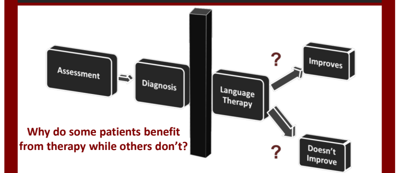
Exploration into feedback and non-feedback based learning in aphasia

Sofia Vallila[1,2] & Swathi Kiran[2]

[1]Harvard-MIT Division of Health Sciences and Technology, Boston, MA [2]Aphasia Research Laboratory, Boston University, Boston, MA

Introduction



Despite numerous treatment methods and advancements, researchers and therapists remain unable to reliably predict outcomes or explain why some patients respond to aphasia therapy while others do not. We hypothesize that **learning ability** is a **critical** factor in aphasia rehabilitation whose sparse investigation creates a **barrier** between therapy and predictability of outcomes. To this end, we ask:

- How do patients with aphasia learn novel non-linguistic information?
- Does instruction method differentially lead to success with learning?
- If differences arise, is there a relationship between effective learning method and patient profile?

Background

Studies involving populations with brain damage have demonstrated that features of learning such as **training method, feedback, stimulus characteristics** and **response selection** are significant, differentially affecting learning in clinical populations.

Research has shown that patients with **amnesia**, for example, who have severe **impairments in declarative memory**, exhibit **successful learning of gradual, probabilistic tasks** hypothesized to engage **non-declarative memory** (Knowlton et al., 1992, 1993, 1994). Categorization of **discrete stimuli** involves **automatic recognition**, while **continuous** or **complex stimuli** require **pattern abstraction**, **rule-use**, **feature mapping** and/or **hypothesis testing** (Davis et al., 2009; Love & Markman, 2003; Maddox et al., 2008; Schyns et al., 1998) skills that engage **distinct neural resources** and have been probed in patients with **schizophrenia** (Weickert et al., 2009; Gold et al., 2000; Keri et al., 2005) and **Parkinson's disease** (Ashby et al., 2003; Filoteo et al., 2005; Maddox et al., 2005). Similarly, **feedback** is thought to involve various regions of the **striatum** (Cincotta & Seger, 2007) and has been shown to differentially affect learning in patient populations (Maddox et al., 2008; Reber & Squire, 1999; Shohamy et al., 2004; Waltz et al., 2007). While aphasia is not characterized by learning deficits, cognitive skills have been shown to be affected in aphasia (Ramsberger, 2005).

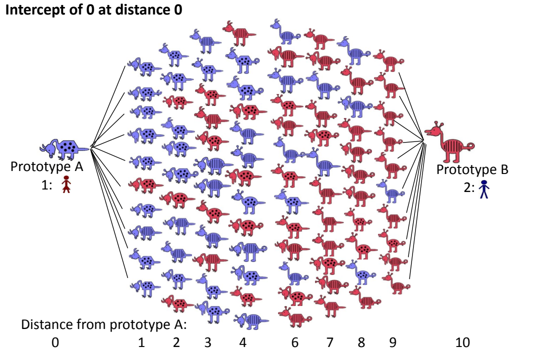
We posit that learning is non-negligible in rehabilitation and is the key towards developing individualized, predictable treatments for aphasia.

Methods

Participants learn to categorize two sets of cartoon animals that vary on 10 binary dimensions (Zeithamova et al., 2008). Two animals are selected as prototypes A and B. The number of features by which an animal differs from prototype A is its *distance* from the prototype. Data are calculated based on the percentage of B responses (%BResp) made at each distance from prototype A.

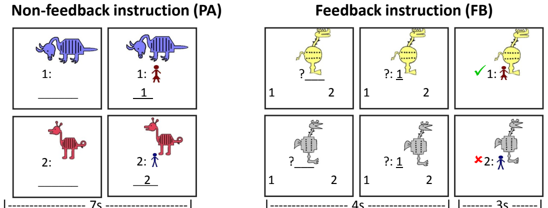
<u>**Categorical learning is represented by:**</u>

- **Linearly increasing %BResp as distance from prototype A increases (slope = 10)**
- **Intercept of 0 at distance 0**



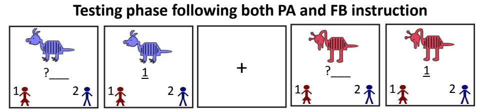
Each participant completes feedback and non-feedback based category learning tasks
Learning is compared between groups and between tasks

Two types of instruction: Non-feedback (PA) and Feedback (FB)



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.

Testing phase following both PA and FB instruction



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

Results

Ten patients (Pt) and ten age-matched control (Cn) participants.

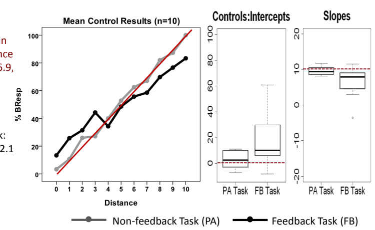
Cn	Age
Cn1	32.9
Cn2	56.8
Cn3	57.6
Cn4	57.2
Cn5	61.2
Cn6	59.7
Cn7	60.6
Cn8	65.4
Cn9	69.5
Cn10	70.0

Pt	Age		Aphasia Type	BNT	AQ	Lesion Characteristics
Pt 1	33.7	F	Conduction	0	24.8	Left MCA
Pt 2	51.9	M	Anomic	31.67	61.3	Left MCA
Pt 3	52.7	F	Wernicke's			Left MCA and PCA territory
Pt 4	59.5	M	Anomic	78.33	82.8	Left MCA
Pt 5	61.0	M	Conduction	43.33		Left MCA
Pt 6	63.6	F	Anomic	30	69.1	Left basal ganglia
Pt 7	65.7	F	Broca's	0	28.4	Left basal ganglia
Pt 8	67.5	F	Transcortical Motor	83.30	82.2	Left MCA
Pt 9	69.5	M	Wernicke's	0	33.8	Left temporal lobe
Pt 10	75.7	M	*testing*			Left internal capsule and parietal

Grouped results

Significant main effect of distance $F(5.67,90) = 46.9$, $p = .000$

No significant interaction of Distance x Task: $F(5.675,90) = 2.1$ $p = .056$



PA Intercept: $M = 4.78$, $SD = 9.64$

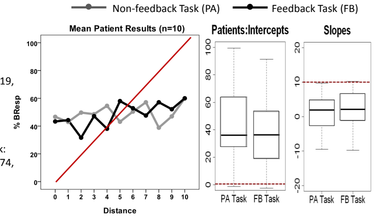
PA slope: $M = 9.45$, $SD = 1.36$

FB intercept: $M = 16.11$, $SD = 19.17$

FB slope: $M = 6.47$, $SD = 4.11$

No significant main effect of distance*: $F(3.67,90) = .719$, $p = .571$

No significant interaction of Distance x Task: $F(3.67,90) = .874$, $p = .477$



PA Intercept: $M = 39.35$, $SD = 30.8$

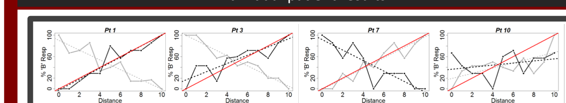
PA slope: $M = .30$, $SD = 6.0$

FB intercept: $M = 51.31$, $SD = 26.64$

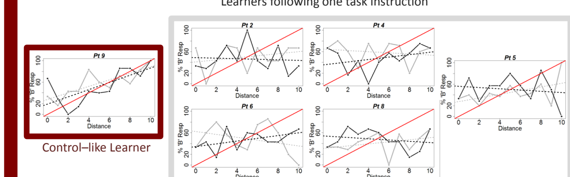
FB slope: $M = 1.41$, $SD = 5.58$

*Repeated measures ANOVA with a Huynh-Felt correction

Individual patient results



Learners following one task instruction



Control–like Learner

Non-Learners

Conclusions

Control Participants

- Demonstrate categorical learning following PA and FB instruction
- Better learning following PA instruction over FB instruction which approaches significance
  - FB instruction is likely to require feedback processing and executive functioning skills likely to decline with normal aging.

Patient Participants

- 5/10 patients show categorical learning following at least one instruction method
  - BNT scores, aphasia quotients (AQ), aphasia type and lesion characteristics do not predict which patients will demonstrate successful learning.
- 4/10 patients learn better following either PA or FB instruction
- 1/10 patient learns equally well following PA and FB instruction
- 5/10 patients do not show learning of categories

Results suggest that though aphasia is not characterized by impairments in memory and learning, **learning is affected in patients with aphasia**. We suggest that additional research is necessary to understand and characterize the critical contribution of learning on language rehabilitation in aphasia.

Selected References

Ashby, F., Maddox, T. & Bohill, C. (2002). Observational versus feedback training in rule-based and information-integration category learning. *Memory and Cognition, 30,* 666-677.

Cincotta, C. & Seger, C. (2007). Dissociation between striatal regions while learning to categorize via feedback and via observation. *Journal of Cognitive Neuroscience, 19*(2), 249-265.

Davis, T., Love, B. & Maddox, T. (2009). Two pathways to stimulus encoding in category learning? *Memory and Cognition, 37*(4), 394 - 413.

Knowlton, B.J., Squire, L.R., & Gluck, M.A. (1994). Probabilistic classification learning in amnesia. *Learning and Memory*. *1,* 106-120.

Maddox, T., Love, B., Glass, B., Filoteo, V. (2008). When more is less: Feedback effects in perceptual category learning. *Cognition, 108,* 578-589.

Ramsberger, G. (2005). Achieving conversational success in aphasia by focusing on non-linguistic cognitive skills: A potentially promising new approach. *Aphasiology, 19(*10/11), 1066 – 1073.

Shohamy, D., Myers, C., Grossman, S., Sage, J., Gluck, M., Poldrack, R. (2004). Cortico-striatal contributions to feedback-based learning: Converging data from neuriomaging and neuropsychology. *Brain, 127*(4), 851-859.

Zeithamova, D., Maddox, W.T., & Schnyer, D.M. (2008). Dissociable prototype learning systems: evidence from brain imaging and behavior. *Journal of Neuroscience*. *28*(49), 13194-201.

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