Nouns, Verbs, Objects and Actions: the View from Neuropsychology

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What is knowledge of language?

A universal or design feature of language:

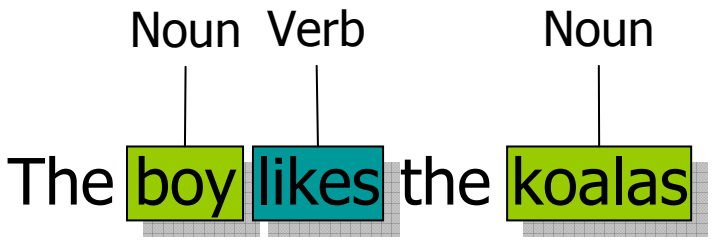
all natural language utterances are made up of distinct units that are "meaningful" and all natural language systems divide those units into a series of two or more classes or syntactic categories, which constrain how words can be combined into sentences: A system of "words and rules"

In this system Nouns and verbs have a special status

Greenberg, 1966; Hocket, 1958; Robins, 1952

On nouns and verbs

The categories "noun" and "verb" are universal across languages (not so for other categories) and represent elemental building blocks for grammatical rules that combine single words into phrases and sentences



but not….

*The likes boy the koalas

Greenberg, 1966; Hocket, 1958; Robins, 1952

On nouns and verbs

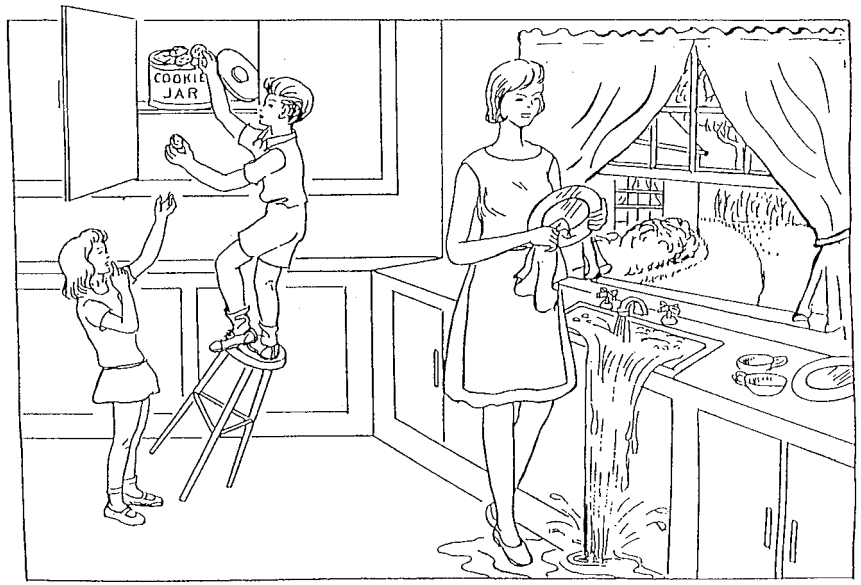
The distinction between nouns and verbs is of fundamental importance not only for understanding language but for all aspects of cognition (think of the structure of propositions, categories, reasoning, mathematics, and even perception and action).

And yet we have only a rudimentary understanding of the role of grammatical category in the organization of the lexicon

What makes nouns and verbs special?

- All languages distinguish them
- Differences in acquisition
- Dissociations following brain damage

e.g. Cazden (1968); Valian (1986); Maratsos (1988)



EBA: “Oh Lordy, she’s making a mess. She let the thing go, and it’s getting on the floor. They’re stealing something. He’s falling; he’s gonna hurt himself. She’s cleaning these things. She’s looking at him falling, and she’s gonna get some of the stuff he’s giving her.”

CH: “Okay, the boy is, his cookies, he is, uh, his sister is look for him cookies, but he is going to fall out of his stool because his legs are not bent that way. And his mother is, all the time her dishes are bein’, and his mother is, she has got this [kəsɪt] and her faucet is never really on that, and then he has a tree, but he is, I don’t know.”

What are grammatical category deficits?

Not obvious that distinction is one of grammatical category as opposed to any one of various other factors that correlate with grammatical category

Nouns	Verbs
objects	actions
entities	relations
concrete	abstract
sensory	functional
imageable	non-imageable

On nouns and verbs versus objects and actions

Edward Sapir

There must be something to talk about and something must be said about this subject of discourse once it is selected. This distinction is of such fundamental importance that the vast majority of languages have emphasized it by creating some sort of formal barrier between the two terms of the proposition. The subject of discourse is a noun. As the most common subject of discourse is either a person or a thing, the noun clusters about concrete concepts of that order. As the thing predicated of a subject is generally an activity in the widest sense of the word, a passage from one moment of existence to another, the form which has been set aside for the business of predicating, in other words, the verb, cluster about concepts of activity. No language wholly fails to distinguish noun and verb, though in particular cases the nature of the distinction may be an elusive one. (Sapir, 1921: 119)

What are grammatical categories?

Nouns are not objects

Abstract nouns: the notion of madness

Deverbal nouns: he prefers action to talk

Verbs are not actions

Stative verbs: cats exist

Psych verbs: I enjoyed the fair, but it didn't amuse you

What are grammatical categories?

Nouns bear noun morphology

Case: cat (nominative/accusative/etc.); cat's (genitive)

Number: cat, ox (singular); cats, oxen (plural)

Verbs bear verb morphology

Tense: walk, run (present); walked, ran (past)

Person and number (φ): walk (1st singular), walks (3rd singular)

So, what are nouns and verbs?

Prototypical examples of nouns and verbs are concrete objects and actions, but the categories “noun” and “verb” are not isomorphic to the categories “object” and “action.”

(In other words, nouns and verbs have grammatical roles that seem to be dissociable from the semantic properties of prototypical members of each category.)

Grammatical categories are…

Distributional categories

A word's grammatical category determines the types of phrases in which it appears

'The boy likes the koalas' but not 'The likes boy the koalas'

Morphosyntactic categories

A word's grammatical category determines the morphological transformations it undergoes

'The boy liked the koalas' but not 'The boyed like the koalas'

How do "grammatical category" deficits arise?

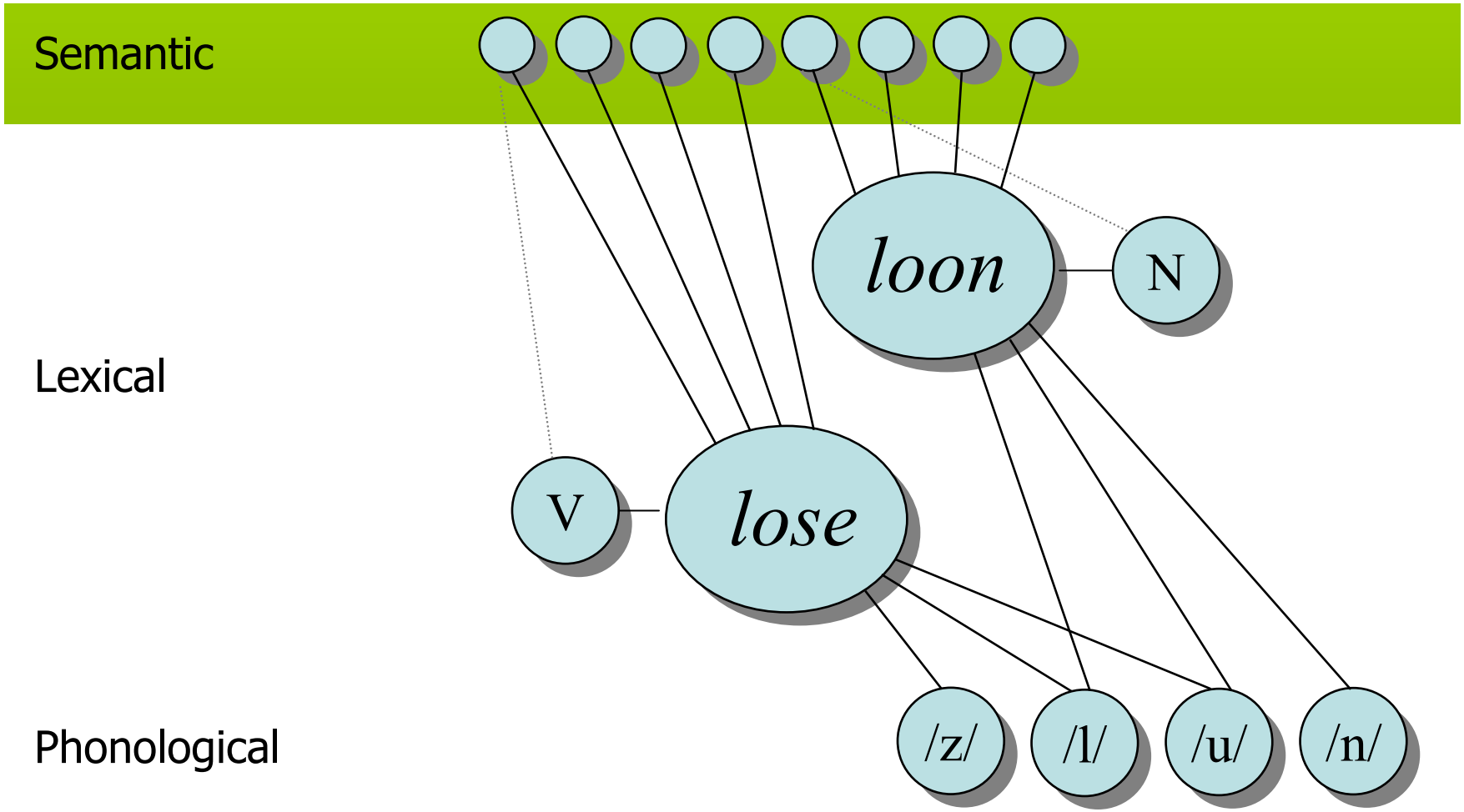
Loss of access to distributional or morphosyntactic information about one category of words

> Grammatical category specific deficits need not be linked to semantic deficits

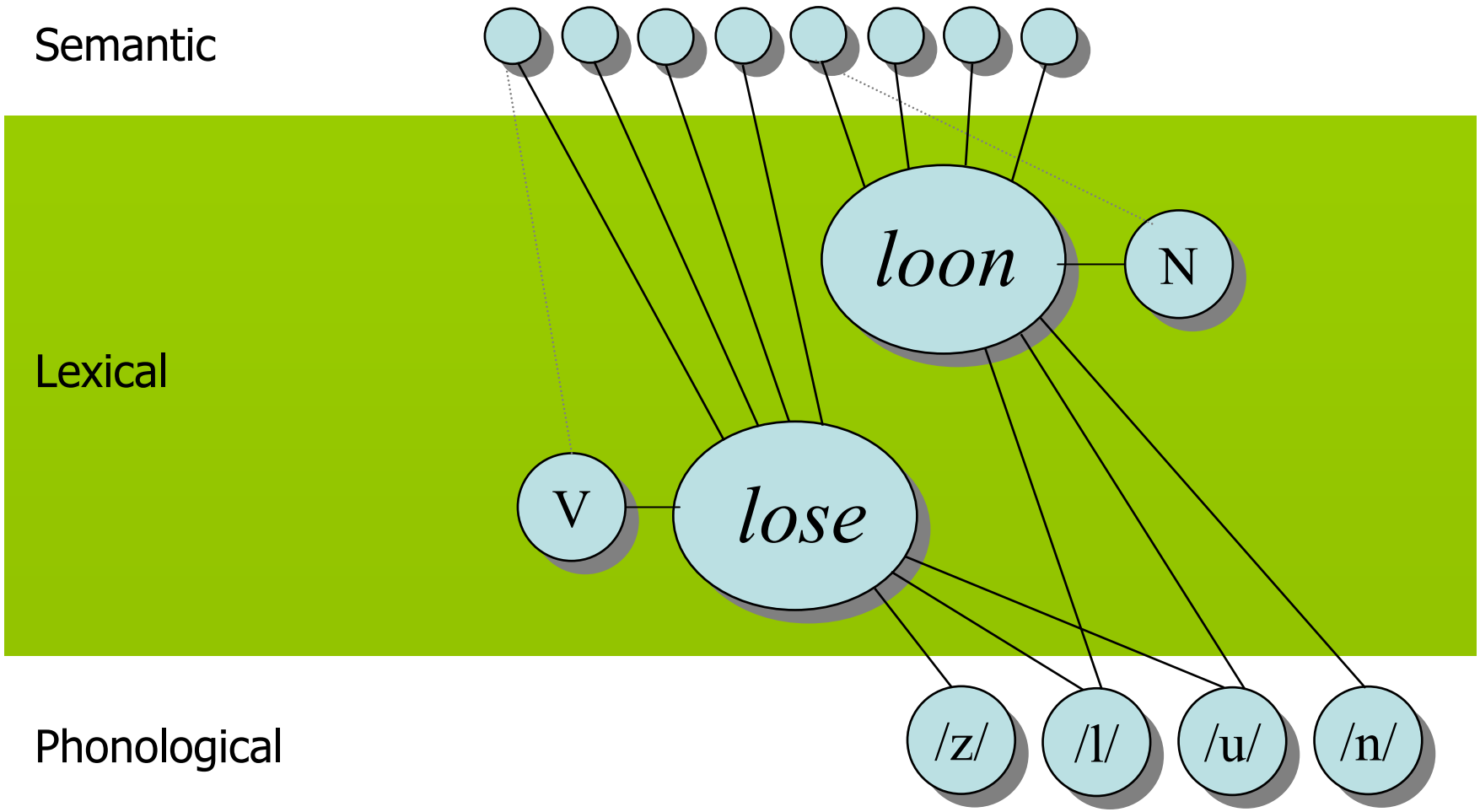
... or from damage to knowledge about certain aspects of word meaning

> Grammatical category specific deficits are always linked to semantic deficits

Locus of damage in semantic accounts



Locus of damage in lexical accounts



Outline

1. Neuropsychology of noun and verb production (experiments of nature)
2. “Virtual” neuropsychology (TMS)
3. Cortical signatures of noun and verb processing (fMRI)

How do "grammatical category" deficits arise?

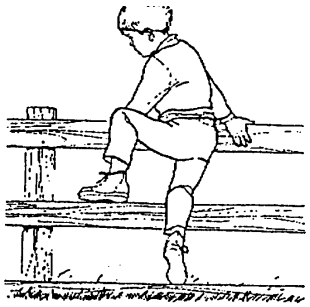
Addressed this issue in two ways.

One way is to find neurological patients whose grammatical category-specific deficits are unlikely to arise from damage to the semantic system

Such evidence is provided by patients with **modality-specific grammatical class deficits**

Caramazza & Hillis, 1991; Hillis & Caramazza, 1995; Rapp & Caramazza, 1998; 1992; Hillis, Tuffiash & Caramazza, 2002

P. W.



The boy — The fence

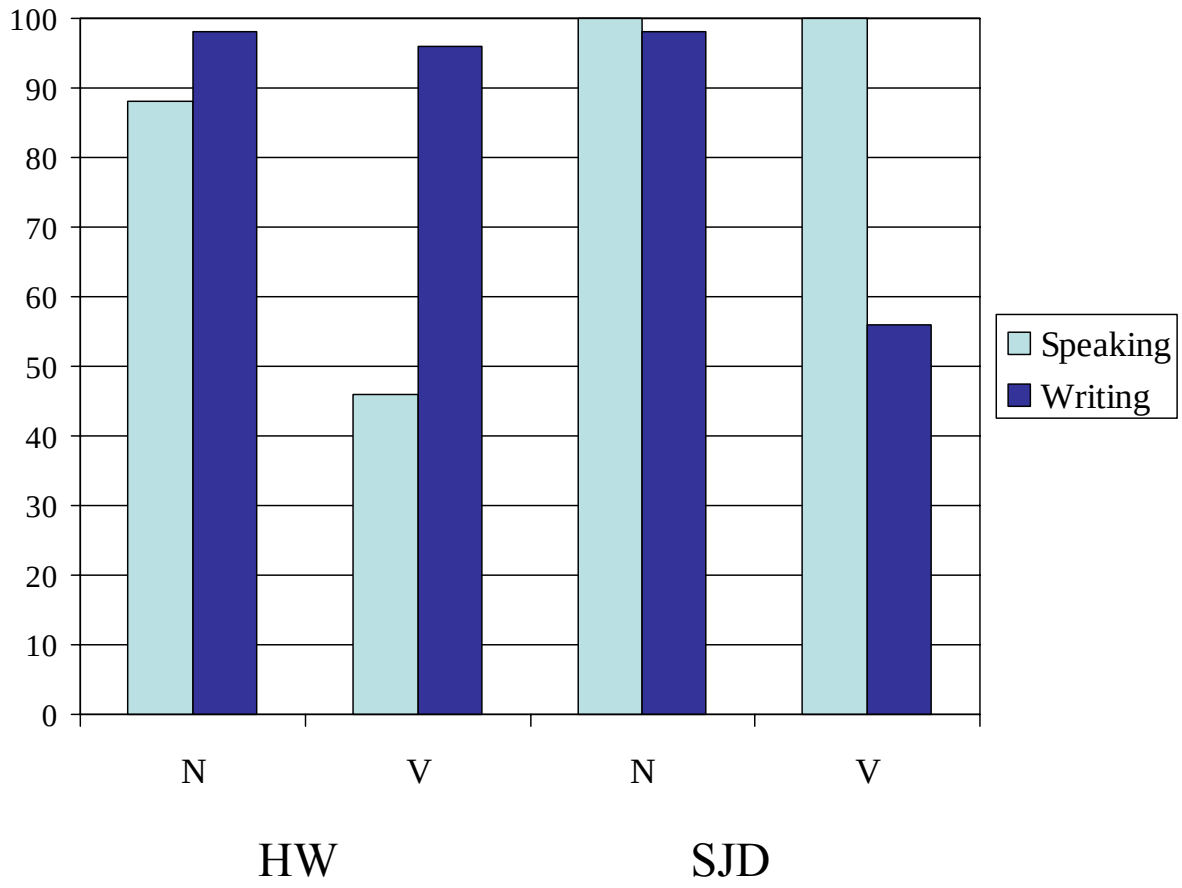
The boy is climbing the fence

The wife is — The dress.

The female is fixing the dress

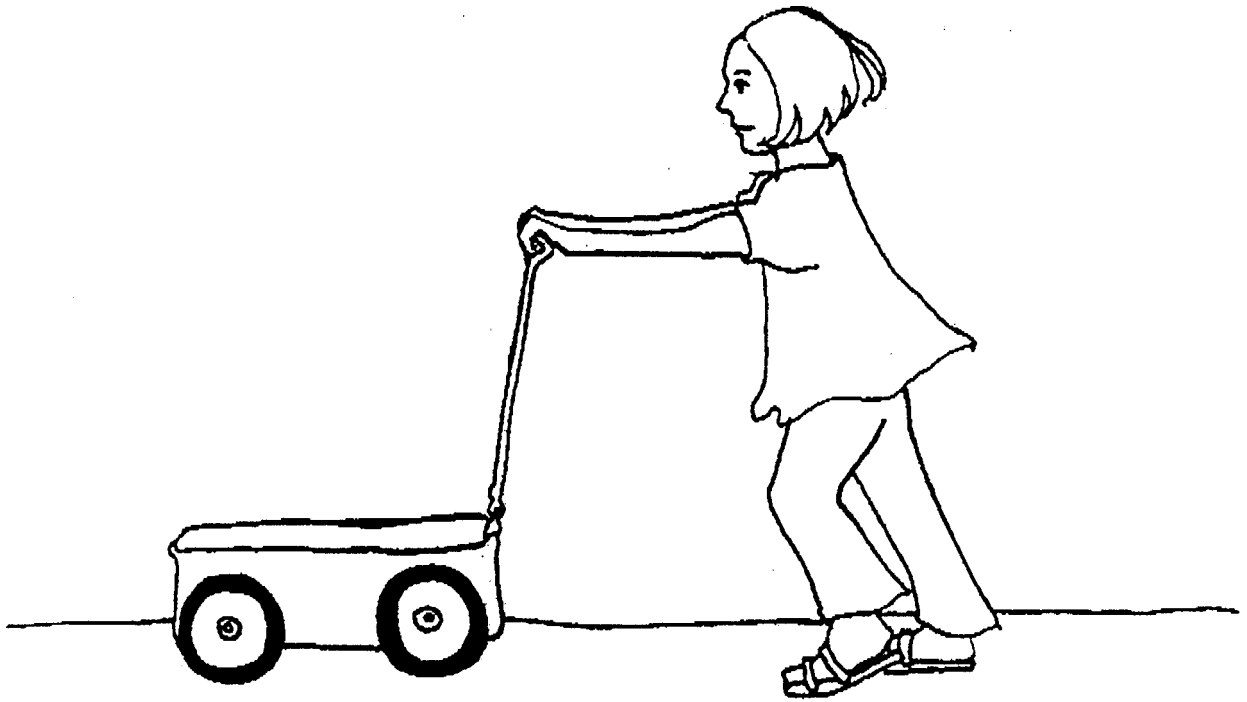
Caramazza & Hillis, 1990; Hillis & Caramazza, 1995; Rapp & Caramazza, 1998, 2002

Oral and written production of homonyms – e.g., play

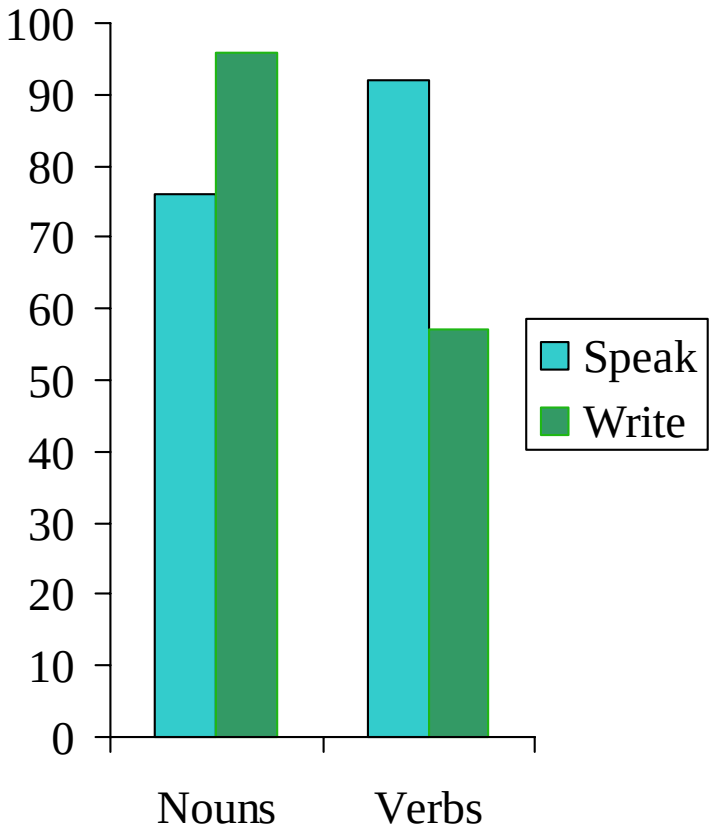


Caramazza & Hillis, 1991

Speaking: The girl is holding the /baêg/.
Writing: The girl is **actions** a wagon.



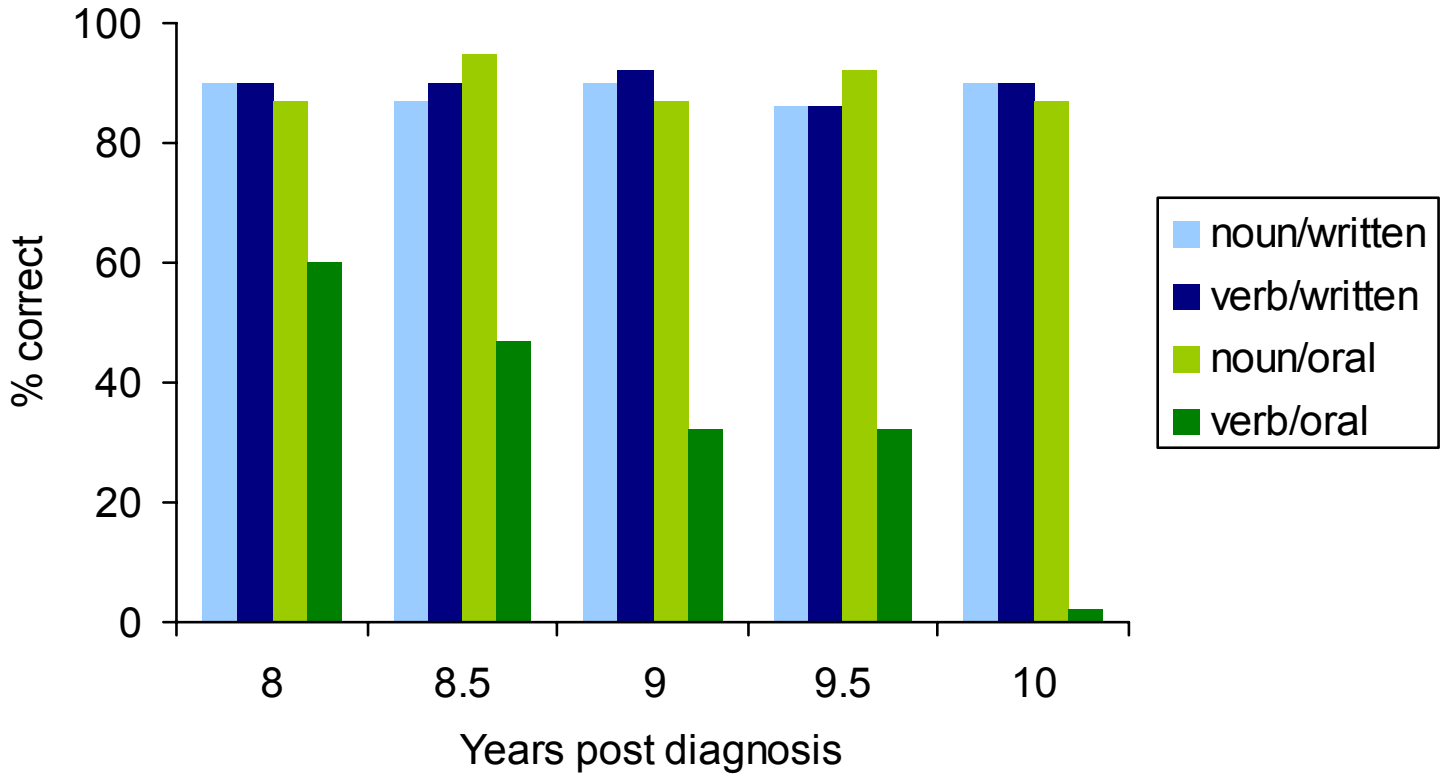
Spoken and written production of nouns and verbs (KSR)



- interaction cannot be attributed to differences in relative difficulty of Ns and Vs since same items used in speaking and writing tasks

Rapp & Caramazza, 2002

Oral and written production of homonyms:
MML (primary progressive aphasic)



Hillis, Tuffiash, & Caramazza, 2002

MML's oral production

At 8 years post onset

"The water is overflowing. The stool is gonna....is gonna happen. The people are... the boy and girl, and they had to... stumble. Also...he's...falling back. The mother is… She's wash... wiping the dishes.

At 10.5 years post onset:

"uh, uh, boy... uh, uh, girl... and... cookies... uh, uh, uh" (patient just wanted to write).

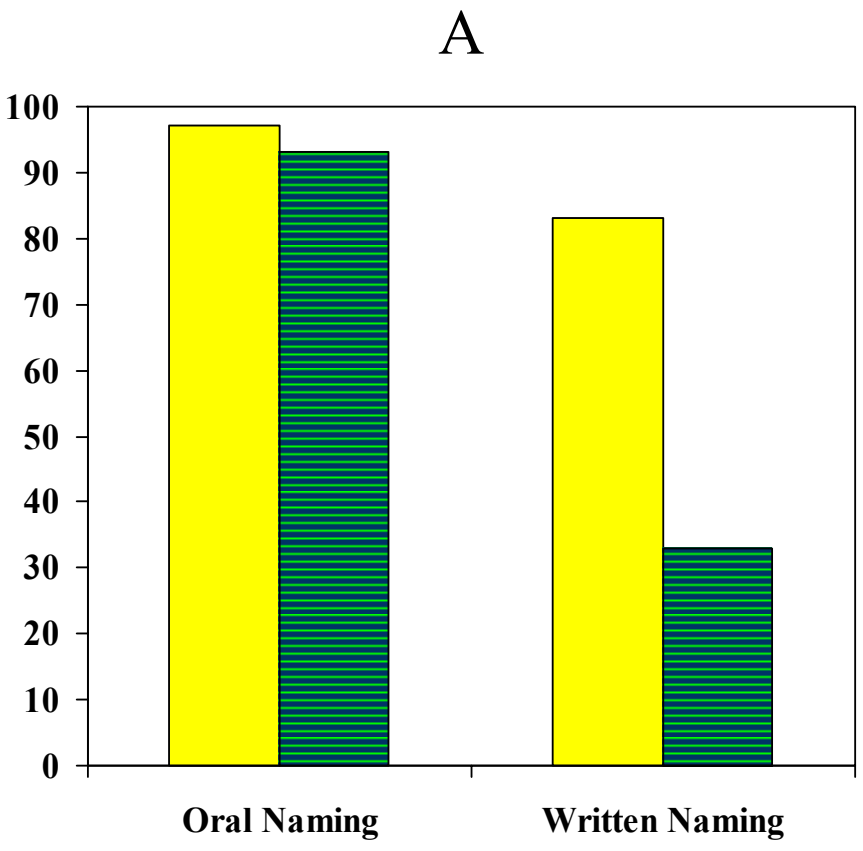
Hillis, Tuffiash, & Caramazza, 2002

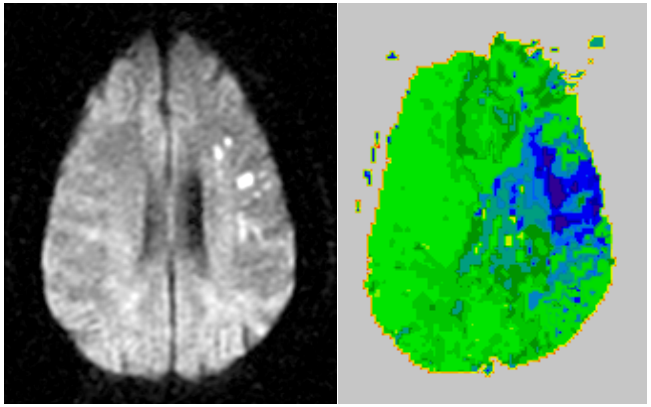
Modality-specific grammatical category deficits

Category-specific grammatical class deficits with spared semantics

..... not strange consequence of re-organization of function – tests at **6 hours** after onset of neurological signs – and reversed with reperfusion

Hillis, Wityk, Barker, & Caramazza, 2002





MR diffusion-weighted imaging (DWI): identify the acute infarct

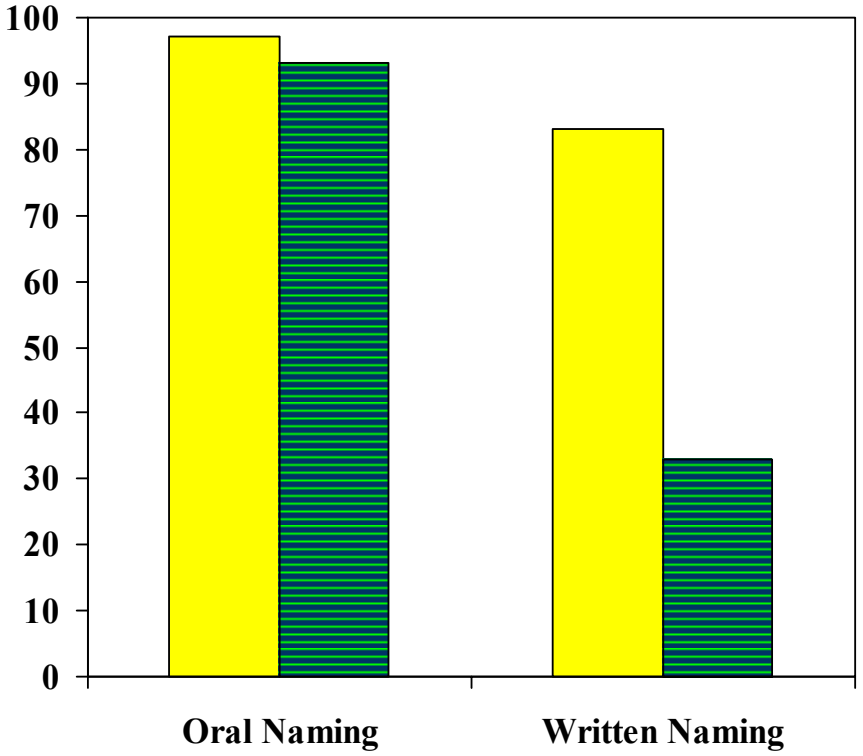
perfusion-weighted imaging (PWI): identify areas of low perfusion (poor blood flow)

Scans obtained within 1 hour of testing

a small, acute left subcortical infarct (DWI), and a larger area of hypoperfusion in left PIFG, inferior precentral and postcentral gyri, and insula (PWI)

Hillis, Wityk, Barker, & Caramazza, 2002

A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Oral Naming
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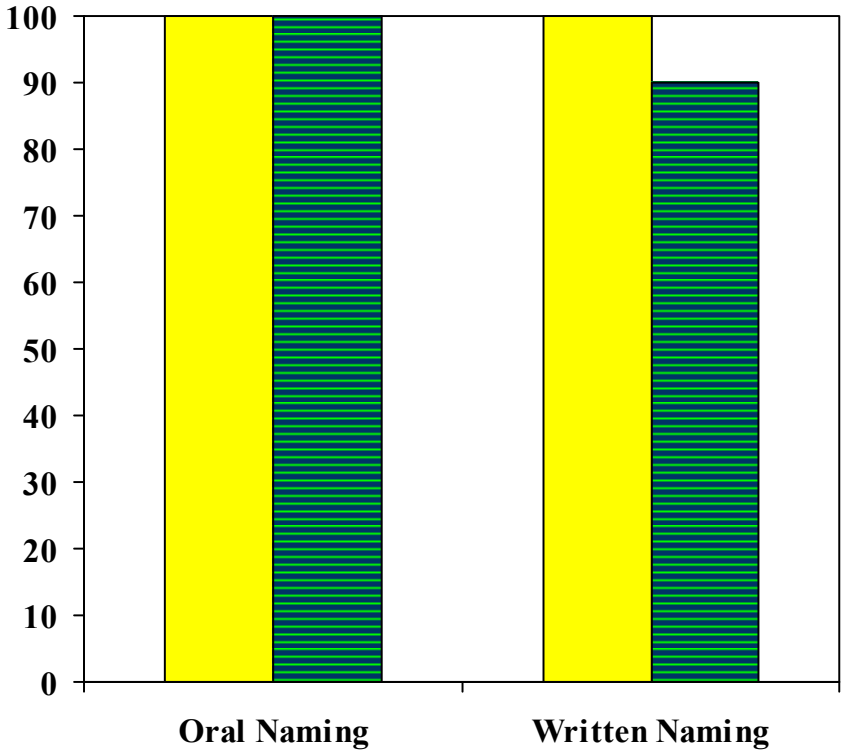
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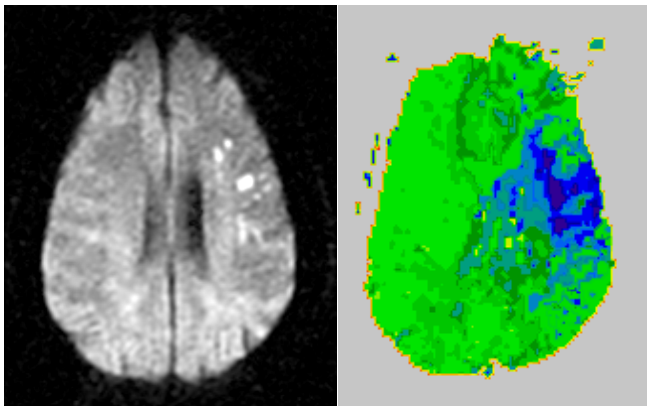
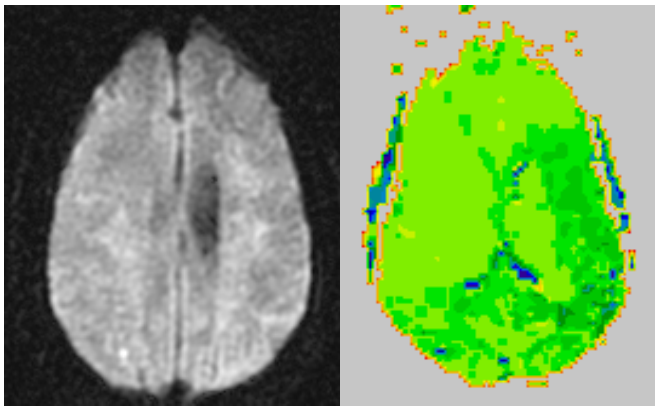
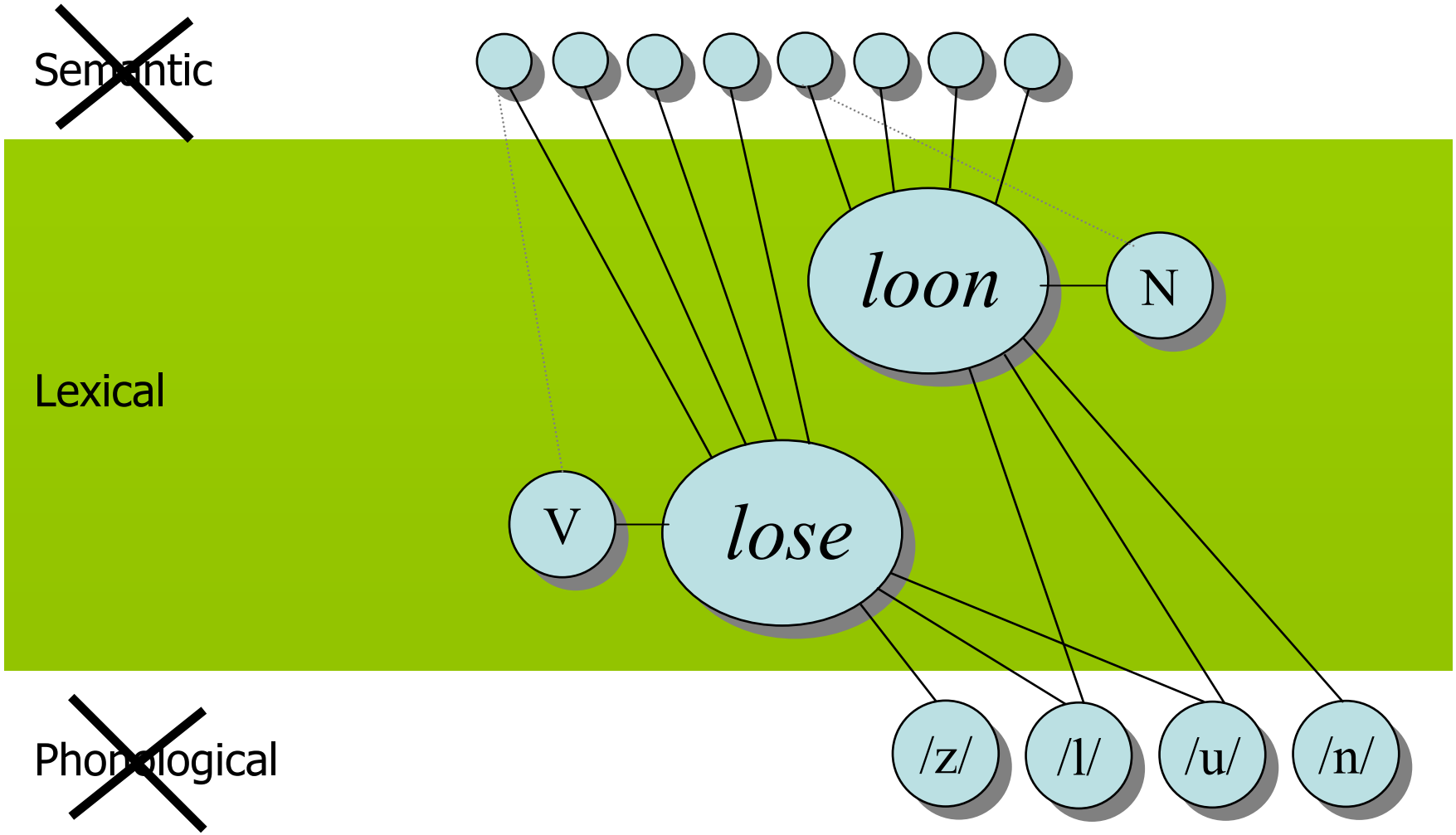




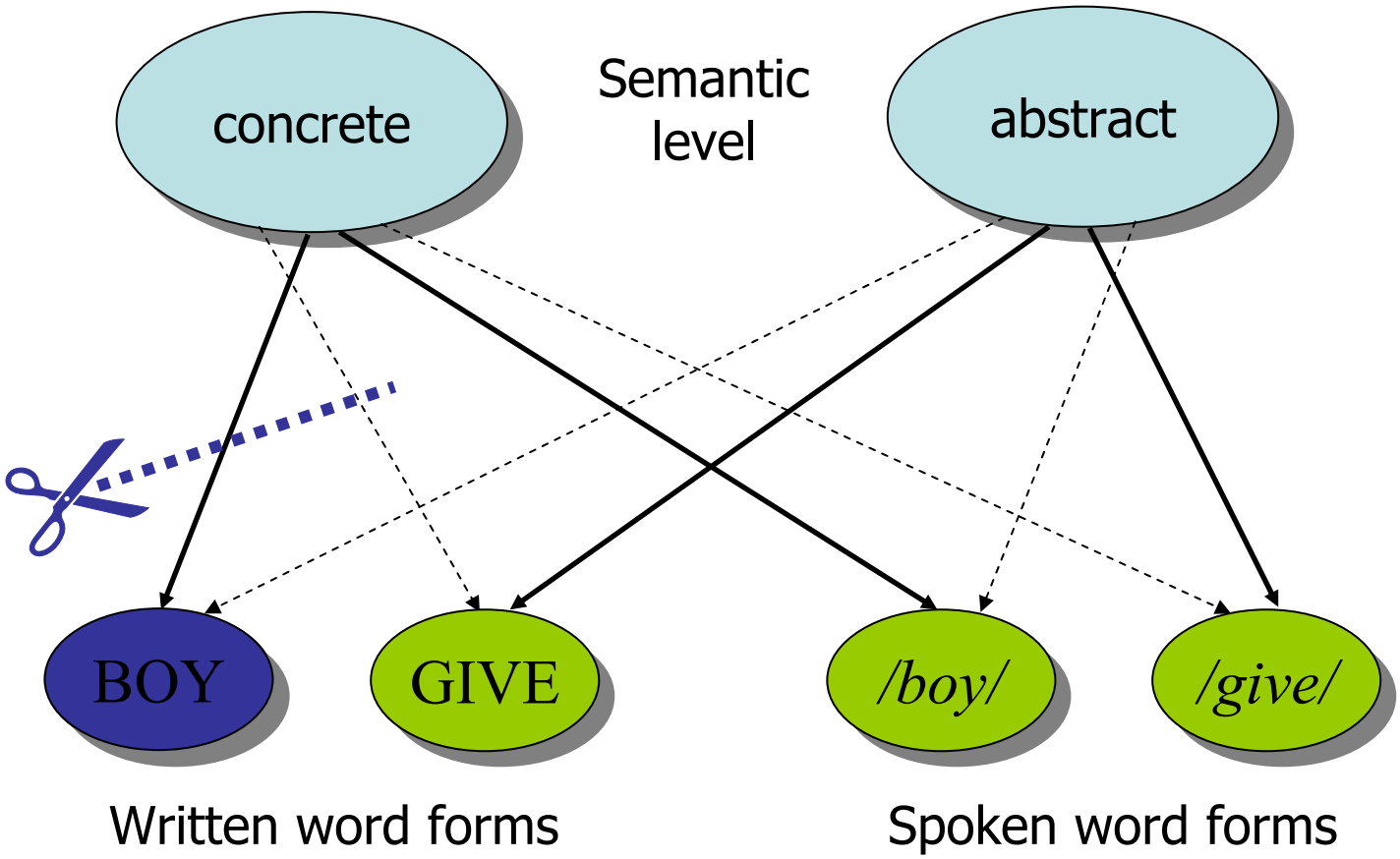
Modality-specific grammatical category deficits: conclusion

Grammatical class dissociations in some patients do not seem to be caused by semantic or peripheral (phonological/orthographic) deficits

Locus of damage in lexical accounts



Disconnection account of modality-specific deficits



How do "grammatical category" deficits arise?

Addressed this issue in two ways.

One way is to find neurological patients whose grammatical category specific deficits are unlikely to arise from damage to the semantic system

Such evidence is provided by patients with **modality-specific grammatical class deficits**

The other way is to test directly for grammatical category-specific morphosyntactic (or morphophonological) deficits

Laiacona & Caramazza, 2004; Shapiro & Caramazza, 2003a,b; Shapiro, Shelton, & Caramazza, 2001

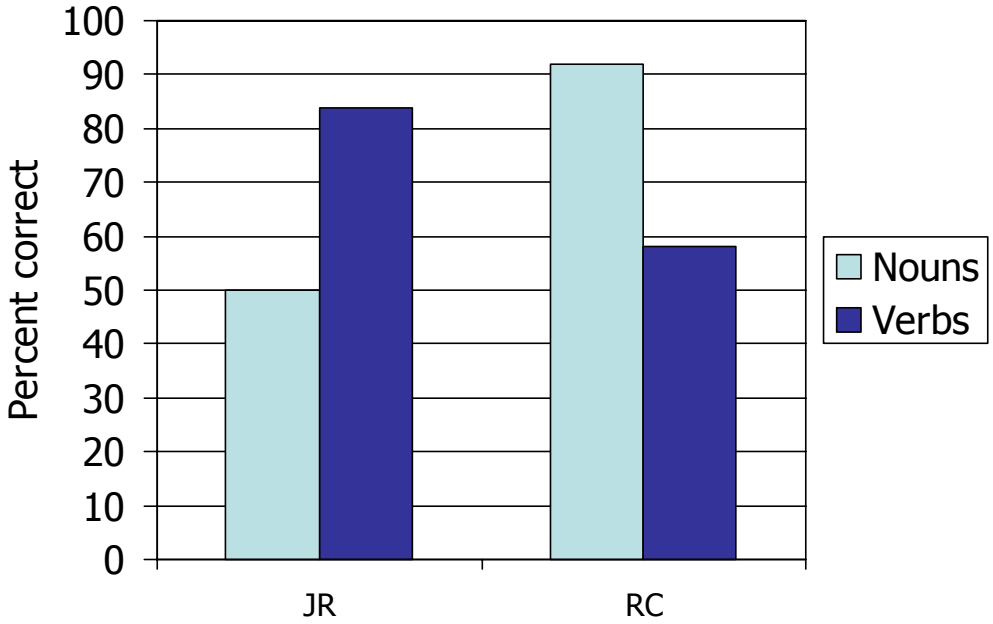
Morphological production task

"This is a fleeve; these are ___"	(fleeves)	add
"These are wugs; this is a ___"	(wug)	remove
"This pig fleeves; these pigs ___"	(fleeve)	remove
"These pigs wug; this pig ___"	(wugs)	add

And consider whether difficulty in morphophonological production can be selective for grammatical category

Shapiro, Shelton & Caramazza, 2000; Shapiro & Caramazza, 2003; Laiacona & Caramazza, 2004

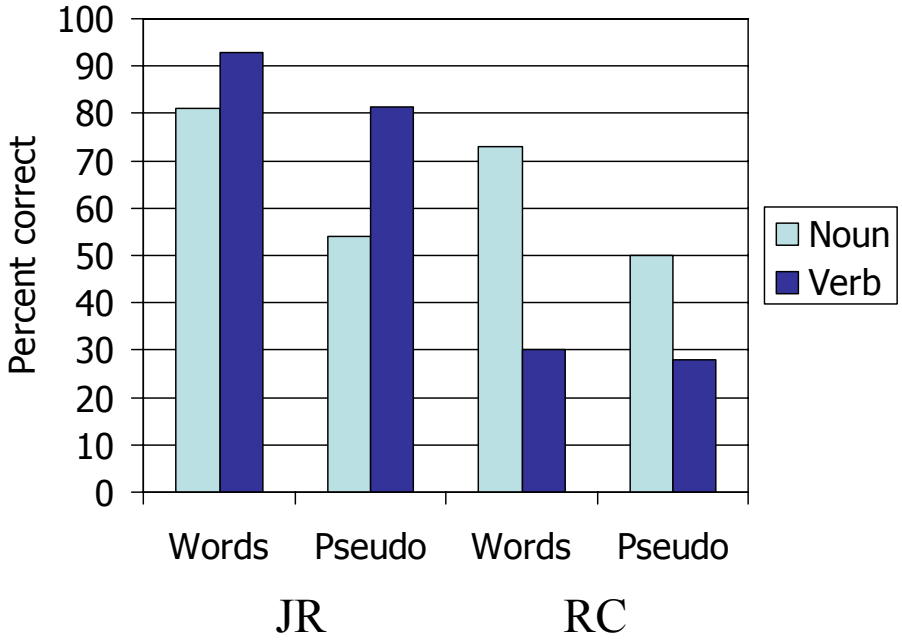
Dissociation in naming nouns and verbs



Shapiro, Shelton & Caramazza, 2000; Shapiro & Caramazza, 2003; Laiacona & Caramazza, 2004

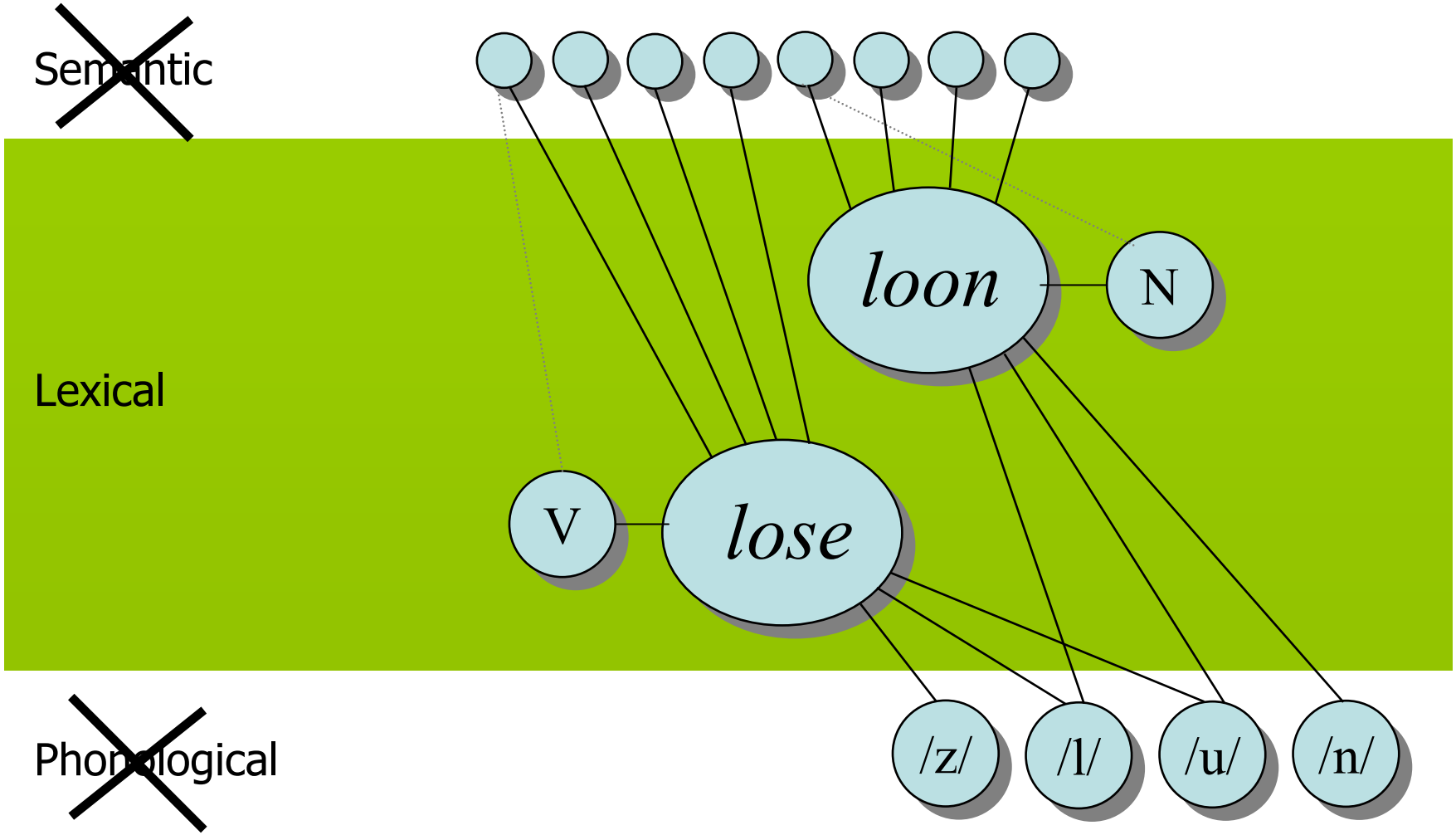
Morphological production task

"This is a guide; these are ___"	(guides)	add
"These are sails: this is a ___"	(sail)	remove
"This pig fleeves; these pigs ___"	(fleeve)	remove
"These pigs wug; this pig ___"	(wugs)	add



Shapiro, Shelton & Caramazza, 2000; Shapiro & Caramazza, 2003; Laiacona & Caramazza, 2004

Locus of damage in lexical accounts



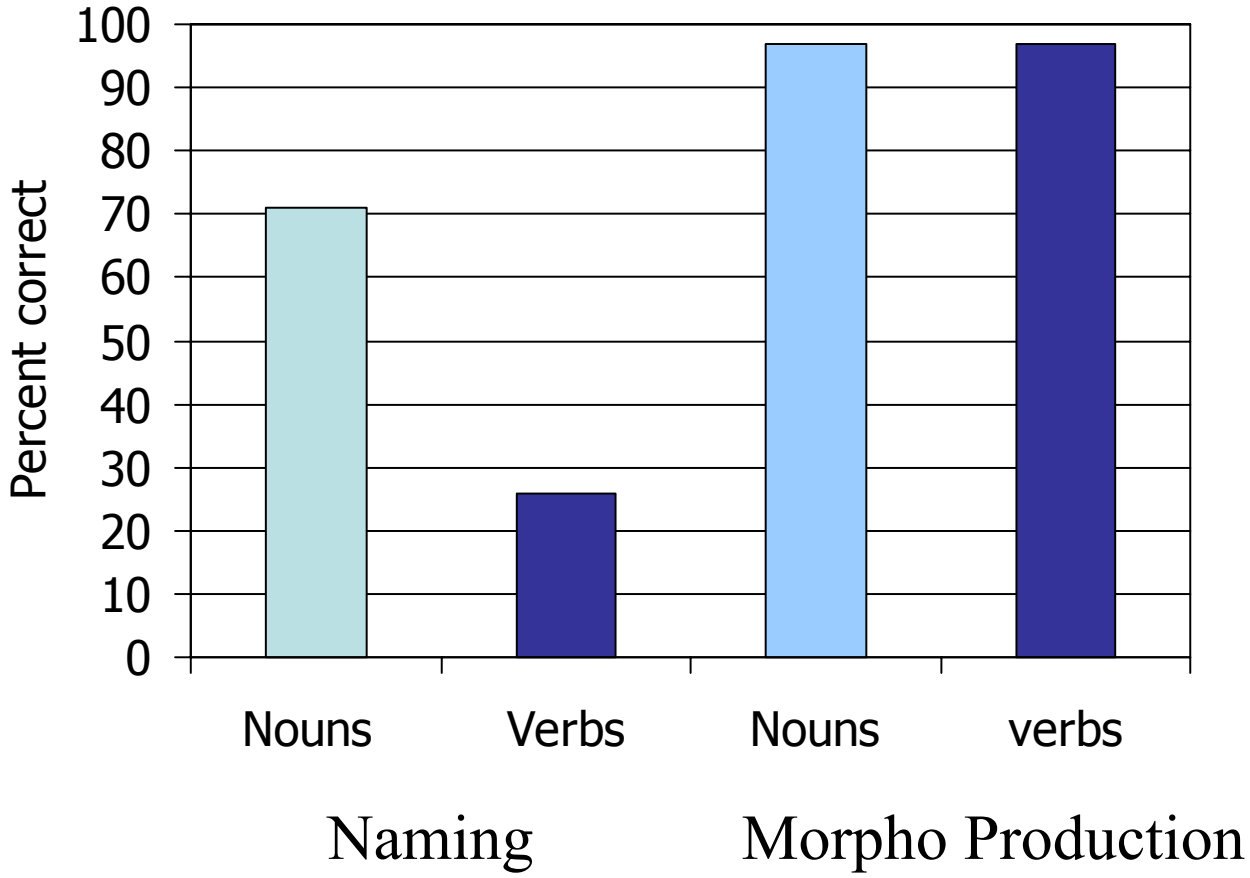
How do grammatical category deficits arise?

However it is possible to imagine a remote semantic cause for the observed dissociations… cascading effects from semantic level to later stages of processing

Implication of this assumption is that whenever a patient presents with a grammatical category-specific naming deficit the patient will also have a grammatical category-specific morphophonological deficit

Laiacona & Caramazza, 2004; Shapiro & Caramazza, 2003a,b; Shapiro, Shelton, & Caramazza, 2001

Dissociation of naming and morphological production deficits



Laiacona & Caramazza, 2004; Shapiro & Caramazza, 2003b

Interim summary and new directions

Grammatical knowledge and semantic knowledge can be damaged independently for a given word category

Processing of grammatical categories constitutes a discrete component (?) of sentence processing

Converging evidence with other methods: a look at the brain

Question

What neural systems subserve the representation of grammatical knowledge about nouns and verbs?

> What areas of the brain are damaged in patients with grammatical category specific deficits?

Verb retrieval impairments tend to occur in patients with damage to the left frontal cortex, while noun deficits are most often associated with damage to the left temporal lobe (Miceli, Silveri, Villa & Caramazza, 1984; Damasio & Tranel, 1993; Daniele et al., 1994; Miceli et al., 1988; Tranel et al., 2001).

What about the brain?

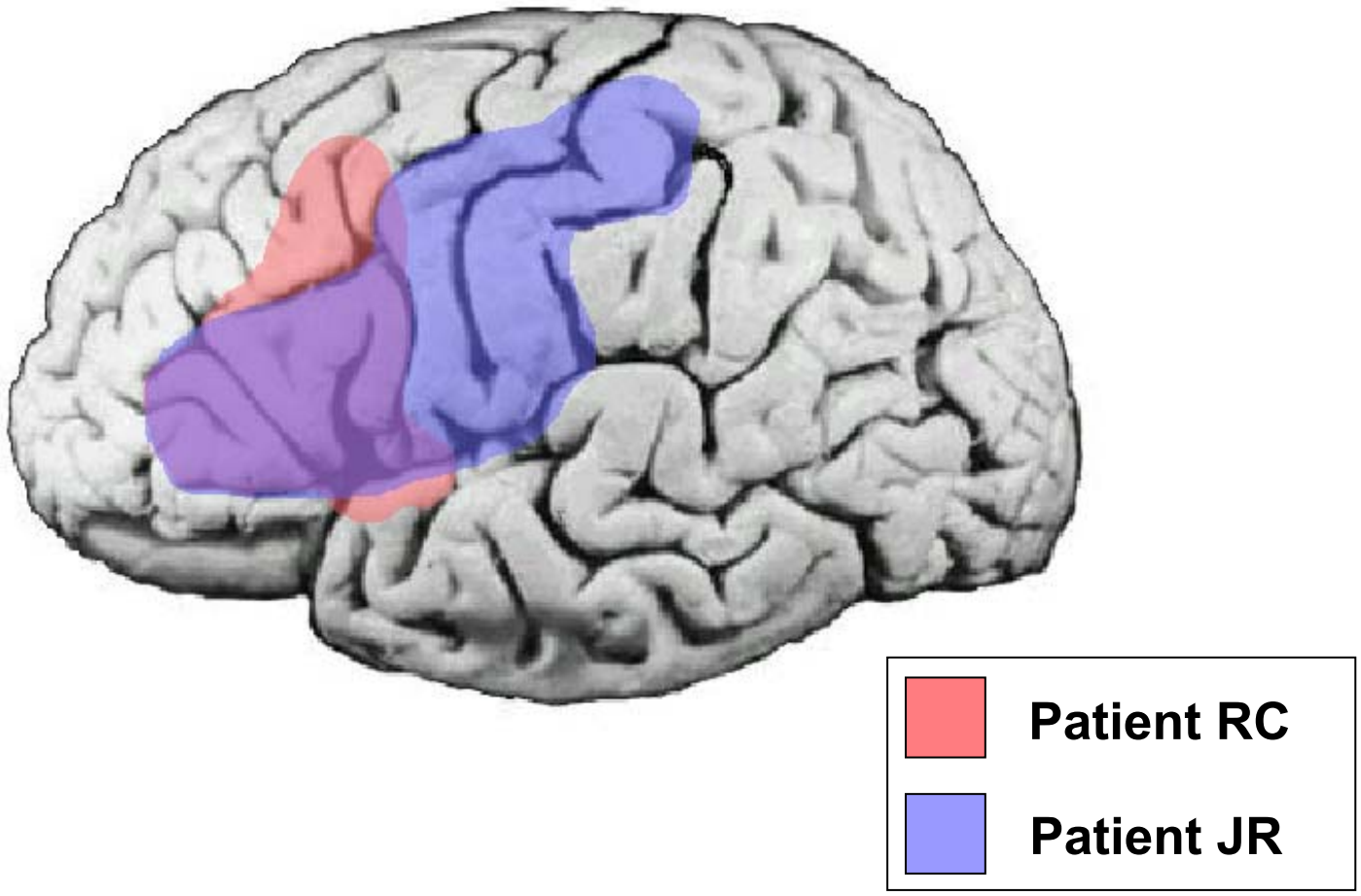
Neuropsychological findings are equivocal with respect to brain areas that may be involved in representing specifically grammatical operations for nouns and verbs

JR: left inferior frontal and parietal lesion

RC: left frontal opercular and posterior prefrontal lesion

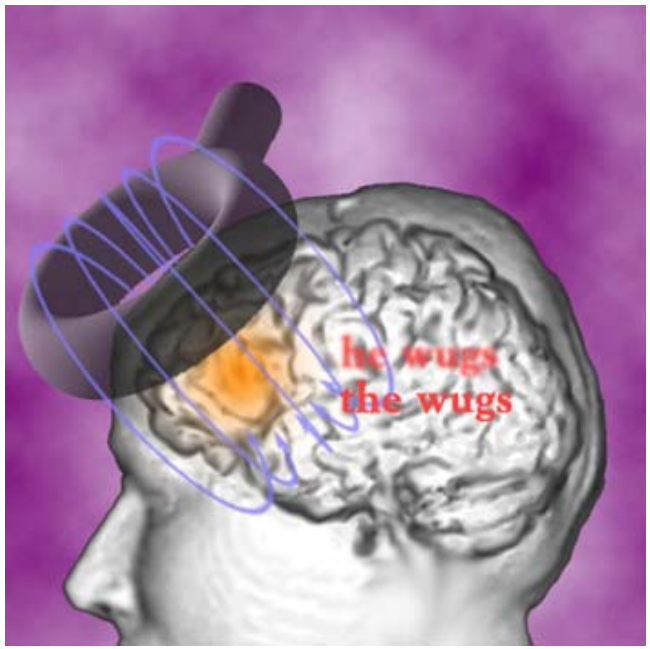
Part of left midfrontal cortex crucial for verb processing?

What about the brain?



Transcranial magnetic stimulation (TMS)

Repetitive transcranial magnetic stimulation (rTMS) modulates activity in targeted brain regions – assess effects on morphological transformations of nouns and verbs



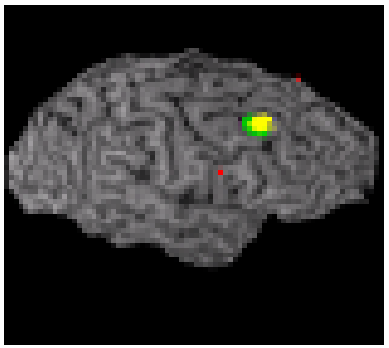
Task:

"This is a sail; these are ___" (sails)
"These are wugs; this is a ___" (wug)
"This person sails; these people__" (sail)
"These pigs wug; this pig___" (wugs)

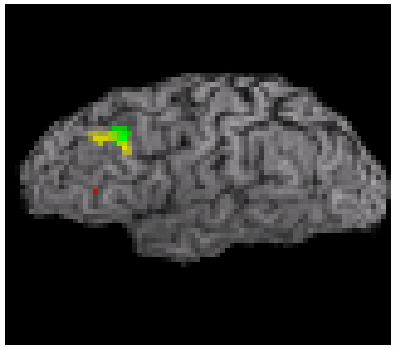
Methods

Target sites were located with a specialized navigation system (Brainsight, Rogue Research), using a high-resolution structural MRI obtained for each subject prior to the experiment.

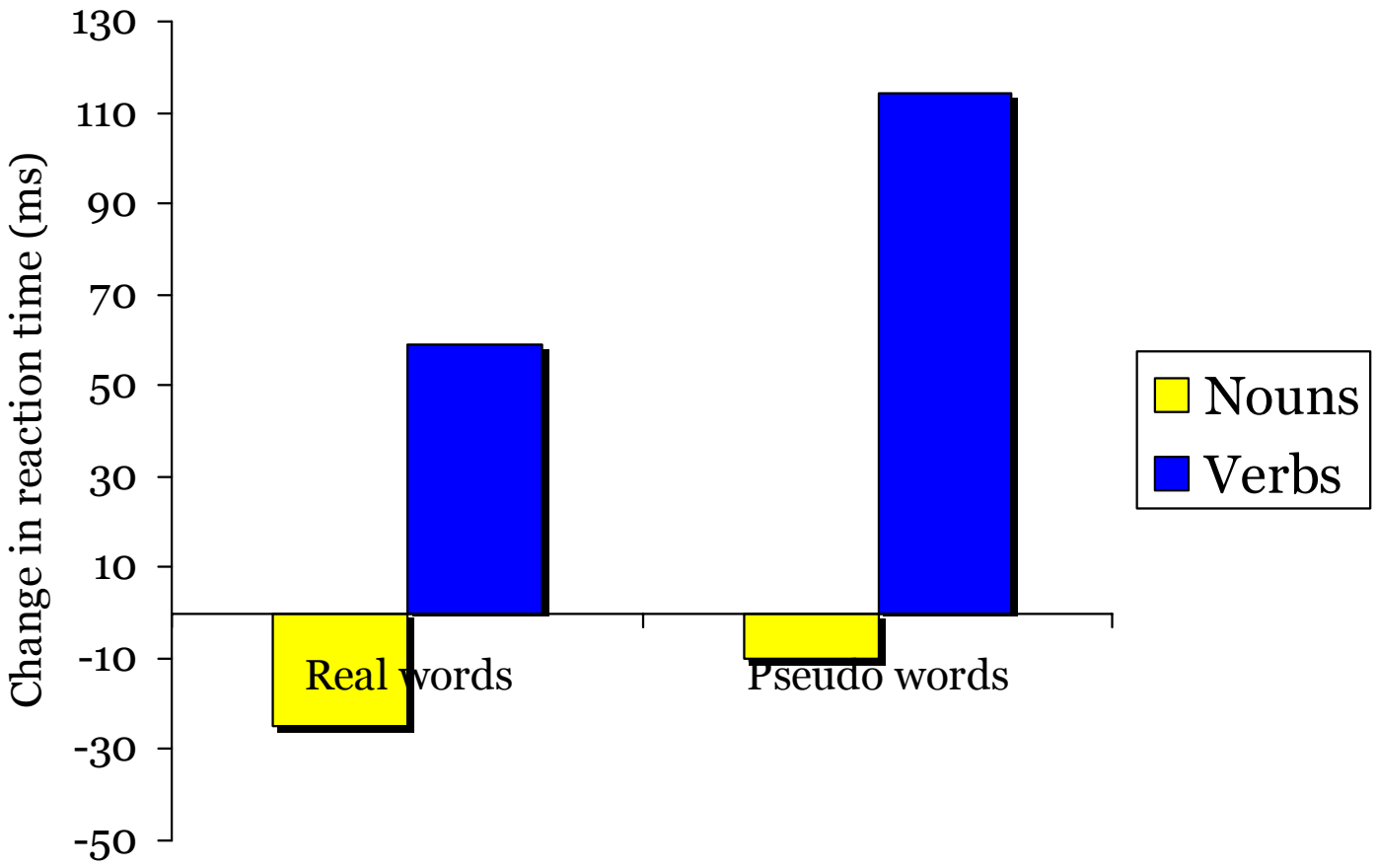
Right IMFG



Left IMFG



TMS results: inferior mid-frontal gyrus



Shapiro, Pascual-Leone, Mottaghy, Gangitano & Caramazza (2001)

further questions

Is the effect *specific* to the area stimulated?

Is the effect *focal* (i.e., does it arise because of stimulation to that site, or spread of inhibition to neighboring sites)?

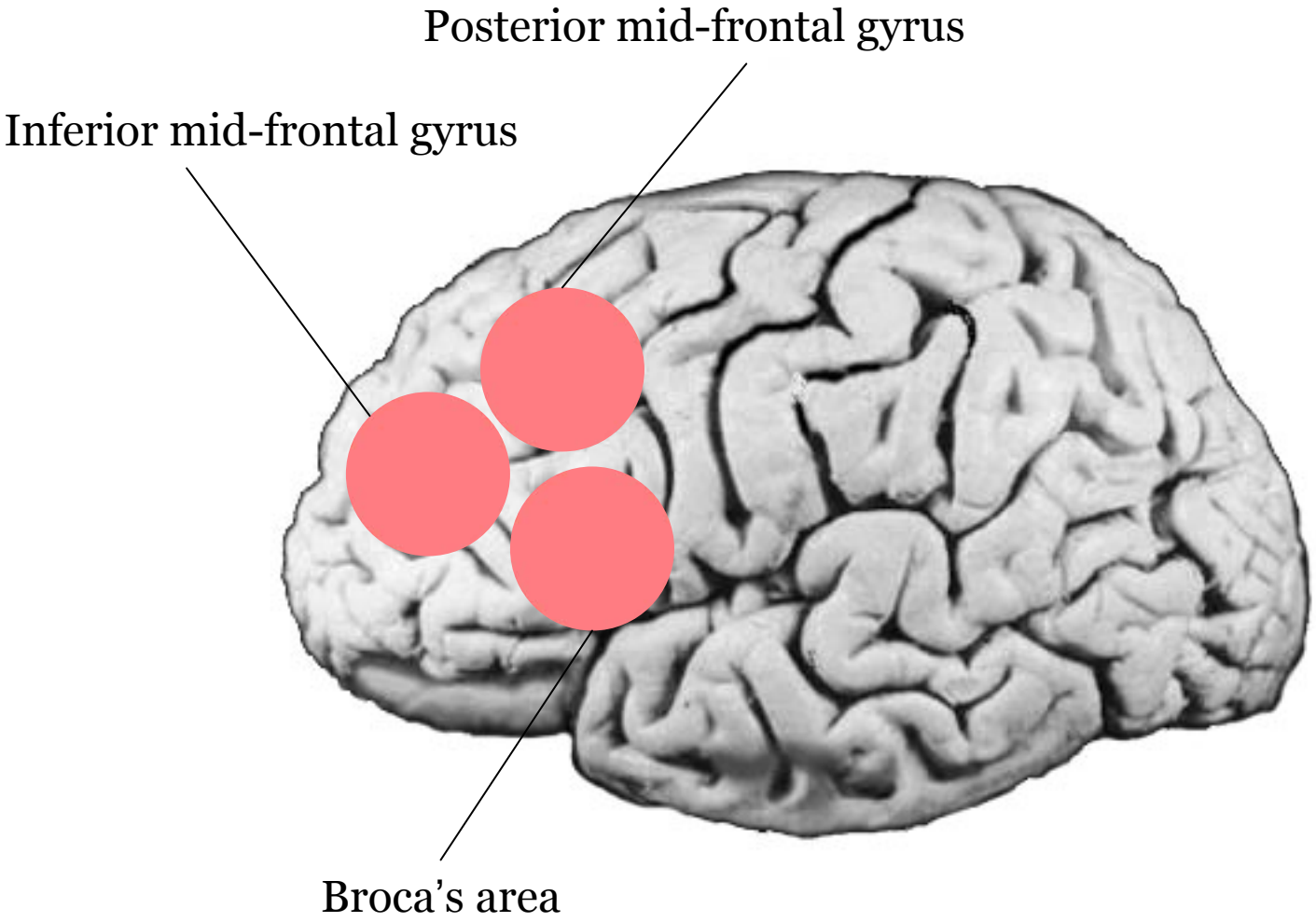
Stimulate the right frontal lobe (Exp. 1) and other sites in the left frontal lobe (Exp. 2)

Can the effect be generalized to other kinds of grammatical operations?

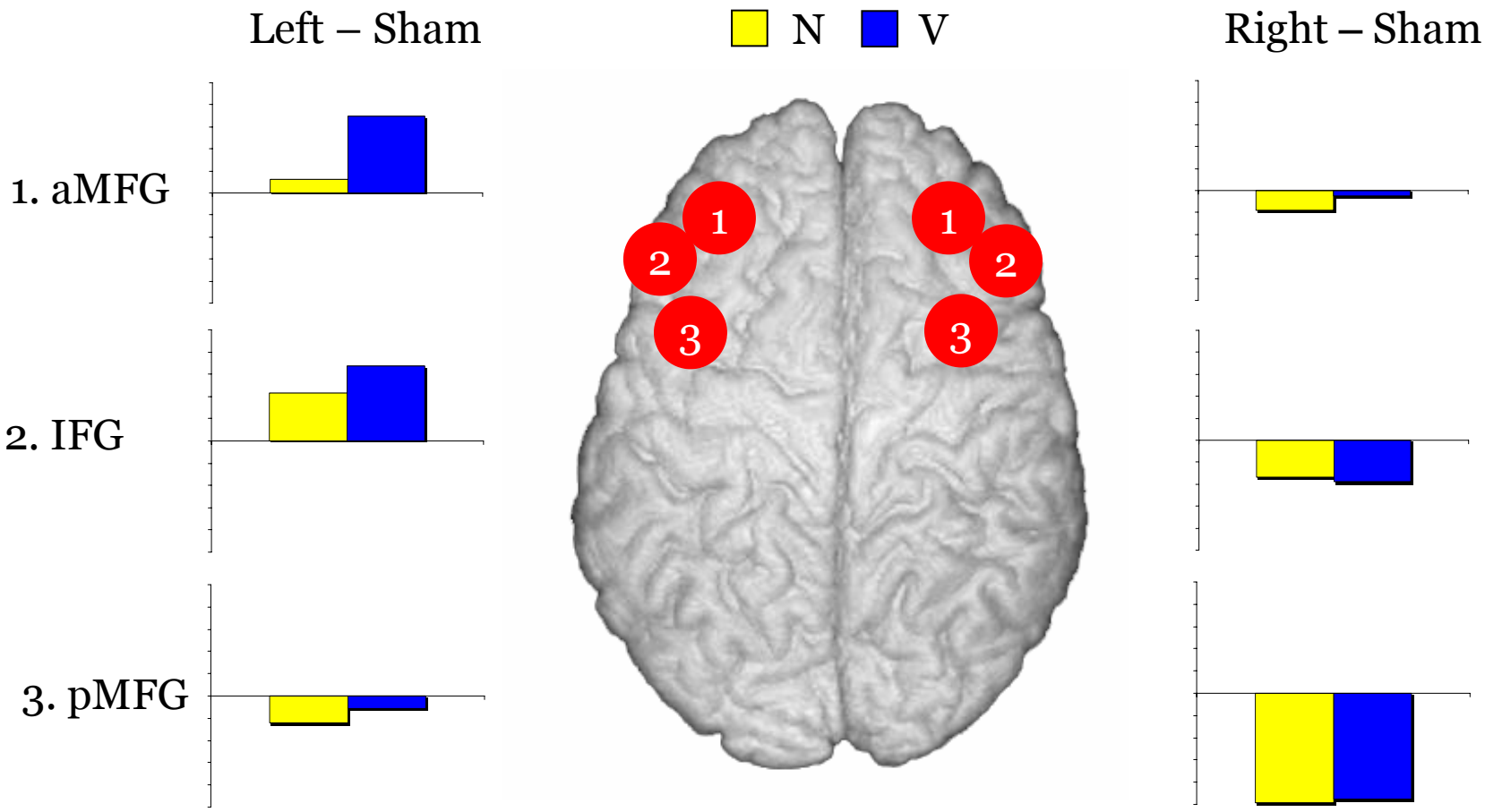
Use regular and irregular morphological transformations; past tense alternation with verbs

Cappelleti, Fregni, Shapiro, Pascual-Leone, & Caramazza, submitted

TMS: areas stimulated



Patterns of noun and verb processing



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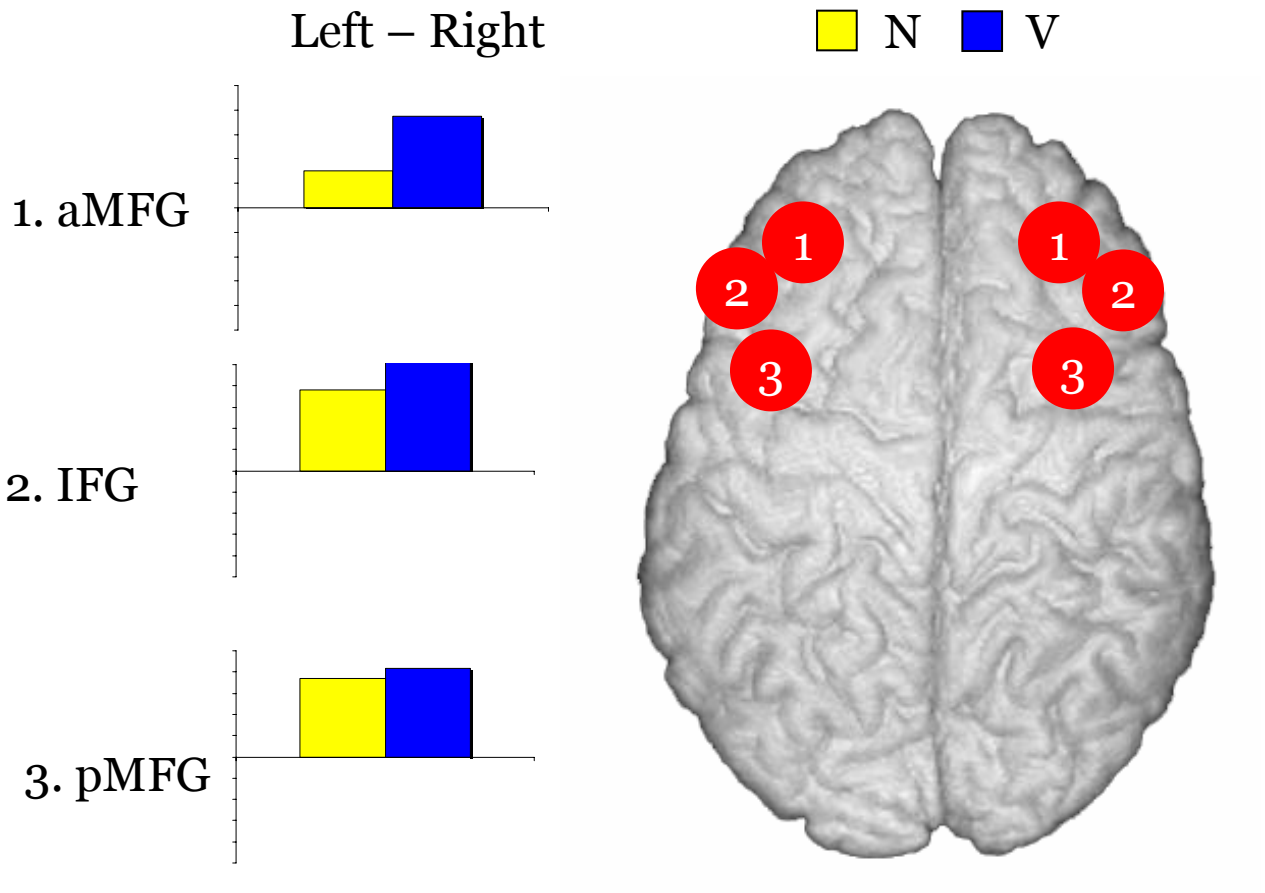
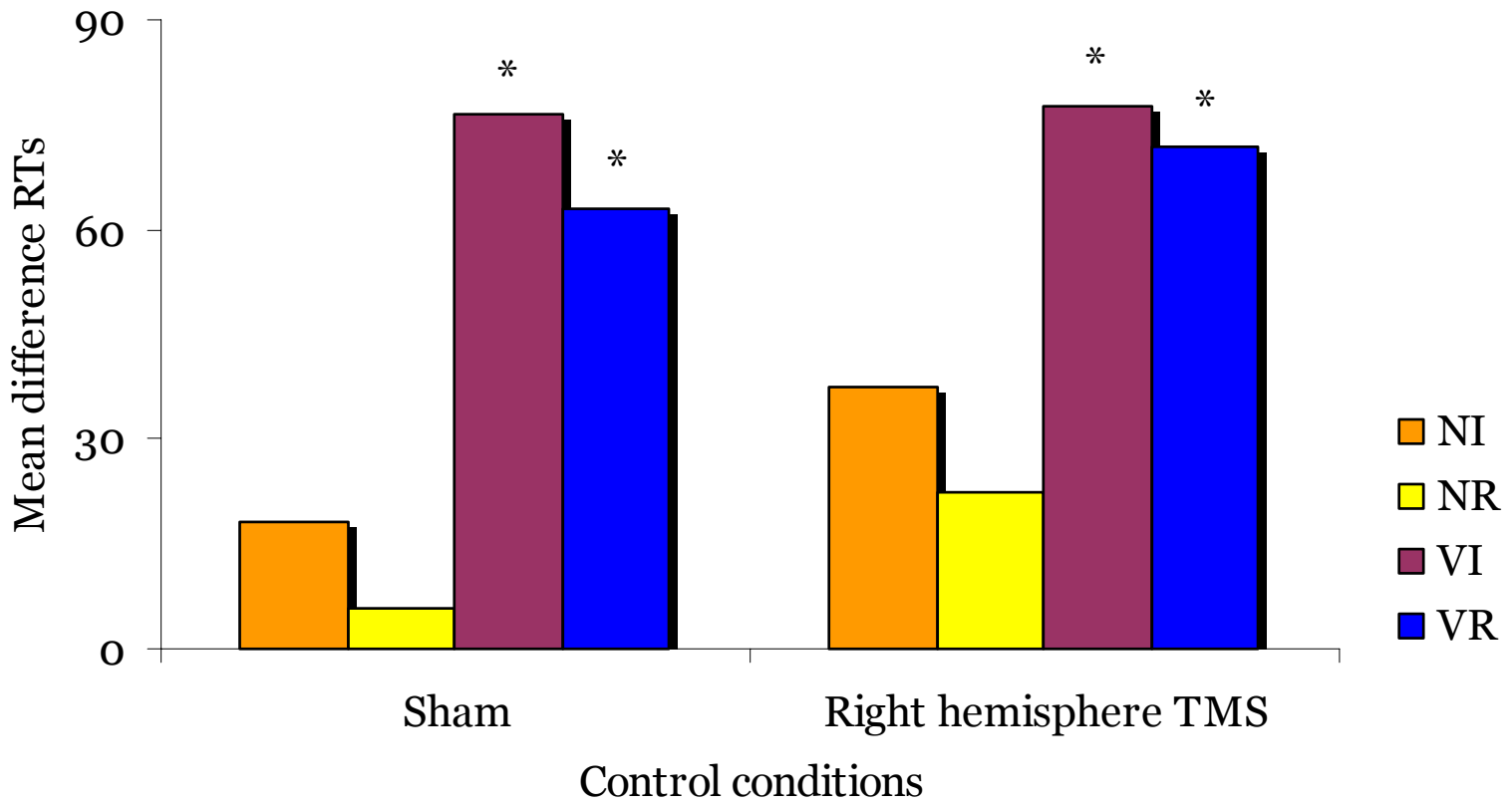


Regularity has no effect

Experiment 1: Stimulation to left inferior MFG



Interim conclusion

Left inferior midfrontal gyrus (IMFG) is crucial for morphological processing of verbs, but not of nouns.

- Not a nonspecific effect of TMS.

Processing in this area does not differentiate between regular and irregular inflection.

A window on the brain

TMS shows that part of the left anterior midfrontal gyrus is specifically and crucially engaged in processing grammatical operations for verbs

What's going on in the rest of the brain?

Results with fMRI (and PET) have not been particularly encouraging (Warburton et al., 1996; Perani et al., 1999; Fujimaki et al. 1999; Tyler et al., 2004)

Further converging evidence from fMRI using the same morphophonological processing task, with:

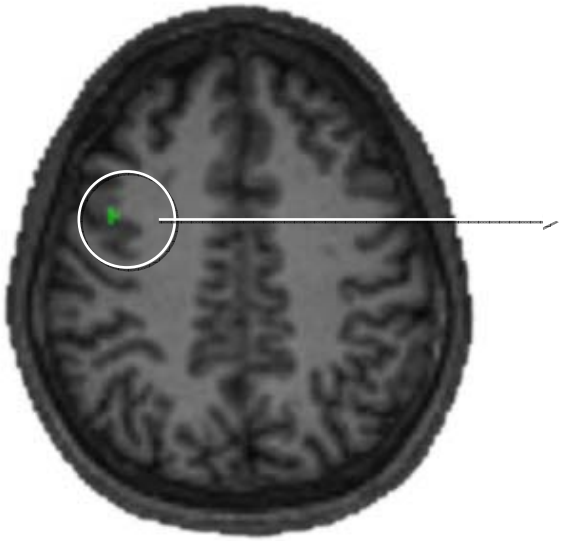
- words and pseudowords (Exp 1)
- imageable and abstract words (Exp 2)
- regular and irregular morphology (Exp 3)

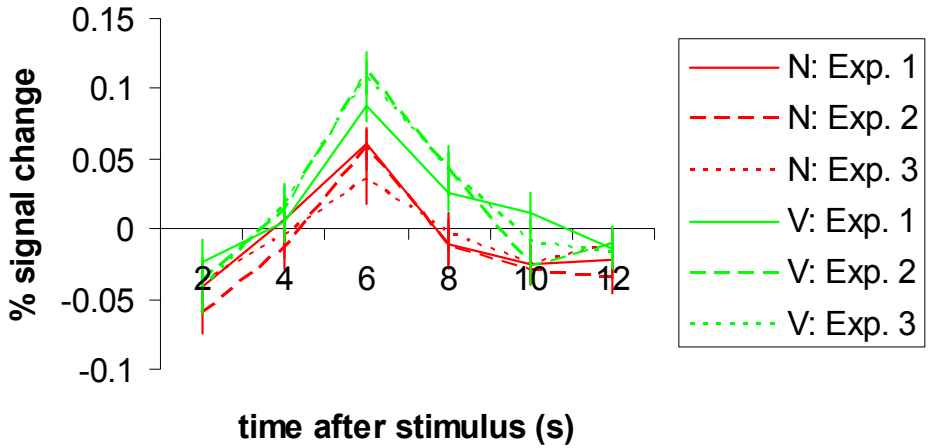
Sample stimuli, Exp. 1-3

	Noun	Verb
Experiment 1		
A: Real words	pond, vase	bathe, teach
B: Pseudo words	wug, bort	bime, wom
Experiment 2		
A: Concrete words	bell, wagon	swim, juggle
B: Abstract words	sound, purpose	think, reckon
Experiment 3		
A: Regular morphology	pig, ball	clean, laugh
B: Irregular morphology	mouse, loaf	fight, steal

Area of maximum activation for verbs

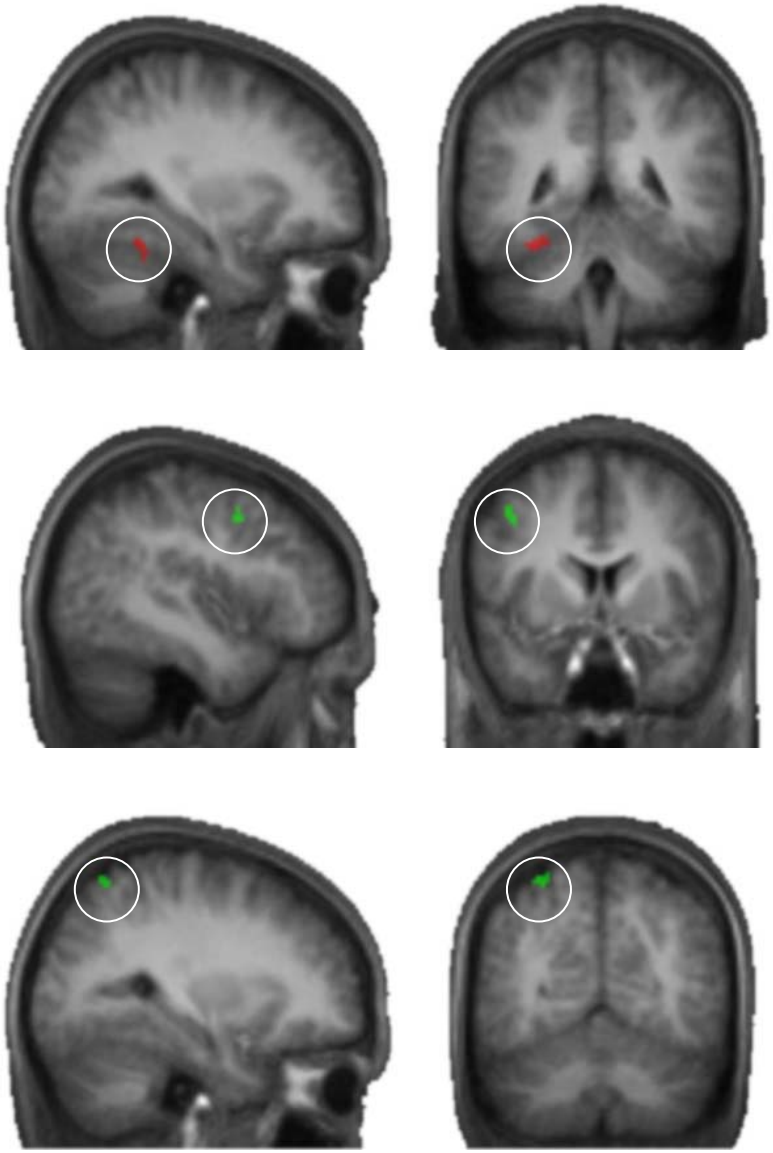
[Controlling for imageability (Exp 2) and varying regularity (Exp 3)]

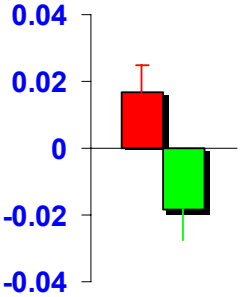




L. middle frontal gyrus

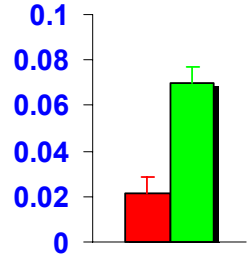
Shapiro, Moo & Caramazza, 2006



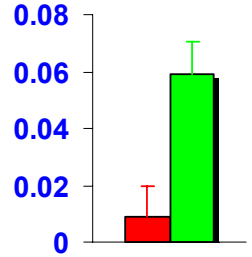


L. fusiform gyrus

% signal change



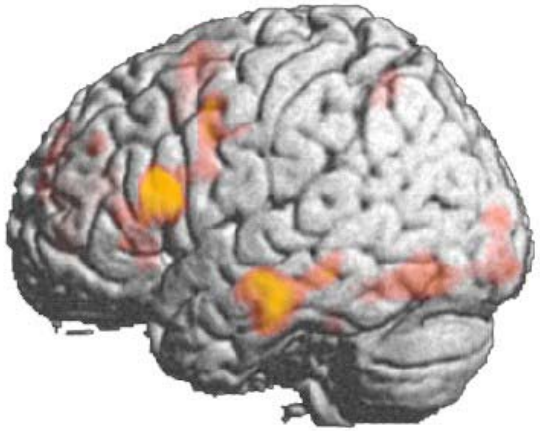
L. middle frontal gyrus



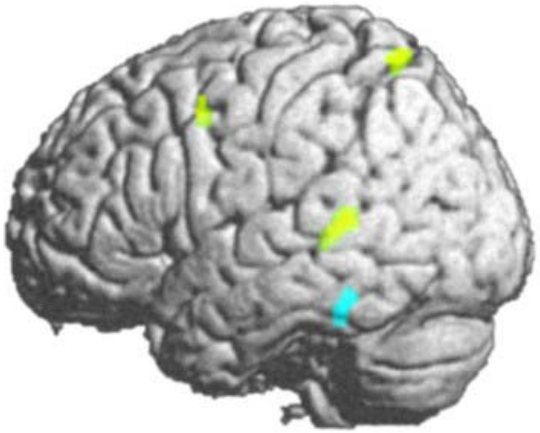
L. superior parietal lobule

Nouns > Verbs **Verbs > Nouns**

Results



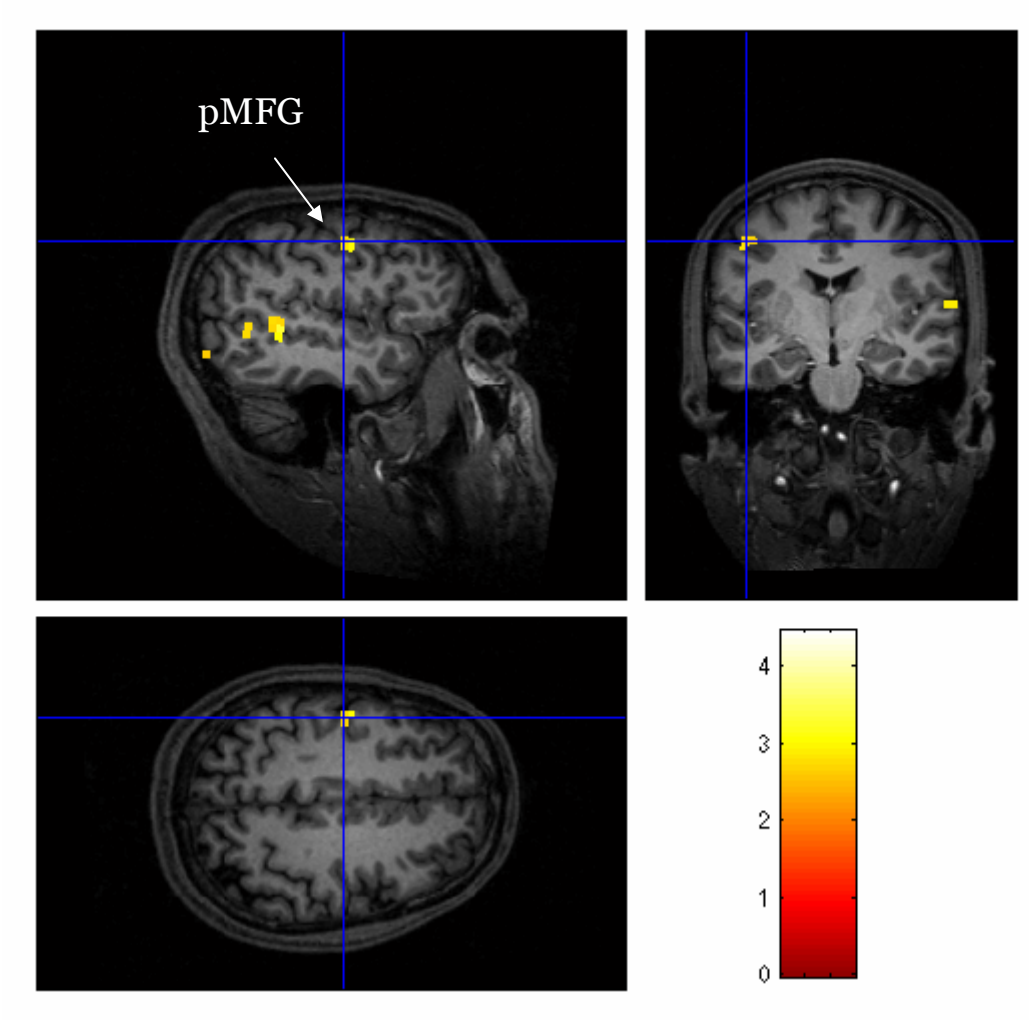
Brain areas activated by the sentence completion task for both nouns and verbs.

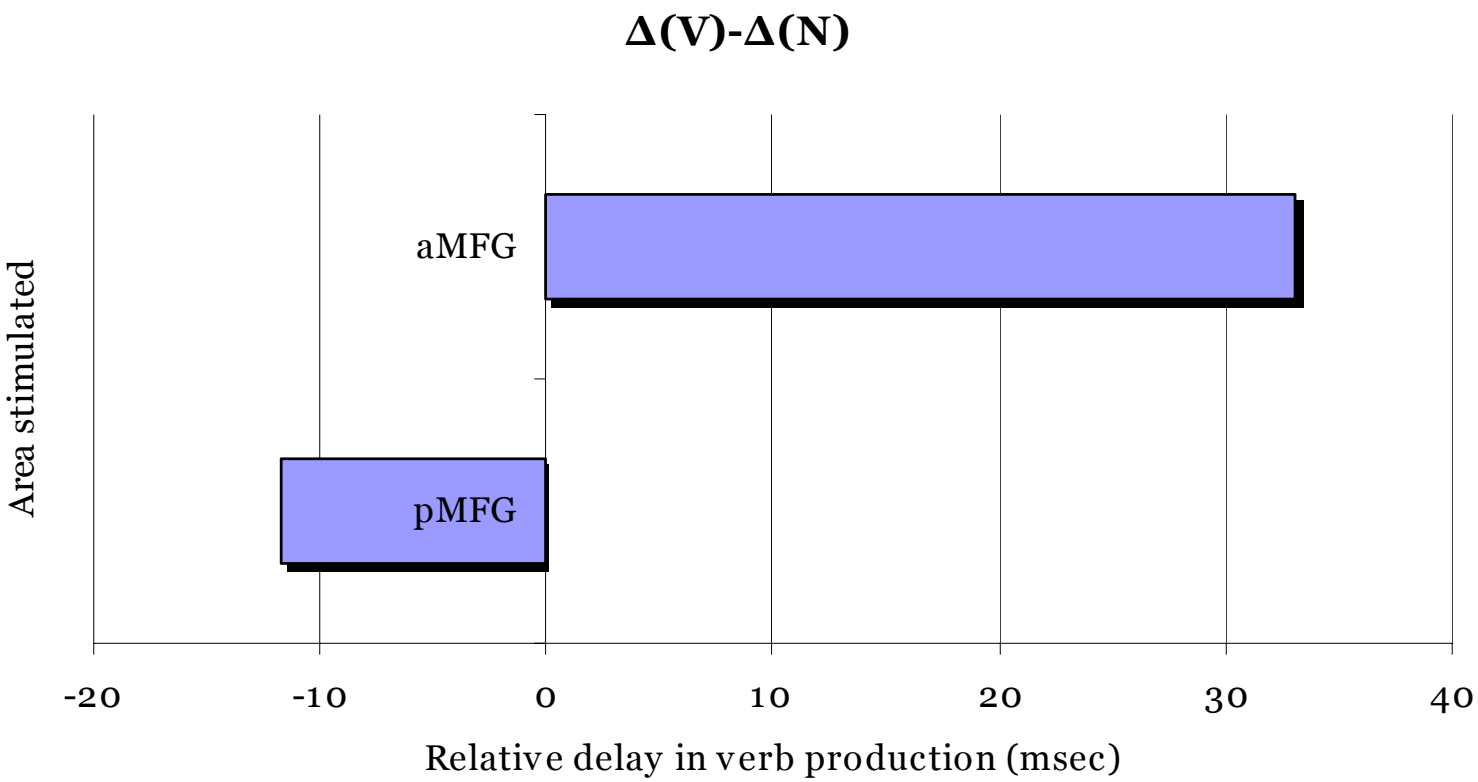


Areas activated only by verbs in green, and areas activated only by nouns in cyan.

A caveat

The areas of maximum activation for verbs relative to nouns do not seem to correspond to the areas which result in verb processing interference consequent to TMS stimulation

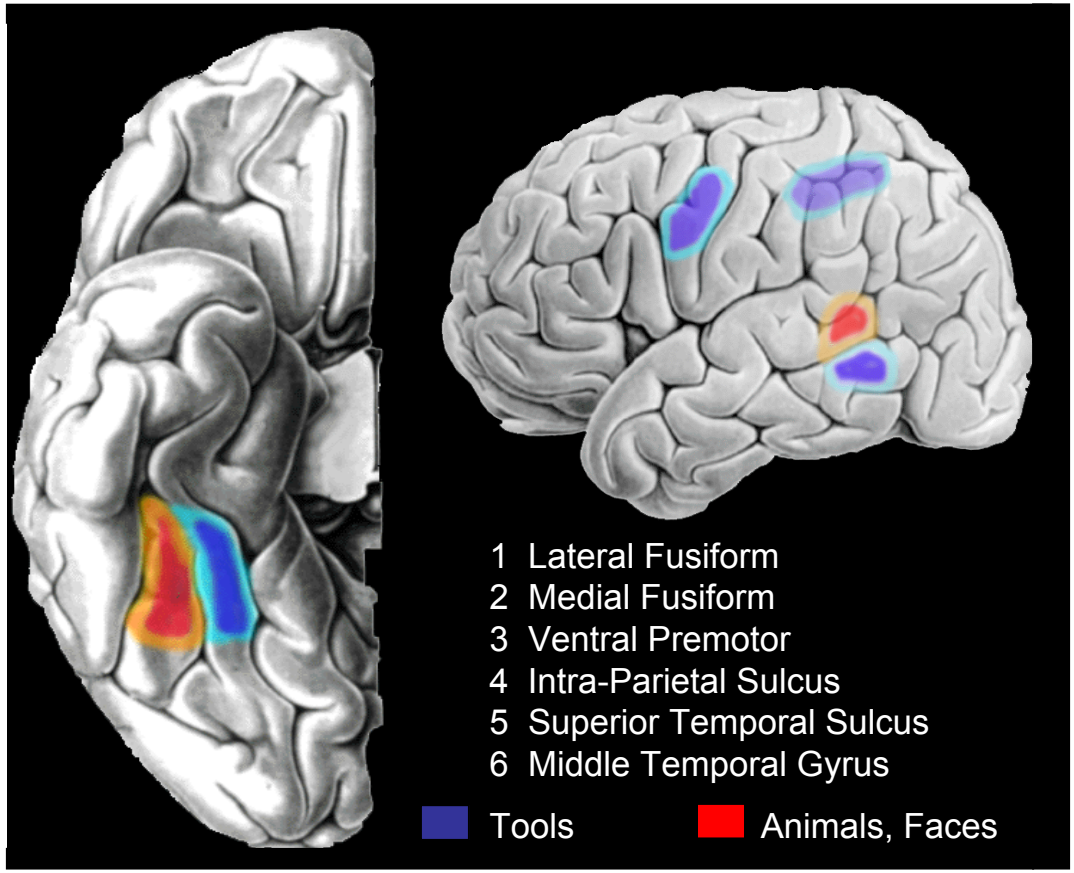

pMFG
4
3
2
1
0


Δ(V)-Δ(N)
aMFG
pMFG
Area stimulated
-20
-10
0
10
20
30
40
Relative delay in verb production (msec)

Another caveat

The areas of maximal activation for verbs and nouns are similar to the areas found to be maximally activated when processing tools/manipulable objects.

Schematic of basic findings



after Martin and colleagues

On Nouns and Verbs

Two interpretations of the fMRI results:

semantic information of a very abstract nature, corresponding to the 'core' conceptual properties of nouns (entities) and verbs (events)

these areas are sensitive to distributional information (pl., det., past tense etc.) that correlates with the grammatical categories noun and verb – and distributional feature networks might be expected to hew closely to areas involved in the semantic representation of the first words over which categorical inductions are made

Caramazza, 1994; Shapiro, Moo, & Caramazza, 2006

So, where are we now?

- Considerable evidence for independence of grammatical from semantic lexical processes (neuropsychology) but perhaps also for semantic organization of objects and actions along with nouns and verbs (fMRI)
- A number of conclusions are supported by the results I have reviewed…

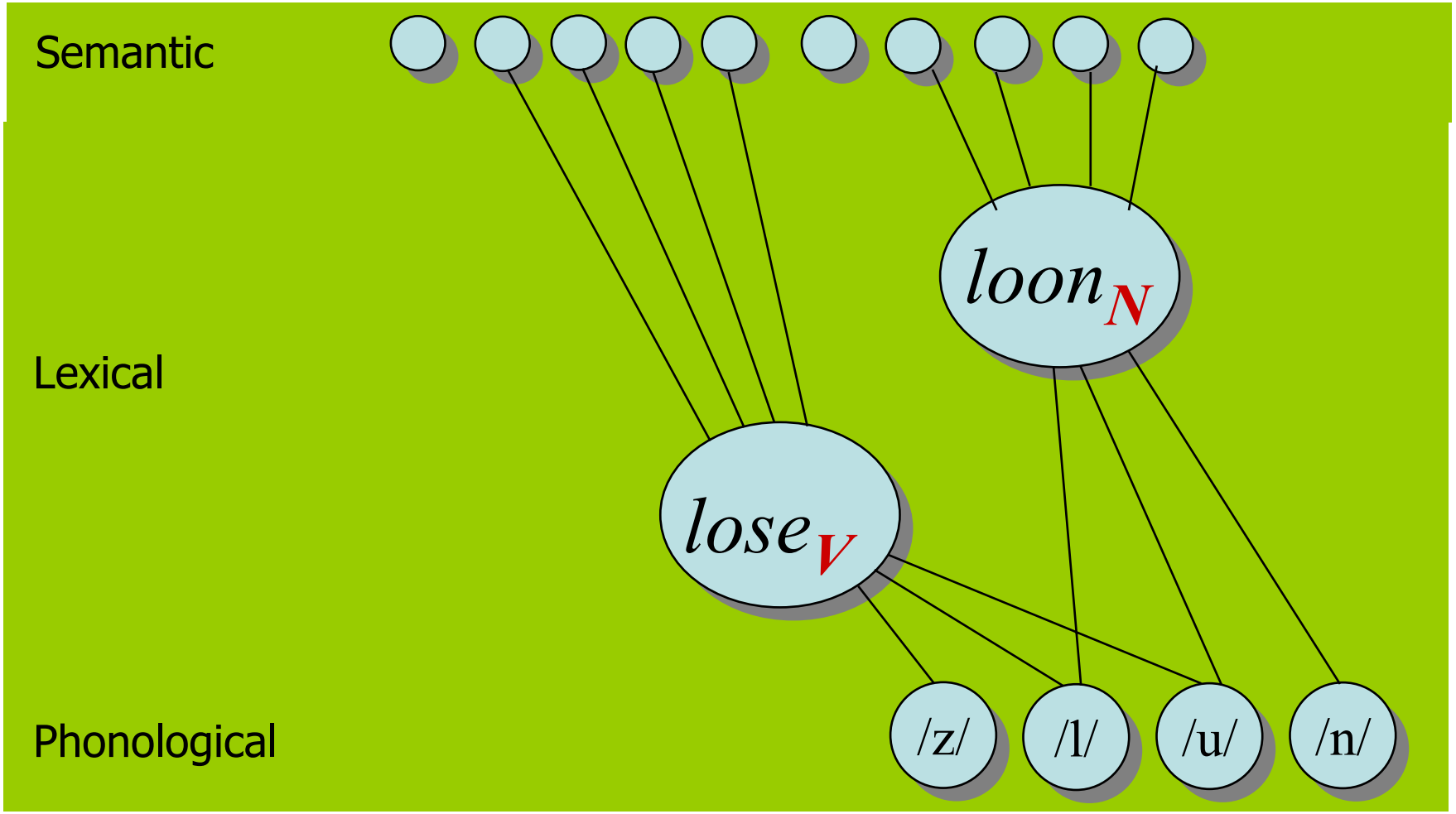
Conclusions

- Clinical: causes of grammatical category-specific deficits

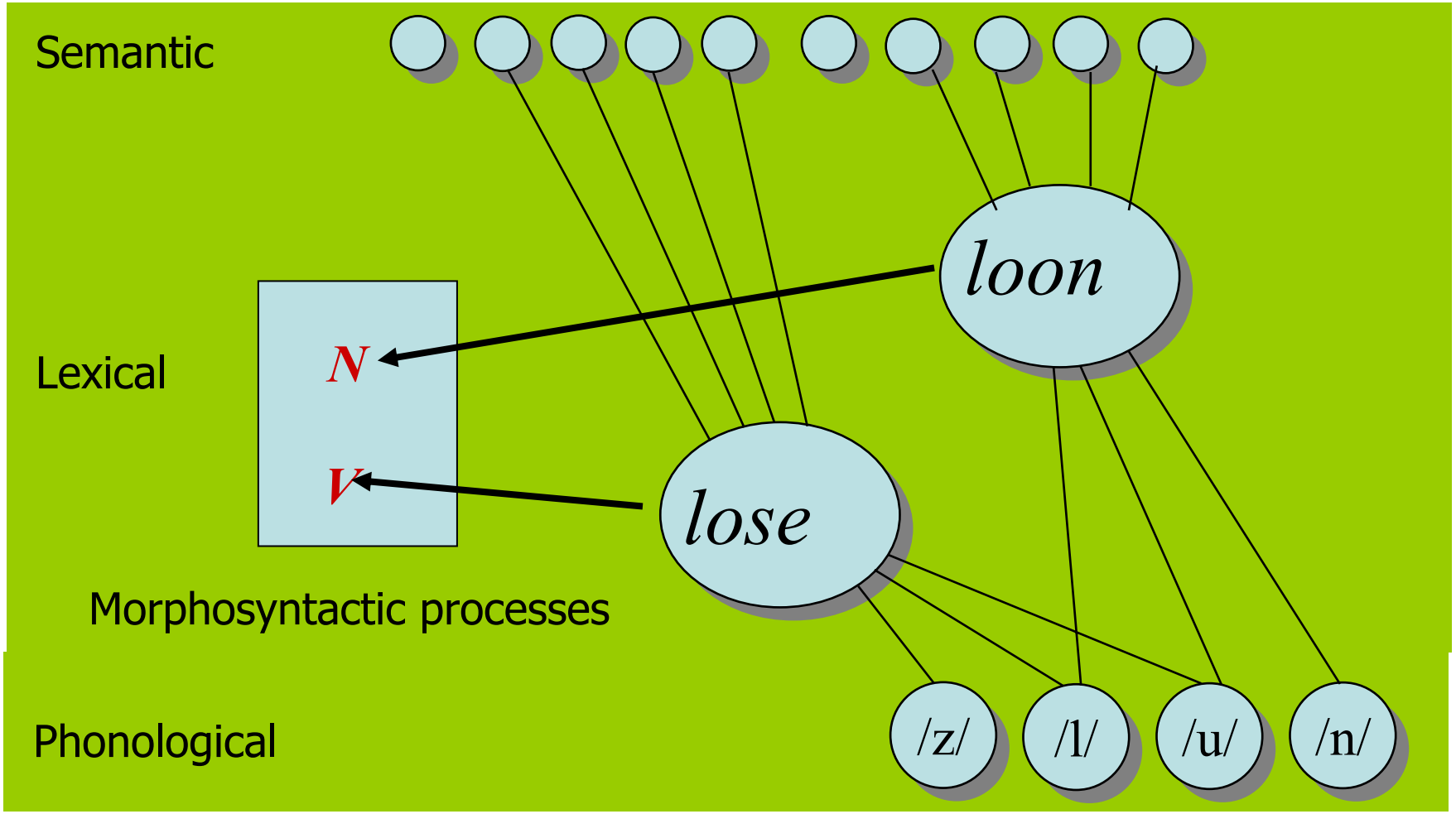
Conclusions

- Clinical: causes of grammatical category-specific deficits
- Functional: a reconsideration of the classical theory

Classical theory



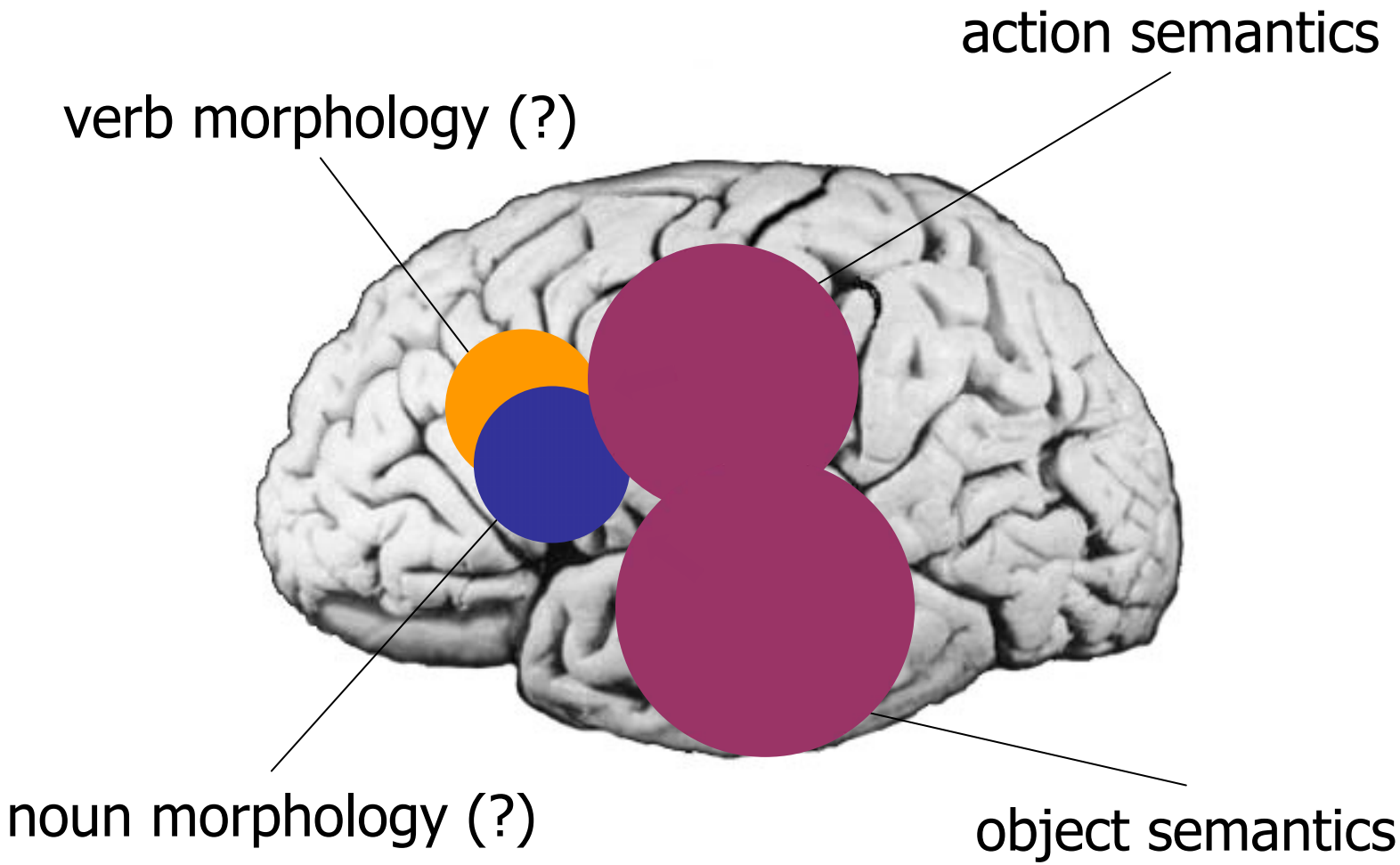
Proposed theory



Conclusions

- Clinical: causes of grammatical category-specific deficits
- Functional: a reconsideration of the classical theory
- Neural: reconciling the data from neuropsychology, TMS and fMRI

Where are grammatical category processes?



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Thank you