rehabilitation into real life (Galski et al., 1993).

Studies in aphasia have begun to identify a mix of cognitive and linguistic factors as measures correlated with success with therapy (Fillingham et al., 2005; Lambon Ralph et al., 2010).

In the current study, we explore a novel factor and its relationship to rehabilitation outcomes: **learning ability.**

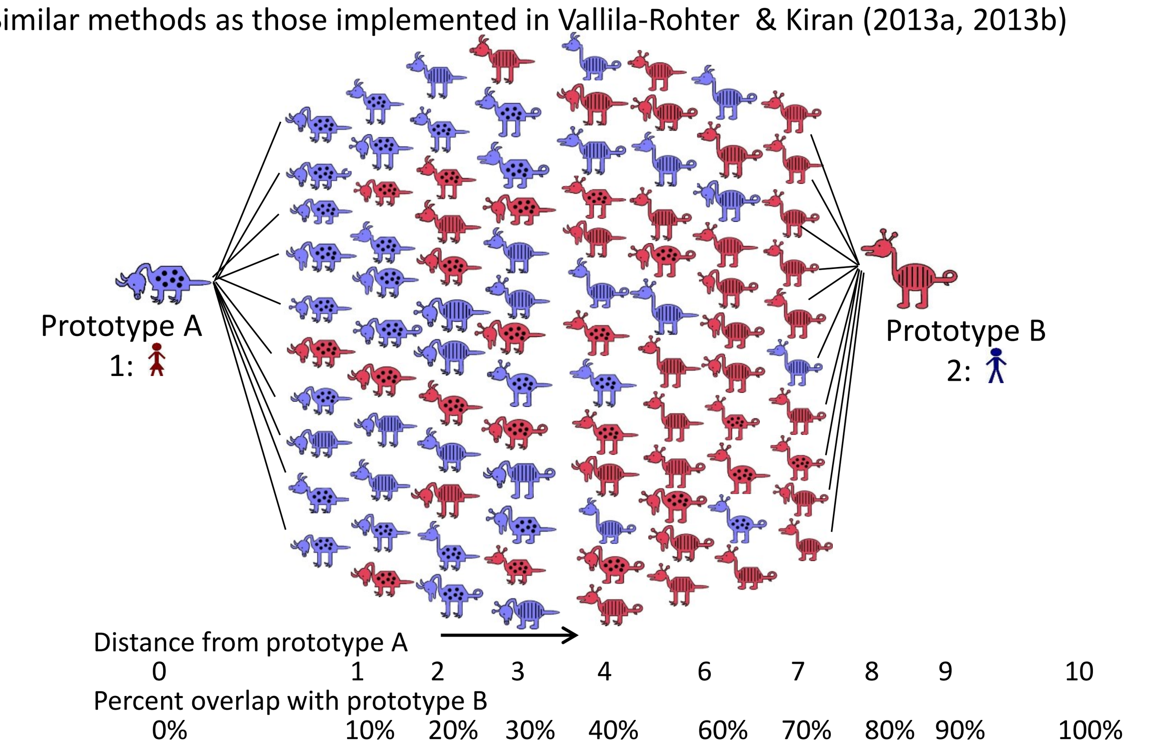
- Recent research has demonstrated that non-linguistic category learning in aphasia is not carried out in a way commensurate with controls (Vallila-Rohter & Kiran, 2013a).
- Furthermore, stimulus characteristics influence degrees of non-linguistic learning in patients with aphasia (Vallila-Rohter & Kiran, 2013b).
- Rehabilitation studies in individuals with Schizophrenia have found an association between measures of *learning potential* and outcomes. Performance on a modified Wisconsin Card Sort Task (WCST) related to performance in rehabilitation and three months post-treatment (Watzke et al., 2008).

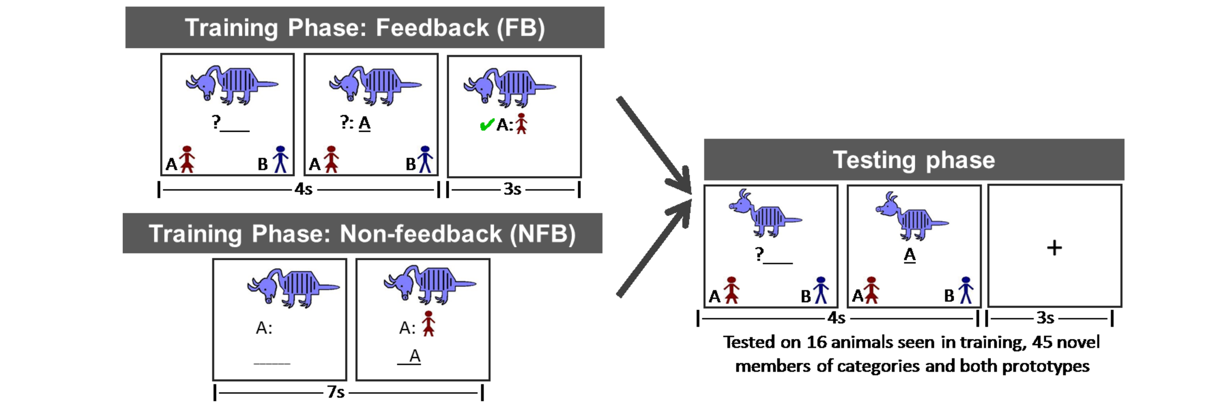
**Could learning ability represent a patient's potential to improve in therapy?**

## Learning Task

**Stimuli:** Cartoon animals with 10 binary dimensions from Zeithamova et al., (2008)
**Paradigm:** Computerized; Training phase followed by a testing phase
**Score of learning assigned to each individual:**

- Scores interpreted as percentage of "B" responses by distance from prototype A
- Ideal learning slope = positive 10
- Similar methods as those implemented in Vallila-Rohter & Kiran (2013a, 2013b)




Trained on 60 animals that differ from prototypes by 1-4 features. Features of each prototype associated 20 – 25 times with their category. Prototypes never trained. Instructed to attend to ALL features.

Tested on 16 animals seen in training, 45 novel members of categories and both prototypes

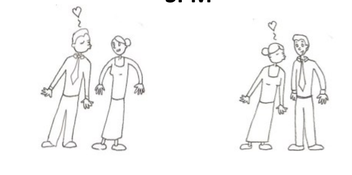
## Therapy Task

**Theoretically guided sentence comprehension treatment (Kiran et al., 2012)**

- Emphasizes thematic role assignment using picture/object cards
- Each individual assigned to a trained sentence type (monitored on multiple sentence types)
- 3 monitoring baselines → Treatment → 3 monitoring baselines
- 10 weeks of treatment or until individual reaches 80% accuracy on consecutive monitors

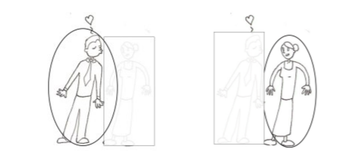
| | | | |
|---|---|---|---|
| **Treatment** | • **2 hour sessions**<br>• **2 times/ week** | **Sentence-to-picture matching (SPM)** | **20 trained sentences** |
| | | Object manipulation (OM) | 20 trained sentences |
| Monitoring | • Pre & post-treatment<br>• Every week | SPM and OM monitoring batteries administered | 75 sentences: trained structure + additional sentence types |

**SPM**



*"The aunt was kissed by the man"*

**OM**



*"The aunt was kissed by the man"*

**Effect Size calculated for each individual:**

$$\frac{\text{Average pre-treatment baseline score – Average post treatment baseline scores}}{\text{Standard deviation of pre-treatment baselines}}$$

## Participants

36 patients with aphasia are currently enrolled or have completed the study (15 females, mean age = 62, *SD* = 11)

| ID | | Age | AQ | Aphasia Type | Comprehension | BNT | Attn | Mem | Exec | VS | Raven | MPO | Education | FB Slope | NFB Slope | Effect Size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PWA1 | M | 49 | 58 | Broca's | 52 | 58 | 163 | 98 | 19 | 74 | 49 | 162 | 12 | -3.3 | -2.5 | -1.2 |
| PWA2 | M | 52 | 61.3 | Anomic | 61 | 32 | 54 | 96 | 21 | 52 | 27 | 260 | 11 | -0.5 | 1.9 | -0.3 |
| PWA3 | M | 53 | 58 | Wernicke's | 49 | 72 | 125 | 108 | 11 | 57 | 86 | 48 | 16 | -6.5 | 0.9 | -0.1 |
| PWA4 | F | 68 | 82 | TCM | 53 | 83 | 110 | 89 | 17 | 35 | 43 | 28 | 12 | -1.2 | 1.9 | 0.6 |
| PWA5 | F | 63 | 69 | Anomic | 43 | 30 | 194 | 139 | 19 | 92 | 92 | 65 | 16 | 2.6 | -2.7 | 0.6 |
| PWA6 | M | 60 | 83 | Anomic | 73 | 78 | 190 | 132 | 25 | 91 | 92 | 27 | 19 | 2.3 | -1.0 | 1.3 |
| PWA7 | M | 54 | 93 | Anomic | 74 | 80 | 193 | 143 | 27 | 96 | 81 | 115 | 16 | 2.1 | 6.0 | 1.4 |
| PWA8 | M | 61 | 91 | Anomic | 89 | 80 | 167 | 145 | 15 | 72 | 57 | 6 | 13 | -1.9 | 9.6 | 2.1 |
| PWA9 | M | 46 | 73 | Broca's | 55 | 82 | 195 | 118 | 30 | 99 | 92 | 86 | 16 | 0.4 | 0.6 | 2.3 |
| PWA10 | F | 77 | 98 | Anomic | 84 | 98 | 206 | 183 | 29 | 86 | 92 | 94 | 16 | 3.9 | 7.8 | 2.6 |
| PWA11 | F | 57 | 80 | Anomic | 61 | 57 | 132 | 118 | 7 | 43 | 51 | 68 | 16 | -0.8 | -4.4 | 3.0 |
| PWA12 | M | 72 | 77 | Wernicke's | 56 | 85 | 173 | 132 | 21 | 83 | 57 | 15 | 18 | -0.6 | 0.4 | 4.0 |
| PWA13 | M | 44 | 96 | Anomic | 79 | 95 | 196 | 151 | 27 | 96 | 95 | 12 | 12 | 5.8 | -5.4 | 4.9 |
| PWA14 | M | 61 | 68 | | 56 | 43 | 199 | 157 | 22 | 94 | | 45 | 16 | -1.2 | 3.4 | 8.7 |
| PWA15 | M | 68 | 74 | Anomic | 53 | 30 | 142 | 136 | 19 | 73 | 68 | 13 | 19 | -0.5 | -0.8 | 9.8 |
| PWA16 | F | 50 | 94 | Anomic | 86 | 100 | 210 | 181 | 31 | 100 | 92 | 24 | 18 | 9.5 | 8.3 | 11.5 |
| PWA17 | M | 76 | | | | 2 | 142 | 102 | 8 | 55 | | 15 | 3 | 2.0 | 4.9 | 0.0 |
| PWA18 | F | 34 | 25 | Wernicke's | | 0 | 184 | 66 | 18 | 92 | 27 | 6 | 14 | 10.3 | -9.1 | 8.2 |
| PWA19 | M | 53 | 91 | Anomic | 89 | 47 | 72 | 113 | 23 | 56 | 78 | 24 | 16 | 1.5 | 6.3 | 7.1 |
| PWA20 | M | 59 | 86 | Anomic | 65 | 82 | 196 | 148 | 26 | 95 | 89 | 28 | 12 | 2.8 | 0.8 | 1.4 |
| PWA21 | F | 83 | 93 | Anomic | 70 | 95 | 172 | 145 | 22 | 79 | 78 | 39 | 16 | -7.5 | 2.6 | 1.7 |
| PWA22 | M | 66 | 97 | Anomic | 84 | 65 | 200 | 142 | 29 | 101 | 81 | 15 | 12 | -2.9 | 9.3 | 4.2 |
| PWA23 | F | 58 | 88 | Anomic | 61 | 97 | 178 | 144 | 20 | 80 | 65 | 65 | 16 | -0.8 | -4.4 | 3.0 |
| PWA24 | F | 74 | 51 | TCM | 51 | 17 | 38 | 113 | 14 | 38 | 59 | 14 | 12 | 0.3 | -6.1 | 3.0 |
| PWA25 | F | 55 | 85 | Anomic | 67 | 90 | 192 | 152 | 26 | 88 | 73 | 10 | 12 | 2.5 | 9.9 | 1.2 |
| PWA26 | M | 65 | | | 53 | | | | | | | 120 | 16 | 8.5 | 8.7 | -1.5 |
| PWA27 | F | 66 | 70 | Conduction | 48 | 62 | 184 | 120 | 20 | 88 | 65 | 84 | 18 | 7.8 | -6.5 | 0.0 |
| PWA28 | M | 87 | 88 | Anomic | 68 | 58 | 143 | 110 | 14 | 56 | 51 | 13 | 12 | 8.8 | -0.2 | 0.4 |
| PWA29 | M | 53 | 48 | Wernicke's | 61 | 7 | 178 | 93 | 24 | 92 | 65 | 107 | 16 | 9.5 | 8.0 | 1.5 |
| PWA30 | F | 64 | 68 | Anomic | 52 | 13 | 146 | 102 | 14 | 71 | 68 | 18 | 18 | -0.5 | -3.4 | 4.7 |
| PWA31 | F | 53 | 41 | Wernicke's | 53 | 7 | 144 | 74 | 17 | 64 | 35 | 25 | 12 | 7.7 | -9.5 | 5.9 |
| PWA32 | M | 70 | 10 | Global | 46 | 0 | 13 | 30 | 3 | 17 | 38 | 76 | 12 | 10.0 | -3.5 | 9.8 |
| PWA33 | F | 66 | 31 | Broca's | 48 | 0 | 101 | 40 | 3 | 39 | 31 | 42 | 18 | -9.7 | 9.8 | 5.8 |
| PWA34 | M | 66 | 86 | Anomic | 52 | | | | | | | 123 | 16 | 8.7 | -10.0 | 0.5 |
| PWA35 | F | | 78 | Anomic | 71 | 55 | 173 | 139 | 22 | 77 | 57 | 53 | 16 | 10.3 | -0.2 | 3.1 |
| PWA36 | M | 68 | 95 | Anomic | 97 | 77 | 192 | 155 | 28 | 97 | 95 | 21 | 17 | 6.4 | -7.0 | 3.5 |

Raw data were analyzed to ensure that patients did not attend to only one feature in training or in testing on learning tasks.

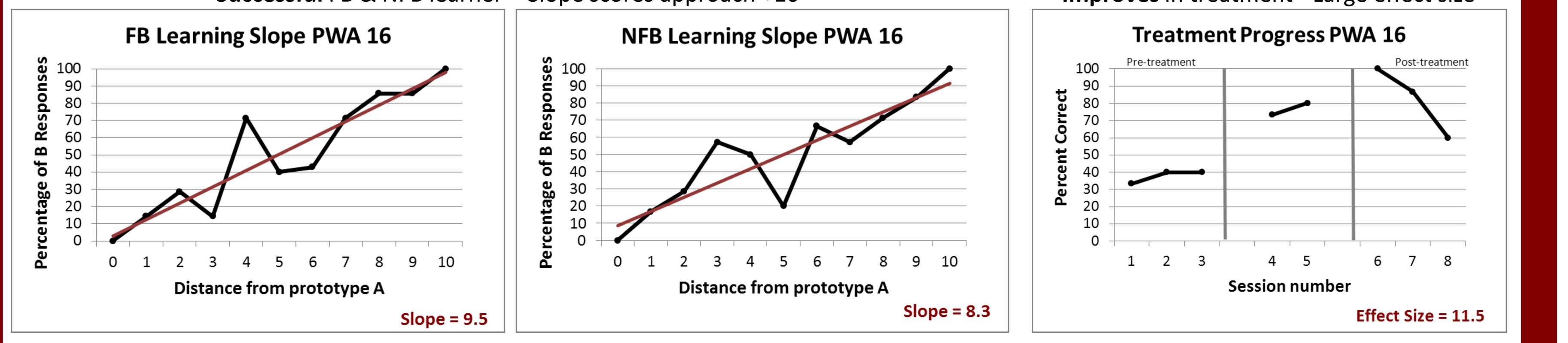
Data from 11 patients were dropped due to FB performance*

AQ = Aphasia Quotient, BNT = Boston Naming Test, Attn = Attention, Mem = Memory, Exec = Executive functions, VS = Visuospatial skills as determined by the CLQT; Raven = Raven's Matrices scores, MPO = months post onset of stroke

## Sample Learning & Treatment Results

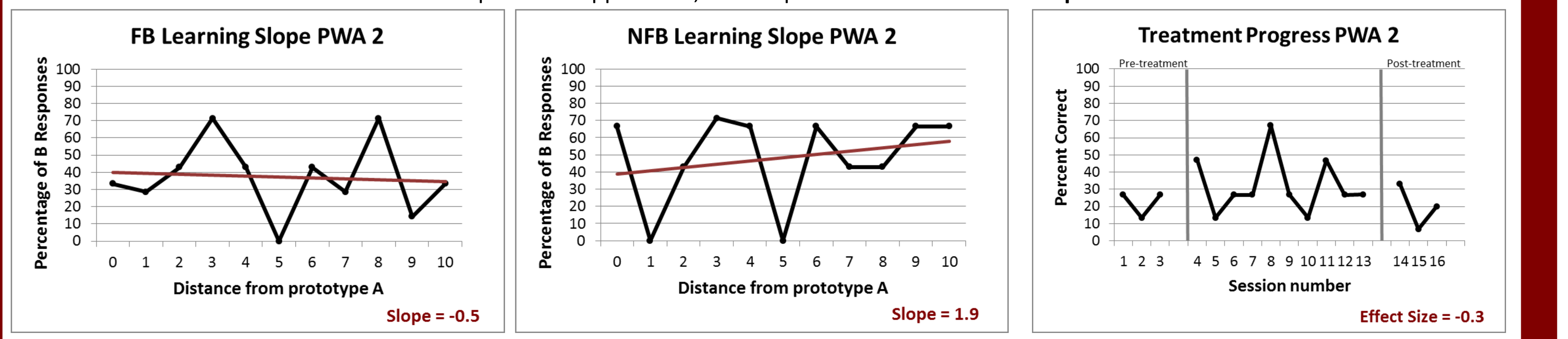
**Successful** FB & NFB learner - Slope scores approach +10

**Improves** in treatment - Large effect size



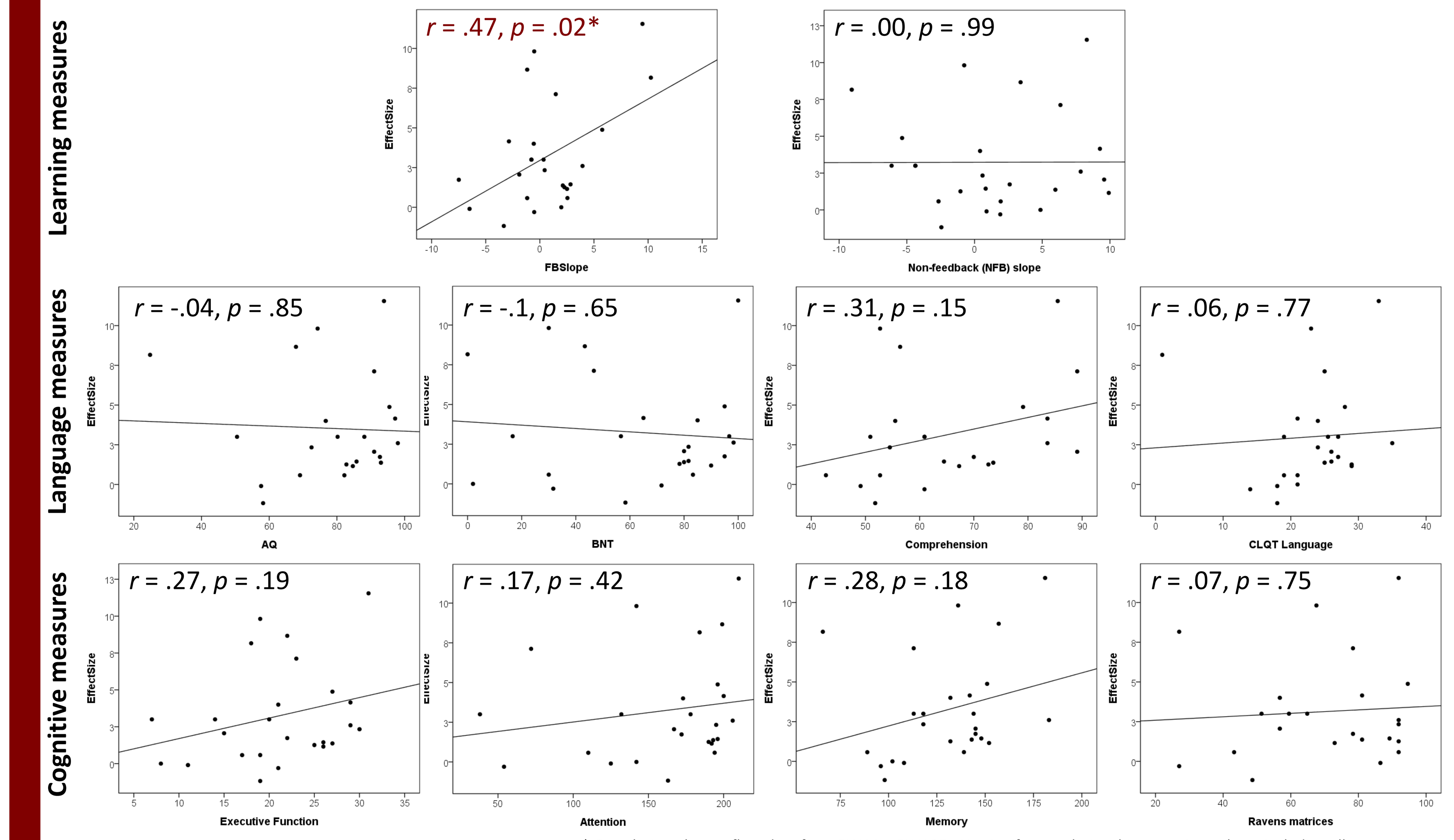

**Unsuccessful** FB & NFB learner - Slope scores approach 0, chance performance

**No improvement** in treatment – small effect size




## Do learning ability scores or cognitive-linguistic measures correlate with outcomes?

Pearson correlations between effect size, learning ability and standardized measures of cognitive – linguistic ability *




* Correlation plots reflect data from PWA1 – PWA25. No significant relationship arose in analyses including all participants

Multiple linear regressions were run to predict effect size from various combined cognitive-linguistic and demographic measures. FB learning slope, months post onset of stroke and years of education were found to produce the best model predicting treatment effect size, $F(3, 21) = 7.04$, $p = .002$, $R^2 = .708$. (FB learning slope & years of education added statistically significantly to the prediction, $p < .05$.)

## Conclusions

- **Feedback learning slope** was the only measure of ability that significantly correlated with effect size.
  - Our feedback learning task likely requires hypothesis generation, testing, tracking and memory, similar to the skills required in this therapy task
- **No standardized cognitive or linguistic measures** correlated with language therapy effect size measures.
- Non-feedback learning slope did not correlate with language therapy effect size measures.
- The strongest model predicting language therapy outcomes included FB learning slope, months post onset of stroke and years of education. This model accounted for 71% of the variance in the data.

Results suggest that learning ability may present an important measure in the diagnostic assessment of individuals with aphasia and may reflect a person's potential for improvement in therapy.

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