Neural activations during nonlinguistic category learning in individuals with aphasia

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Introduction

Probablistic category learning has been extensively researched in cognitive neuroscience to better understand the processes and mechanisms engaged in learning (Ashby & Maddox, 2011 for review).

Little remains known, however, about probablistic category learning in post-stroke aphasia and its impact on relearning during therapy.

Can we use functional magnetic resonance imaging (fMRI) to better understand the neural mechanisms engaged in category-learning in patients with aphasia?

Background

Only recently has research explored category learning in patients with aphasia. Research has demonstrated that:

- **Some patients with aphasia show intact category learning while others do not.** In a recent study, patients with aphasia were found to show patterns of learning that were not commensurate with those of controls (Vallila-Rohter & Kiran, 2013a).
- Furthermore, **measures of nonlinguistic learning ability have been found to depend on stimulus characteristics** (Vallila-Rohter & Kiran, 2013b).
- **Scores of nonlinguistic learning have been found to correlate with progress with therapy** (Vallila-Rohter & Kiran, under review).

In this study, we aim to understand what neural mechanisms are involved when patients undergo category-learning tasks.

We hypothesize that participants who learn categories successfully may recruit distinct neural regions from those who do not learn successfully.

Participants

4 patients with aphasia (PWA)
- Premorbidly right handed
- Single left-hemisphere stroke

3 age-matched controls (Cn)
- Right handed
- No history of neurological disorders

ID		Age	Edu	MPO	Aphasia Type	AQ
PWA 1	M	53	18	107	Conduction/ Wernicke's	48
PWA 2	M	44	12	12	Anomic	96
PWA 3	M	46	16	86	Broca's	73
PWA 4	F	60	16	70	Anomic	99
Cn 1	F	56	19			
Cn 2	M	56	12			
Cn 3	M	47	13			

Edu = Years of education; *MPO* = months post onset of stroke; *AQ* = Aphasia Quotient, an indicator of aphasia severity (high scores correspond to low levels of impairment)

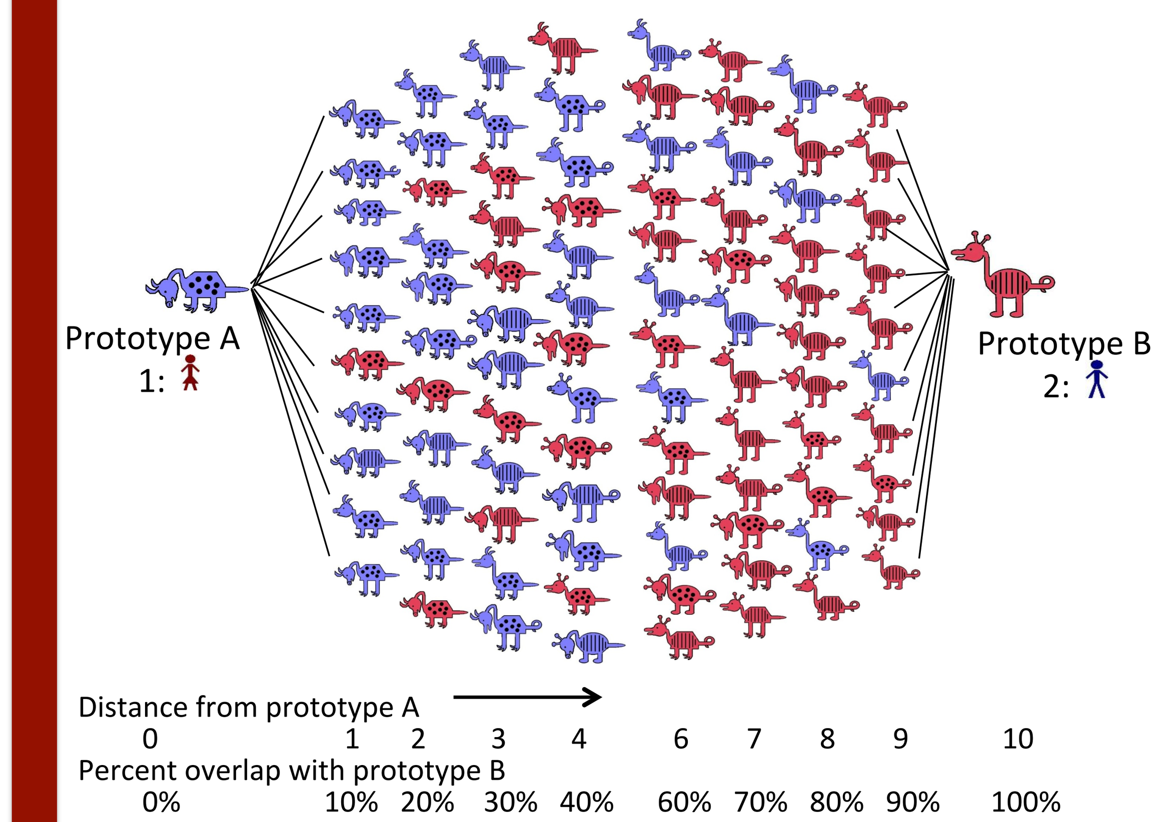
Stimuli & Category Structure

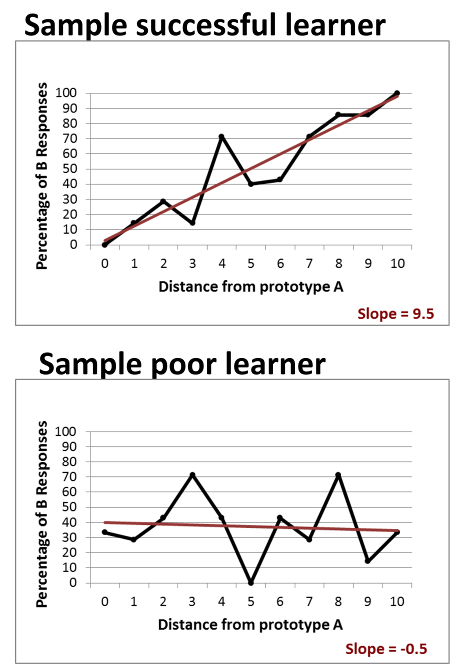
Stimuli: Cartoon animals with 10 binary dimensions (from Zeithamova et al., 2008)
Two categories established along a continuum based on the percentage of feature overlap with each prototype

Paradigm: Computerized, feedback-based training interspersed with a perceptual-motor baseline

Behavioral data analysis: Score of learning assigned to each individual:

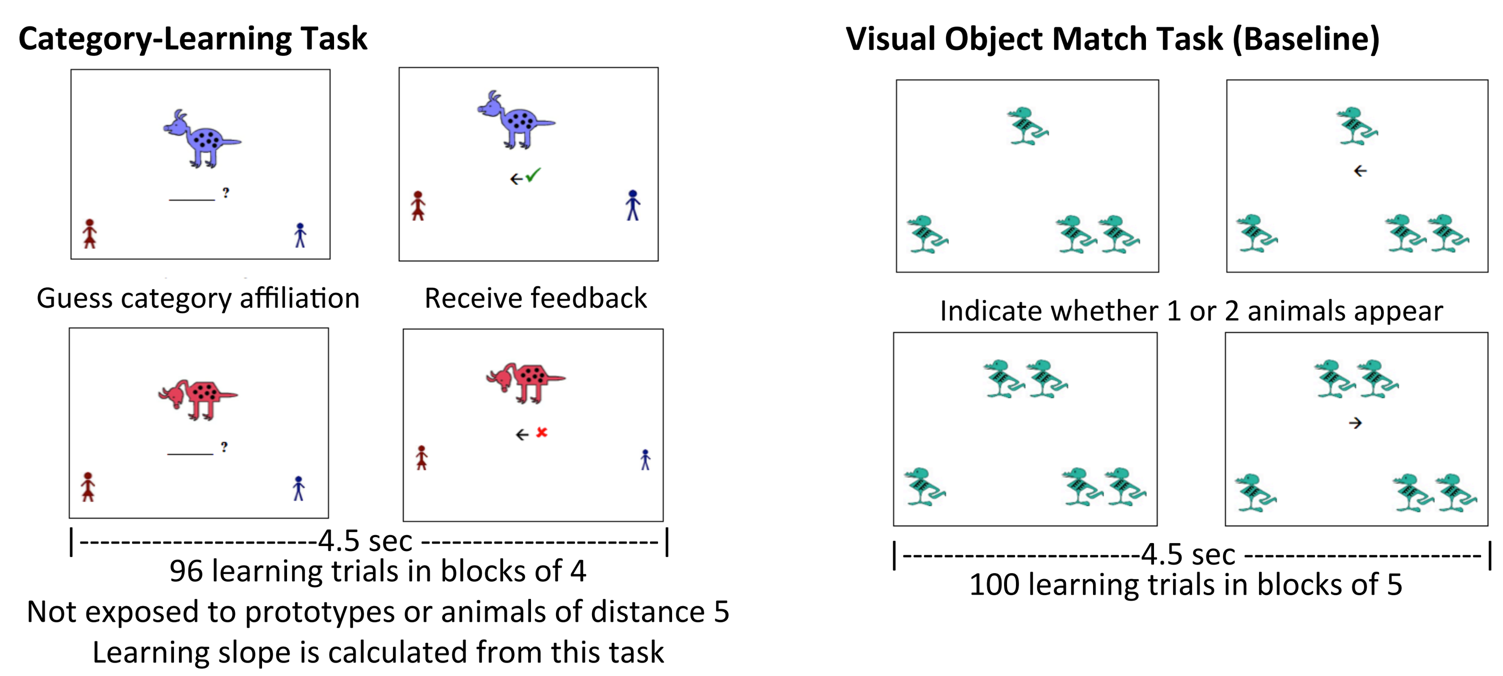
- Scores interpreted as percentage of "B" responses by distance from prototype A
- Ideal learning slope = positive 10
- Similar methods as those implemented in Vallila-Rohter & Kiran (2013a, 2013b)





Data from Vallila-Rohter & Kiran (2013b)

fMRI Task and Structure



Block design, alternating between category-learning and visual object match task baseline trials

Imaging Parameters and Preprocessing

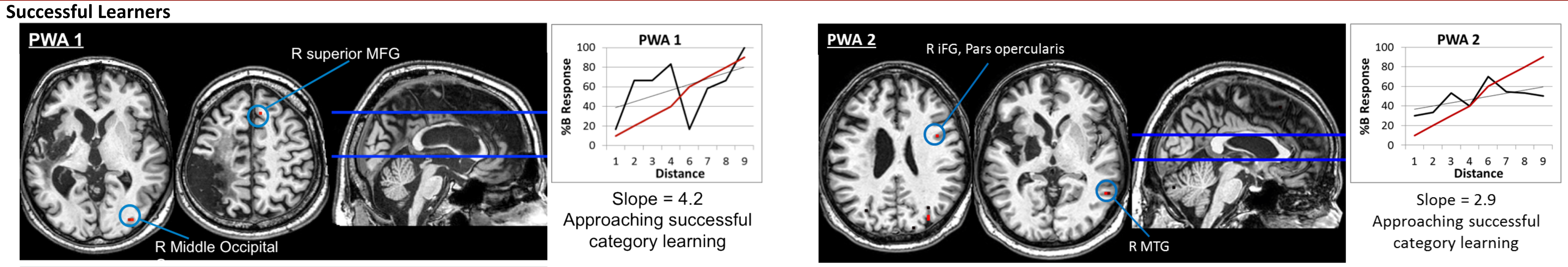
- Structural and Functional images acquired using a 3T, 6-channel scanner
- Lesion masks created for every patient participant using MRIcron

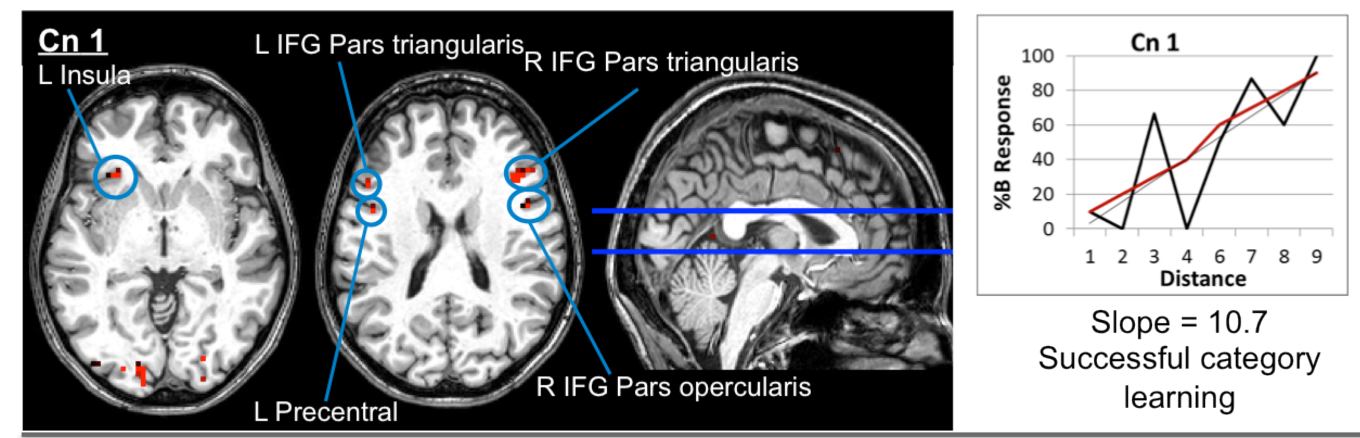
PREPROCESSING

- Images Realigned, Coregistered, Segmented & Normalized
- TR = 2.5s
- All results FWE corrected, p<.05
- T threshold > 4.8

Results : Category Learning > Baseline

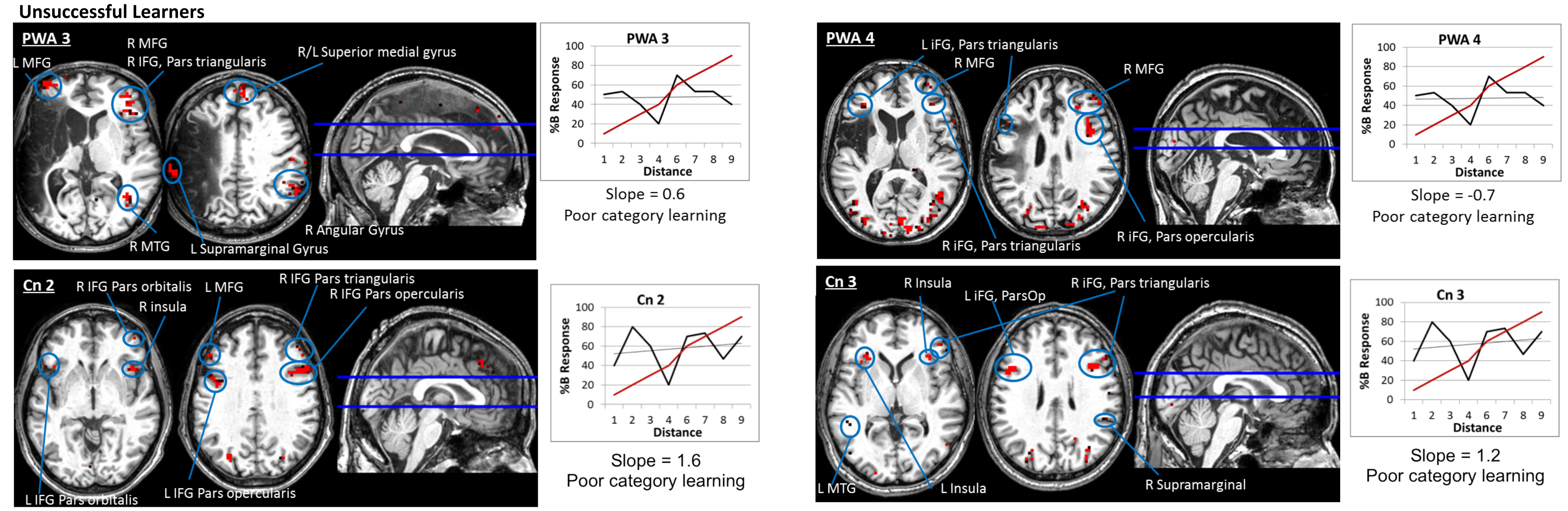
Successful Learners





- Both controls and patients with aphasia who **learned categories successfully** (PWA 1, PWA 2, Cn1) produced **few clusters of activation**.
- Activations for patients with aphasia were in L SMA (PWA2), **R MFG** (PWA1), **R IFG Pars opercularis** (PWA2), **L ITG** (PWA2), R angular gyrus (PWA2) and visual processing areas.
- Activations for the control learner (CN1) were found in **L & R IFG Pars triangularis and pars opercularis**, **L insula**, L precentral gyrus, R SMA and visual processing areas.

Unsuccessful Learners



- **Unsuccessful learners** (PWA3, PWA4, Cn2, Cn3) showed **diffuse activation bilaterally** in frontal, temporal, and occipital regions.
- Activation was seen in the L & R middle frontal gyri, L & R IFG Pars triangularis, R IFG Pars opercularis, L precentral gyrus, R insula, R fusiform gyrus, R supramarginal gyrus and additional visual areas bilaterally for at least 3/4 unsuccessful learners. (Additional activations seen in L & R superior medial and superior frontal gyri, L&R superior, middle and inferior temporal gyri)

Conclusions

- Patterns of neural activation were different for successful and unsuccessful learners (both controls and patients).
- Patients with aphasia who learned categories efficiently, recruited few regions, in particular right hemisphere areas of MFG and IFG during learning.
- Similarly, our successful control learner recruited few regions (among them bilateral IFG), consistent with previous studies in control individuals that showed bilateral activation in IFG and MFG during category learning tasks (Poldrack et al. 1999)
- In contrast, non-learners (both patients and controls) engaged many regions bilaterally . These regions included bilateral MFG, IFG, L precentral, R insula and visual areas bilaterally.

Selected References

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