Lexical Access

(sandwiched by Speech Perception and Morphological Processing)

Psycholinguistics

LING/PSYC 27010

Autumn 2016

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agenda for today (Tuesday)

1. housekeeping
   - homework
   - readings for Thurs
   - anything else?
2. from learning words to using words
3. speech perception
4. bridge to lexical access

last week we saw some strategies children use in establishing associations between words and objects (word learning)

the output of the word learning process is a

mental lexicon

once associations are internalized, that knowledge must be stored, organized, and deployed in real-time

- lexical access
- speech perception and production

what do you know when you know a word?

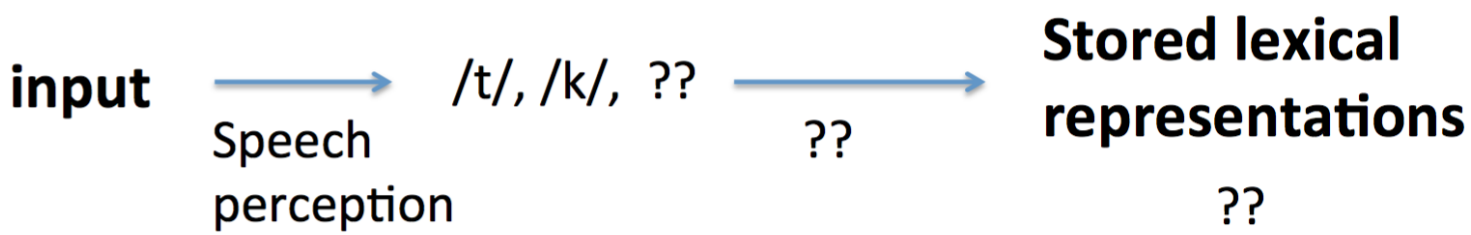
- phonology
- morphology
- orthography
- syntax
- semantics

a lexicon is a kind of enriched mental dictionary

contains all idiosyncratic word information

average person has around 50,000-75,000 words in memory

takes only around 250ms to find a word!



today:

- how do we get from raw, unsegmented speech signal to a meaningful interpretation?

→ word-level: speech perception + lexical access

→ sentence-level: parsing + syntactic processing

- what is the lexicon like?
- how can we study properties of the lexicon?

cognitive perception

bottom-up information processing

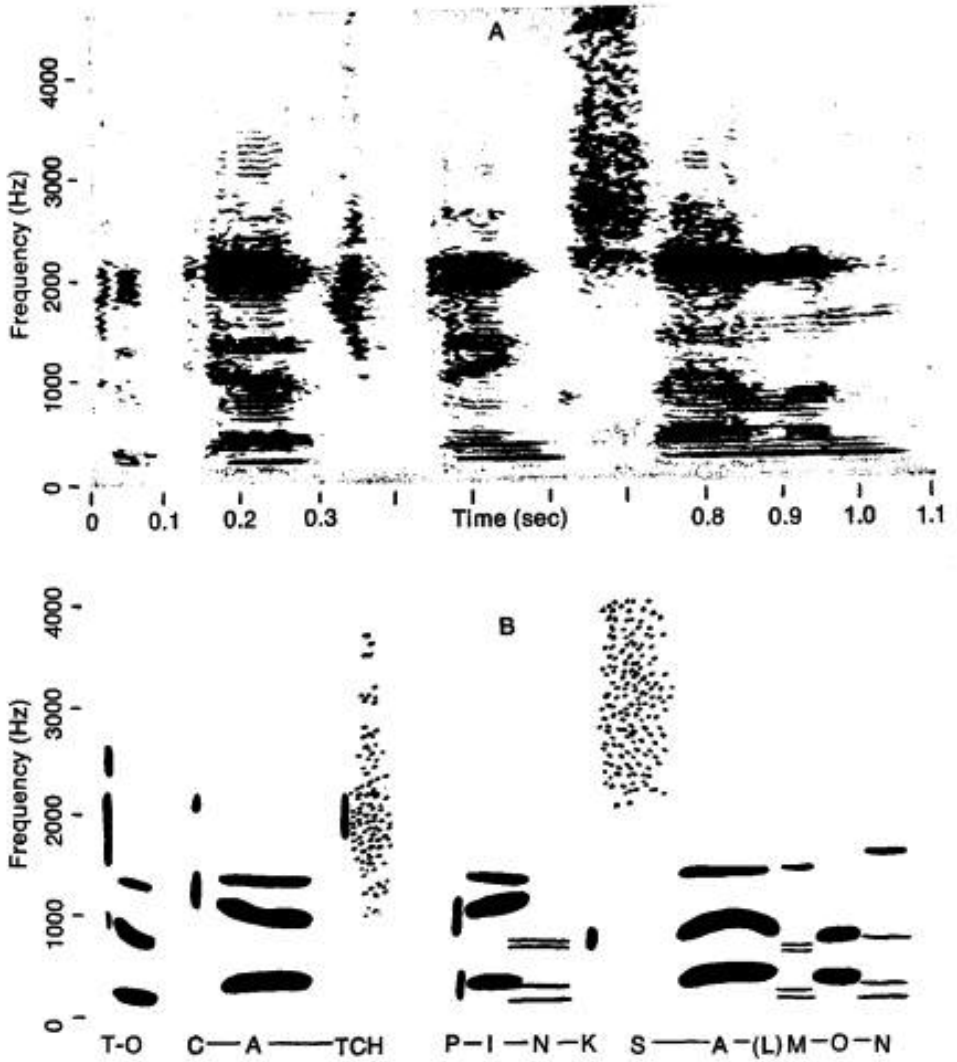
raw sensory data; perception drives cognition

top-down information processing

conceptual knowledge (from higher levels); cognition drives perception; perception constructed by cognition

what's in the middle?

lang. comprehension is a difficult problem



spectrogram generator

(though it doesn't feel difficult!)

lang. comprehension is a difficult problem

segmentation problem

coarticulation

lack of invariance

major question is how much of speech perception (and language comprehension generally) is top-down and how much is bottom-up

categorical perception

which picture best represents the speech signal?
what about our interpretation of the speech signal?

categorical perception

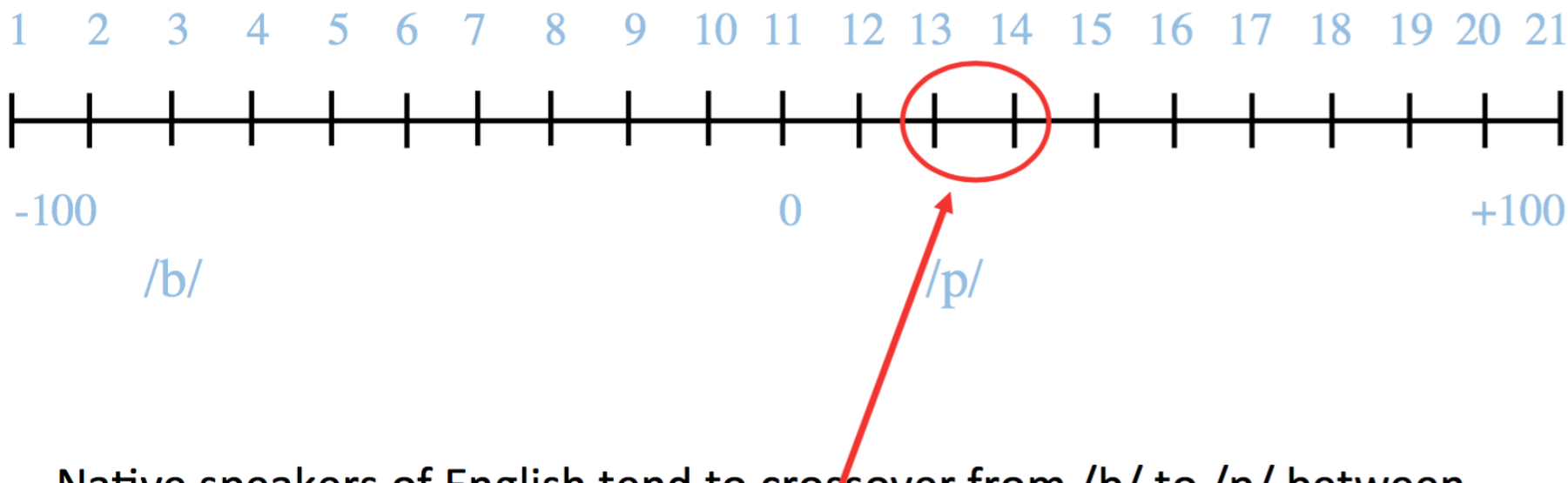
voice-onset time is gradient in speech

/d/ $\longrightarrow$ 0-30ms VOT
/t/ $\longrightarrow$ 50-80ms VOT
otherwise basically identical segments

youtube

def'n: time between release of a (stop/plosive) consonant and the onset of voicing (or vocal fold vibration)

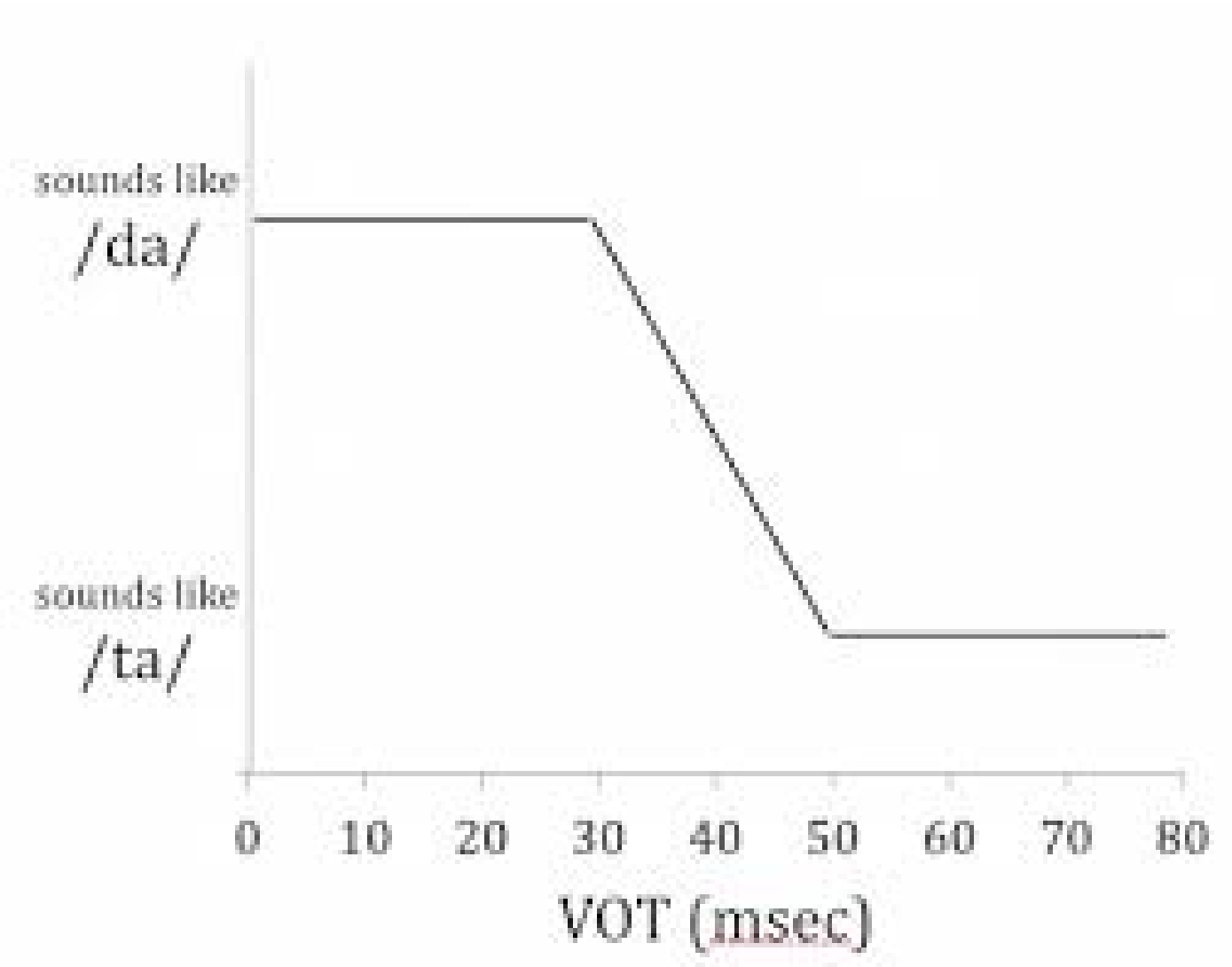
categorical perception



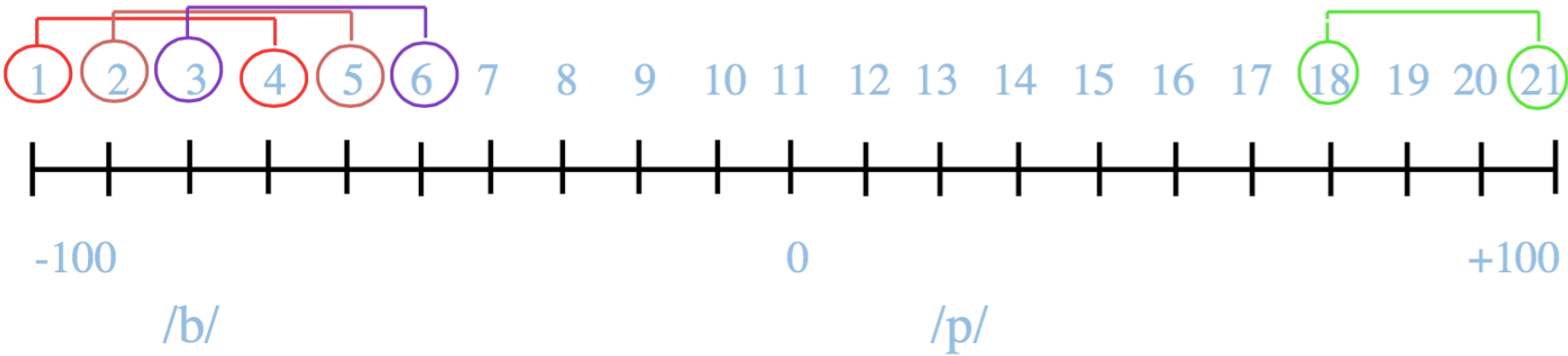
Native speakers of English tend to crossover from /b/ to /p/ between

(Lisker & Abramson 1960s)

categorical perception

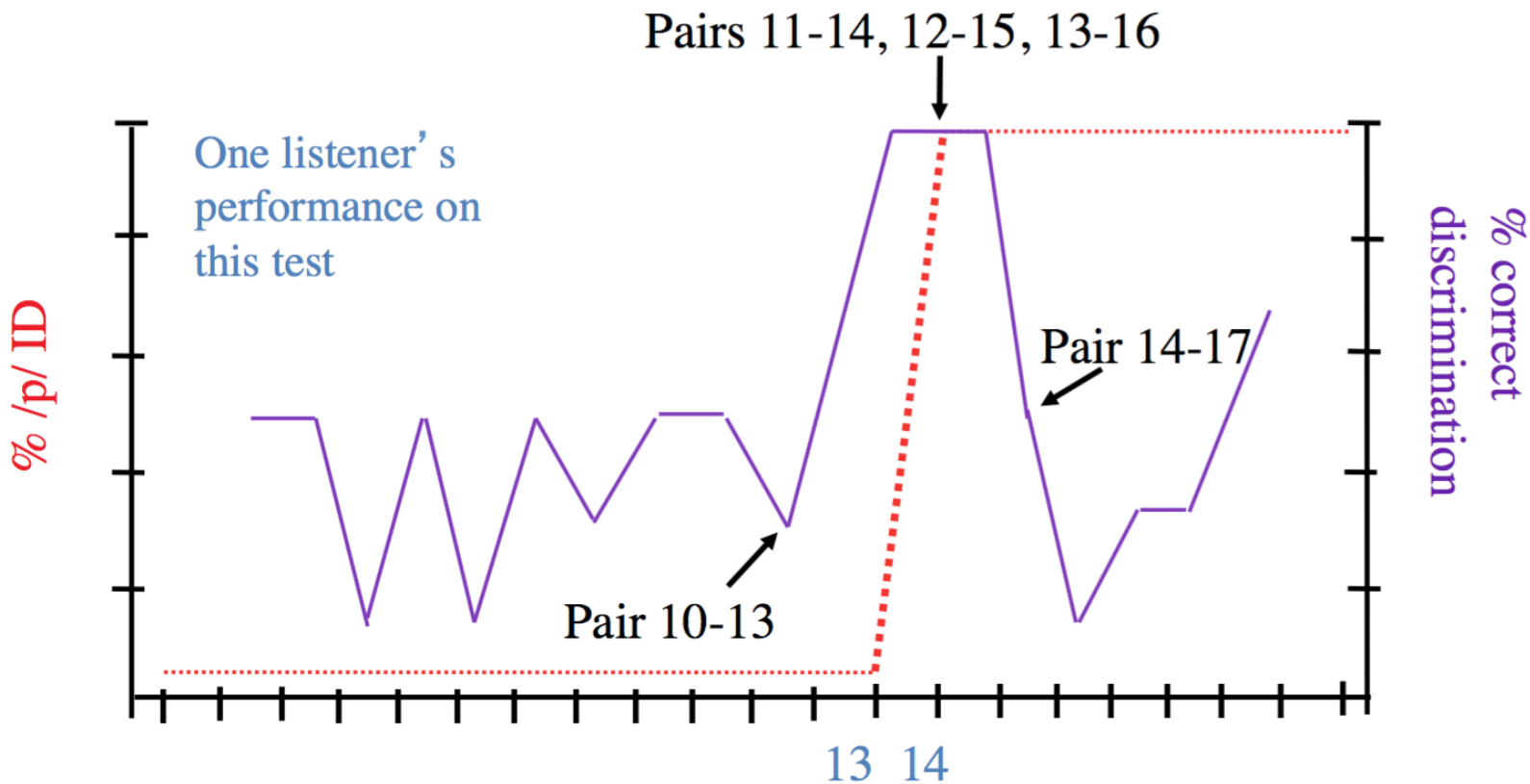


categorical perception



discrimination task – which is /p/ and which is /b/?

categorical perception



the McGurk effect

video

the McGurk effect

the McGurk effect illustrates multi-modal speech perception (McGurk & MacDonald 1976)

$\Longrightarrow$ top-down input from other senses

phoneme restoration effect

phoneme restoration effect

...the *eel was on the orange. (peel)

...the *eel was on the axle. (wheel)

...the *eel was on the shoe. (heel)

...the *eel was on the table. (meal)

participants understand sentence + report hearing sound (Warren & Warren 1970)

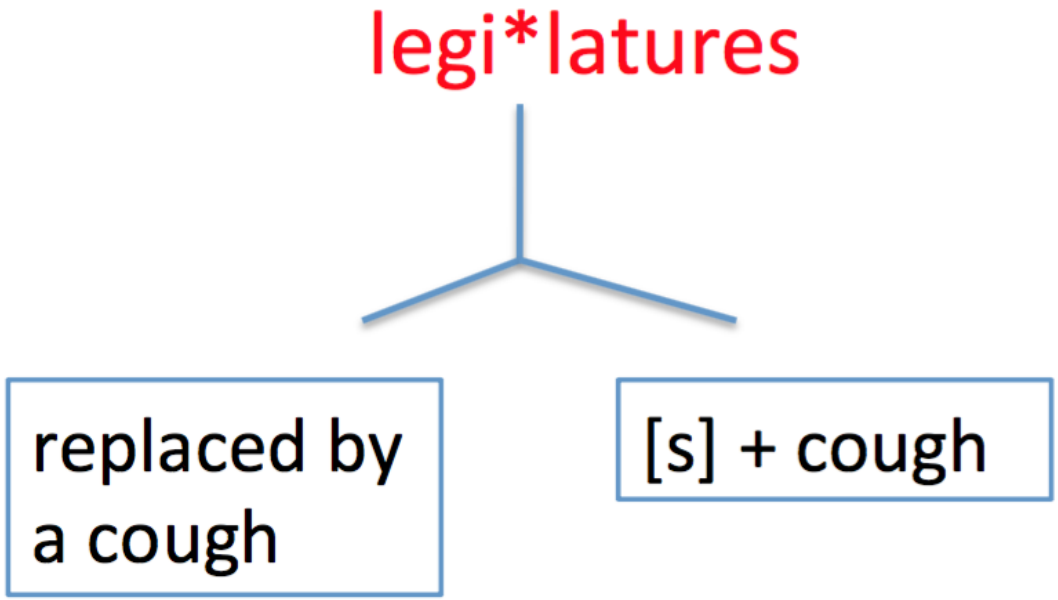
phoneme restoration effect

does context affect perception or post-perception? (filling in what's missing)

context might influence how listeners perceive (actually hear) the phoneme $\longrightarrow$ immediate effect

context might influence listeners' decision on the corrupted phoneme $\longrightarrow$ post-perceptual effect...

phoneme restoration effect



inability to distinguish between these two indicates presence of genuine and immediate perceptual effect (Samuel 1981)

agenda for today (Thursday)

1. housekeeping
   - homework
   - textbook
   - anything else?
2. some terminology in experiments
3. lexical access
4. morphological processing

experimental design/analysis terminology

variables

- independent variables
- dependent variable

factorial design

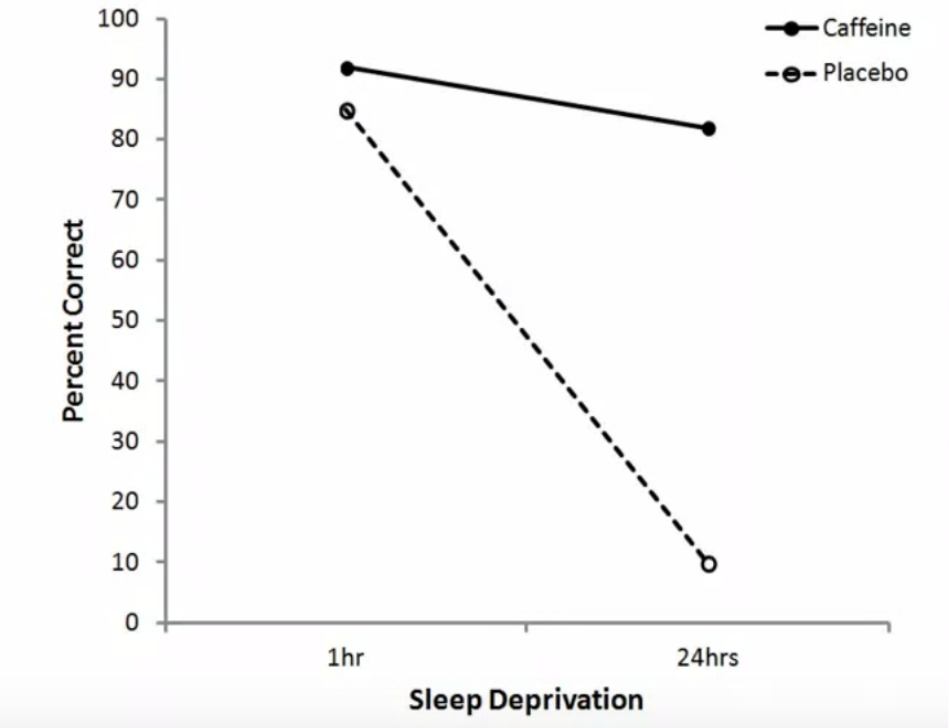
- factors
- levels

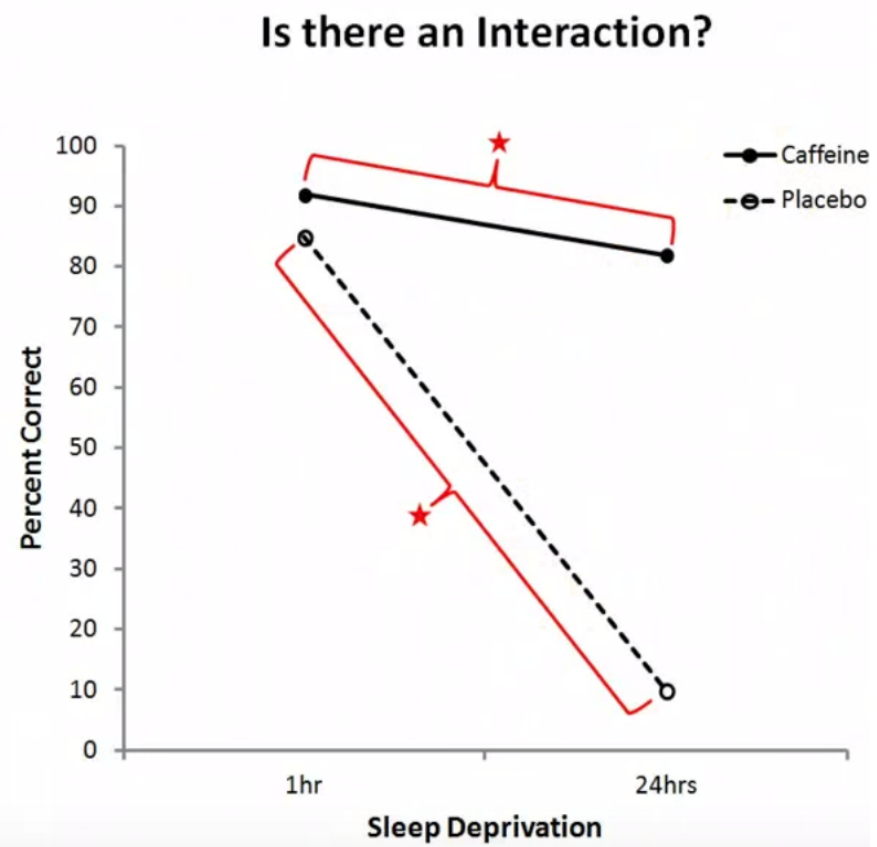
effects

- main effects
- interactions
- reliability (p-values)
- effect size/magnitude (various)

experimental design/analysis terminology

ex. 2×2 design – effect of caffeine and sleep deprivation on memory

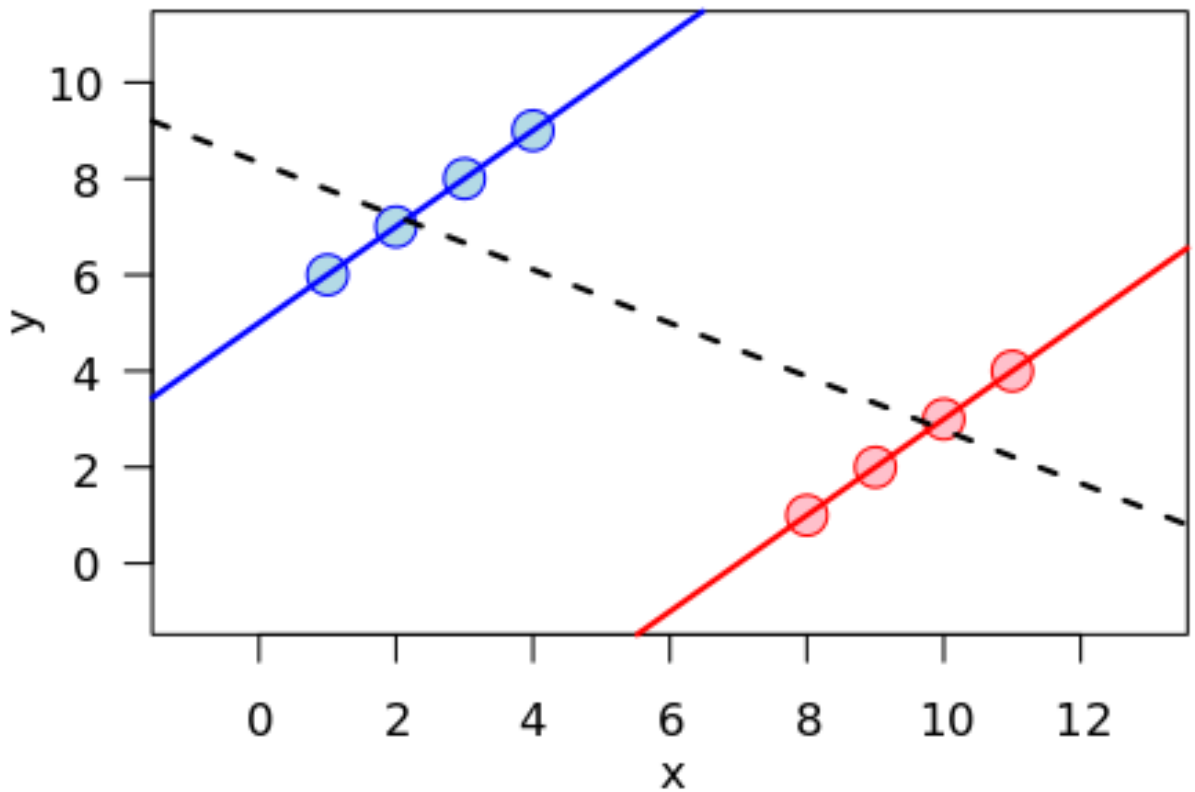




c/o: Jim Grange

experimental design/analysis terminology

interesting: check out Simpson's paradox!
(on your own time, for personal enrichment)

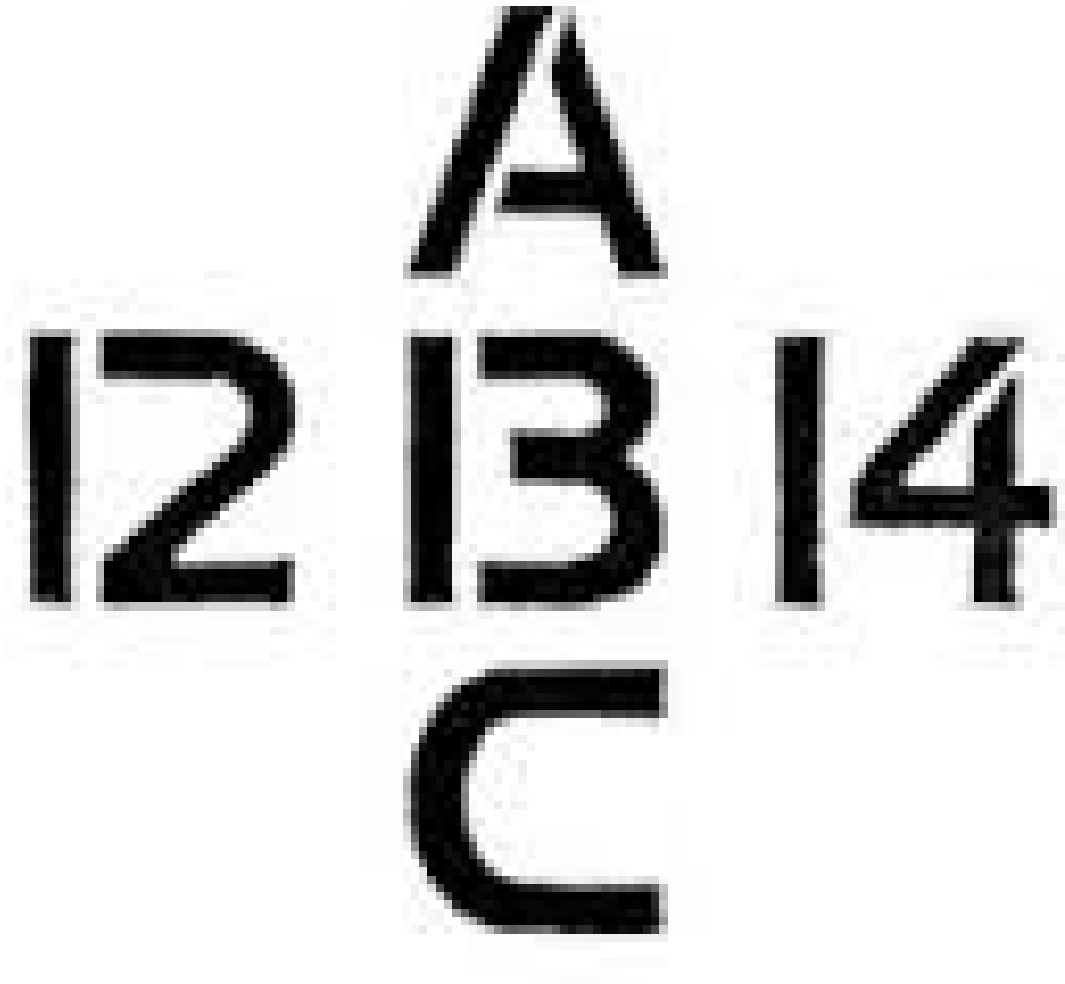


c/o: wikipedia article on Simpson's paradox

perceptual priming

perceptual priming

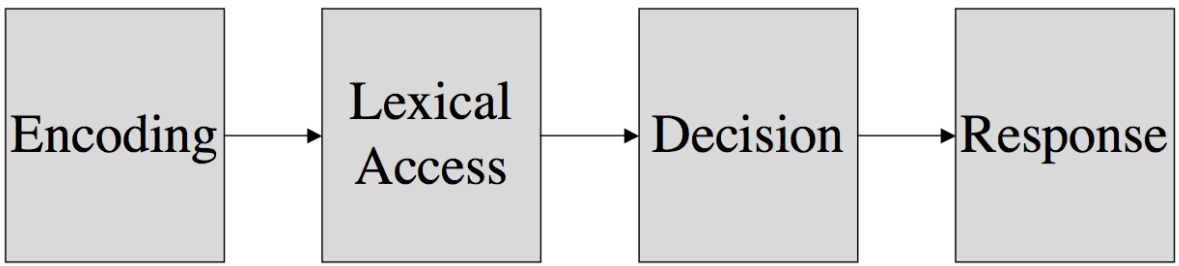
but...



lexical decision task

lexical decision task: is this a word of English? (y/n)

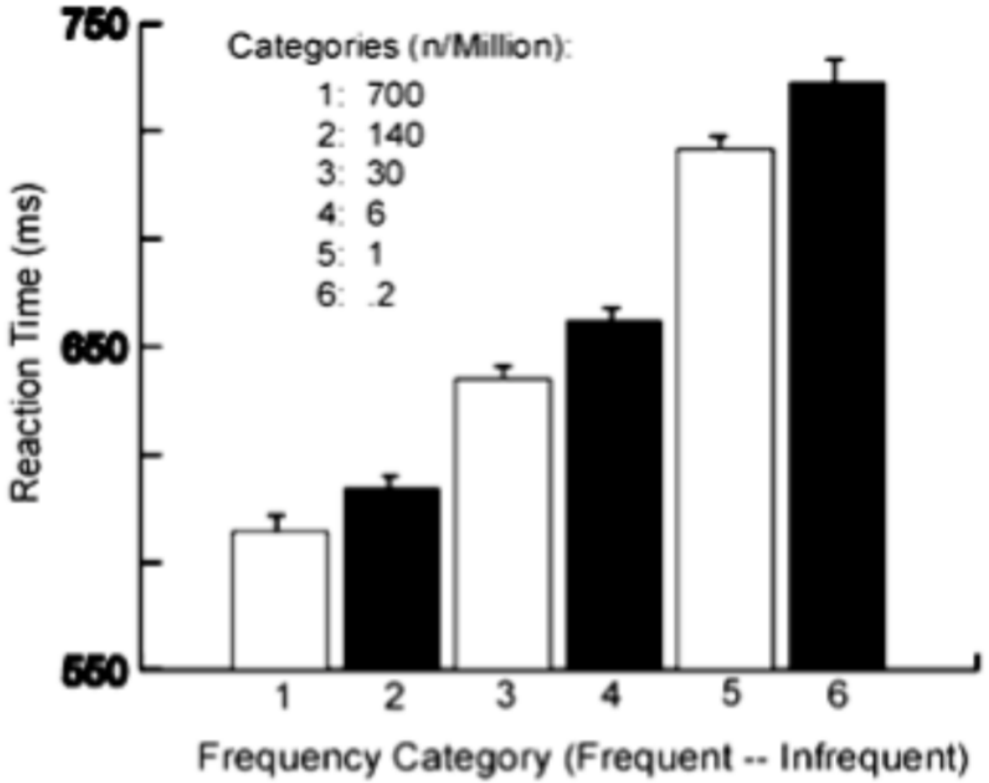
reaction time: time between onset of visual stimulus and judgment (nb. RT also response time)



manipulate stims to investigate mechanisms of access, accuracy and RT key dependent measures

lexical decision task

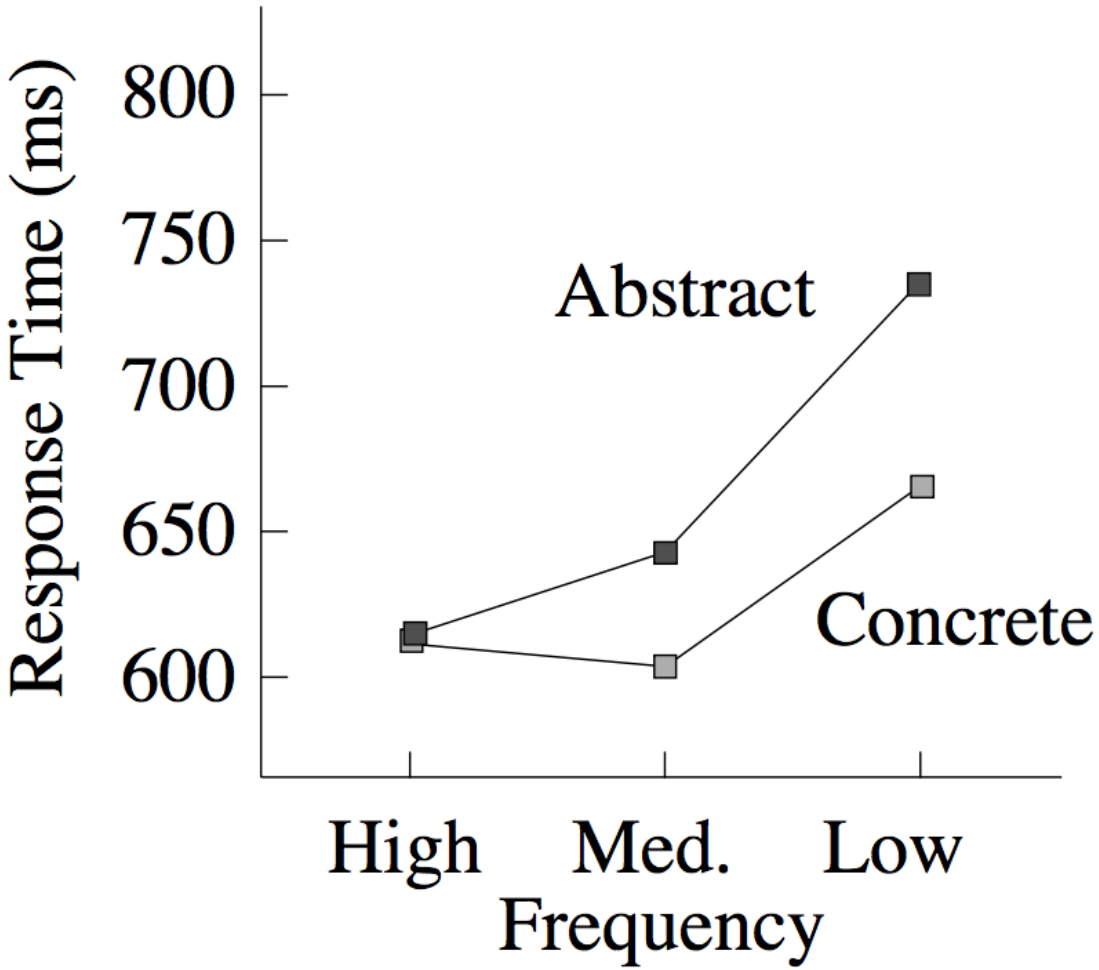
word frequency affects lexical decision RT



[number,ask,wheel,candle,clam,snarl]

lexical decision task

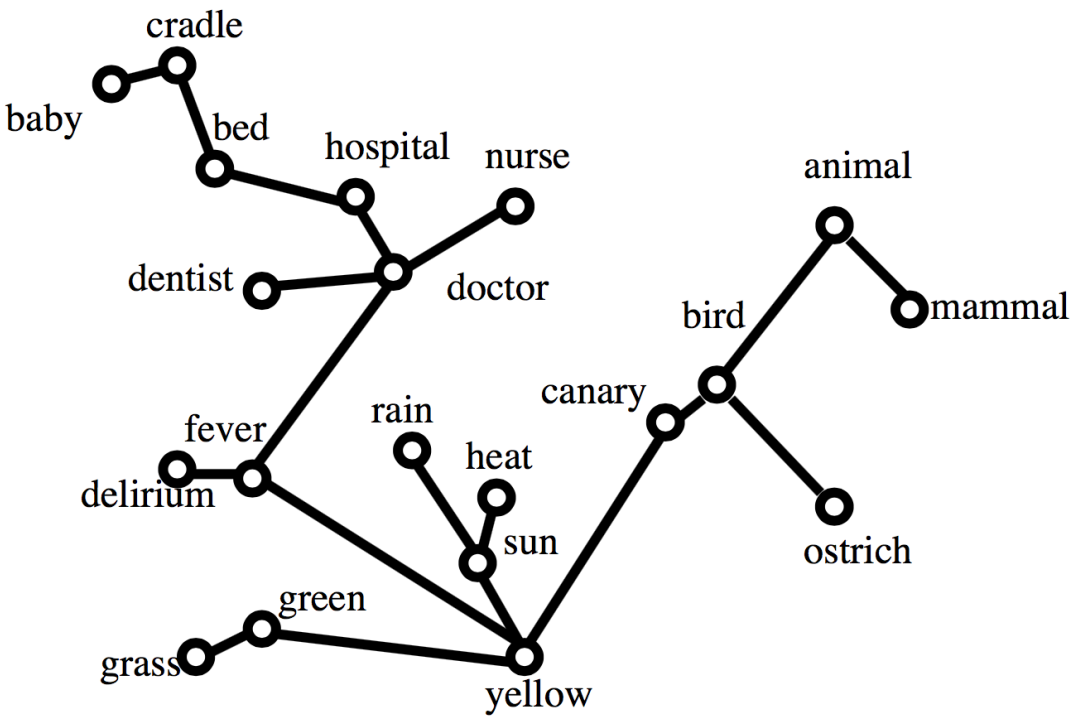
frequency effect stronger for abstract than concrete



suggests that lexicon has some kind of structure

but what *kind* of structure??

one intuitive possibility:
(frequency can be represented by "thresholds")



lexical decision-based priming paradigms

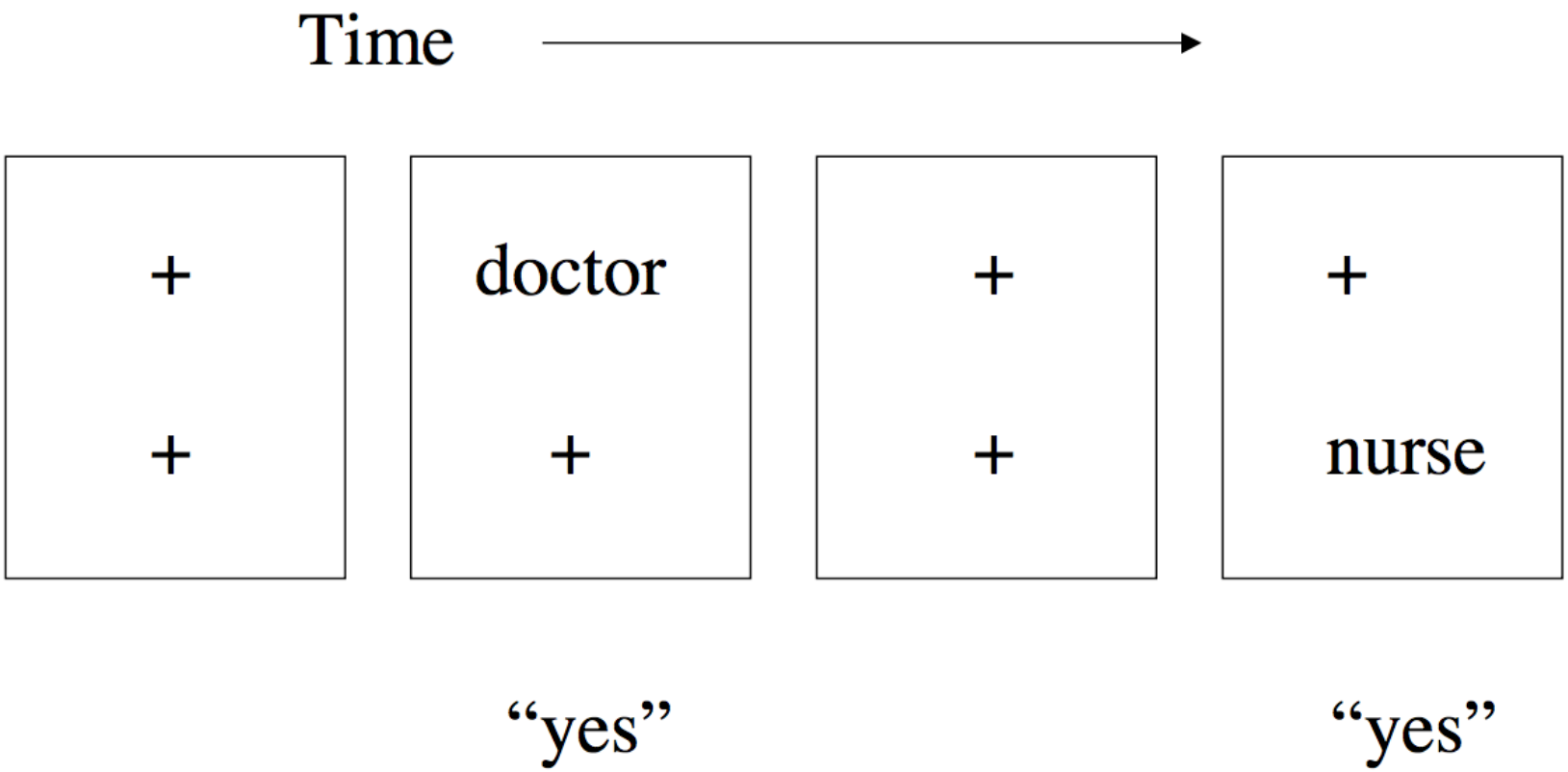
lots of different formats for priming studies

we'll look at just a few
some terminology

- stimulus-onset asynchrony (SOA): time between prime onset and target onset
- reaction time (RT): time between target onset and response
-

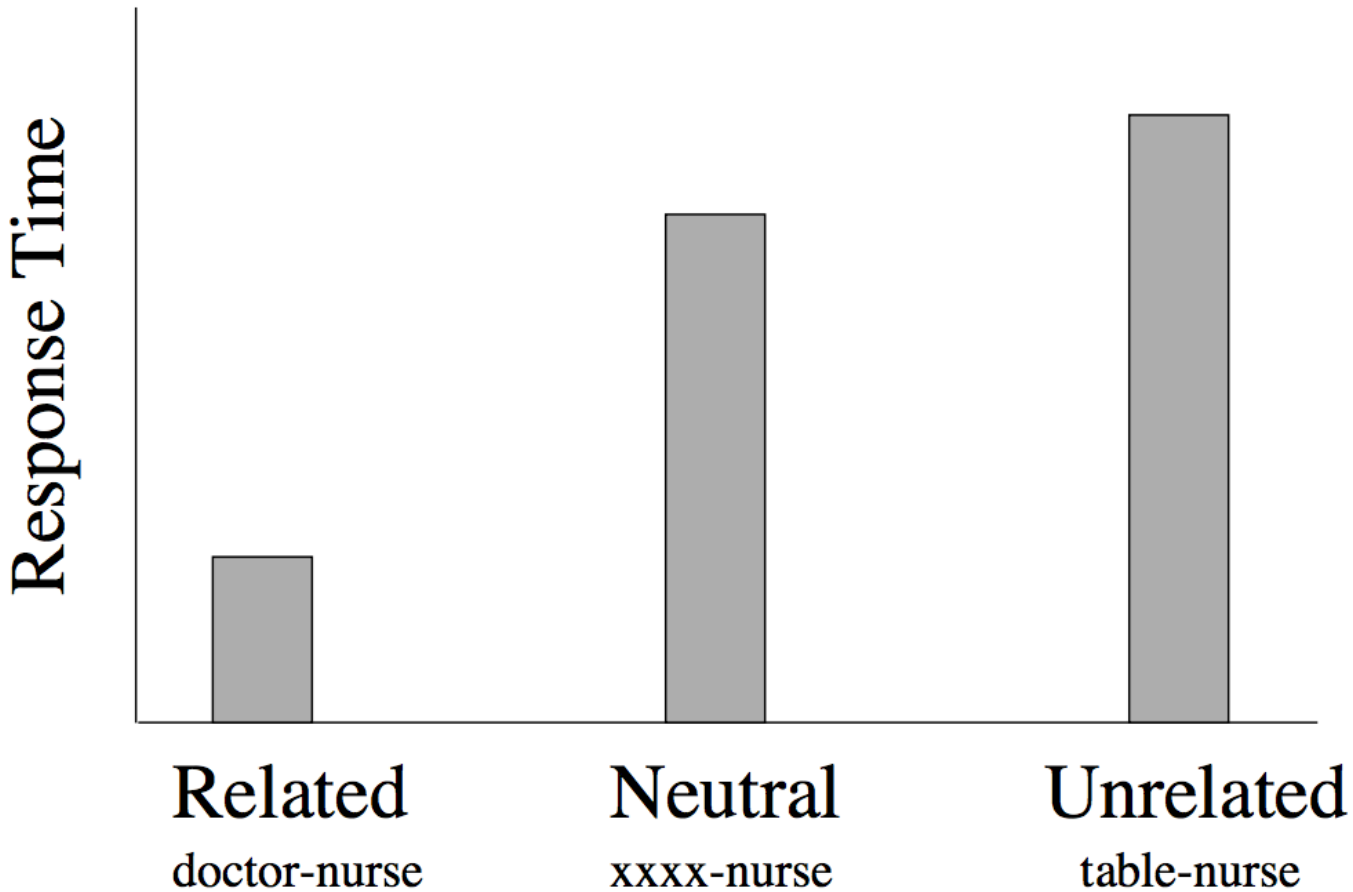
semantic priming

basic/common priming paradigm:



an even simpler example: demo

semantic priming



nb. there are also phonological, orthographic, and other priming effects

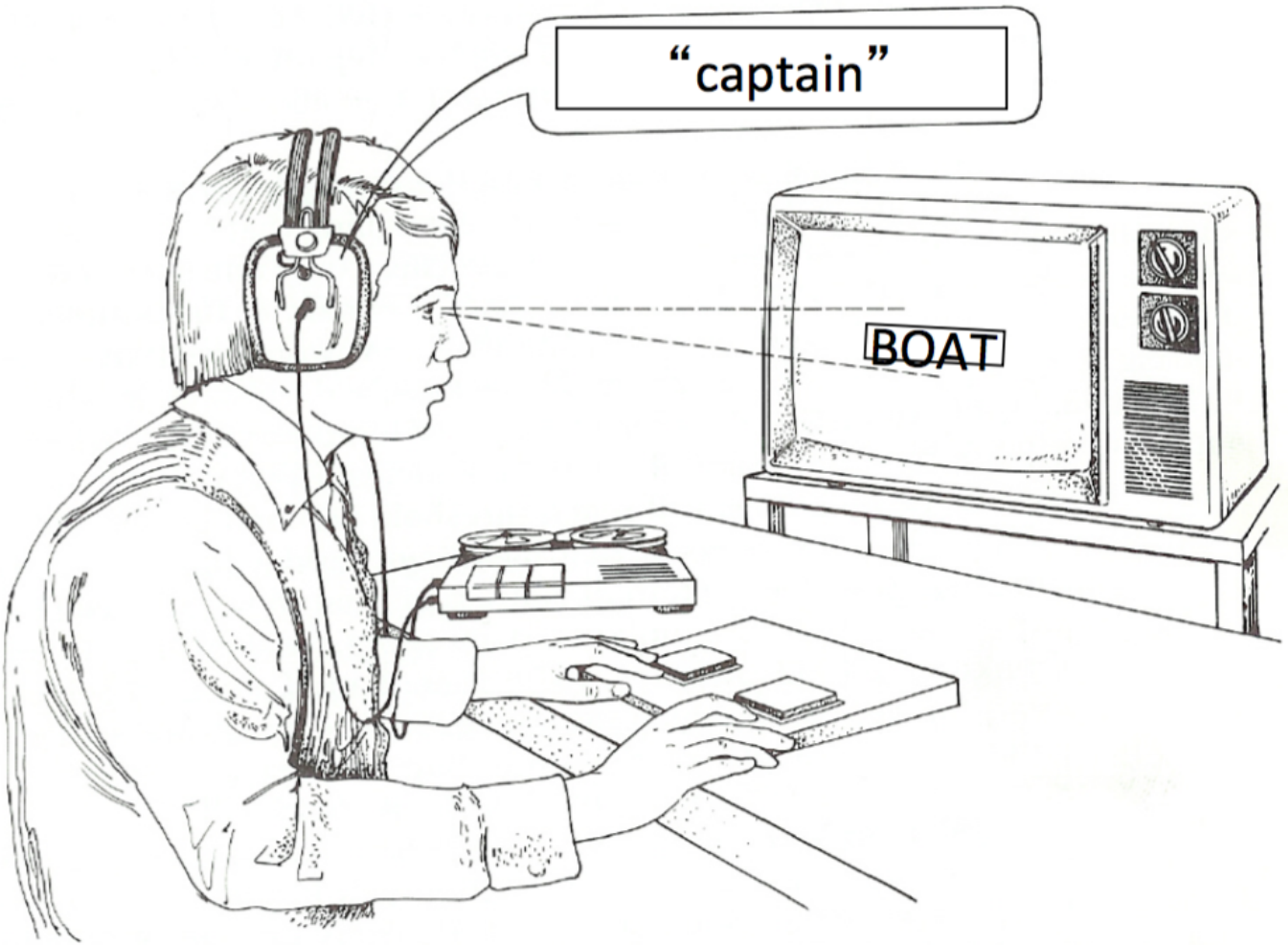
masked priming

Forster & Davis (1984) – online demo

####	⟶	prime	⟶	TARGET	⟶	yes/no
500ms		40ms or 100ms		500ms	⇑ RT	lexical decision

so cool rite?!

cross-modal priming



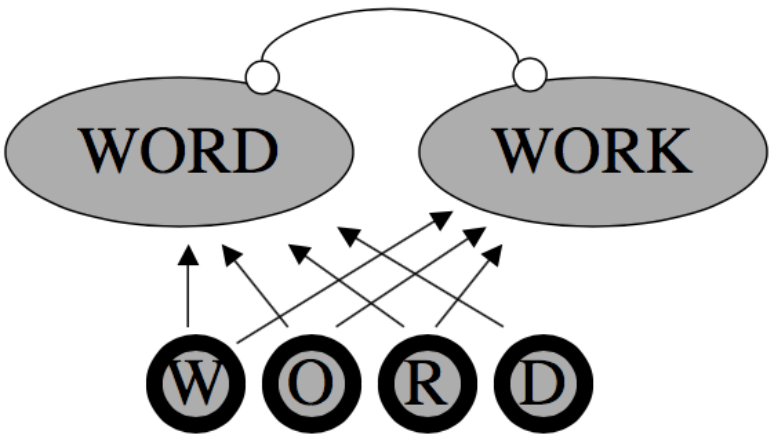
youtube ex

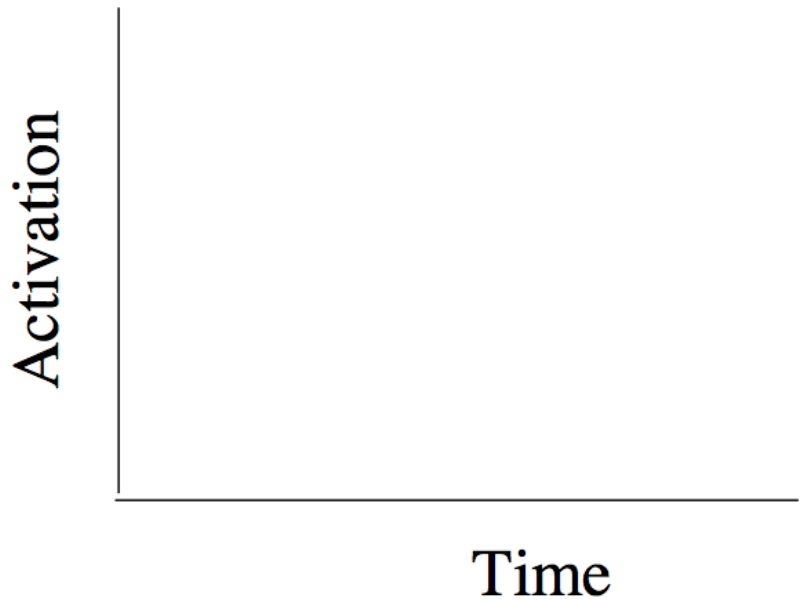
we see these effects in people's behavior,
but what's driving them?

in other words,

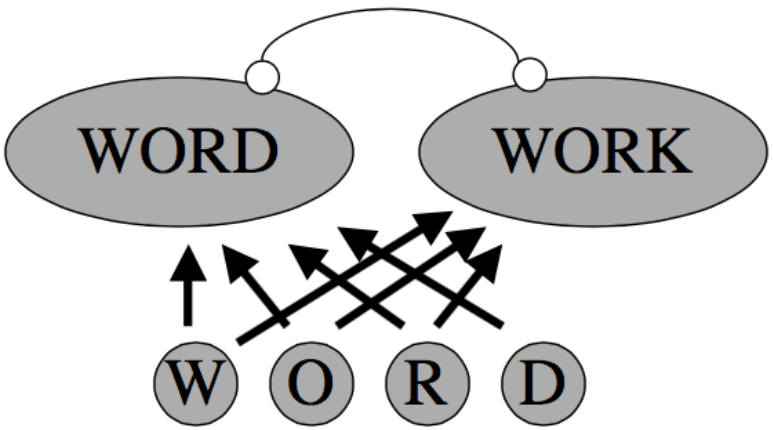
what's going on under the hood??

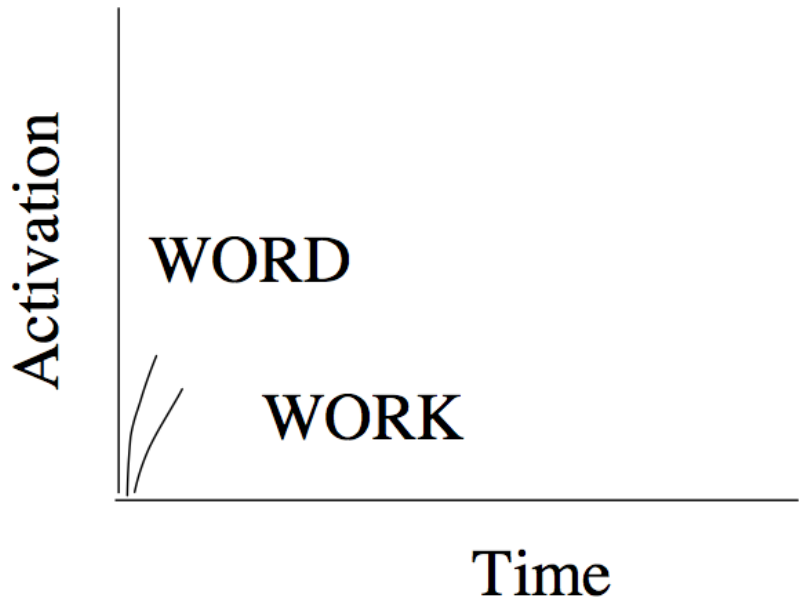
activation and competition



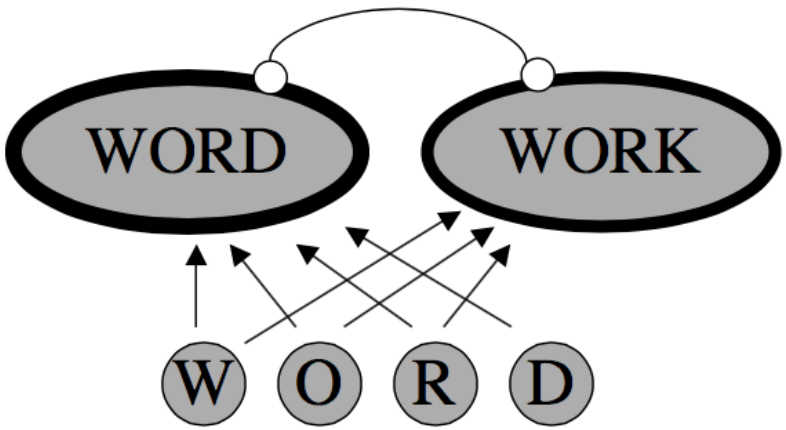


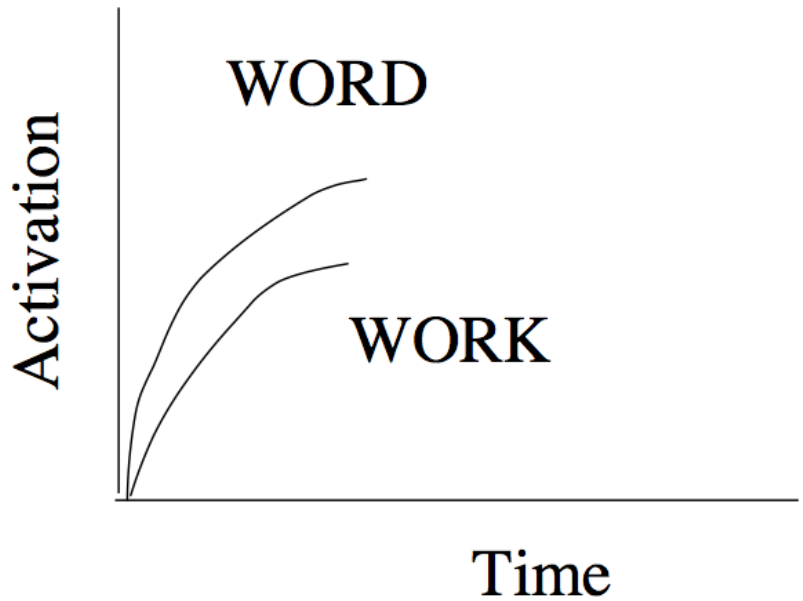
activation and competition



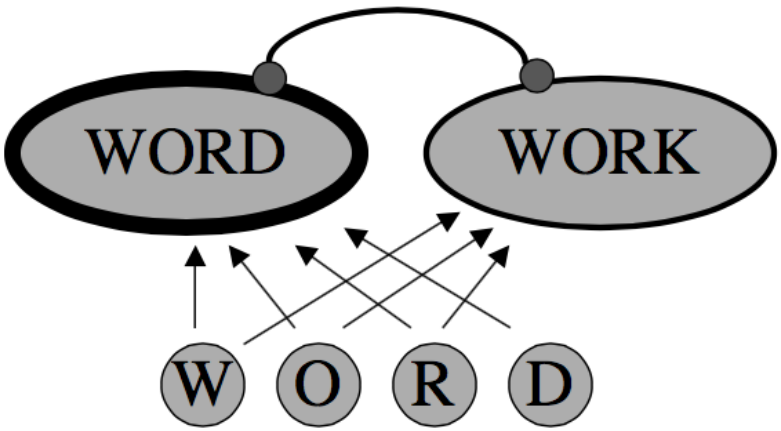


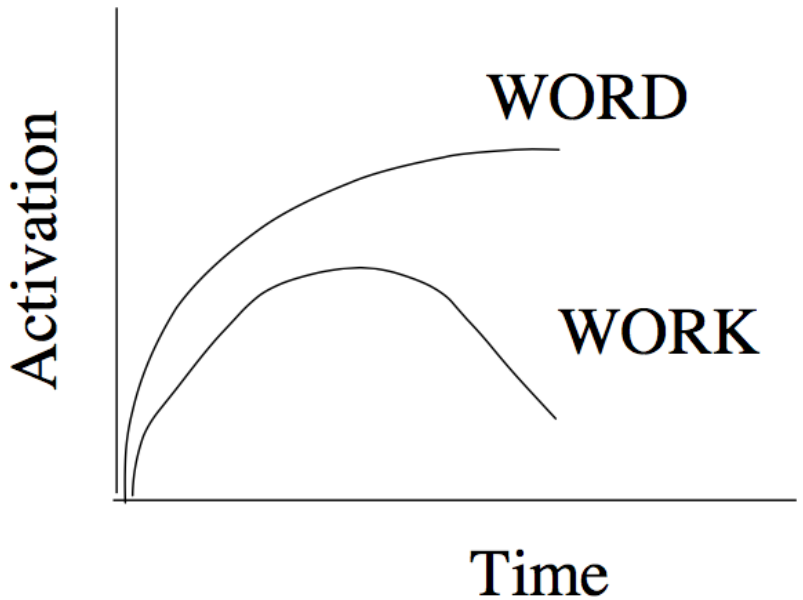
activation and competition



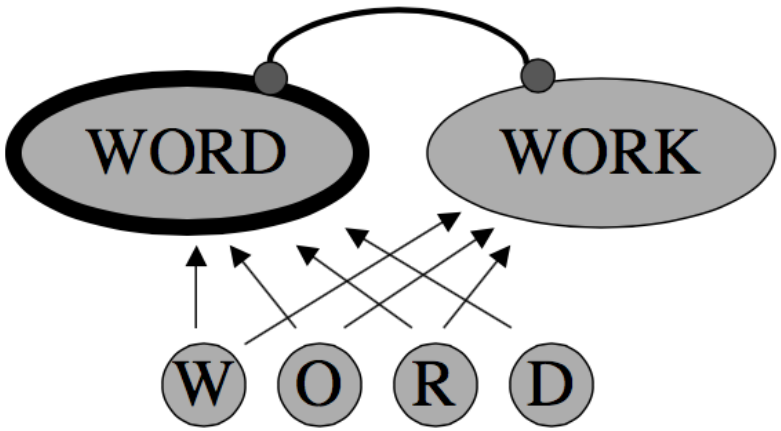


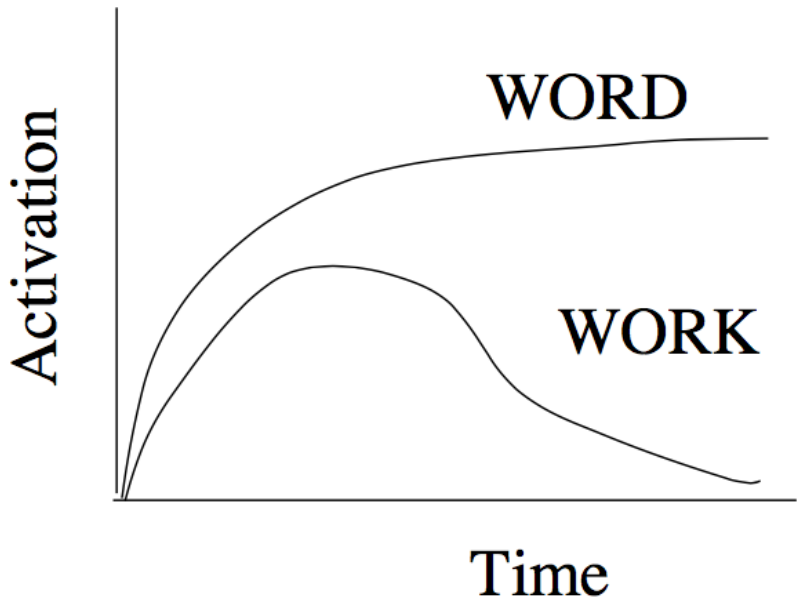
activation and competition





activation and competition

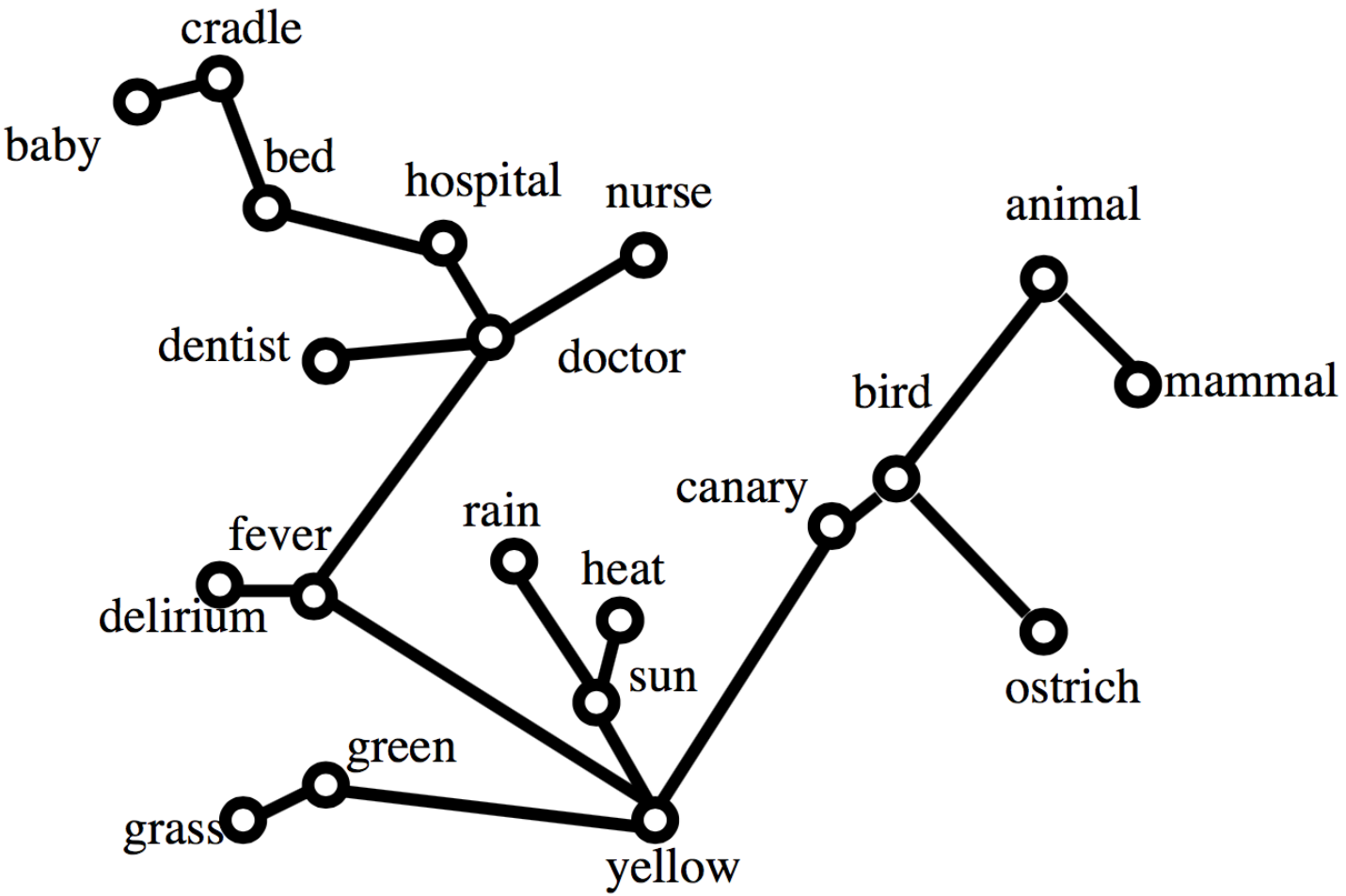




activation and competition

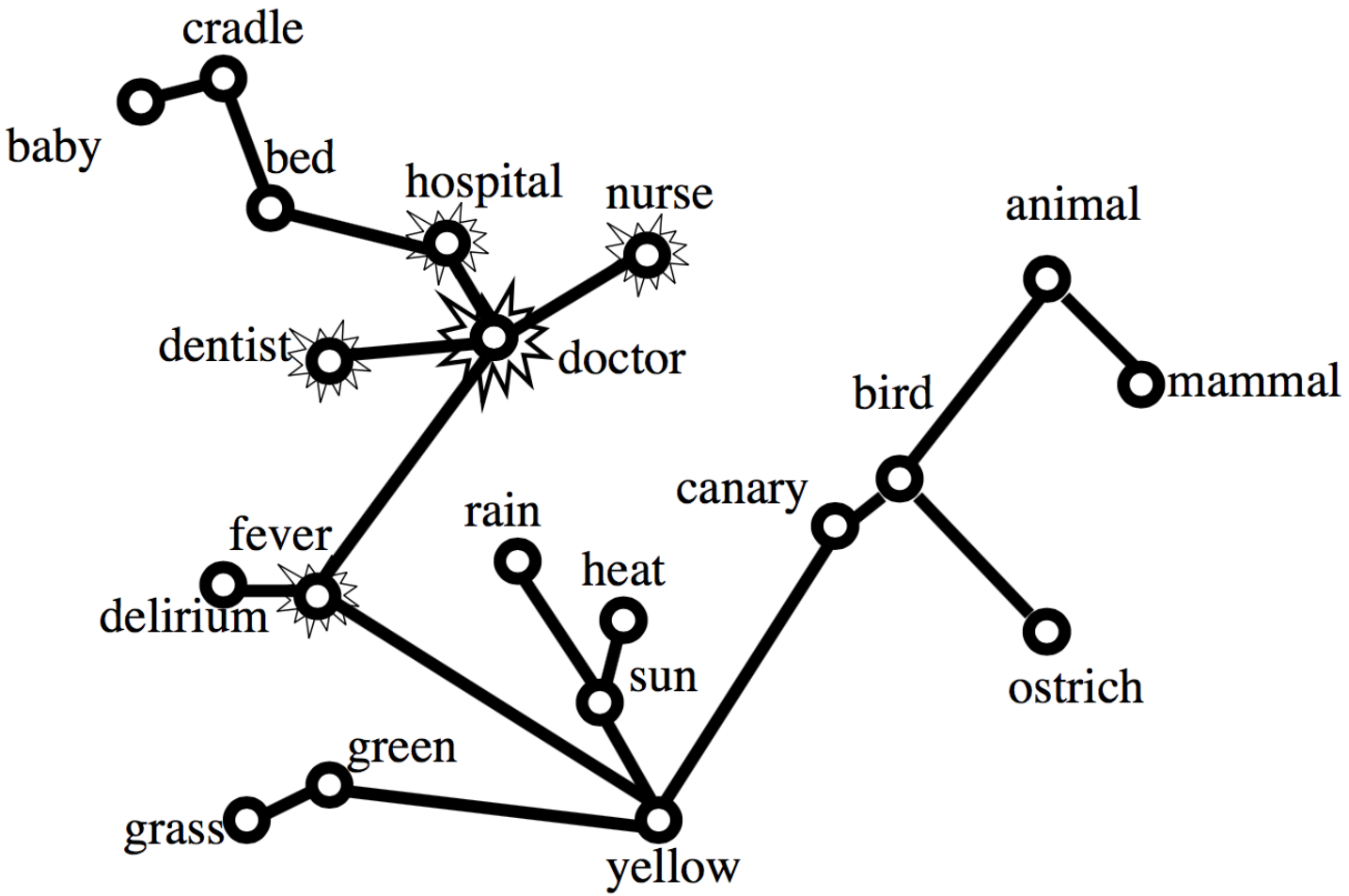
word recognition is incremental, and therefore introduces temporary ambiguity

basic semantic network models



- spreading activation
- mediated semantic priming expected
- decay function

basic semantic network models



- spreading activation
- mediated semantic priming expected
- decay function

two models of lexical access

Cohort Model (Marlen-Wilson & Welsh 1978)

- autonomous, modular
- bottom-up (mostly)

TRACE Model (McClelland et al. 1986)

- interactive
- top-down (mostly)

Cohort Model

linguistic input induces a set of possible meanings (a cohort)

cohort generation is bottom-up only
$\rightarrow$ not affected by top-down context

Cohort Model

S

song
story
sparrow
saunter
slow
secret
sentry
etc.

Cohort Model

SP

spice
spoke
spare
spin
splendid
spelling
spread
etc.

Cohort Model

SPI

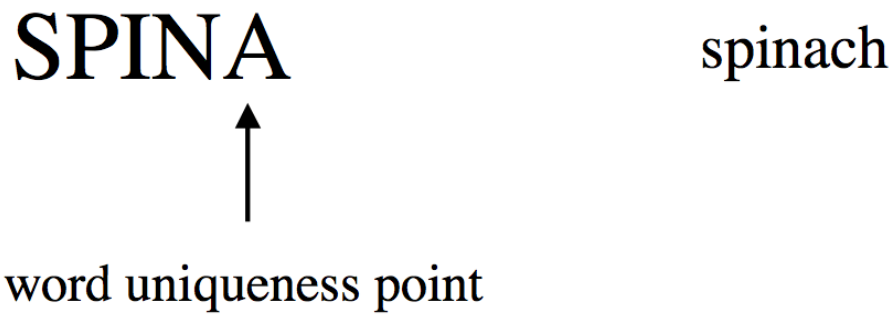
spit
spigot
spill
spiffy
spinaker
spirit
spin
etc.

Cohort Model

SPIN

spin
spinach
spinster
spinnaker
spindle

Cohort Model

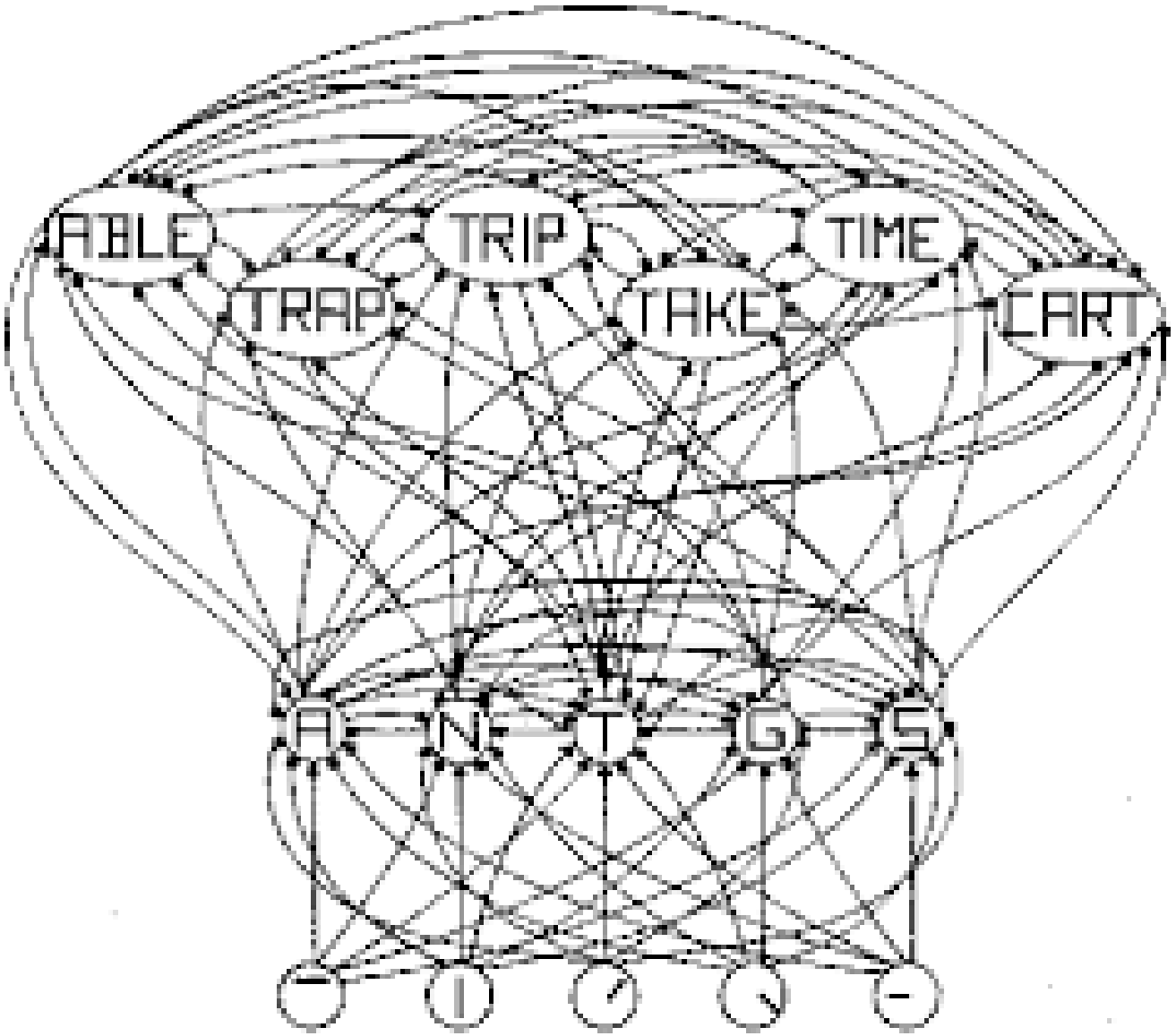


Cohort Model

evidence from...

do the next homework!

TRACE Model



wha, wth is?!?! aghhhhh!

TRACE Model

recognition network has disjoint hierarchical levels

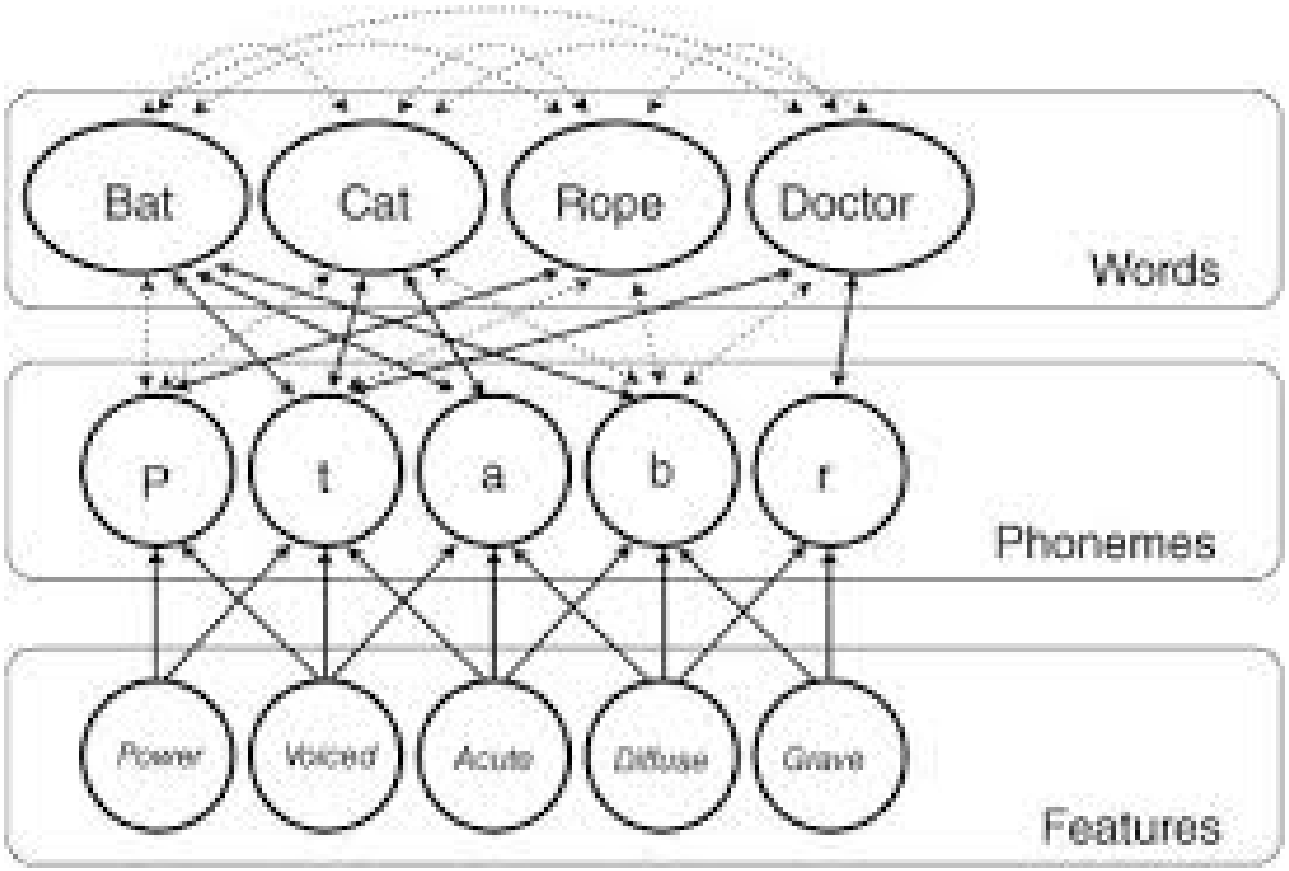
- feature/ligature
- phoneme/grapheme
- word

interaction between levels is a top-down process

McClelland, Elman, Rumelhart, et al.

TRACE Model

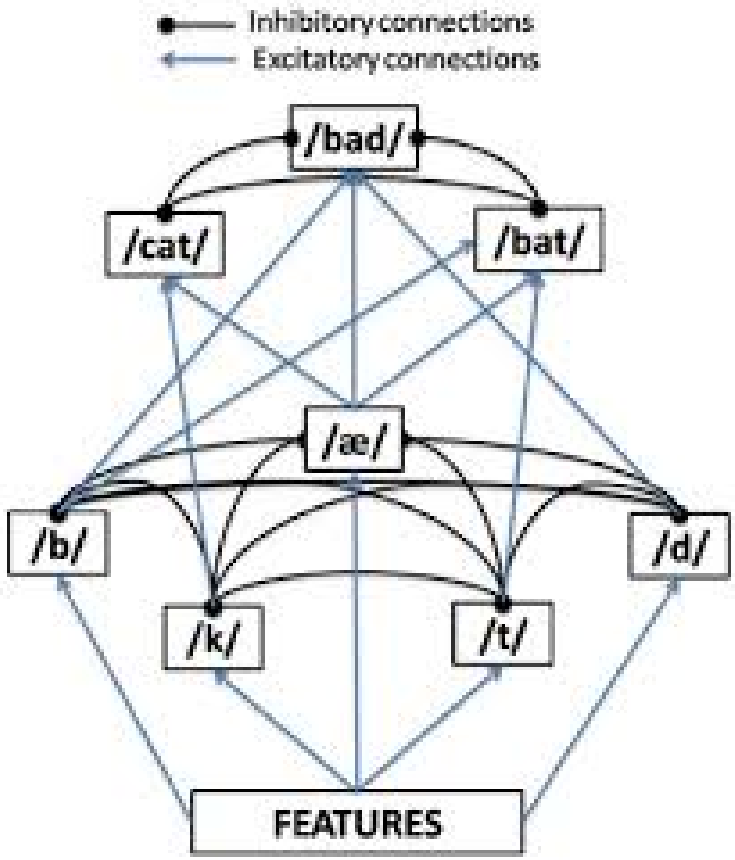
recognition network has disjoint hierarchical levels



TRACE Model

excitatory and inhibitory connections can link nodes

- same level $\rightarrow$ inhibitory connection
- different levels $\rightarrow$ excitatory connection



TRACE Model

evidence from...

do the next homework!

beyond simple word recognition

we've only looked at simple words so far

but we clearly have to access all kinds of internally-complex words, in order to syntactically assemble them

question: do we store complex words just like simple ones, or is morphology part of the syntactic assembly process?

beyond simple word recognition

in language comprehension, there is

lexical access

and there is also

syntactic processing (parsing)

but are there *intermediate* stages?

is the output of lexical access *the direct input* to syntactic processing?

beyond simple word recognition

these are questions about the nature of

morphological processing

one hypothesis

accessing morphologically complex words is same process as accessing morph. simple words

a second hypothesis

accessing complex words recruits processing resources *not recruited* in access of simple words

the past tense debate

English past tense is mostly regular

walk → walk-ed
wander → wander-ed
braid → braid-ed
wug → ???

but ≈180 verbs have irregular past tense forms

come → came
break → broke
sleep → slept
...

Pinker & Ullman (2002)

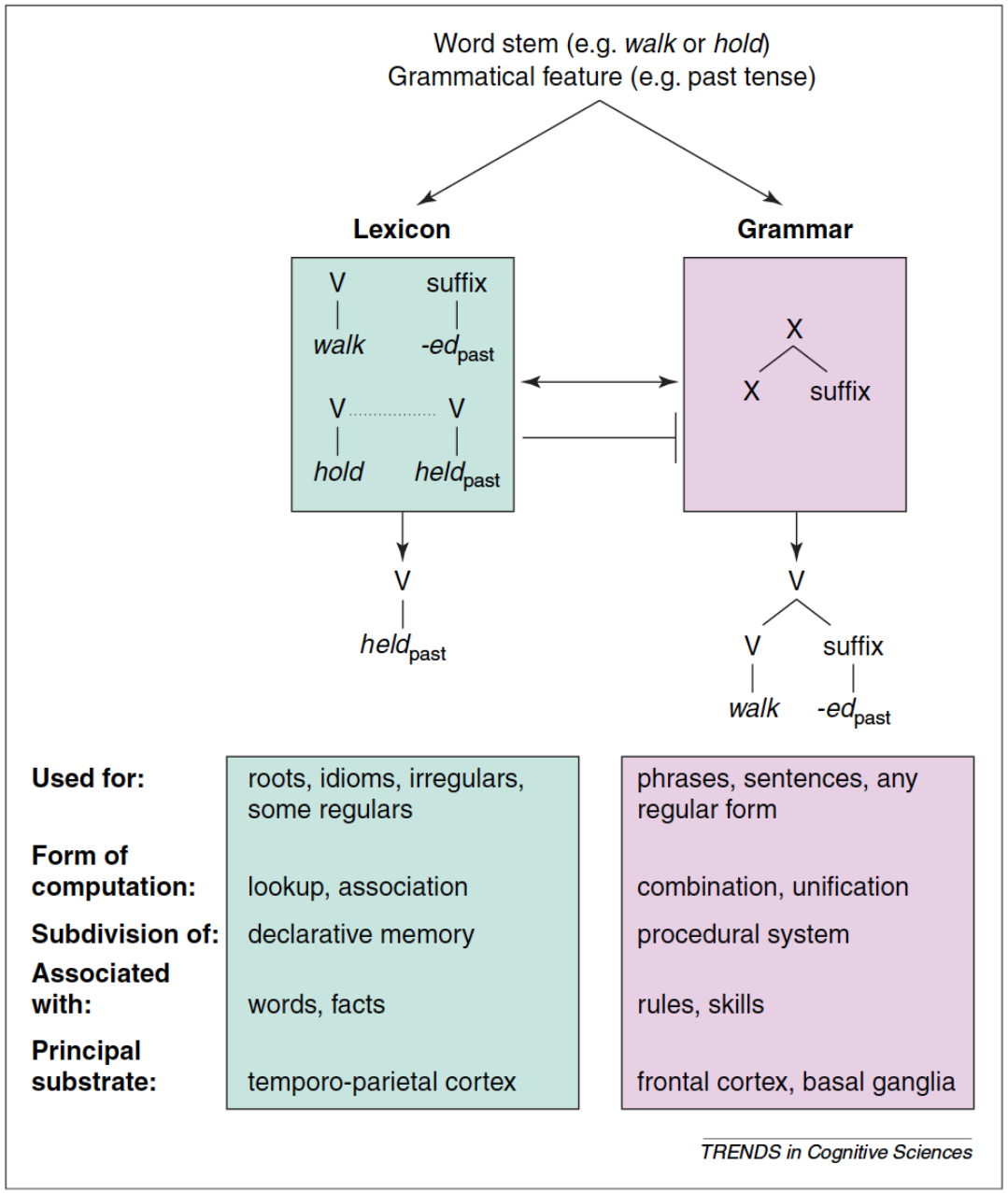
the past tense debate

main questions

what is the psychological relationship between an English verb and its past tense form?

does the nature of that relationship depend on whether it is regular or irregular?

the past tense debate



the words and rules theory

(Pinker et al.)

- regulars derived by **combining morphemes**
- irregulars **stored as wholes**

the past tense debate

connectionist models

(Rumelhart, McClelland, others)

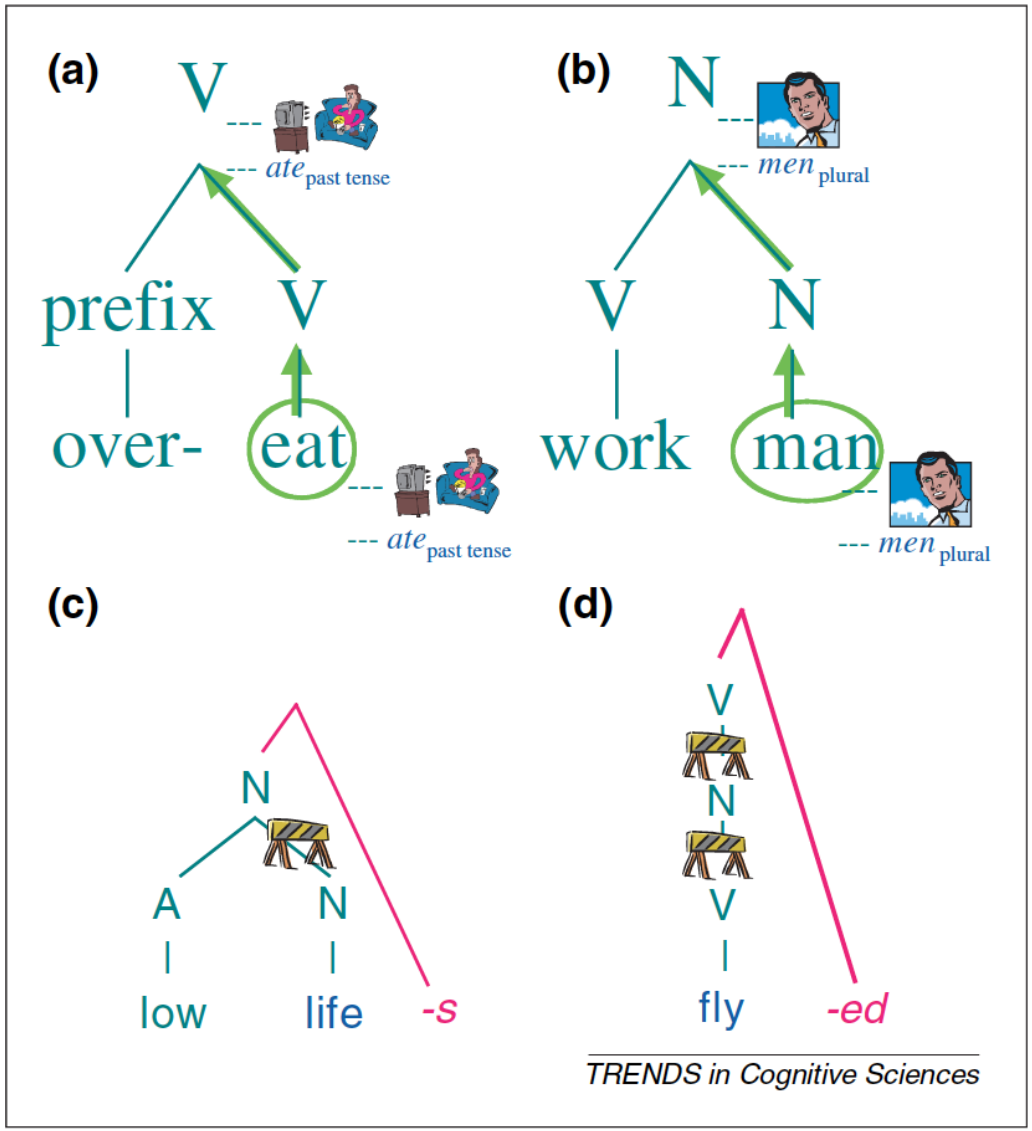
there is just a single pattern associator that computes similarity between words

could account for (limited) regularity in irregulars:

ring-rang; sink-sank; sit-sat
feel-felt; sleep-slept; bleed-bled

the past tense debate

evidence for W+R theory from systematic regularization



the past tense debate

evidence for W+R theory from
neuropsychological dissociations

- Alzheimer's disease associated with greater impairment of lexical and conceptual knowledge than grammatical knowledge

  $\Longrightarrow$ more difficulty with irregulars than regulars
- Parkinson's disease associated with greater impairment of grammatical than lexical knowledge

  $\Longrightarrow$ more difficulty with regulars than irregulars

the past tense debate

solid evidence base for W+R theory

but as with all scientific theorizing,
things are complicated!

you can explore this more in the homework!

remaining questions

what exactly does it mean for two words to be morphologically related?

necessary to assume that morphological processing is psychologically distinct from lexical access??

(one could argue that W+R theory is compatible with either answer)

Rastle et al. (2000)

main question

in language comprehension, is there a level of morphological representation that *cannot* be reduced to orthographic and semantic similarity?

strategy

assess priming effects from morphological, orthographic, and semantic relatedness independently (to the extent possible)

Rastle et al. (2000)

expt 1 – design

TABLE 1
Stimulus characteristics in Experiment 1

Condition	*No. Letters*	*No. Syllables*	*Frequency*	N
+M+S+O (departure-DEPART)	5.17	1.38	24.38	4.79
+M–S+O (apartment-APART)	5.12	1.54	34.92	4.62
–M+S–O (cello-VIOLIN)	5.12	1.42	30.58	6.42
–M–S+O (electrode-ELECT)	4.50	1.33	30.62	7.50
ID (church-CHURCH)	4.79	1.54	39.29	4.71

Note: M, morphological; S, semantic; O, orthographic.

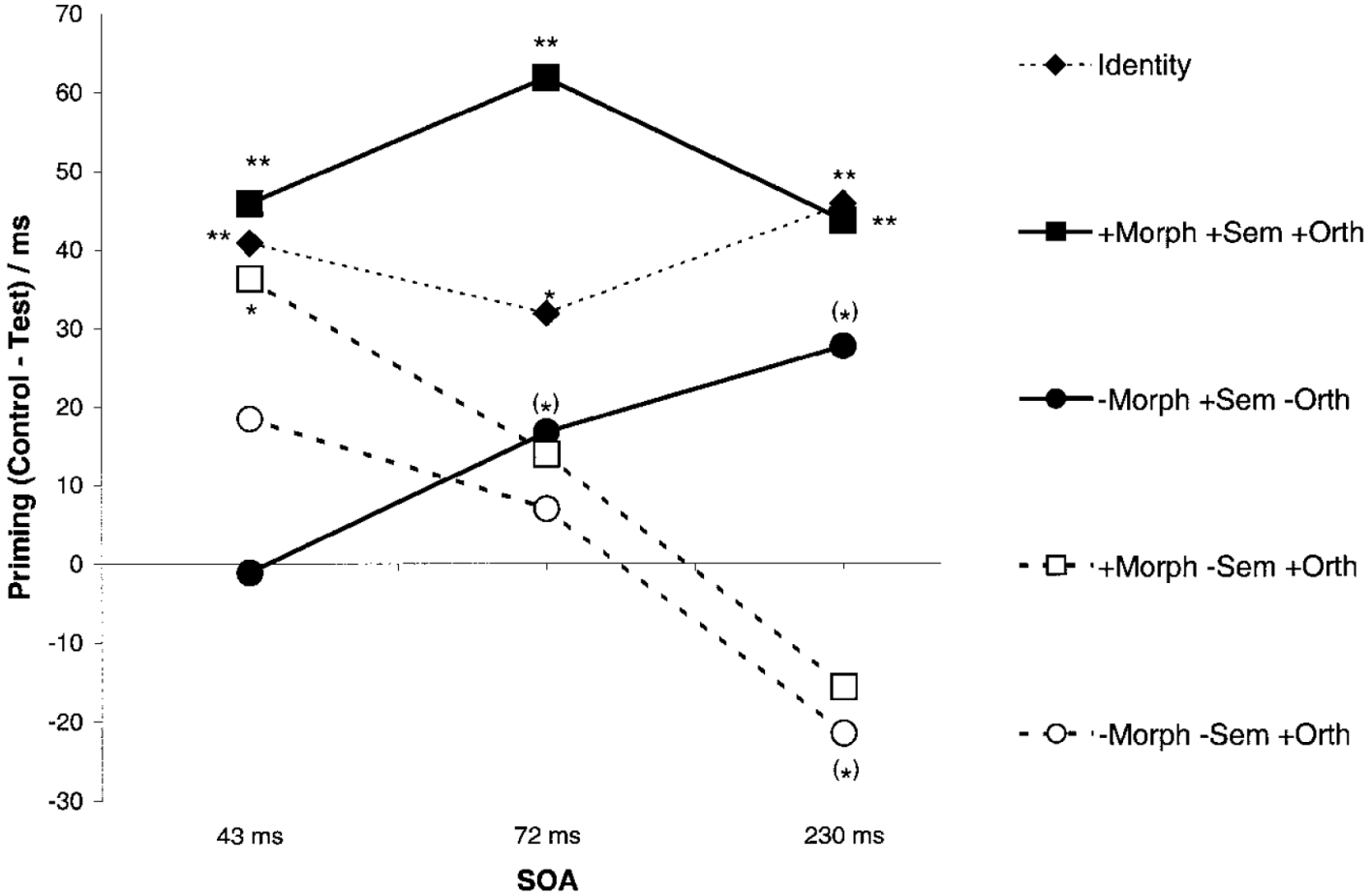
Rastle et al. (2000)

expt 1 – results

TABLE 2
Latency and error data for Experiment 1, by subjects

		SOA		
Condition		*43 ms*	*72 ms*	*230 ms*
+M+S+O	Primed	561 (3.26%)	539 (1.74%)	568 (1.45%)
	Unprimed	607 (2.57%)	600 (5.62%)	613 (3.66%)
+M–S+O	Primed	582 (3.69%)	577 (2.87%)	654 (4.26%)
	Unprimed	617 (4.15%)	593 (3.60%)	639 (2.24%)
–M+S–O	Primed	602 (3.97%)	556 (3.13%)	586 (2.17%)
	Unprimed	605 (2.90%)	575 (1.74%)	613 (2.54%)
–M–S+O	Primed	594 (5.24%)	571 (9.82%)	632 (7.39%)
	Unprimed	613 (3.46%)	586 (4.77%)	611 (3.10%)
ID	Primed	559 (5.37%)	541 (1.52%)	564 (1.98%)
	Unprimed	601 (7.38%)	571 (6.22%)	606 (2.60%)

Rastle et al. (2000): expt1 results



- clear priming effects for +M+S+O and identity
- larger effect for +M+S+O than for -M-S+O (form controls) and -M+S-O
- no difference between +M-S+O and -M-S+O

Rastle et al. (2000)

question: how are these results interpreted?

still compatible with

morphology = semantics + orthography

Rastle et al. (2000)

expt 2 – design

TABLE 3
Stimulus characteristics in Experiment 2

Condition	*Frequency*	*N*	*No. letters*
+M+S+O (adapter-ADAPTABLE)	7.33	1.27	6.83
–M+S+O (screech-SCREAM)	7.07	1.70	6.00
–M+S–O (cello-VIOLIN)	18.06	3.34	6.06
–M–S+O (typhoid-TYPHOON)	18.38	2.22	6.38
ID (church-CHURCH)	16.59	2.21	6.16

Note: M, morphological; S, semantic; O, orthographic.

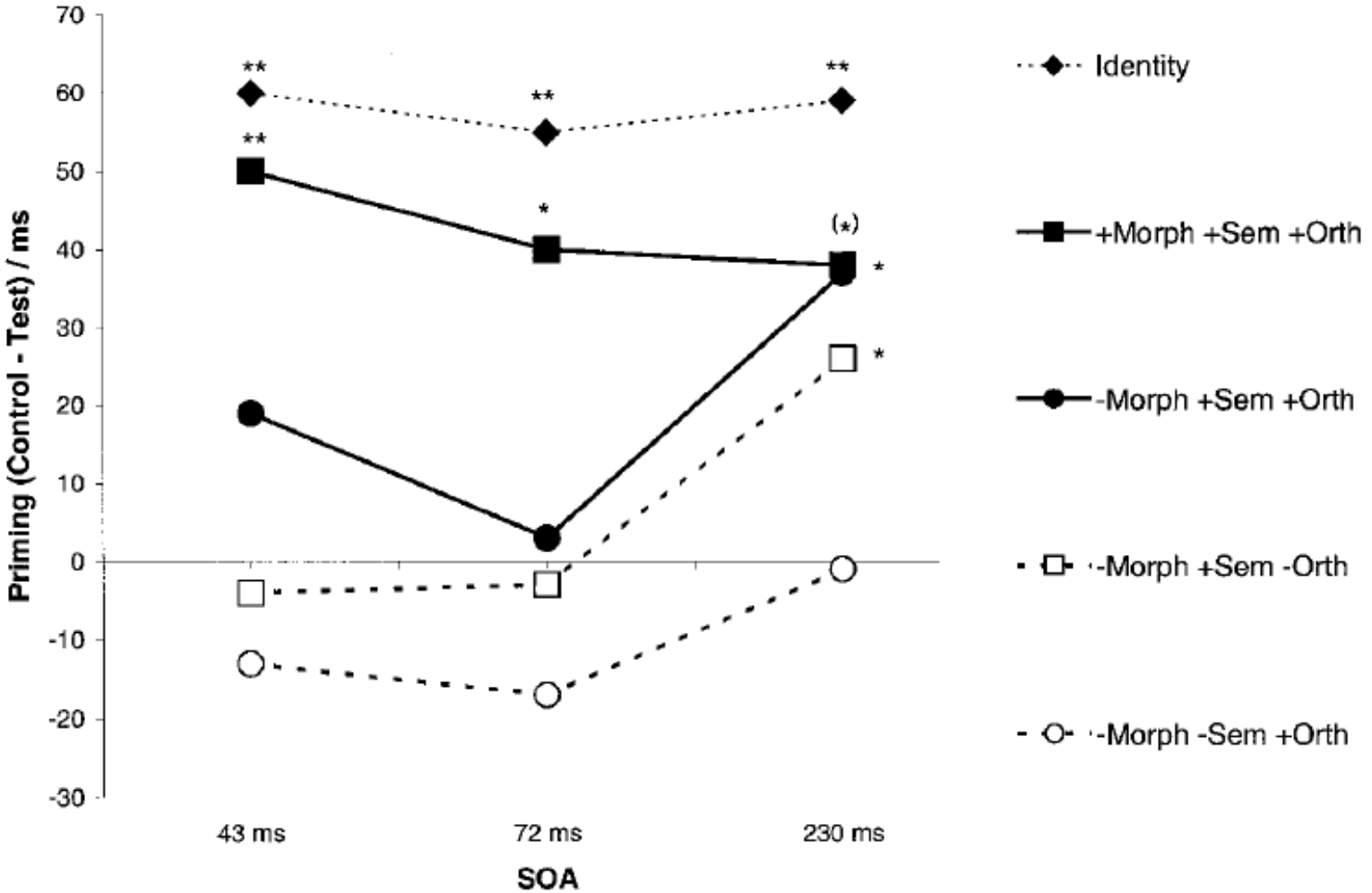
Rastle et al. (2000)

expt 2 – results

TABLE 4
Latency and error data for Experiment 1, by subjects

Condition		*SOA* 43 ms	72 ms	230 ms
+M+S+O	Primed	651 (6.78%)	666 (7.14%)	690 (5.26%)
	Unprimed	695 (6.52%)	697 (11.50%)	728 (11.00%)
–M+S+O	Primed	635 (8.09%)	645 (10.82%)	684 (8.22%)
	Unprimed	650 (7.27%)	649 (13.73%)	718 (10.00%)
–M+S–O	Primed	616 (6.61%)	625 (8.00%)	635 (5.39%)
	Unprimed	617 (5.09%)	625 (9.32%)	663 (5.17%)
–M–S+O	Primed	626 (5.57%)	643 (8.09%)	683 (5.65%)
	Unprimed	618 (6.00%)	629 (6.55%)	682 (5.52%)
ID	Primed	568 (1.57%)	550 (1.96%)	582 (2.17%)
	Unprimed	621 (4.13%)	603 (3.59%)	637 (3.26%)

Rastle et al. (2000): expt2 results



most important finding

signif. priming difference btwn **-M+S+O** and **+M+S+O**

Rastle et al. (2000)

conclusion (interpretation of results)

"...effects of English derivational morphology cannot be reduced to semantic effects, orthographic effects, or a simple summation of semantic and orthographic effects. This finding therefore constitutes strong evidence in support of an account in which a morphologically structured level of representation plays an important role in the word recognition process." *Rastle et al. (2000):529*

next week

we have seen how lexical items are learned and accessed, and how complex words are morphologically built in comprehension

next we jump up to a "higher" level of structure:

syntactic processing

we will ask:

what kinds of mental resources and strategies do we use in sentence processing?

what is the underlying combinatorial system like?