Neural activations during nonlinguistic category learning in individuals with aphasia

Sofia Vallila-Rohter1,2 & Swathi Kiran2

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

Introduction

Probabilistic 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 probabilistic category learning in post-stroke aphasia and its impact on relapsing 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, mechanisms of non-linguistic learning ability have been found to depend on stimulus characteristics (Vallila-Rohter & Kiran, 2013b).

• Scores of non-linguistic 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

Participants with aphasia (PWA):

• Premorbidly right handed
• Single left hemisphere stroke
• 32-month matched controls (CT)
• Right handed

No history of neurological disorders

Visual Object Match Task (Baseline)

96 learning trials in blocks of 4
No exposure to prototypes or animals at distance 5
Learning slope is calculated from this task

Category-Learning Task

Guess category affiliation
Receive feedback

60 learning trials in blocks of 4
Not exposed to prototypes or animals at distance 5
Learning slope is calculated from this task

FMRIs Task and Structure

Stimuli & Category Structure

Stimuli: Cartoon animals with 10 binary dimensions (from Zelikoff 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)

fMRI

Imaging Parameters and Preprocessing

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

• PREPROCESSING:
  - Images realigned, corrected, segmented & normalized
  - TR = 2.5s
  - All trials FWE corrected, p < 0.05
  - Threshold = 4.8

• Functional data

Results: Category Learning > Baseline

Successful Learners

• Both controls and patients with aphasia who learned categories successfully (PWA 1, PWA 2, Cn 2) showed diffuse activation bilaterally in frontal, temporal, and occipital regions.

• Activation was seen in the L & R middle frontal gyrus, L & R IFG pars triangularis, L & R fusiform gyrus, R supramarginal gyrus and additional visual areas bilaterally for at least 3/4 successful learners. (Additional activations seen in L & R superior medial and frontal gyrus, L & R inferior temporal gyrus).

Unsuccessful Learners

• Unsuccessful learners (PWA 3, PWA 4, Cn 2, Cn 3) showed diffuse activation bilaterally in frontal, temporal, and occipital regions.

• Activation was seen in the L & R middle frontal gyrus, L & R IFG pars triangularis, L & 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 frontal gyrus, L & R inferior temporal gyrus).

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 (Poladdock 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.


