The representation and processing of similar word senses

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The Cogsci "story"

- Chomsky and his attack on Skinner and behaviorism is said to have ushered the Cogsci revolution
- Other language sciences moved away from Linguistics in the 80's and 90's
  - Psycholinguistics is predominantly constraint-based and bayesian and/or connectionist
  - CL is more statistical or "constraint-based" (in the other sense!)

Linguistics is coming around methodologically

- Introspection was for a long time providing critical pieces of evidence in linguistics
    - Corpus studies started to change that already in the 70's
    - Questionnaires (for typology)
    - Stories, field-work
- Introspection provides *metalinguistic* judgments in order to get to representations culled for automatic processes
- More and more, introspection is seen as a surrogate for other kinds of evidence: production (corpus or lab studies) and comprehension experiments

What to use sophisticated research methods for

- Testing claims linguists make:
  - E.g., using judgments of acceptability as evidence of nature of certain islands (Philipps and colleagues, Hoffmeister and Sag, Chaves and Dery, …)
- *Asking new questions, thinking about traditional questions differently*

What kind of relation between linguistics and language sciences?

- Linguistics is not as important to language sciences as it used to be

- Three kinds of attitude to the new world order:

  - Moving all the way to the “dark side” of the new world order

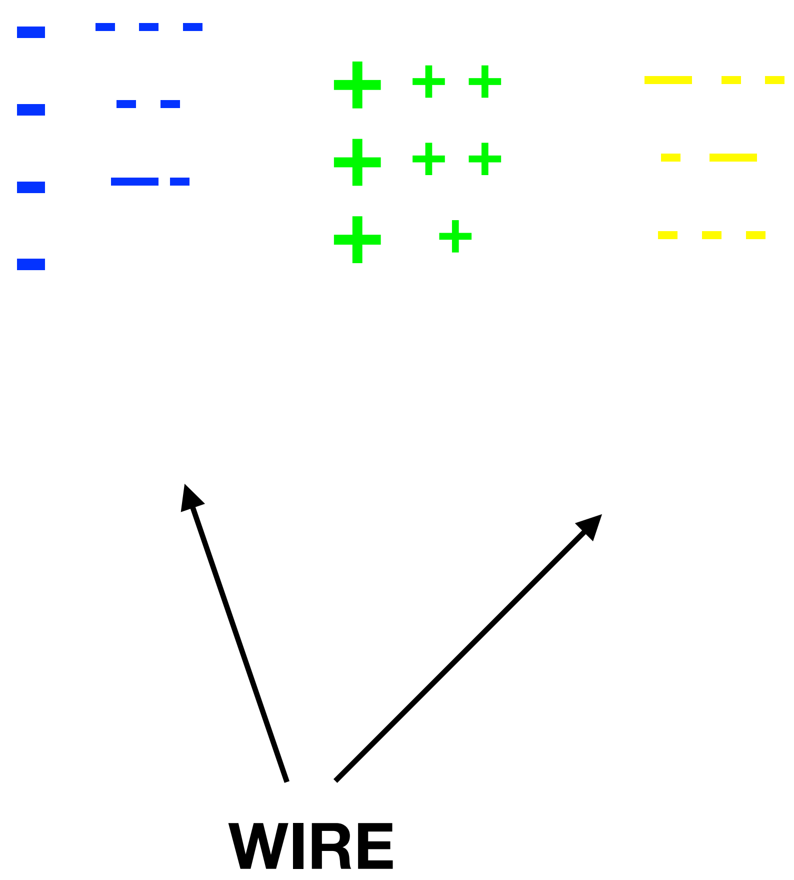
  - Maintaining the tradition: Use new methods to complement traditional methods and continue to do much of the same

  - *Ecumenism: Embrace the language sciences, but continue to value “traditional” methods*

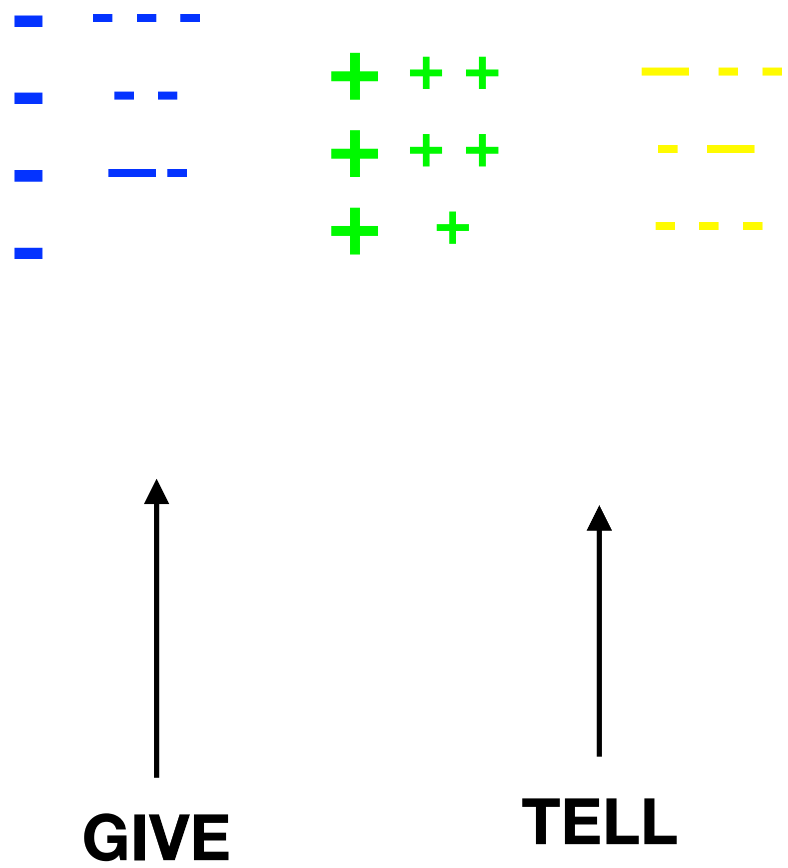
Conceptual organization

- We learn lots of meanings: about 4,000 verbs known in English, each verb has between 3 and 4 meanings
- How are these meanings related?
  - Meanings are monads and are related through meaning postulates
  - Meanings are bundled of properties (features) and are related (at least in part) via feature overlaps

Feature overlap between word senses



Feature overlap between word meanings



What these lectures are about

- Single words have several senses that are semantically similar
- Sets of words are semantically similar
- What are the effects of semantic similarity between the meanings of words on syntactic structure, lexical access, and processing of sentences and discourses?

Most words violate the principle of contrast

- Assuming that each word only has one meaning is supposed to help learning language (E. Clark, Rieger)
- But it is false: English verbs have between 3 and 4 senses on average
- Why?
  - More efficient for communication (?)
  - The assumption that there is something like *a sense* is half of a fiction (c.f. exemplar theories of categorization)
- How are words with several meanings represented? How are they processed?

Distinguishing multisemous words

- Homonyms (different meanings): BANK (but also EAR)
- Polysemes (different senses): WIRE (but also PORT)
    - Regular polysemes: CHICKEN
    - *Irregular polysemes: WIRE*

Word meanings and senses are often biased

- Not all meanings/senses of a word have equal frequency
- Some meanings/senses are much more frequent than others (*dominant* vs. *subordinate* meanings/senses):
    - BANK is a biased homonym; WIRE is a biased polyseme
    - CALF is a balanced homonym; CONE is a balanced polyseme

The relevance of dominance to lexical activation: Simpson and Burgess (1985)

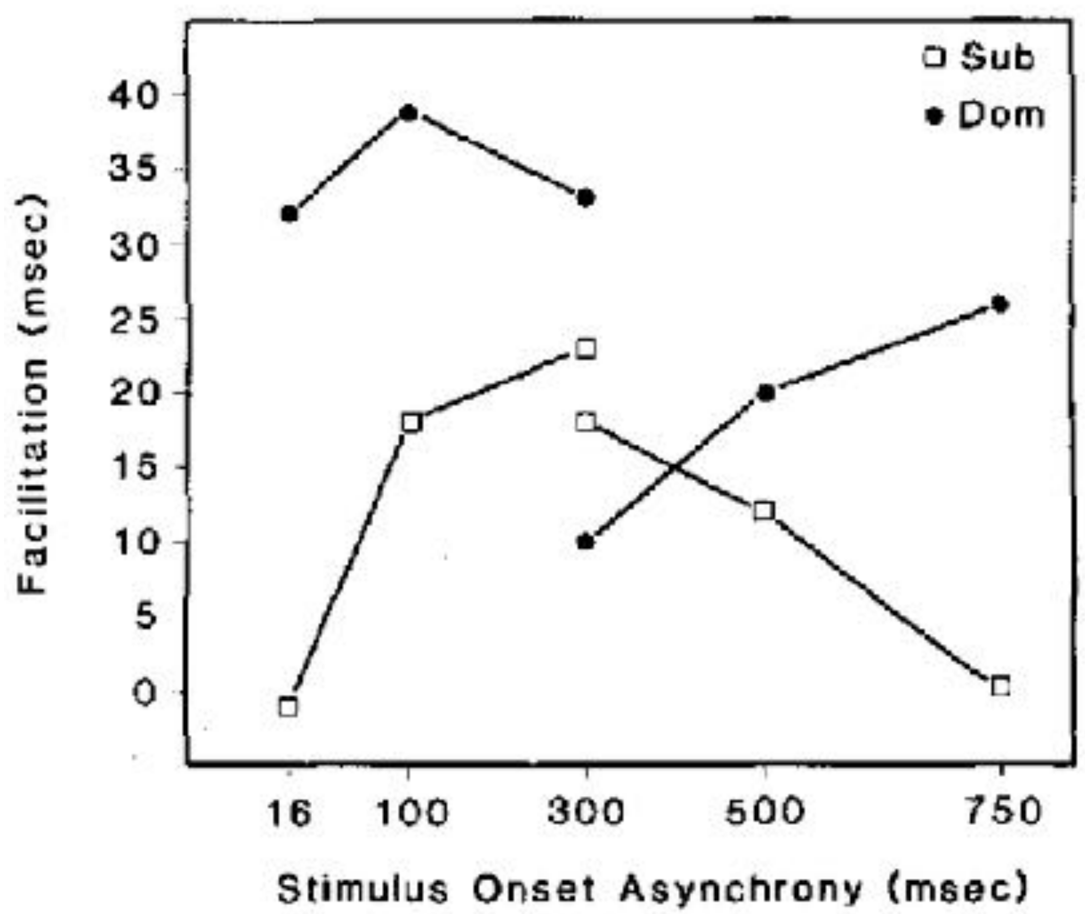


Figure 1. Mean facilitation of dominant (Dom) and subordinate (Sub) associates at five SOAs (16–300-ms SOAs are from Experiment 1; 300–750-ms SOAs are from Experiment 2).

A linguistic view on polysemy

- 1980's: Polysemes are represented as networks of related senses (c.f. Brugman on *over*)
  - The relations between senses recur across polysemes and languages
  - There is a "central" sense from which other senses are derived (possibly through indirect relations)
- Different parts of enriched meanings are accessed (Pustejovsky) or related by "rules"

Polysemy of spatial prepositions (Brugman, Rice)

1. The painting is *over* the mantle.
2. The plane is flying *over* the hill.
3. The wall fell over.
4. The play is *over*.
5. Do it *over*.
6. Look *over* my corrections.

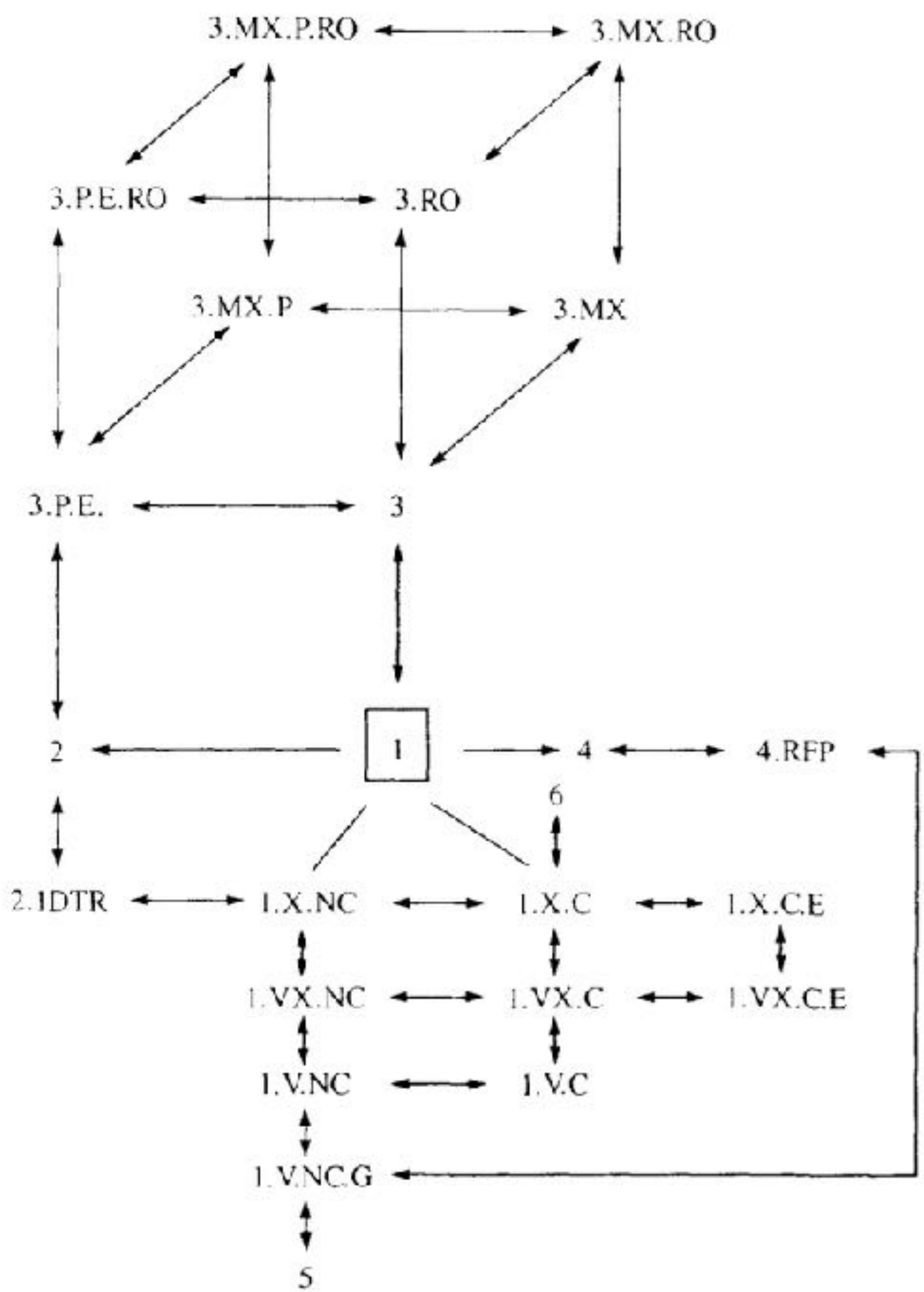


Fig. 27. Relations among the schemas

Does the mental representation of polysemes support the linguistic analysis?

- Dictionaries, for the most part, do not distinguish between homonyms and polysemes
- The representation of senses (of polysemes) and meanings (of homonyms) might be the same
  - It could be that the network is a rational reconstruction of the diachronic development of senses
  - Senses could be represented separately and related by “meaning postulates”

Are homonyms and polysemes represented the same way?

- Homonym meanings *must* have separate representations
- Klein and Murphy (a.o.) claim polyseme senses are represented the same way
- Frisson and Pickering (a.o.) claim the representation of *regular* polysemes include an underspecified node that covers both senses
- Brocher and colleagues claim the representation of *irregular* polysemes involves overlapping features

Three possible models of polysemy

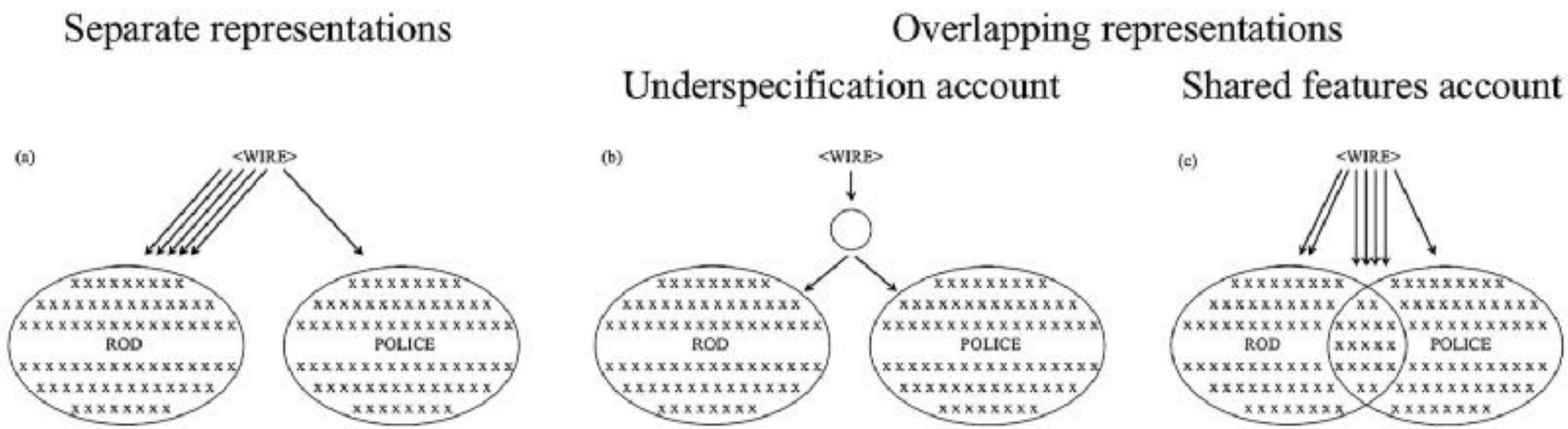


Figure 1. Illustration of representation models for irregular polysemes. A separate representations model of lexical representation is depicted in (a), while the two versions of an overlapping representations model are shown in (b) underspecification account, and (c) shared features account. Orthographic representations are represented via angled brackets while meaning representations are illustrated via the series of *x*'s in the ovals. Number of arrows represent strength of activation from orthography to meaning; *x*'s represent meaning features.

Klein and Murphy (1981)

Daily paper

Wrapping paper

Liberal paper

Commercial bank

Creek bank

Savings bank

- *Semantic* judgment task: Sensicality of phrase
- Main effect of consistency, but no interaction between consistency and word type

Frisson and Pickering (1999)

9a. During my trip, I hitchhiked around Vietnam, but in the end I decided to rent a car for a couple of days. (LC-FM)
9b. A lot of Americans protested during Vietnam, but in the end this did not alter the president's decision. (MC-FM)
9c. During my trip, I hitchhiked around Finland, but in the end I decided to rent a car for a couple of days. (LC-NM)
9d. A lot of Americans protested during Finland, but in the end this did not alter the president's decision. (MC-NM)

- Difficulty for non-familiar metonymic senses in metaphoric contexts *after the noun and in reanalysis measures* (for PLACE FOR EVENT, not for PLACE FOR INSTITUTION)

- Relative frequency of literal vs. metonymic does not affect reading difficulty supporting an underspecified node account (which does not record relative frequency of senses)

Why isn't there consensus?

- Factors that influence processing of lexical items not always all controlled for quantificationally
  - Frequency of senses (for polysemes)
  - How related meanings/senses are? Are they related regularly or irregularly?
  - The kind of polysemes that are included in the study (irregular vs. regular)
- Studies do not use the same tasks

Why frequency of senses matters

- The more frequent a word is, the faster it is accessed
- The same is true of meanings of homonyms
  - Different models of access of various meanings of homonyms (context sensitive model vs. reordered access model)
- Balanced homonyms and biased homonyms behave differently
  - Only dominant meaning of homonyms prime semantically related targets at some SOA/ITI (dominance effect)
  - Processing of a biased homonym in a context that favors the subordinate meaning is slowed down (subordinate bias effect)

Duffy et al. (1986)

TABLE 1
EXAMPLE SENTENCES

Equibiased	
Ambiguous Before:	Because it was kept on the back of a high shelf, the *pitcher* (whiskey) was often forgotten.
Ambiguous After:	Of course the *pitcher* (whiskey) was often forgotten because it was kept on the back of a high shelf.
Non-equibiased	
Ambiguous Before:	When she finally served it to her guests, the *port* (soup) was a great success.
Ambiguous After:	Last night the *port* (soup) was a great success when she finally served it to her guests.

Note. The ambiguous target word is italicized. The corresponding control word is included in parentheses.

TABLE 2
MEAN GAZE DURATIONS (IN MS) ON TARGET WORDS

	Position of disambiguating clause			
	Before		After	
	Ambiguous	Control	Ambiguous	Control
Equibiased	264	264	279	261
Non-equibiased	276	255	261	259

How to argue for the shared features model

- Our claim: The "shared feature" model is the right model of the representation of *irregular* polysemes
  - Not two *entirely separate* entries like homonyms
  - No node that is underspecified between senses
- Logic (inferring representations from access and processing)
  - If polysemes are represented like homonyms, dominance effect and subordinate bias effect should be observed
  - If an underspecified node is initially accessed, relative frequency of senses should have no effect on processing

Using priming to test for Shared Features Hypothesis

- **Priming:** Exposure to a prior stimulus (unconsciously) influences response to a subsequent stimulus

BANK - ROB/CREEK

- How priming works, presumably:
  - When we access a meaning, “related” concepts are activated (Collins and Loftus 1975)
  - These related concepts pre-activate word forms
  - Processing or words with “related” meanings should be faster

Interlude: What is a "related" meaning?

- Traditionally, two very distinct kinds of relations between concepts: association (spatio-temporal co-occurrence: *agony*-*pain*) and "true" semantic relations (*dog*-*cat*)
- When using priming to study semantic relatedness, we need to be careful to exclude associations
- But, maybe associative relations and semantic relations are not that different (McRae, Khalkhali, and Hare 2012)

Examples of semantic relations

TABLE 2.1
Semantic Relatedness Taxonomy

Relationship type	Subtype	Examples
Similar concepts	category coordinates	fox–wolf, hammer–pliers
	category exemplar pairs	vehicle–truck, dog–spaniel
	synonyms	car–automobile, dawn–daybreak
	antonyms	light–dark, good–evil
Entity	made-of	sink–enamel, pliers–metal
	entity behavior	clock–ticking
	external component	tricycle–pedals
	external surface property	apple–red
	internal component	cherry–pit
	internal surface property	fridge–cold, cake–sweet
	larger whole	ant–colony
	quantity	slippers–pair
	systemic feature	dolphin–intelligent
Situation	action/manner	screwdriver–turning
	situational	saucer–teacup
	function	drill–carpentry
	location	cupboard–kitchen
	origin	walnut–trees
	patient	mop–floor
	participant	wand–magician
	time	turkey–Thanksgiving
Introspective	affect emotion	wasp–annoyance, rattlesnake–fear
	contingency	car–gasoline
	evaluation	gown–fancy
Event	event-agent	lecture–professor
	event-patient	arrest–criminal
	event-instrument	cut–knife
	event-location	swim–lake

Examples of associative relations

TABLE 2.2
A Taxonomy of Associative Relatedness

Type of association	Examples
1. Compound continuation forward	baseball–bat
2. Compound continuation backward	golf–miniature
3. Sound similarity	nature–nurture, roar–bore
4. Root similarity	convey–conveyance
5. Synonyms	car–automobile
6. Antonyms	light–heavy
7. Domain higher level	chair–furniture
8. Domain lower level	car–convertible
9. Domain same level	wolf–fox
10. Aspect of an object or situation	shark–teeth, restaurant–menu

Note. Data from Santos, Chaigneau, Simmons, & Barsalou (2011).

Moral of the story

- If you expand your conception of semantic relations, most associative relations are semantic in some sense
- We should expand on our view of semantic relations when studying the organization of concepts and words
- *But*, we should continue to make sure our materials are semantically and not “associatively related,” both for practical reasons and to allow comparisons with previous studies

A lexical decision experiment

- Task: Is X a word of English?
- Method: Continuous priming (to avoid strategies)
- Assumption: Targets that are semantically related (but not associatively related) to prime should be responded to faster
- Baseline: Non-words (semantically unrelated) (including pseudo-homophones like GRANE)
- Conditions: Prime type (3), Bias (2), Intertrial interval (2)

How the experiment works

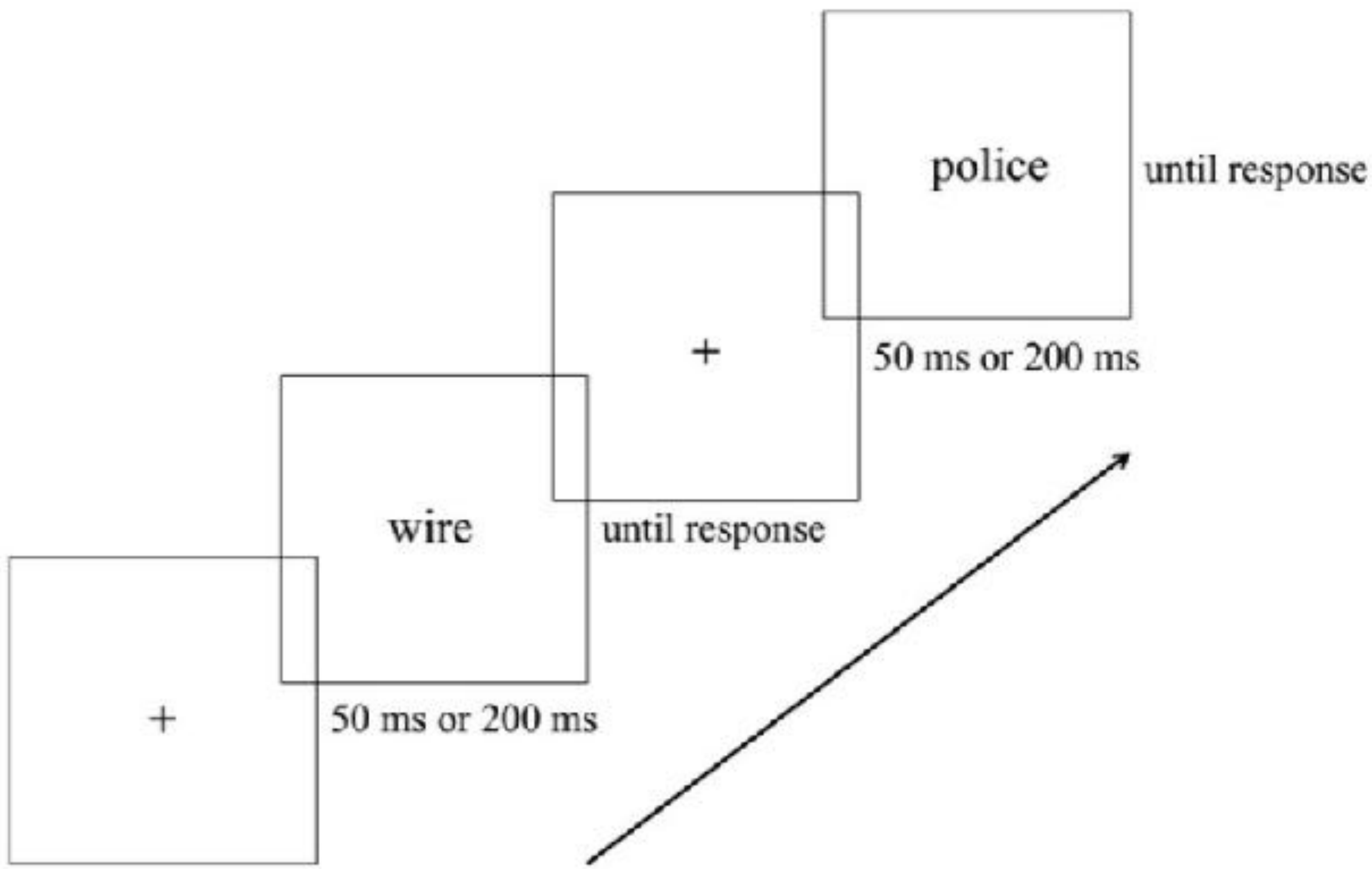


Figure 2. Illustration of the structure of trials in Experiment 1. The difference between 50 and 200 ms is due to the two different ISIs (see text).

Stimulus set

Table 1. Example set of materials for Experiment 1.

Ambiguity	Bias	Dominance	Prime type	PRIME	TARGET
Homonymy	Biased	Dominant	Ambiguous	BANK	ROB
	Biased	Subordinate	Ambiguous	BANK	CREEK
	Biased	Dominant	Nonword	TRANSITIF	ROB
	Biased	Subordinate	Nonword	TRANSITIF	CREEK
Polysemy	Biased	Dominant	Ambiguous	WIRE	CABLE
	Biased	Subordinate	Ambiguous	WIRE	POLICE
	Biased	Dominant	Nonword	GINDER	CABLE
	Biased	Subordinate	Nonword	GINDER	POLICE
Homonymy	Balanced	Meaning 1	Ambiguous	CALF	GOAT
	Balanced	Meaning 2	Ambiguous	CALF	SHIN
	Balanced	Meaning 1	Nonword	INSTITUDE	GOAT
	Balanced	Meaning 2	Nonword	INSTITUDE	SHIN
Polysemy	Balanced	Sense 1	Ambiguous	CONE	WAFFLE
	Balanced	Sense 2	Ambiguous	CONE	CRASH
	Balanced	Sense 1	Nonword	SPACEZ	WAFFLE
	Balanced	Sense 2	Nonword	SPACEZ	CRASH

Notes: *Biased* = biased ambiguous word, *Balanced* = balanced ambiguous word, *Dominant* = dominant meaning/sense of biased ambiguous word, *Subordinate* = subordinate meaning/sense of biased ambiguous word, *Meaning1/Sense1* = first meaning/sense of balanced ambiguous word, *Meaning2/Sense2* = second meaning/sense of balanced ambiguous word.

https://www.tandfonline.com/doi/suppl/10.1080/23273798.2017.1381748

What are “shared features”?

TABLE 1
Role Features and Production Frequencies for FRIGHTEN

Agent Feature	*Production Frequency*	*Patient Feature*	*Production Frequency*
is mean	10	is scared	10
is scary	10	is small	7
is ugly	8	is weak	7
is big	7	is helpless	4
is sadistic	6	is jumpy	4
has problems	4	is nervous	4
is insensitive	4	is not knowledgeable	4
is heartless	3	is insecure	3
is unfriendly	3	is in trouble	3
		is shuddering	3

https://www.tandfonline.com/doi/suppl/10.1080/23273798.2017.1381748

How to norm for semantic similarity

(a) Paul wanted to deposit all his cash but the bank was already closed.

(b) The couple went for a nice, long walk alongside the bank.

How similar are the two underlined words (1-7 Likert scale)

(Can the two meanings appear in similar contexts? Do they share physical or functional properties? Do they taste, smell, sound, or feel similarly? Do they behave similarly?

Homonyms: 1.35/1.32; *Polysemes*: 3.27/3.23

How to norm for dominance?

- Write down what comes to your mind (5 lines)

WIRE________________

- Raters judge which meaning/sense instantiated in completions (92% agreement after resolution)

- Ratio of most frequent meaning/sense over first most frequent meanings/senses completions as dominance score

	Biased	Balanced
Homonyms	.91/.7	.88/.12
Polysemes	.57/.43	.56/.44

Results

Table 3. Error rates, priming effects, and Cohen's *d* for target words in Experiment 1.

ITI	Bias	Condition	Target ER	Baseline ER	RT Priming (ms)	*d*
50	Biased	Homonymy				
		Dominant	1.8 (1.9)	1.3 (1.6)	60	0.33
		Subordinate	0.8 (1.2)	1.5 (1.8)	31	0.22
		Polysemy				
		Dominant	1.5 (1.8)	0.8 (1.2)	29	0.16
		Subordinate	2.3 (2.1)	4.3 (2.9)	28	0.15
	Balanced	Homonymy				
		Meaning1	2.6 (2.3)	2.3 (2.2)	59	0.26
		Meaning2	3.0 (2.5)	3.3 (2.6)	42	0.19
		Polysemy				
		Sense1	1.0 (1.4)	1.5 (1.8)	33	0.31
		Sense2	4.9 (3.1)	1.5 (1.8)	23	0.19
200	Biased	Homonymy				
		Dominant	1.8 (1.9)	2.3 (2.1)	64	0.46
		Subordinate	2.0 (2.0)	2.2 (2.1)	0	0.08
		Polysemy				
		Dominant	1.7 (1.9)	1.7 (1.9)	4	0.04
		Subordinate	2.2 (2.1)	3.0 (2.4)	4	0.03
	Balanced	Homonymy				
		Meaning1	2.2 (2.1)	3.0 (2.4)	66	0.47
		Meaning2	1.5 (1.7)	3.7 (2.7)	40	0.27
		Polysemy				
		Sense1	1.5 (1.7)	2.5 (2.2)	59	0.27
		Sense2	2.7 (2.3)	3.2 (2.5)	53	0.32

Notes: *Biased* = biased ambiguous word, *Balanced* = balanced ambiguous word, *Dominant* = dominant meaning/sense of biased ambiguous word, *Subordinate* = subordinate meaning/sense of biased ambiguous word, *Meaning1/Sense1* = first meaning/sense of balanced ambiguous word, *Meaning2/Sense2* = second meaning/sense of balanced ambiguous word, *d* = Cohen's *d*, ER = mean error rate (in %).

Statistics for the 50ms ITI

Table 4. Inferential statistics for RT data of the 50 ms ITI condition in Experiment 1.

	Main effect/Interaction	*b*	*SE*	*t*
Full model	Intercept	1.04	16.44 e-05	6347
	Prime Type	**8.47 e-05**	**2.16 e-05**	**3.92**
	Bias × Prime Type	−1.30 e-05	3.68 e-05	−0.35
	Ambiguity × Prime Type	2.85 e-05	3.54 e-05	0.81
	Dominance × Prime Type	1.52 e-05	3.54 e-05	0.43
	Bias × Ambiguity × Prime Type	2.64 e-05	6.98 e-05	0.38
	Bias × Dominance × Prime Type	−1.38 e-05	6.98 e-05	−0.20
	Ambiguity × Dominance × Prime Type	2.07 e-05	6.96 e-05	0.30
	Bias × Ambiguity × Dominance × Prime Type	7.85 e-05	13.92 e-05	0.56
Homonyms	Intercept	1.04	25.14 e-05	4150
	Prime Type	**11.57 e-05**	**3.31 e-05**	**3.80**
	Bias × Prime Type	−0.46 e-05	4.75 e-05	−0.10
	Dominance × Prime Type	1.66 e-05	5.04 e-05	0.33
	Bias × Dominance × Prime Type	2.44 e-05	9.07 e-05	0.27
Polysemes	Intercept	1.04	23.11 e-05	4514
	Prime Type	**5.98 e-05**	**2.99 e-05**	**2.00**
	Bias × Prime Type	−1.76 e-05	5.55 e-05	−0.32
	Dominance × Prime Type	1.34 e-05	5.28 e-05	0.25
	Bias × Dominance × Prime Type	−3.86 e-05	10.38 e-05	−0.37
Biased	Intercept	1.04	23.59 e-05	4422
	Prime Type	**7.78 e-05**	**3.30 e-05**	**2.36**
	Ambiguity × Prime Type	4.45 e-05	4.88 e-05	0.91
	Dominance × Prime Type	1.60 e-05	4.95 e-05	0.32
	Ambiguity × Dominance × Prime Type	7.02 e-05	9.72 e-05	0.74
Balanced	Intercept	1.04	2745 e-05	3800
	Prime Type	**8.07 e-05**	**3.05 e-05**	**2.65**
	Ambiguity × Prime Type	1.47 e-05	5.43 e-05	0.27
	Dominance × Prime Type	1.44 e-05	5.37 e-05	0.27
	Ambiguity × Dominance × Prime Type	−1.58 e-05	10.42 e-05	−0.15

Notes: *Prime Type* = ambiguous vs. unrelated prime word; *Bias* = biased vs. balanced prime word; *Ambiguity* = homonym vs. polyseme prime word; *Dominance* = dominant vs. subordinate target word. Significant effects appear in bold.

Statistics for the 200 ms ITI

Table 5. Inferential statistics for RT data of the 200 ms ITI condition in Experiment 1.

	Main effect/Interaction	*b*	*SE*	*t*
Full model	Intercept	1.04	20.96 e-05	4977
	Prime Type	**6.80 e-05**	**2.64 e-05**	**2.58**
	Bias × Prime Type	−8.03 e-05	4.40 e-05	−1.83
	Ambiguity × Prime Type	3.65 e-05	4.35 e-05	0.84
	Dominance × Prime Type	1.52 e-05	4.41 e-05	0.35
	Bias × Ambiguity × Prime Type	6.97 e-05	8.68 e-05	0.80
	Bias × Dominance × Prime Type	3.65 e-05	8.76 e-05	0.42
	Ambiguity × Dominance × Prime Type	1.12 e-05	8.69 e-05	1.29
	Bias × Ambiguity × Dominance × Prime Type	**50.76 e-05**	**17.31 e-05**	**2.93**
Homonyms	Intercept	1.04	28.10 e-05	3713
	Prime Type	17.40 e-05	18.74 e-05	0.93
	Bias × Prime Type	−7.04 e-05	4.53 e-05	−1.56
	Dominance × Prime Type	**9.16 e-05**	**4.15 e-05**	**2.21**
	Bias × Dominance × Prime Type	8.01 e-05	8.08 e-05	0.99
Polysemes	Intercept	1.04	25.13 e-05	4149
	Prime Type	4.38 e-05	2.86 e-05	1.54
	Bias × Prime Type	**−12.15 e-05**	**5.13 e-05**	**−2.37**
	Dominance × Prime Type	−3.28 e-05	5.13 e-05	−0.64
	Bias × Dominance × Prime Type	−0.86 e-05	10.09 e-05	−0.09
Biased	Intercept	1.04	29.71 e-05	3510
	Prime Type	1.73 e-05	2.86 e-05	0.60
	Ambiguity × Prime Type	**9.30 e-05**	**3.98 e-05**	**2.33**
	Dominance × Prime Type	5.14 e-05	3.99 e-05	1.29
	Ambiguity × Dominance × Prime Type	**17.13 e-05**	**7.86 e-05**	**2.18**
Balanced	Intercept	1.04	30.30 e-05	3442
	Prime Type	**11.33 e-05**	**3.62 e-05**	**3.13**
	Ambiguity × Prime Type	2.12 e-05	6.64 e-05	0.32
	Dominance × Prime Type	−0.76 e-05	6.36 e-05	−0.12
	Ambiguity × Dominance × Prime Type	−12.23 e-05	12.98 e-05	−0.94

Notes: *Prime Type* = ambiguous vs. unrelated prime word; *Bias* = biased vs. balanced prime word; *Ambiguity* = homonym vs. polyseme prime word; *Dominance* = dominant vs. subordinate target word. Significant effects of interest appear in bold.

Biased polysemes do not behave like biased homonyms

- At 50ms ITI, all semantically related primes facilitate lexical decision on targets (both homonyms and polysemes, whether biased or balanced):
  - This result is consistent with exhaustive access at intermediate delay between homonym primes and targets
- At 200ms ITI,
  - For biased homonyms and polysemes: only dominant meaning of prime facilitate lexical decision on targets (expected selective access at longer ITI)
  - For balanced homonyms and polysemes: all meanings/senses lead to facilitation of lexical decision on target

Our model of the results

- Initial activation of both shared and unshared features (of polysemes) lead to marginal facilitation of targets

- Stronger decay of unshared features for biased polysemes and the fact that shared features are not enough to strongly activate target leads to no priming at 200ms ITI and no dominance effect

- Stronger competition between *unshared* features of balanced polysemes explain priming of targets by both senses balanced polysemes

The representation of irregular polysemes

- Polysemes are not represented like homonyms (otherwise we would have found consistent dominance effects for polysemes)

- An underspecified node is not initially accessed for *irregular* polysemes (otherwise we would not have found a difference between biased and balanced polysemes)

A negative priming dominance effect

- Sometimes, you find interesting things by mistake!
- Initial question: Could we replicate our priming results using masked priming rather than continuous priming?

How a masked priming experiment works

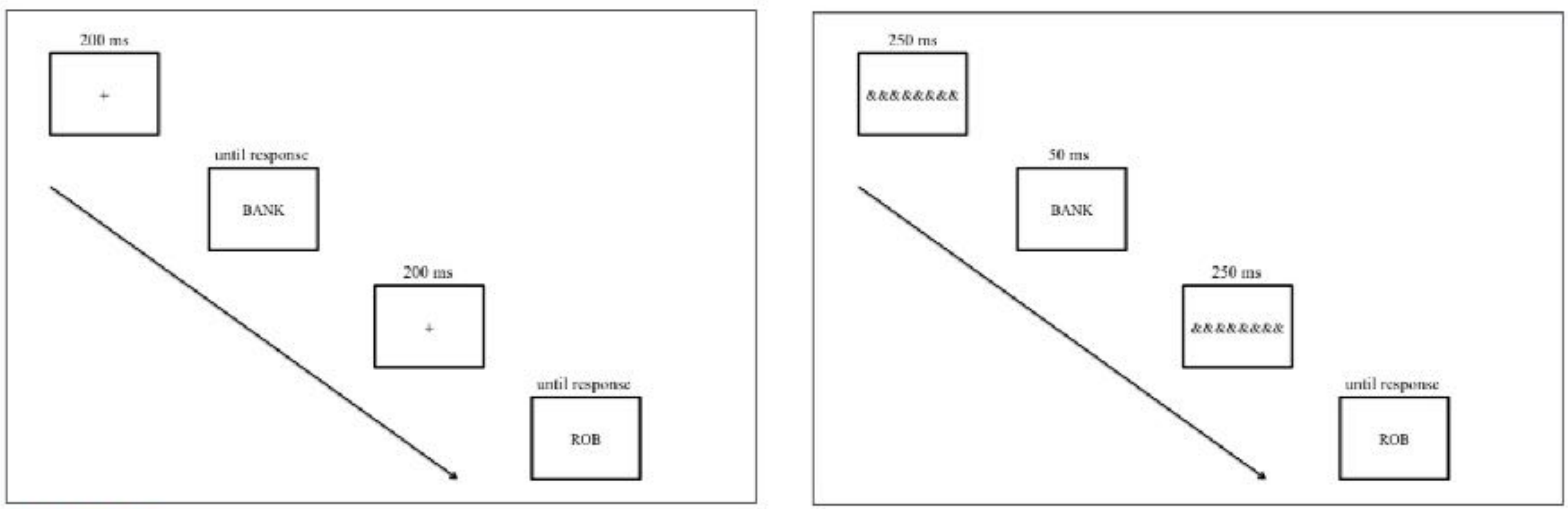


FIGURE 1.

Illustration of materials and trial structure in Experiment 1 (left box) and Experiment 2 (right box).

What we predicted

- Masking primes would not make a difference:
  - Lexical decisions to targets related to dominant meaning of primes would be faster than baseline
  - Lexical decisions to targets related to subordinate meaning of primes would not be different from baseline

What we observed

- Masking primes *do* make a difference:
  - Lexical decisions to targets related to dominant meaning of primes *are slower* than baseline
  - Lexical decisions to targets related to subordinate meaning of primes are not different from baseline

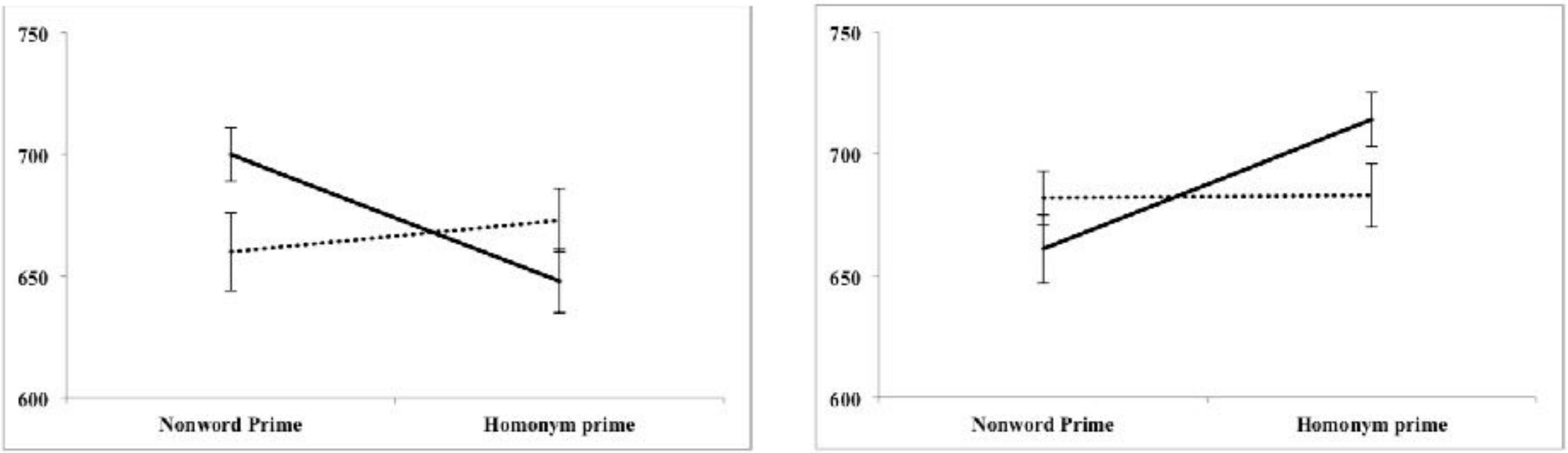


FIGURE 2.

Mean lexical decision latencies and standard errors (bars around the mean) for target words in Experiment 1 (left box) and Experiment 2 (right box); solid lines = responses to targets related to homonyms' dominant meaning; dotted lines = responses to targets related to homonyms' subordinate meaning.

The inhibition of targets related to dominant meaning is modulated by Stimulus Onset Asynchrony

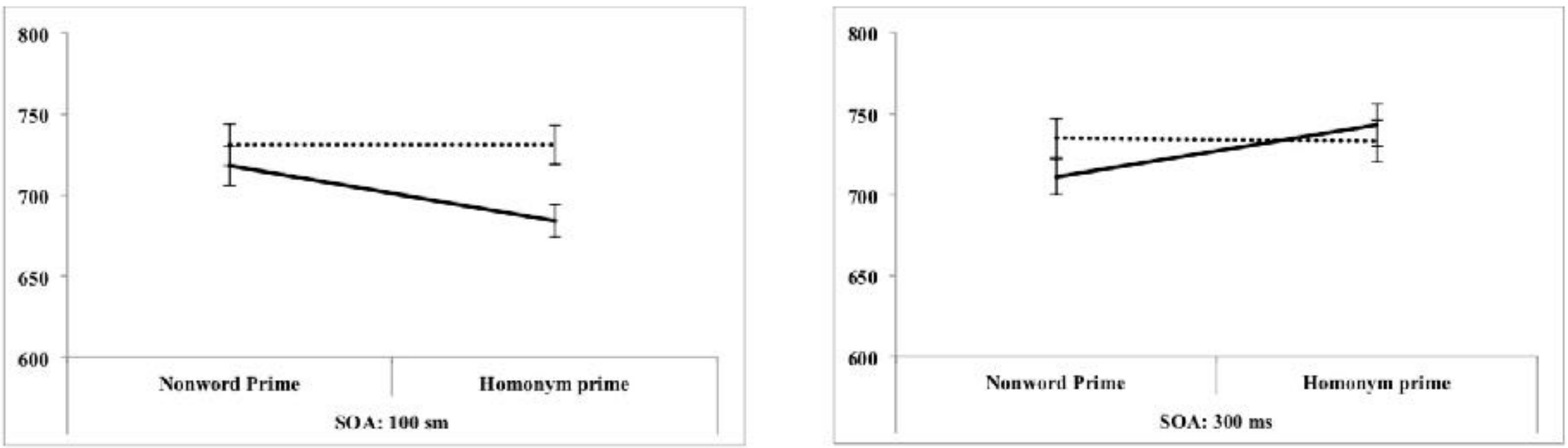


FIGURE 3.

Mean lexical decision latencies and standard errors (bars around the mean) for target words in Experiment 3 for the 100 ms SOA (Stimulus Onset Asynchrony), (left box) and the 300 ms SOA condition (right box); solid lines = responses to targets related to homonyms' dominant meaning; dotted lines = responses to targets related to homonyms' subordinate meaning.

Negative Compatibility Effects in perception

- Visual similarity between successively presented can lead to processing slow down (Eimer and Schlaghecken)

  >> (16ms) + 100ms mask + >>/<<

- NCE characterized by biphasic pattern: facilitation if brief mask (0-32ms), inhibition if longer mask (96-192ms)

Where are NCEs generated?

- NCE often assumed to be generated within motor-response system
- Our results suggest that mental representations *can* be involved in NCE (so not just for stimuli that allow direct S-R links)
- Evaluation window account might explain our results:
  - Priming occurs if primes fall within evaluation window (of target stimuli)
  - Inhibition occurs if primes do not fall within evaluation window
  - Masks delimits stimuli

How are polysemes processed in reading?

- Polysemes may be represented differently, but does that make a difference in reading?
- Can we get converging evidence for our lexical priming results?
- We can “mimic” eye-tracking experiments that demonstrated subordinate bias effects to compare homonyms and polysemes

A good-enough processing kinda hypothesis

- Some evidence that readers need not process sentences that deeply and, e.g., decide on ambiguities if there is no absolute need (Ferreira)

- Maybe readers can take advantage of shared features of polysemes and not resolve sense ambiguity by only initially activating shared features

Probing the subordinate bias effect with polysemes

- Reading difficulty if a subsequent context favors the subordinate meaning of a homonym
- If a preceding context favors the subordinate meaning of a homonym, processing of biased homonym is slowed down (competing effects of relative frequency and context)
- Is the same true for polysemes?

The “good enough” reading of polysemes

- People do not resolve the sense ambiguity of polysemes if they do not need to
  - There should be less or no reading difficulty when a subsequent context favors the subordinate sense of a polyseme
  - There should be a subordinate bias effect for polysemes, but it should be less strong

Stimulus set from Brocher el al. (2016)

Table 2
Example Materials

<table>
<tr><th>Ambiguity</th><th>Context</th><th>Sentence</th></tr>
<tr><td>Homonym</td><td>After</td><td>Michael didn't like the |bank (lake) |in the |suburbs, because the |fishing |was not |very good.</td></tr>
<tr><td>Polyseme</td><td>After</td><td>Because the |wire (bomb) |was well |hidden, the skilled |spy |of the |agency remained undetected.</td></tr>
<tr><td>Homonym</td><td>Before</td><td>Because the fishing was not very good, Michael didn't like the |bank (lake) |in the |suburbs.</td></tr>
<tr><td>Polyseme</td><td>Before</td><td>The skilled spy of the agency remained undetected, because the |wire (bomb) |was well |hidden.</td></tr>
</table>

Note. For illustration purposes only, the ambiguous word appears in bold and its matched control follows in parentheses, the disambiguating word appears in italics, and the pipe symbols indicate analysis regions.

Longer reading times only for homonyms when context follows

- Longer reading times (first pass; regression path) only for homonyms in context words spillover

Table 3
Context After Conditions: Dependent Measures and Effect Sizes

		Context words			Context words spillover		
Measure	Ambiguity	Ambiguous	Control	*d*	Ambiguous	Control	*d*
First fixation	Homonym	250 (3)	251 (5)	.03	→ 245 (4)	237 (4)	.23
	Polyseme	249 (4)	251 (3)	.06	245 (4)	247 (4)	.04
Single fixation	Homonym	249 (4)	250 (6)	.01	→ 247 (5)	239 (4)	.21
	Polyseme	254 (4)	251 (5)	.11	249 (5)	250 (4)	.01
First pass	Homonym	292 (5)	295 (5)	.01	→ 303 (7)	282 (6)	.30
	Polyseme	297 (6)	300 (5)	.05	294 (7)	295 (6)	.00
First pass regression	Homonym	17.6 (4.3)	16.1 (4.1)	.10	14.0 (3.7)	11.5 (3.6)	.09
	Polyseme	20.2 (4.5)	18.9 (4.4)	.07	10.3 (3.4)	10.8 (3.5)	.03
Regression path	Homonym	375 (11)	361 (9)	.07	→ 371 (12)	336 (10)	.28
	Polyseme	392 (10)	378 (9)	.09	339 (10)	341 (9)	.03
Total time	Homonym	387 (10)	373 (9)	.11	391 (11)	364 (9)	.14
	Polyseme	386 (9)	379 (9)	.07	375 (10)	378 (9)	.05

Note. Standard error appears in parentheses following the mean, both in ms. First pass regressions are presented as proportions. *d* = Cohen's *d*.

-

Between senses competition smaller than between meanings competition

Table 6

Context Before Conditions: Dependent Measures and Effect Sizes

		Ambiguous words			Ambiguous words spillover		
Measure	Ambiguity	Ambiguous	Control	*d*	Ambiguous	Control	*d*
First fixation	Homonym	252 (4)	245 (3)	.13	271 (5)	253 (4)	.27
	Polyseme	249 (3)	247 (4)	.08	261 (5)	251 (4)	.22
Single fixation	Homonym	256 (4)	246 (4)	.12	280 (6)	260 (5)	.30
	Polyseme	251 (4)	248 (4)	.08	276 (6)	261 (6)	.23
First pass	Homonym	281 (5)	266 (4)	.25	→ 374 (10)	343 (8)	.28
	Polyseme	273 (5)	272 (5)	.09	372 (9)	363 (9)	.08
First pass regression	Homonym	18.1 (4.3)	18.7 (4.4)	.02	37.9 (5.4)	27.7 (5.0)	.44
	Polyseme	13.3 (3.8)	16.7 (4.2)	.20	33.8 (5.3)	34.9 (5.3)	.03
Regression path	Homonym	343 (7)	332 (8)	.21	568 (16)	482 (15)	.51
	Polyseme	318 (7)	339 (9)	.06	544 (16)	529 (16)	.08
Total time	Homonym	422 (10)	377 (9)	.36	530 (13)	478 (11)	.32
	Polyseme	374 (8)	377 (10)	.11	493 (12)	490 (12)	.04

Note. Standard error appears in parentheses following the mean, both in ms. First pass regressions are presented as proportions. *d* = Cohen's *d*.

Bias only matters when context precedes polysemes

Subordinate-bias context after

- Homonyms, but not polysemes showed a dominance effect

Subordinate-bias before

- Reading slow down when context and bias support different senses
- Competition between senses was weaker and resolved sooner than competition for homonyms

Do *balanced* polysemes behave like *balanced* homonyms in reading too?

Table 6. Example materials for Experiment 2.

Frequency	Ambiguity	Sentence
Biased	Homonym	Ken decided on the |**bank** (lake) |near the | clubhouse, since the other |*beaches were too* | crowded for swimming.
Biased	Polyseme	When Mr. Jordon discovered the |**wire** (bomb) |in the |lamp, the |*FBI aborted* |the top secret mission.
Balanced	Homonym	Something seemed to be wrong with the |**calf** (pony) |that day |, because the |*animal did not* | drink nor eat.
Balanced	Polyseme	Marlene looked out for a |**cone** (barrel) |on her | way home, since a big |*pothole had been* | marked there yesterday.

Notes: For illustration purposes only, the ambiguous word appears in bold and its matched control follows in parentheses, the disambiguating region appears in italics, and the pipe symbols indicate analysis regions.

The “split” behavior of balanced polysemes

Ambiguous word spillover region

- A Bias x Ambiguity interaction: Balanced homonyms *and* polysemes take longer to read (first pass measure) than controls
- This is likely to be the consequence of between sense/meaning competition

Disambiguating region

- Longer first pass, regression path, total RT for homonyms than polysemes (relative to controls)
- No reliable longer RTs for balanced polysemes than their controls
- This is likely to be the consequence of shared features between senses

Making sense of it all (based on Armstrong and Plaut)

- Early on in word retrieval, mostly cooperation between shared features
  - Word with related meanings are accessed quicker than words with unrelated meanings
  - Competitive processes stronger already for balanced polysemes (slower lexical access)
- Later on, more competition between unshared features, particularly for balanced ambiguous words
  - More competition leads to stronger activation of unshared features and more priming of semantically related targets

Making sense of it all
Shared features vs. semantic relatedness

- Our model is a *shared* features model of (mostly) metonymically related *irregular* polysemes
- Disjoint representations of sense is incompatible with our results that polysemes and homonyms behave differently
- Underspecification is incompatible with our results that the relative frequency of polysemes makes a difference
- Our data do not speak to the representation and processing of *regular* polysemes
    - An underspecification model may be correct there
    - There may be few if any shared features between the senses of regular polysemes (c.f. NEWSPAPER): semantic relatedness ≠ semantic overlap