Modeling Word Recognition

Ben Weissman

COGS 4780

Cohort model

- We process speech (or written language) incrementally in linear order
  - (like the gating task – with each increase in information intake, our candidate set shrinks until you’re left with one winner)

TRACE model

- TRACE model of spoken word recognition

- How independent/interrelated are language processes?
  - Modular vs. **Interactive**

- This means that higher-order processes (like lexical context) can affect lower-order processes (like speech perception)

TRACE model

- At the lowest (input) level is detailed perceptual/acoustic processing, tracking phonetic features (like voicing)
- In the middle are phoneme units
- At the highest (output) level are representations of words

- Units at each level are activated, and this activation can spread within and across levels
    - **Bidirectional** flow of activation
- Eventually a “winner” will be selected at the output level

TRACE model

- One of the biggest issues with the cohort model is its reliance on the left edge of words
  - You start at the beginning and narrow down the list of candidates as you intake more information
- TRACE model decreases reliance on left edges, helpful in cases in which the cohort model will fail
  - [əkado]
- Allows room for top-down influence
  - If input is ambiguous between [blʌg] and [plʌg] we'll be able to select the latter

Discuss

- Subjects listen to sound files that consist of sequences of syllables, with each syllable separated by a one-second interval. The syllable sequences consist of an equal mixture of real words and non-words.

jut, tin, geel, sim, bit, lan, leg, gum, daj, keej, bip, well, run, meg, sin, hig

- Subjects are instructed to press a button on the left as soon as they hear a syllable that starts with the sound /s/ and a button on the right as soon as they hear a syllable that starts with the sound /b/. Reaction times relative to the onset of the target syllable are collected and analyzed; reaction times are averaged separately for words and non-words.

Discuss

jut, tin, geel, sim, bit, lan, leg, gum, daj, keej, bip, well, run, meg, sin, hig

- Consider the predictions made by a unidirectional (bottom-up connections only) and a bi-directional (bottom-up and top-down connections) model of speech perception. What does each model predict about the relative speed of responses to words and non-words in this experimental scenario?

Rubin et al. (1976)

Initial phonemes are detected faster in spoken words than in spoken nonwords

Table 3
Experiment II: Mean of Subjects' Mean Reaction Times in Milliseconds for /b/ in Initial Position

	Ear of Presentation		
	Left	Right	Binaural
Word	589	609	580
Nonword	645	655	631

What affects word recognition?

- **Word frequency** affects word recognition
  - More frequent words are recognized quicker and more easily than less frequent words
  - On an individual basis, but usually largely the same as the population
- As does **Age of Acquisition (AoA)**
  - Words that are learned earlier in life are recognized quicker and more easily than words that are learned later in life
- Sometimes frequent words are the ones learned early, but not always
  - What happens when frequent words are learned late, or when infrequent words are learned early?

Gerhand & Barry (1999)

Table 1
Characteristics of the Stimuli Used

Stimuli	KF Freq.		HJ Freq.		AoA		Con.	Imag.	Length
	M	Range	*M*	Range	*M*	Range			
Early, high-frequency (e.g., *cousin*)	206.3	51–847	197.9	19–953	2.67	2.19–2.92	5.05	5.25	5.6
Early, low-frequency (e.g., *rattle*)	4.2	0–9	4.6	0–17	2.71	2.19–2.97	4.92	5.35	5.6
Late, high-frequency (e.g., *union*)	146.2	57–382	121.1	40–206	4.82	4.50–5.39	4.52	4.95	5.9
Late, low-frequency (e.g., *marvel*)	3.3	0–9	2.6	0–13	4.91	4.42–5.52	5.03	5.14	5.6

Note—For each condition, we give the mean value (and, for some, the range of values) for the following variables: Kučera and Francis (1967) word frequency (KF Freq.), Hofland and Johansson (1982) word frequency (HJ Freq.), Gilhooly and Logie (1980) age of acquisition (AoA), concreteness (Con.) and imageability ratings (Imag.), and word length in number of letters.

Gerhand & Barry (1999)

Table 2
Results of Experiments 1–5: Mean (Correct) Lexical Decision Latencies (in Milliseconds) and Percentage Error Rates in Each Condition, Along With the Magnitudes of the Age of Acquisition Effects (Late Minus Early) and of the Interactions

	High-Frequency Words					Low-Frequency Words					
	Early		Late			Early		Late			
Experiment	*M*	%E	*M*	%E	AoA Effect	*M*	%E	*M*	%E	AoA Effect	Interaction
1	593	0.5	603	0.5	10	621	0.2	730	3.4	109	99

Gerhand & Barry (1999)

- “clear and sizeable effects of both AoA and frequency were found. Also, these variables interacted in such a way that the AoA effect was reliable for only low frequency words.”

Gerhand & Barry (1999)

- "This interaction was interpreted in terms of frequency affecting lexical access and AoA affecting a post access decision, or checking, stage… in which phonological representations are consulted in order to make confident lexical decisions, particularly for low frequency words. We propose that AoA affects the ease with which phonological information becomes available in this process in such a way that the phonology of late acquired words is slower to be activated, and thus lexical decisions will be made more slowly to late-acquired than to early-acquired, low-frequency words."

What affects word recognition?

- AoA's role in word recognition suggests importance of neural plasticity
  - (not a full *critical period*, but learning things early can provide a small boost)

What affects word recognition?

- Orthographic neighborhood can affect visual word recognition
  - (as can phonological neighborhood in spoken word recognition)
  - Having a dense neighborhood (lots of neighbors) seems to facilitate processing (for low-frequency words, at least)
    - mine: pine, mile, mane, line, mint, etc.
  - Even the frequency of the neighbors in the neighborhood might facilitate processing
    - High frequency neighbors will give more of a boost than low frequency neighbors
  - Why would this make sense?

What affects word recognition?

- Orthographic neighborhood can affect visual word recognition
  - (as can phonological neighborhood in spoken word recognition)
  - Having a dense neighborhood (lots of neighbors) seems to facilitate processing (for low-frequency words, at least)
    - mine: pine, mile, mane, line, mint, etc.
  - But sometimes having a dense neighborhood (lots of neighbors) seems to inhibit processing
    - Why would this make sense?

What affects word recognition?

- Orthographic neighborhood can affect visual word recognition
  - (as can phonological neighborhood in spoken word recognition)
  - Having a dense neighborhood (lots of neighbors) seems to facilitate processing (for low-frequency words, at least)
    - mine: pine, mile, mane, line, mint, etc.
  - Perhaps the inhibition/facilitation effect is hemisphere-dependent?
  - Also different effects in individuals with dyslexia

What affects word recognition?

- The extent to which something *looks like* a real word, even if it isn't
  - Plausible pseudowords will get rejected more slowly than implausible ones

siant

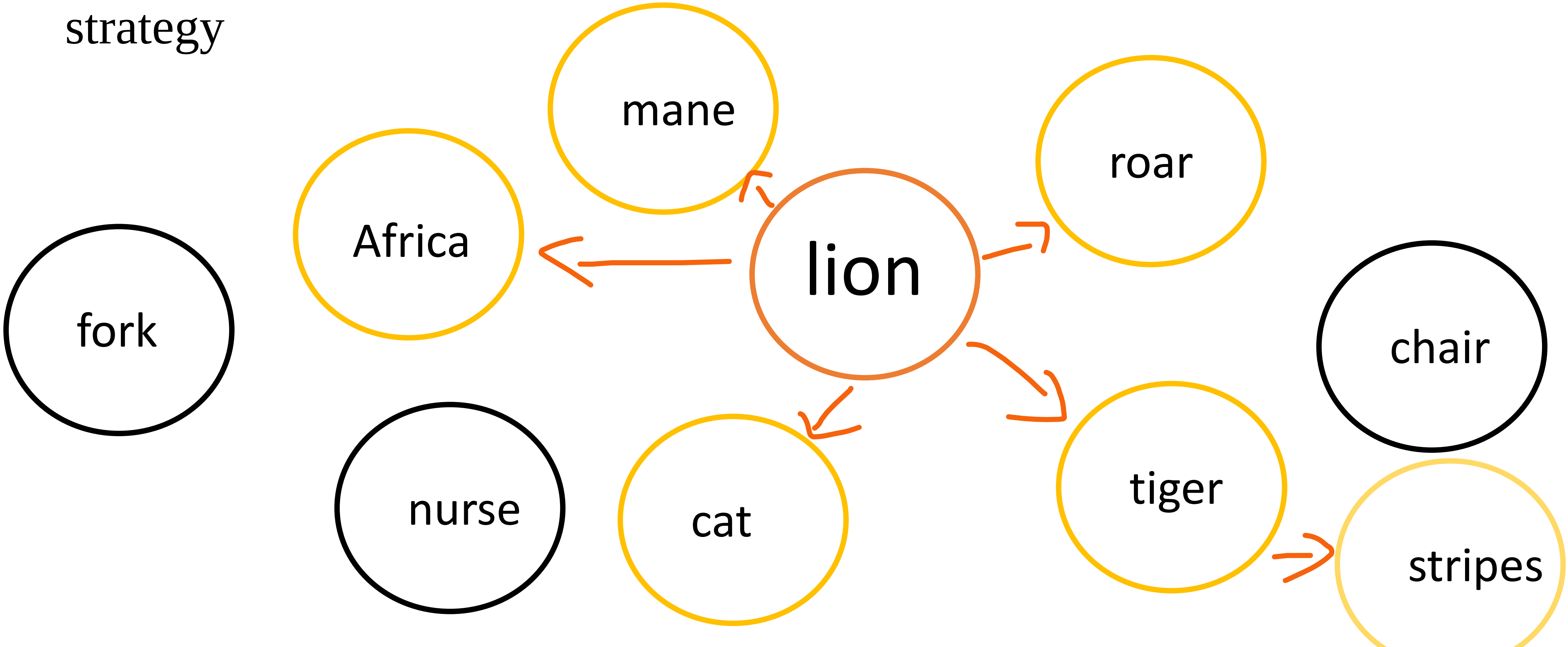
ynszv

What affects word recognition?

- Various other factors:
  - Grammatical category of the word
  - Imageability and concreteness of the word
  - Emotionality

Word recognition models

- Thinking about the lexicon as a network seems to be a productive strategy

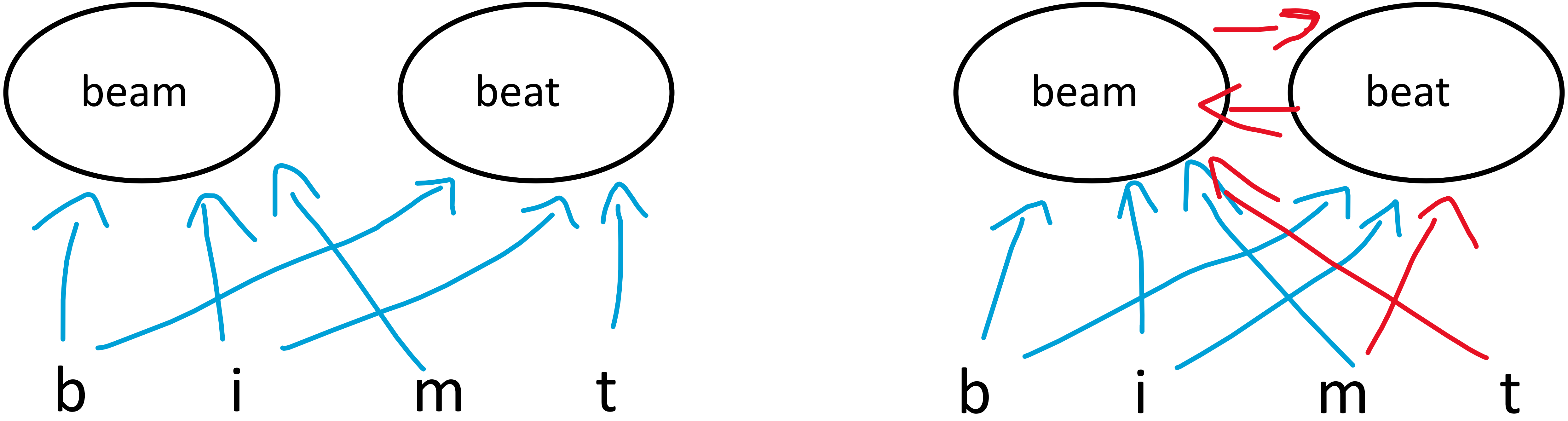


Word recognition models

- Thinking about the lexicon as a network seems to be a productive strategy
- Connections would exist between any two words between which there is a connection
  - Semantic connections (lion → mane)
  - Orthographic connections (heat → heap)
  - Phonological connections (deer → here)
  - Frequency-based connections (birthday → cake)
- A network like this can explain the priming effects described earlier
  - And even **mediated priming**, in which the connection is more than one step away
  - There needs to be some decay function to slow the spread and not overactivate

Word recognition models

- The links in this network can be facilitatory or inhibitory in nature

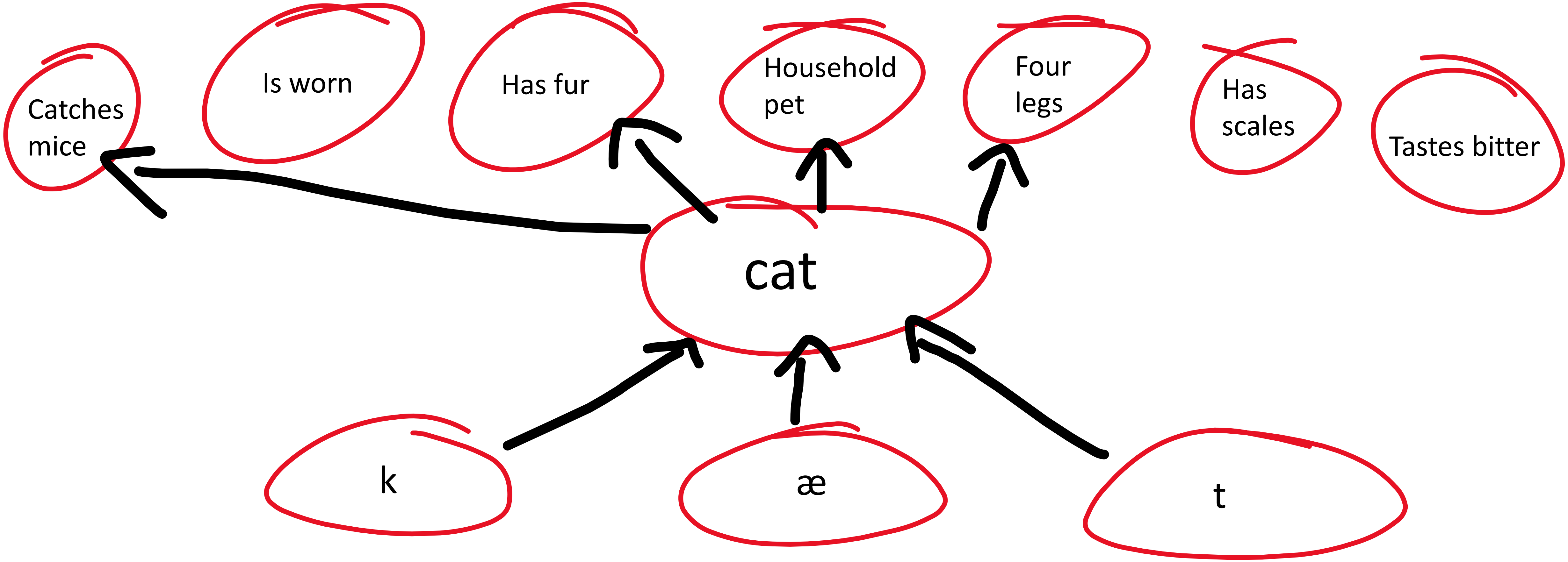


Word recognition models

- The links in this network can be facilitatory or inhibitory in nature
- Inhibitory connections allow a mechanism by which to explain findings
  - Such as: encountering “beam” will make it harder to subsequently access “beat”
  - Without inhibitory connections, no way to explain this phenomenon

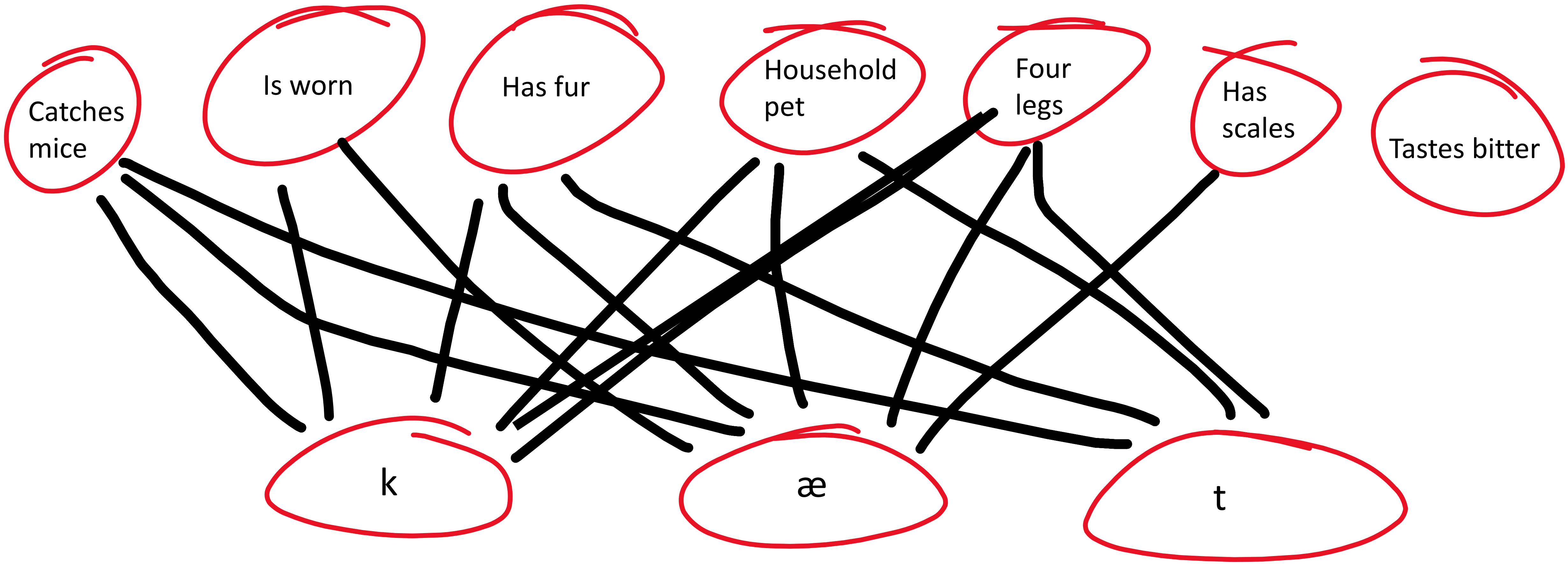
Word recognition models

- A network like that positions every word in its own node, a container for all of the information relevant to that word



Word recognition models

- Another approach is a *distributed* representation



Word recognition models

- In a localist representation, every word has its own container
- In a distributed representation, bundles of sound units directly connect to bundles of semantic features without central organizing nodes
  - Evidence from patients with brain damage lends some support to this setup
    - In some cases, it appears like there's partial damage to word representations as opposed to complete damage to a subset of word representations
- Connections may be one-way or may be bi-directional