Anterior Temporal Involvement in Semantic Word Retrieval: VLSM Evidence from Aphasia

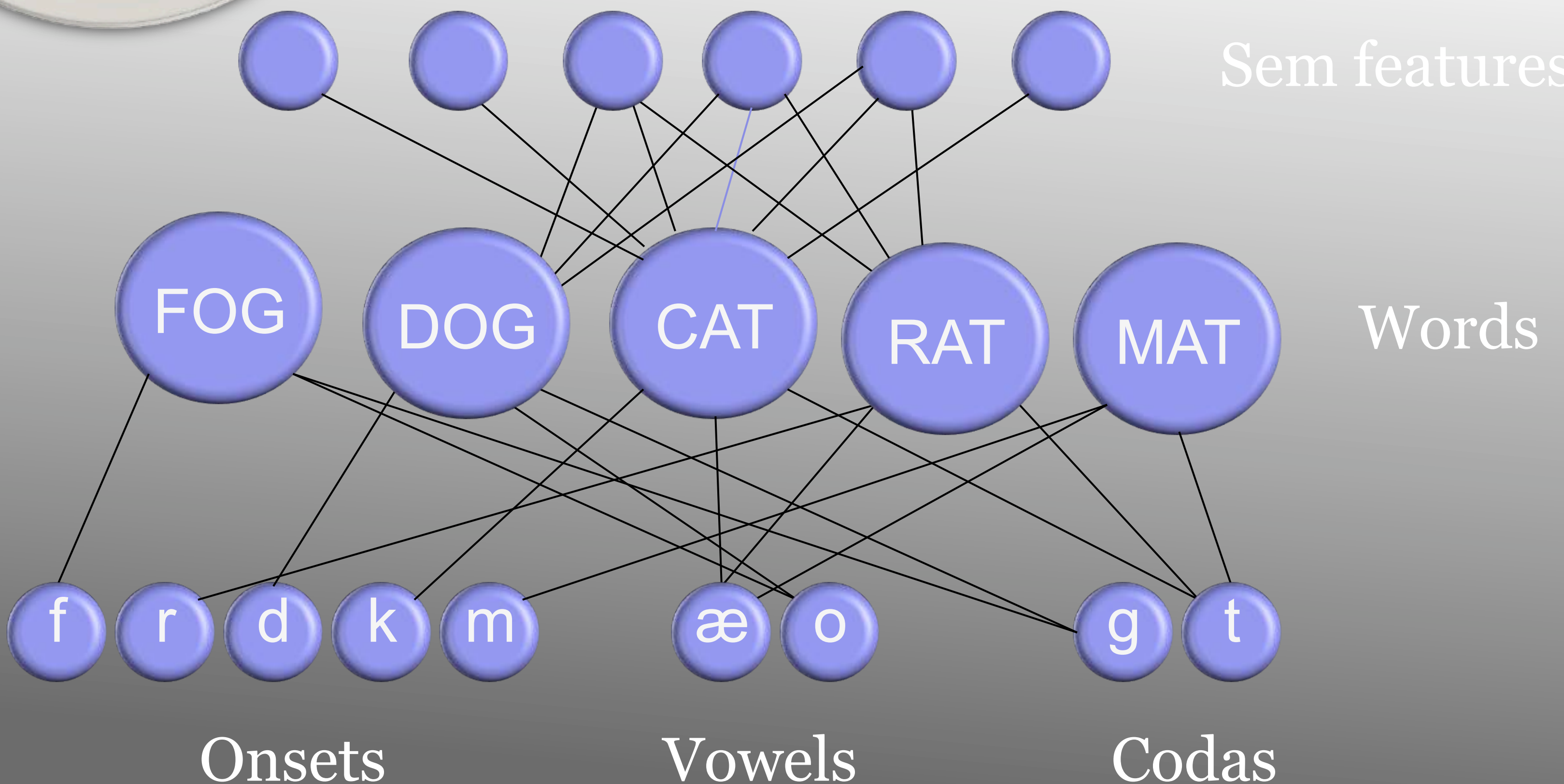
Myrna Schwartz, Dan Kimberg, Grant Walker, Olufunsho Faseyitan, Adelyn Brecher, Gary Dell & Branch Coslett

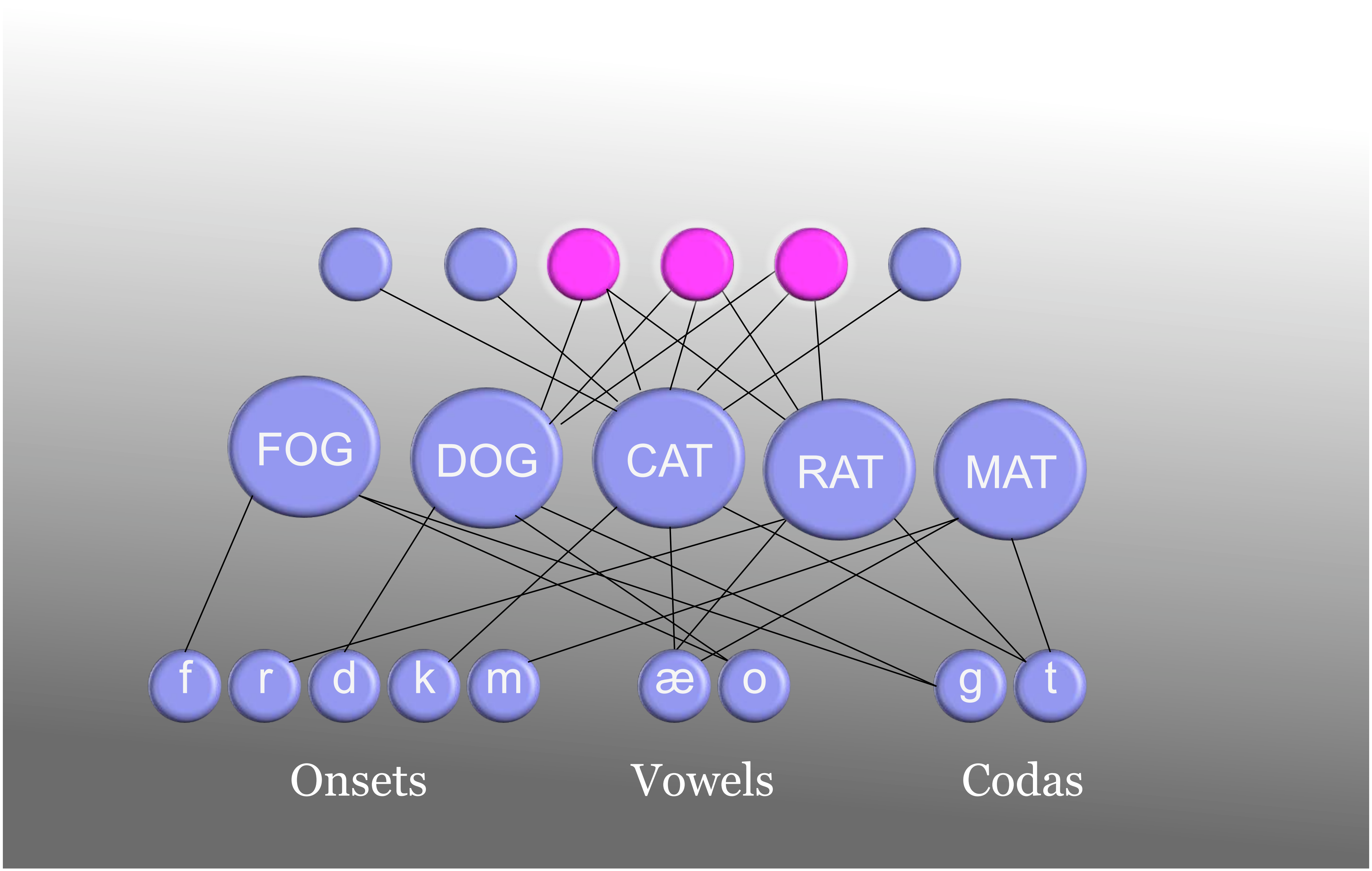
Versions of this talk were presented at the Academy of Aphasia meeting, Boston, October 2009 and the Neurobiology of Language Conference, Chicago, October 2009.

Computational case-series investigations of picture naming in aphasia

- ✧ Dell, Schwartz, Martin, Saffran & Gagnon (1997) *Psych Review*
- ✧ Foygel & Dell (2000) *JML*
- ✧ Schwartz & Brecher (2000) *Brain & Language*
- ✧ Schwartz, Dell, Gahl & Sobel (2006) *JML*
- ✧ Dell, Martin & Schwartz (2006) *JML*
- ✧ Kittredge, Dell, Verkuilen & Schwartz (2008) *CN*
- ✧ Nozari, Kittredge, Dell & Schwartz (in prep)

Picture Naming

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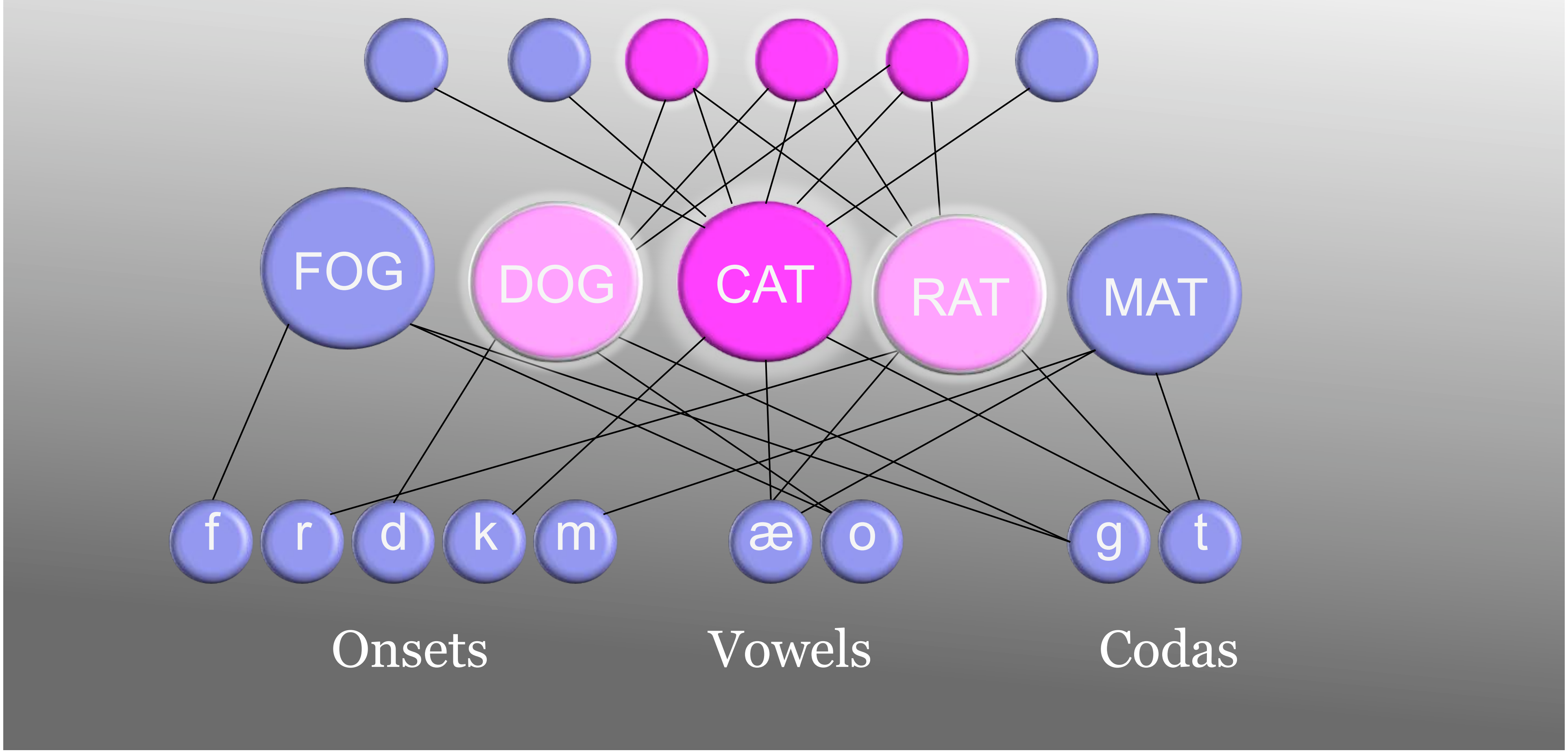
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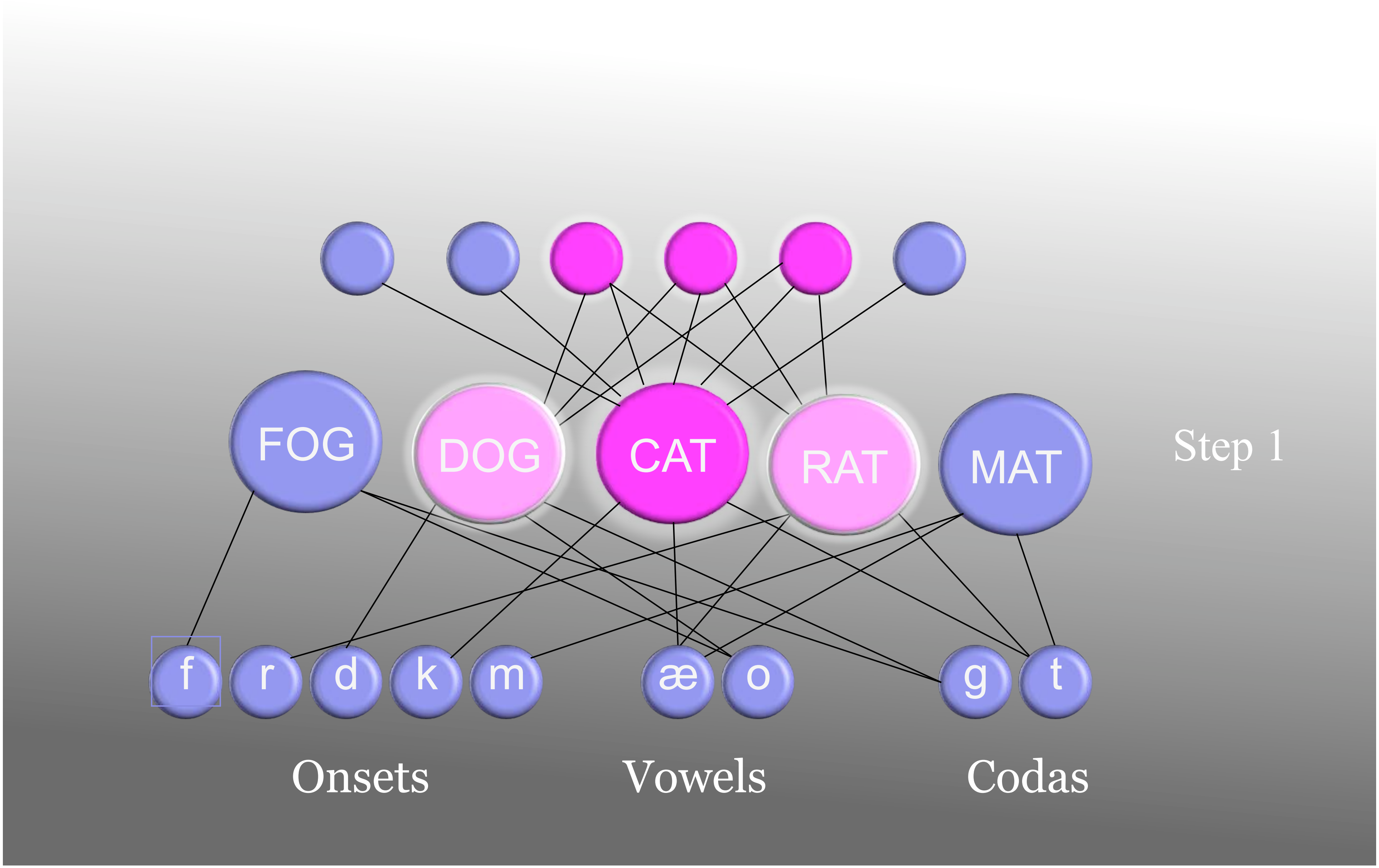
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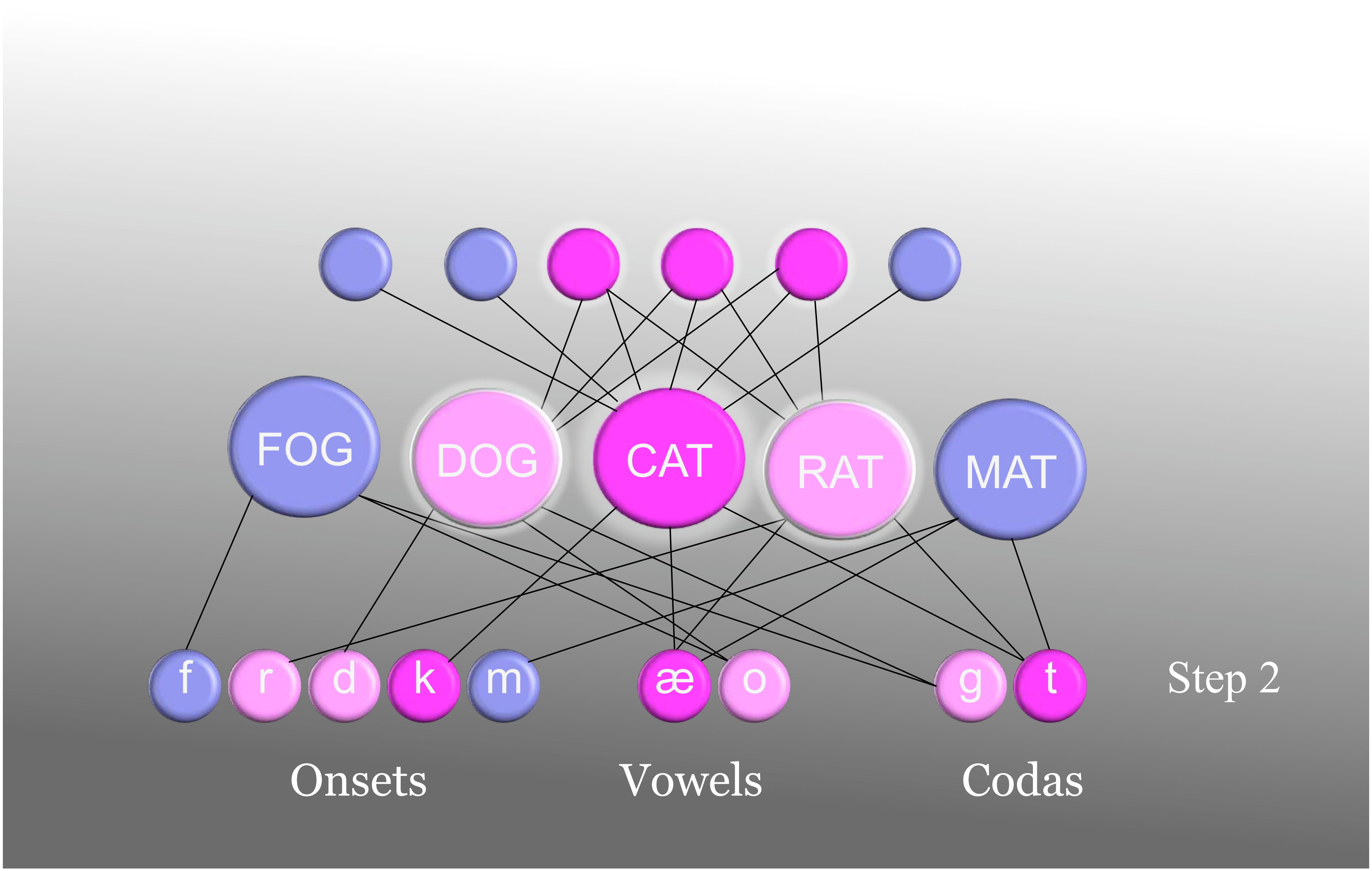
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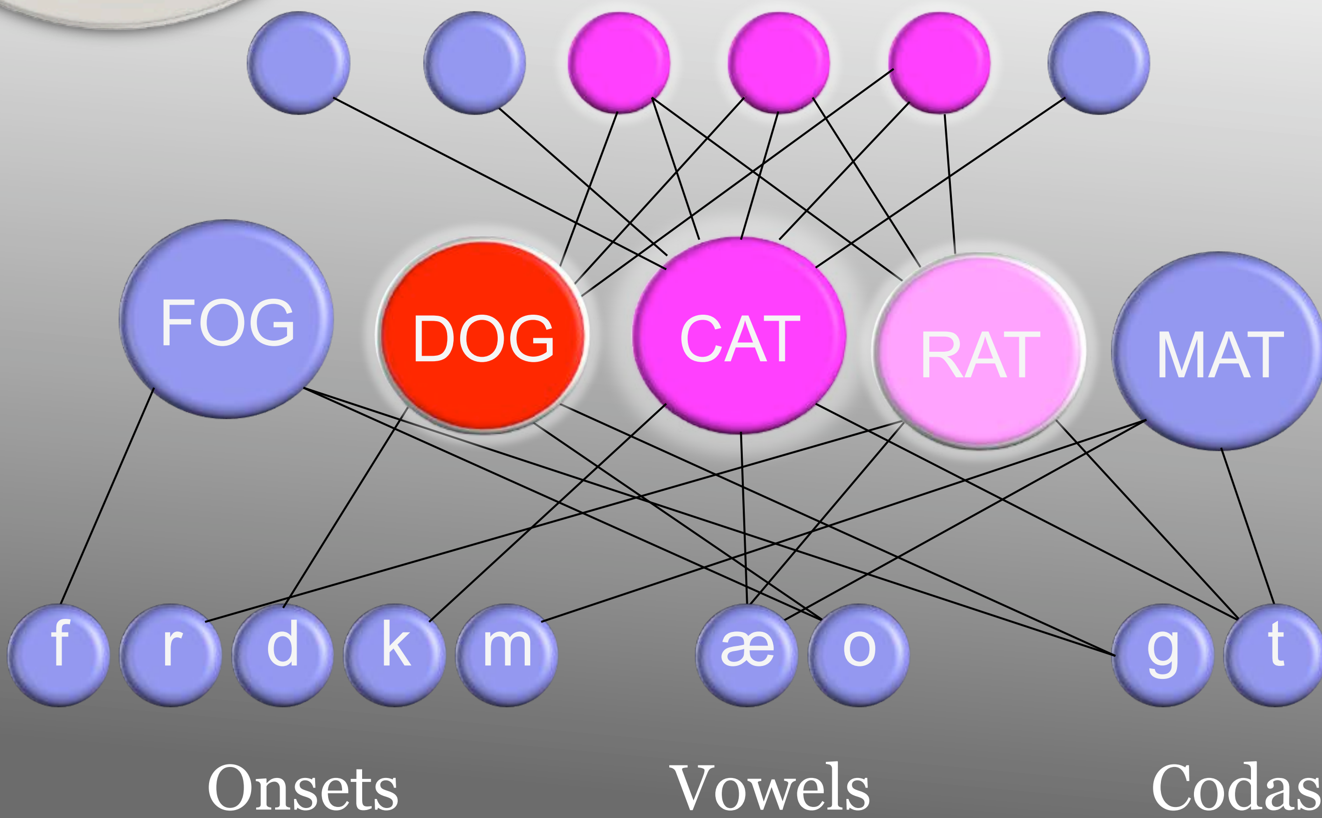
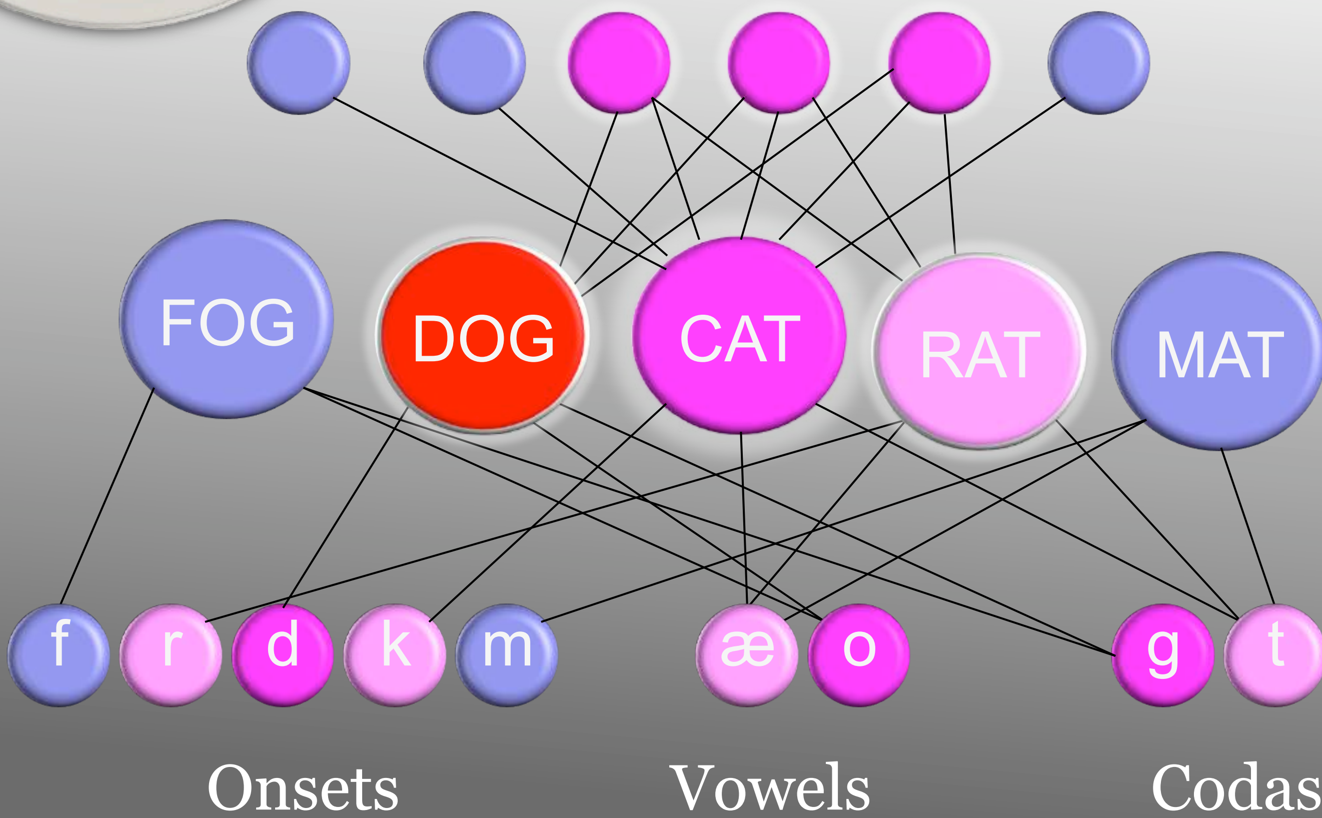
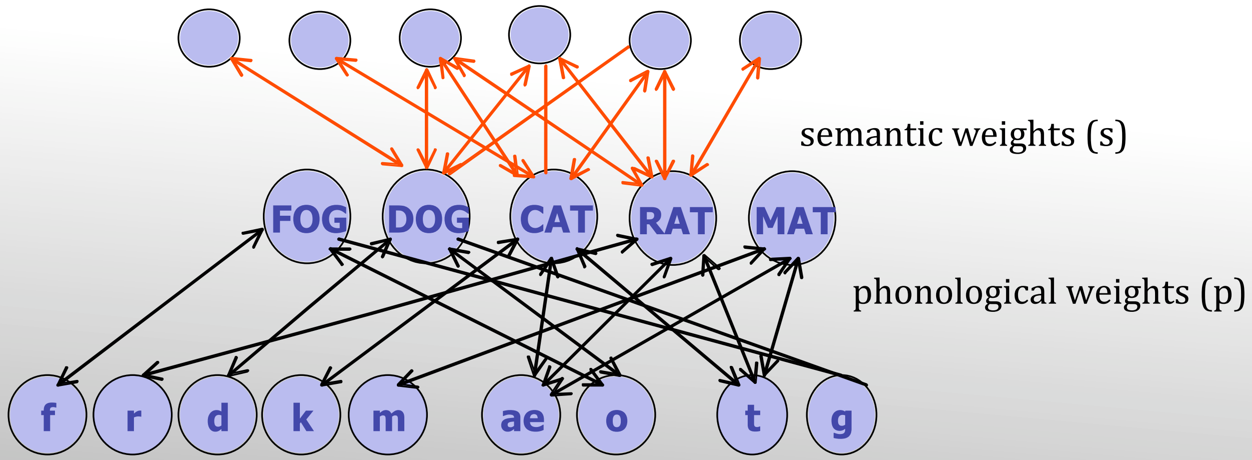
Semantic Error

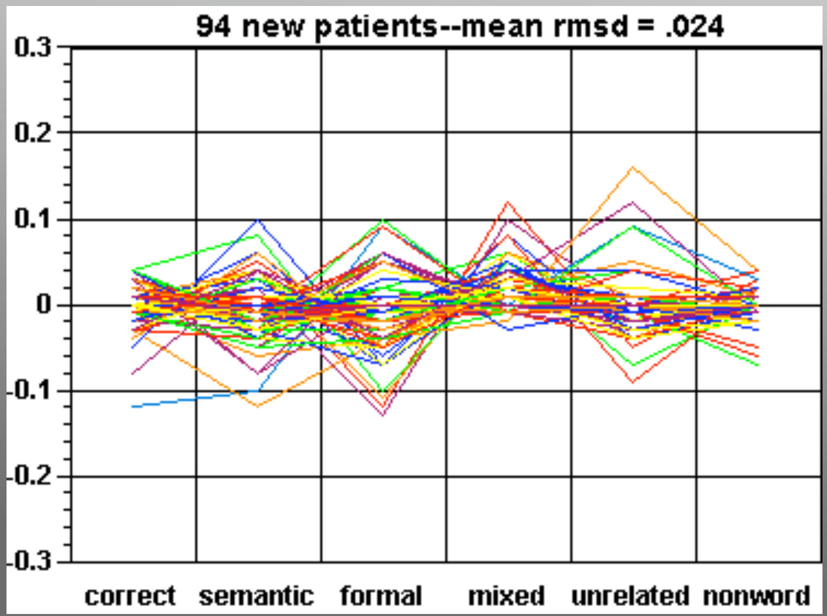


Semantic Error



Semantic-Phonological Model of Aphasic Naming





- Model deviations cluster around zero
- Model explains 94.4% of total variance in naming response proportions

Schwartz, Dell, Gahl & Sobel (2006) *JML*

Where are the lesions that give rise semantic naming errors?

New case-series (n = 64)

- MRI/CT confirmed unilateral L cortical lesion
- Mn. MPO 68 (range 1-381); 92% were at least 6 months post
- Mn. 58 y.o. (28-78)
- Mn. 14 yrs. education (10-21)

Philadelphia Naming Test (PNT)

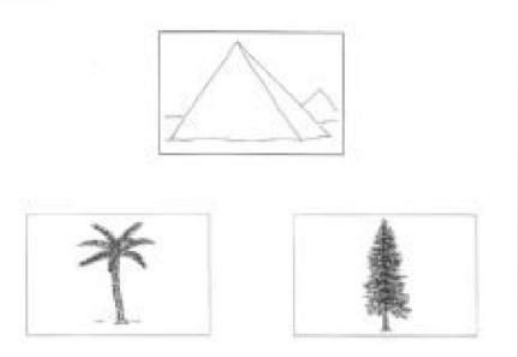
- 175 black and white line drawings of non-unique entities
- Varied semantic categories (e.g., manipulable objects, 41%; animals, 15%)
- Pictures have high familiarity, name agreement, and image quality
- Names range in length from 1 to 4 syllables and in noun frequency from 1 to 2110 tokens per million (Francis and Kucera, 1982)

Semantic Errors

Type	Target	Response
Coordinate	bus	car
Subordinate	flower	rose
Superordinate	necklace	jewelry
Synonym	frog	toad
Associated	cow	milk

Roach A, Schwartz MF, Martin N, Grewal RS, Brecher A. The Philadelphia naming test: Scoring and rationale. Clinical Aphasiology 1996; 24: 121-133.

Nonverbal Comprehension Tests



Pyramids and Palm Trees – Forced 2-choice decision, match picture of probe to picture of semantic associate. 52 trials. (Howard & Peterson, 1992)

Camels and Cactus – Forced 4-choice decision, match picture of probe to picture of semantic associate. 64 trials. (Bozeat et al., 2000)

Conceptual SEMANTIC ERROR

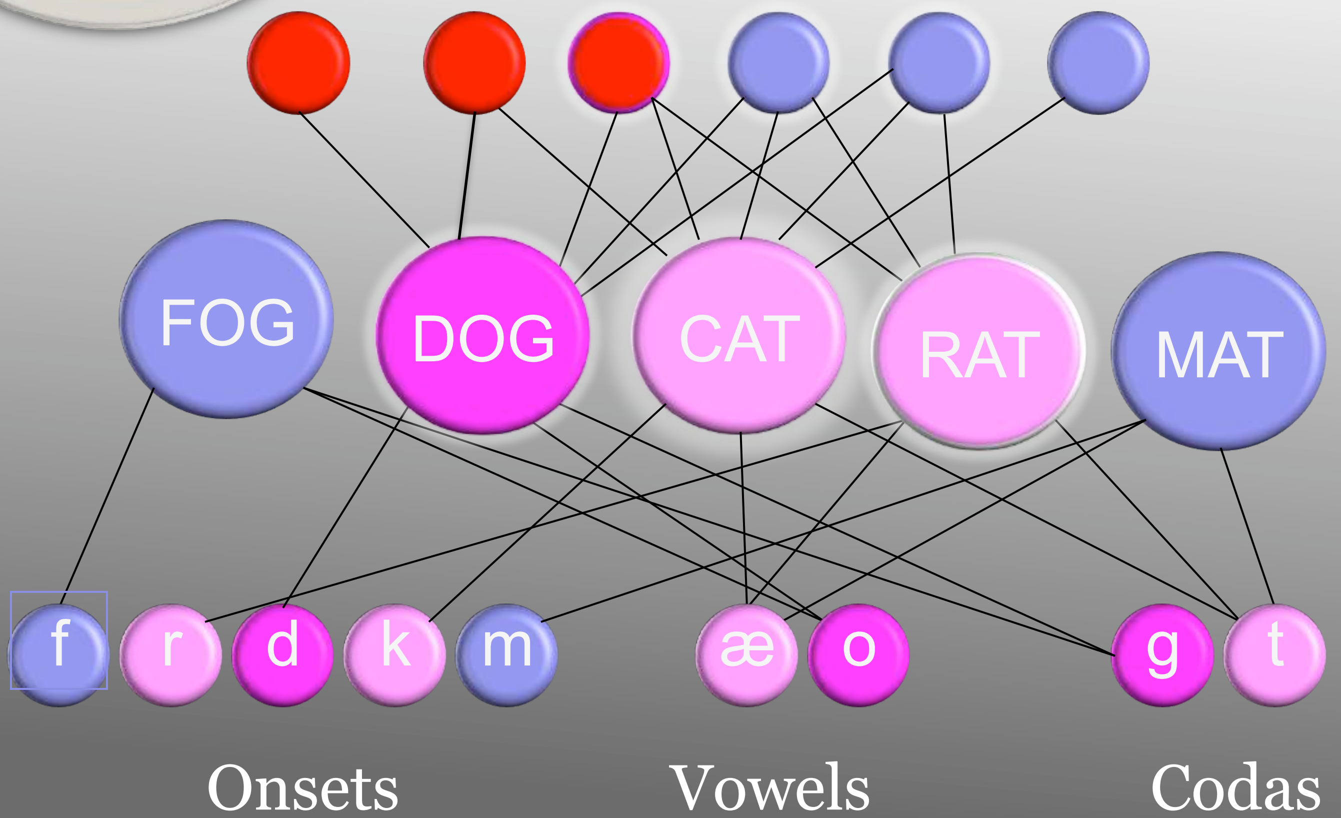


Table 1 *Language test data and control norms*

	Participants with aphasia (n = 64)				Norms for healthy controls
Test/Measure	Mean (SD)	Mdn	Low	High	
WAB Aphasia Quotient	**76.8 (15.2)**	**81.5**	**33.3**	**97.6**	**Cut-off score 93.8[a]**

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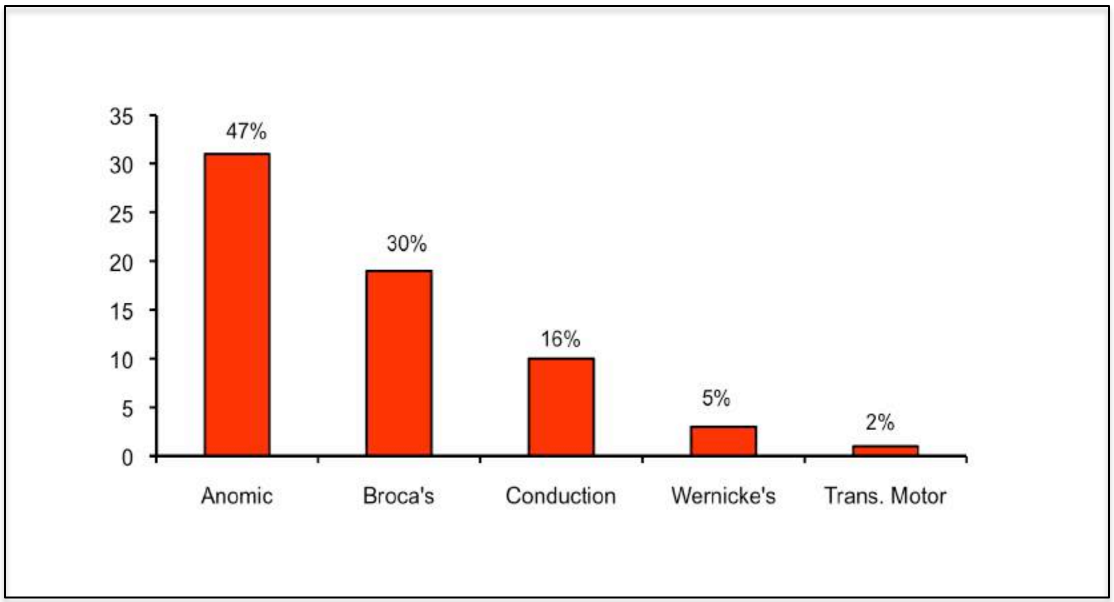

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Philadelphia naming test (PNT):					
Prop. Correct	**0.69 (.26)**	**0.8**	**0.02**	**0.97**	**Mn (SD) .97 (.018)[b]**
Prop. SemErr (SemErr)	**0.03 (.03)**	**0.03**	**0.00**	**0.12**	**n/a**
SemErr/TotErr	**0.17 (.15)**	**0.14**	**0.00**	**0.77**	**n/a**

Table 1 *Language test data and control norms*

Test/Measure	Participants with aphasia (n = 64) Mean (SD)	Median	Low	Highest	Norms for healthy controls
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SemErr/TotErr	0.17 (.15)	0.14	0.00	0.77	n/a
Nonverbal Comprehension tests:					
Pyramids and palm trees test (pictures; max. 52)	**46.4 (5.0)**	**47.8**	**24**	**52**	**Mn (SD) 51.2 (1.4)[c]**
Camel and cactus test (pictures; max. 64)	**50.1 (7.6)**	**51.8**	**23**	**61**	**Mn (SD) 58.4 (3.4)[d]**
Composite measure (NVcomp; Mean of z-scores)	**-.04 (1.04)**	**0.16**	**-4.0**	**1.16**	**n/a**

Lesion segmentation and warping

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- CTs (n = 30) – HBC drew lesion maps directly onto the template

Two VLSM Analyses

Unfiltered – Semantic error scores (SemErr) were mapped to lesions on a voxel-wise basis.

Filtered – (a) NVcomp scores were factored out of the SemErr measure by regression; (b) Residualized SemError scores were mapped to lesions on a voxel-wise basis.

Filtered analysis controls for faulty conceptualization processes that could give rise to SemErr at a pre-lexical stage

VLSM Methods

<u>Unfiltered</u> – At each voxel, a t-test was performed comparing SemErr scores between patients with and without a lesion in that voxel

<u>Filtered</u> – At each voxel a t-test was performed comparing residualized Sem Err scores between patients with and without a lesion in that voxel.

In each analysis, voxels in which fewer than 5 patients were lesioned were excluded.

Correction for multiple comparisons - t-maps were thresholded to control the False Discovery Rate (FDR) at q = 0.01, where q is the expected proportion of false positives among supra-threshold voxels.

Analyses were done using the VoxBo brain imaging package: www.voxbo.org

Voxel-wise Lesion-Symptom Mapping: Coverage

Fig. 2

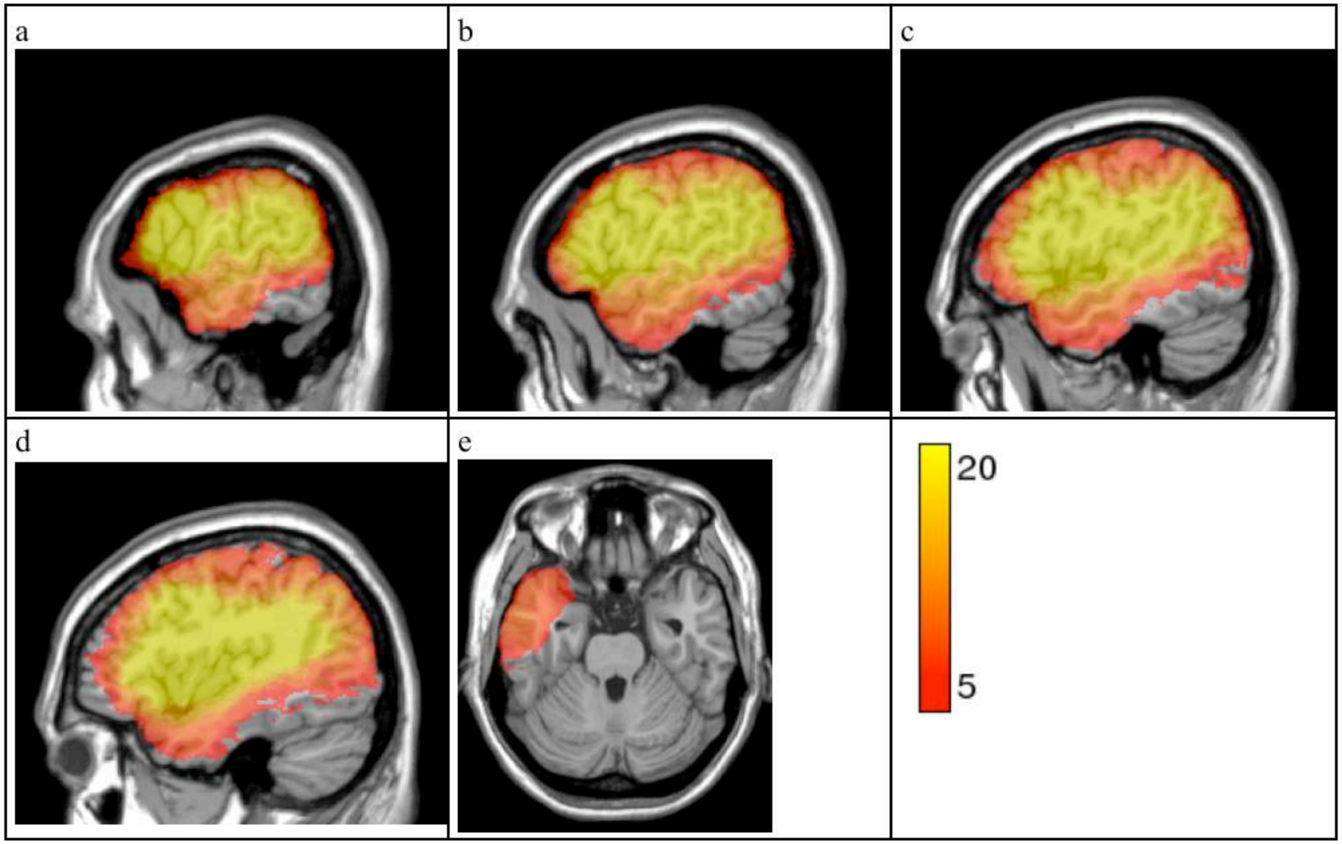
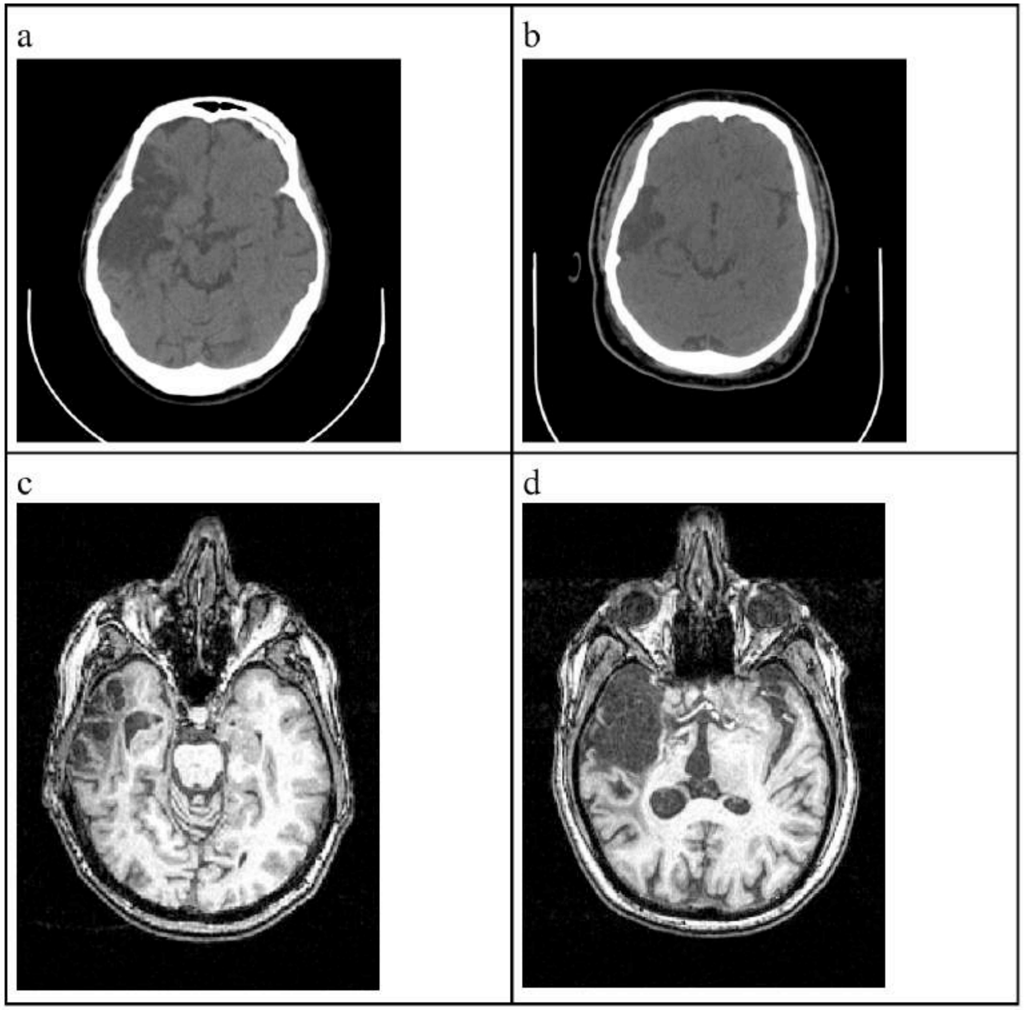


Fig. 2 Maps depicting lesion overlaps of the 64 subjects in the left hemisphere. Maps A-D are at MNI x coordinates of -60, -54, -48, and -42 respectively. Map E is a single axial slice at z=-27.


a
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d

Voxel-wise Lesion-Symptom Mapping: Unfiltered (SemErr)

Fig. 4

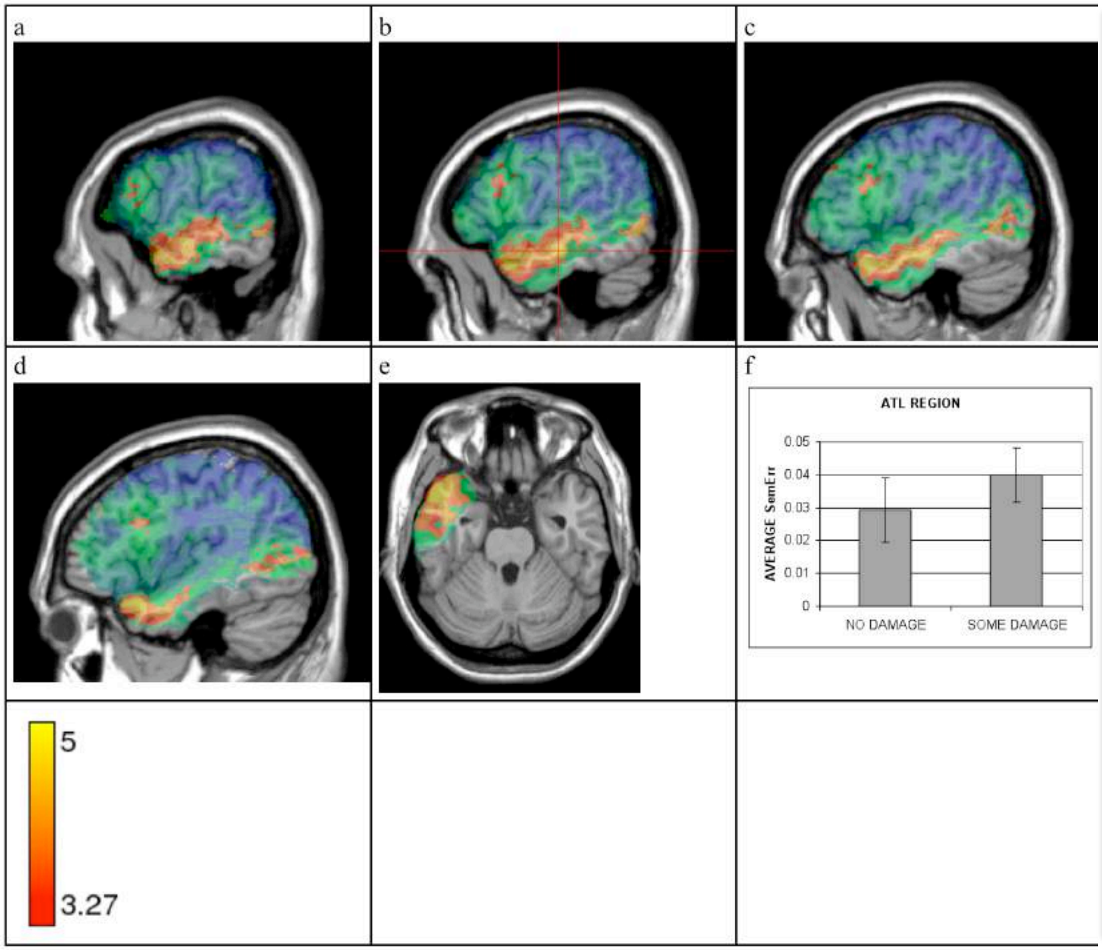

Fig. 4. Voxel-wise t-value map. Supra-threshold voxels rendered on red (t = 3.27) to yellow (t > 5) scale.

Sub-threshold voxels rendered on scale of green (just below threshold) to blue (t < 0 or below).

Voxel-wise Lesion-Symptom Mapping: Unfiltered (SemErr)

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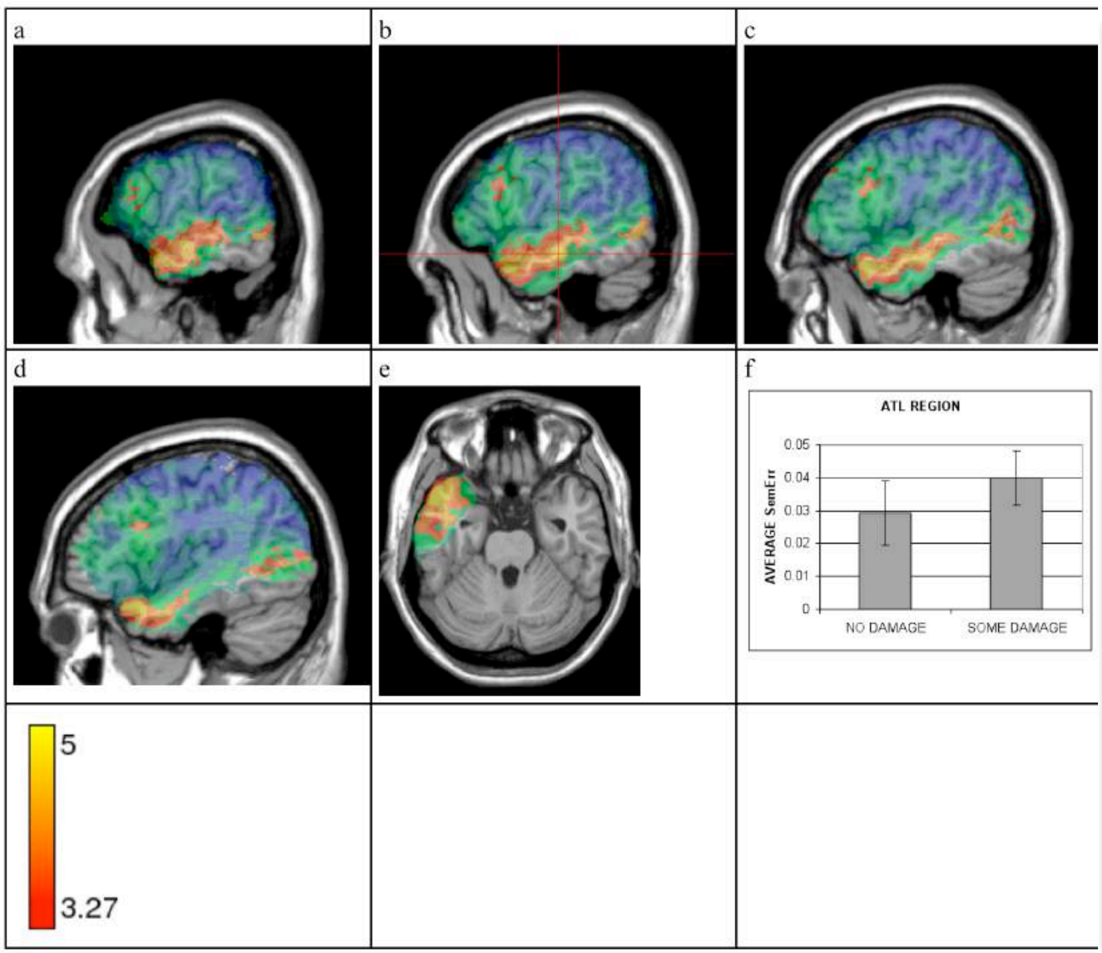
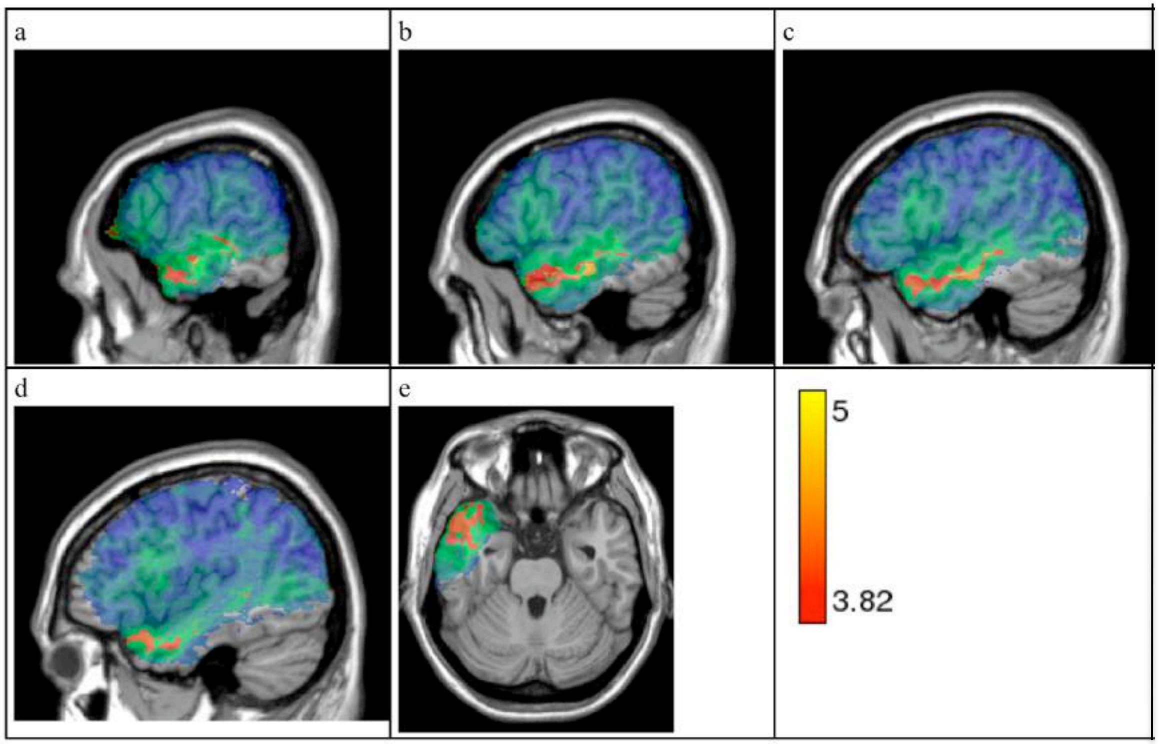


Significant correlation between lesion status and SemErr in:

1. **ATL (BA 21/38) -- highest concentration of significant voxels**
2. **pMTG (lateral superior BA 37)**
3. **IFG/MFG (BA 45/46)**

Voxel-wise Lesion-Symptom Mapping: Filtered (residualized SemErr)

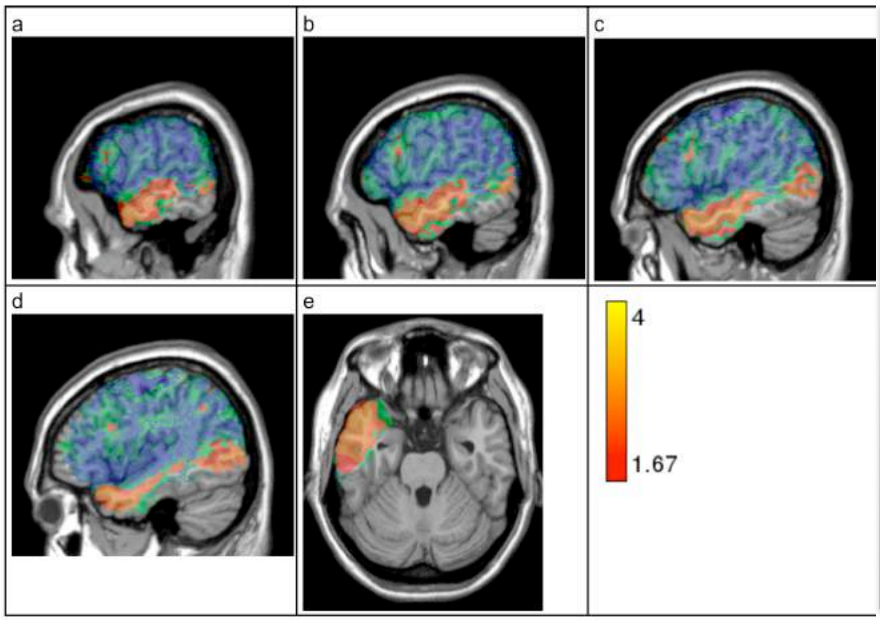


Controlling for conceptual processing weakened effects in all three areas

Only voxels in mid to anterior MTG remain significant.

ATL effect survives lesion-size correction

Uncorrected t-test threshold



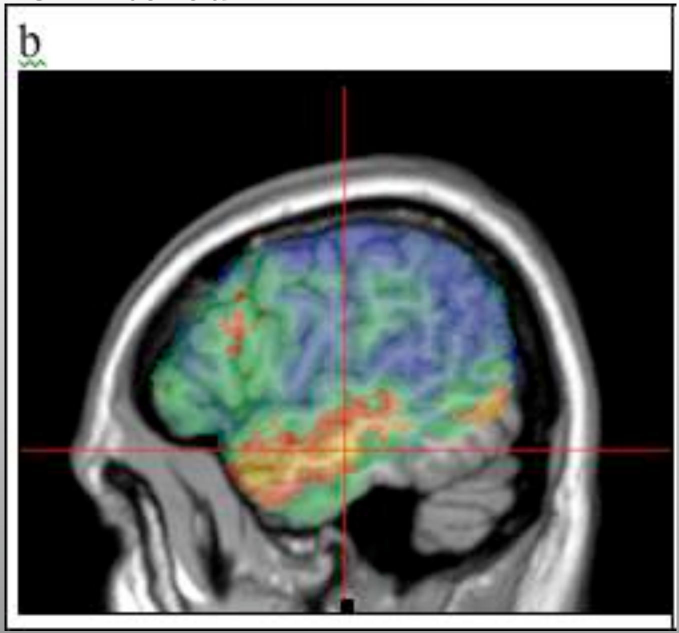
Partial correlations:

Region	Partial Correl[a]	P-value
BA 21	.34	.006
BA 38	.33	.008

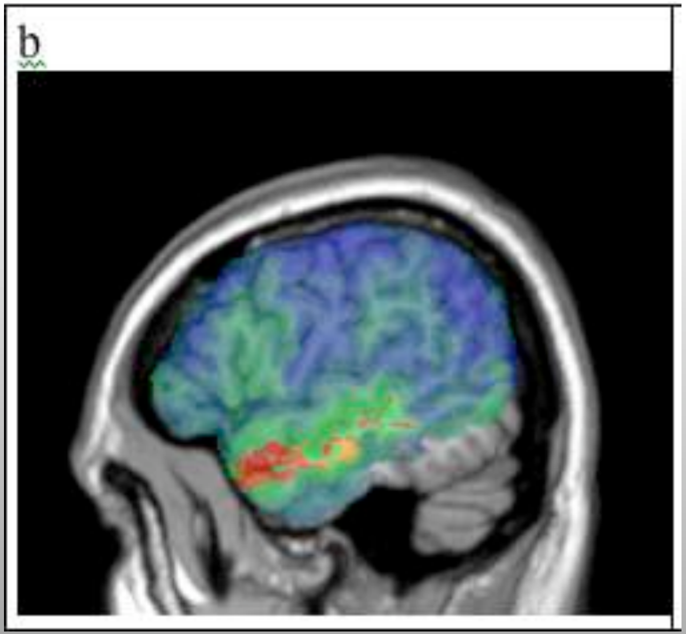
[a] % damage w. SemErr, partialling out total lesion volume

Negative Findings for Wernicke's Area

Unfiltered



Filtered



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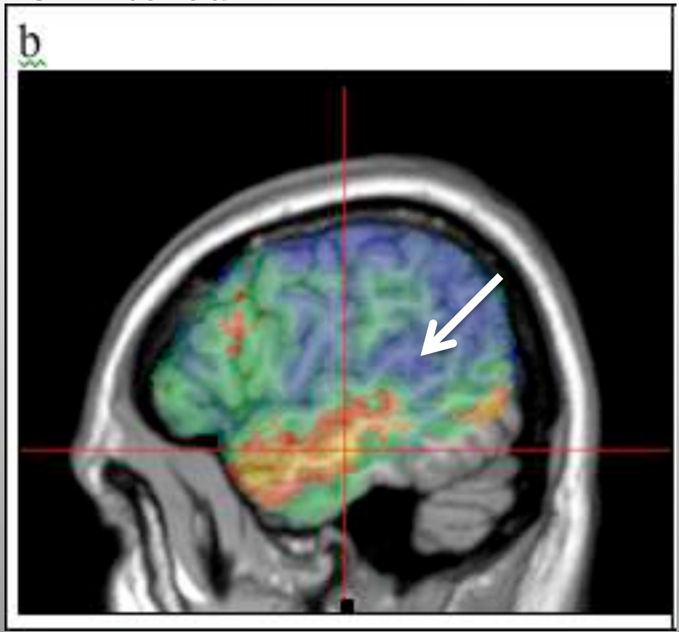
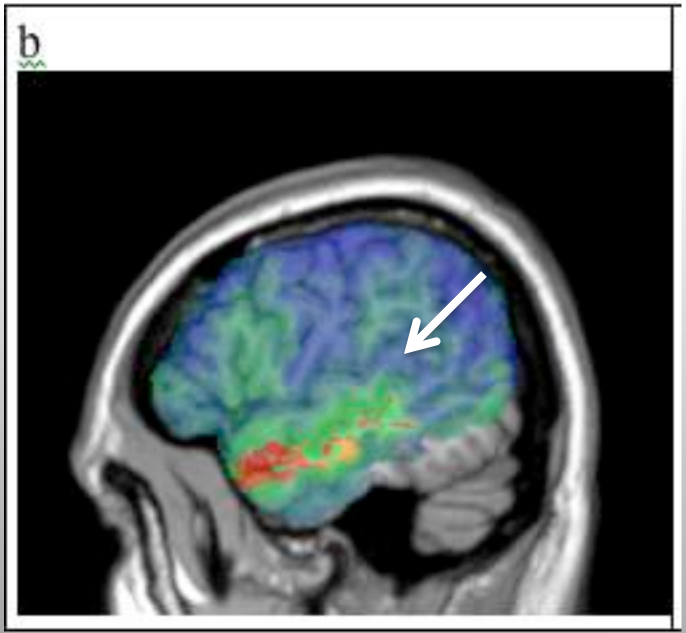
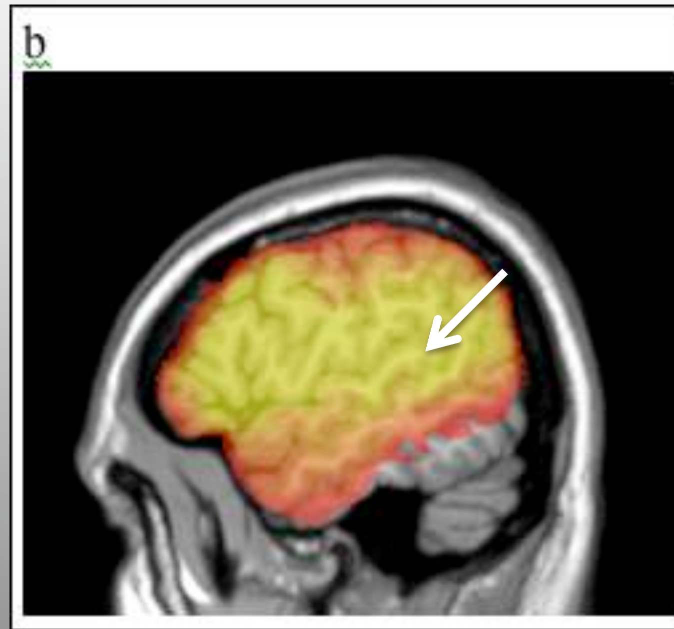


Filtered

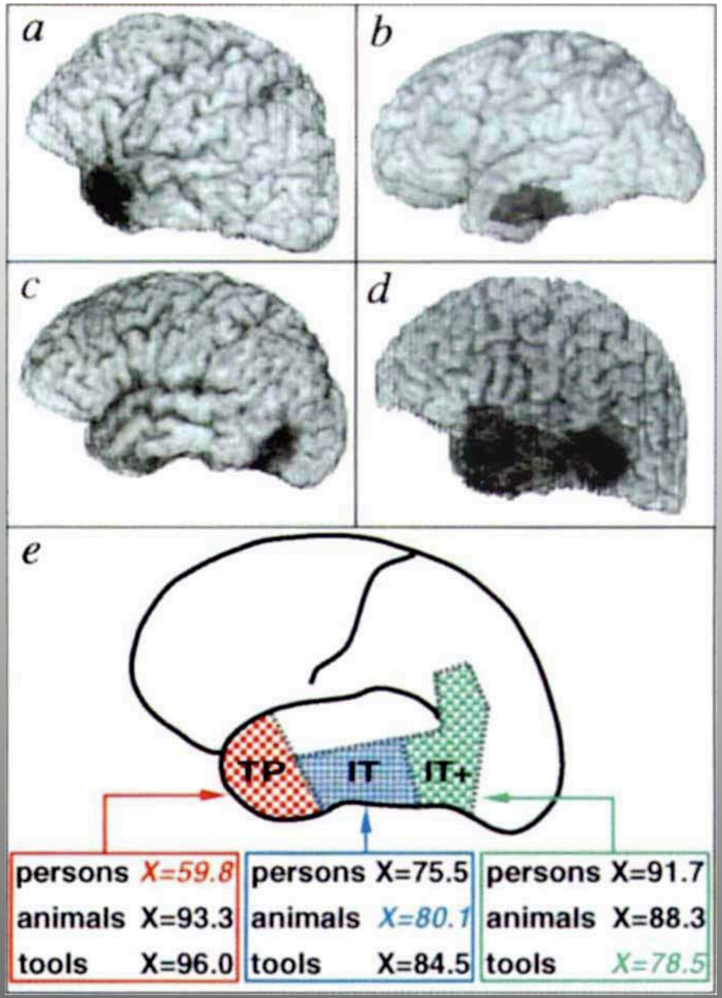


… despite adequate coverage there



ATL locus agrees with ....

Iowa lesion studies:
  "Convergence regions" for lexical retrieval in L-ATL



Damasio, Grabowski, Tranel, Hichwa, & Damasio, *Nature* (1996)

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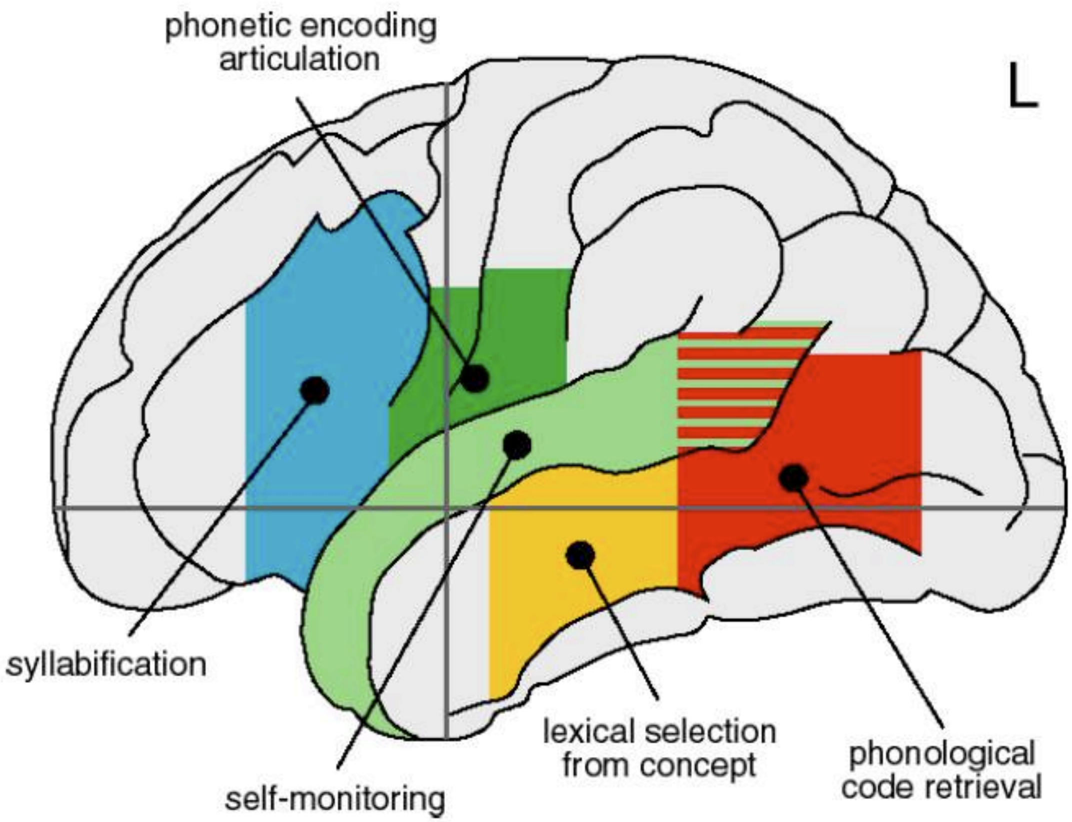
Meta-analysis of imaging studies (Indefrey & Levelt, 2004)



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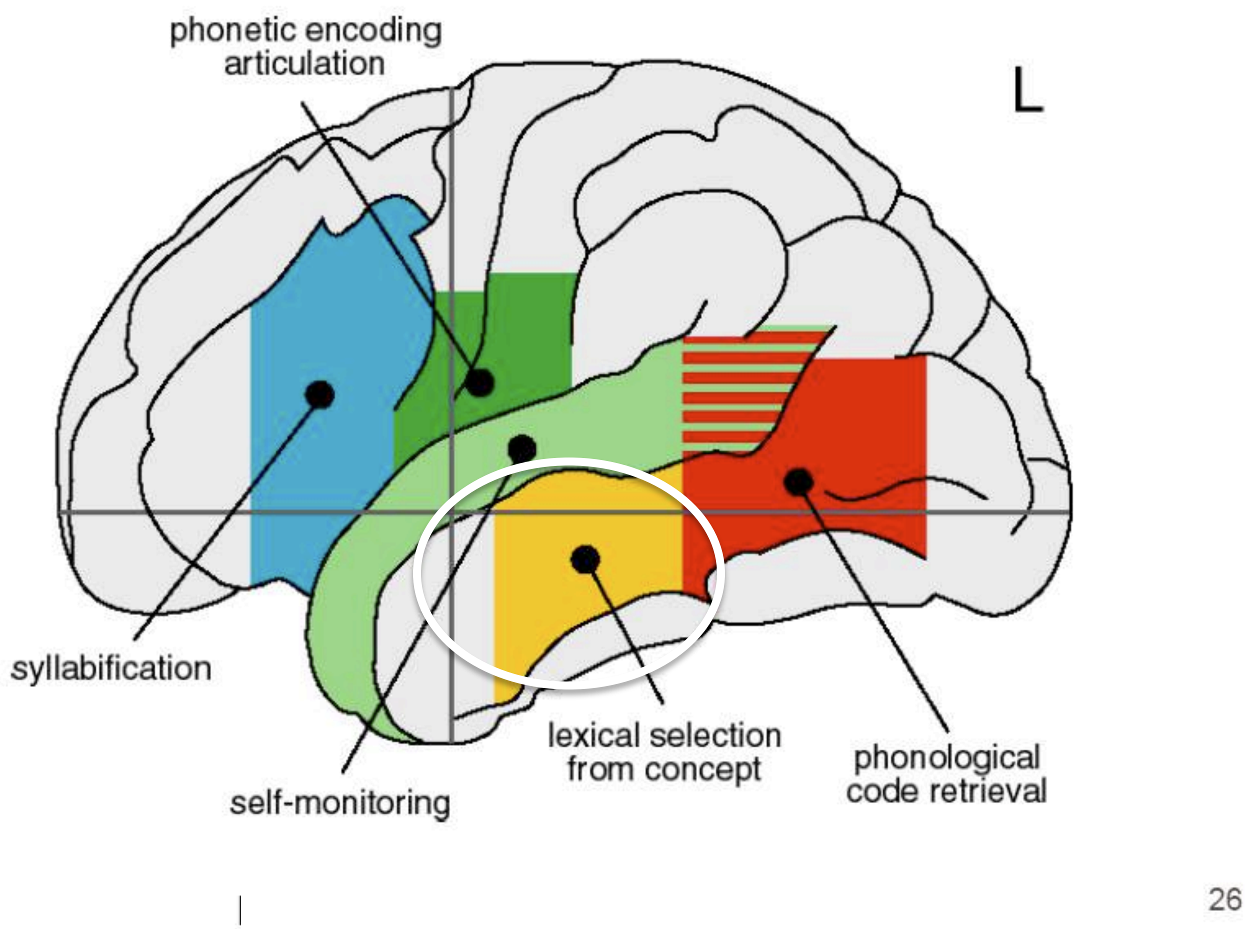
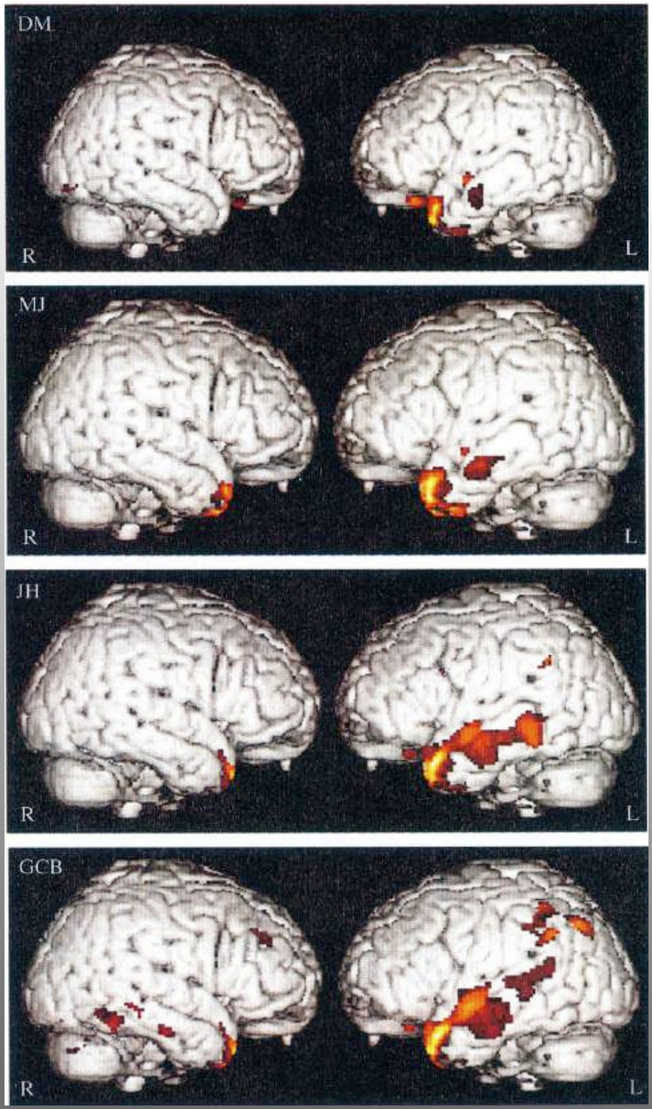


ATL locus agrees with ….

Site of maximal atrophy in semantic dementia



C. J. Mummery, K. Patterson, R. J. S. Wise, R. Vandenbergh, C. J. Price and J. R. Hodges. *Brain (1999),* ***122, 61–73***

Conclusions - 1

- Specific and necessary role for L-ATL in mapping concepts to words in production
- Role may be to convey fine-grained distinctions to the lexical system
  - Which features of a concept are more important, which less important, for selecting the right name from a competing set
  - Information that in the interactive 2-step model is expressed in the weighted connections between features and lemmas
- Hypothesize that damage to left ATL blunts this finer grain of differentiation, thereby raising the probability of semantic errors
-

Conclusions - 2

- In line with evidence from convergence zone theory, functional neuro-imaging, and
- Fails to support causal link between semantic error production and Wernicke's area dysfunction (Hopkins acute stroke studies: DeLeon et al., 2007; Cloutman et al., 2009; others)
- *Acute and chronic* damage may have different effects on the brain's network for concept-word mapping in production

We gratefully acknowledge the dedicated patients and families who made this study possible

And the dedicated labmates who helped out with recruitment, and behavioral testing and scoring:

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Krista Cullen	Laura MacMullen
Jennifer Gallagher	Michelle Rapp
Marisa Gauger	Paula Sobel

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Visit ncrrn.org

Thank you!

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