Class 2 (Jan. 5): Models of lexical access in speech production

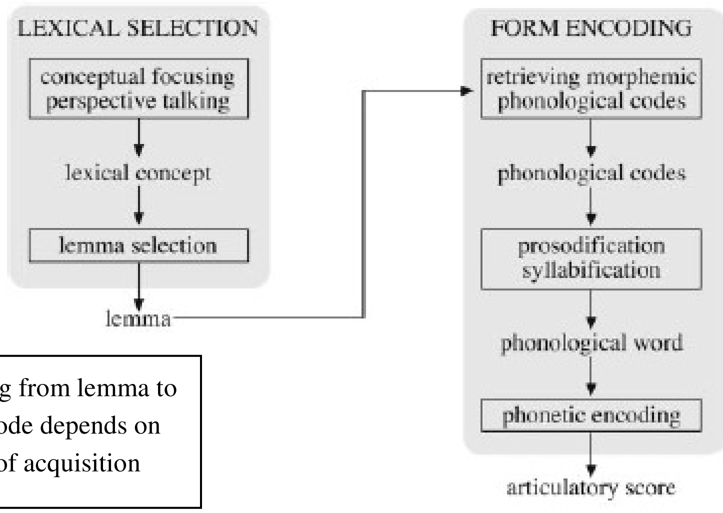
1 Administrative matters

- 251A is 4 units and letter grade; 251B is 2 units and S/U grade.

2 Levelt's model

(1) The model

- "inspired by speech error evidence", but "empirically largely based on reaction time data" (Levelt 2001, p. 13464)



Speed of getting from lemma to phonological code depends on frequency/age of acquisition

Fig. 1. Serial two-system architecture of the theory: two stages of lexical selection followed by three stages of form encoding.

(Levelt 2001, p. 13465)

- concept (HORSE) ≠ lemma (*horse*) ≠ lexeme (<horse>)
- form encoding doesn't begin till single lemma chosen
  - no activation of <animal>
  - two lemmas could get chosen if very close synonyms
- *horse* and *hoarse* share lexeme[1]
- lemma *horse* "when marked for plural" points to <horse> and <ɪz>
- phonological codes are unprosodified segment strings, w/ prosodic template[2]
- after prosodification, choose from set of stored, syllable-sized articulatory programs
- As Levelt points out, comparing reaction times at end of process doesn't tell us which stage contains difference.

called "lexemes" elsewhere by Levelt

Example (Levelt 2001, p. 13465):

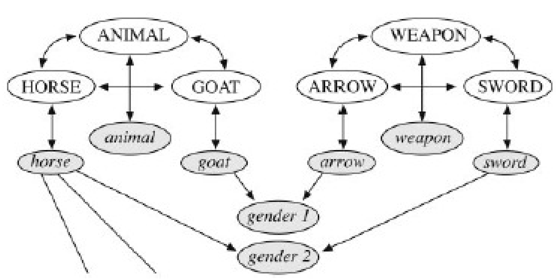


Fig. 2. Fragment of the WEAVER++ lexical selection network. (*Upper* stratum) Lexical concept nodes. (*Lower* stratum) Lemma and gender nodes.

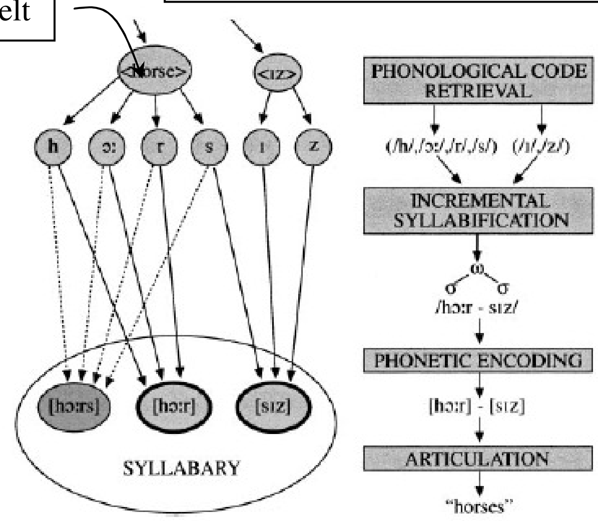


Fig. 3. Fragment of the WEAVER++ form encoding network (*Left*) with corresponding form-processing stages (*Right*). (*Upper* stratum) Nodes representing morphemic phonological codes and their phonemic "spellouts." (*Lower* stratum) Nodes representing syllabic articulatory scores. 12

[1] Jescheniak & Willem J.M. Levelt 1994
[2] Willem J. M. Levelt 1999

(2) Model's interpretation of tip-of-the-tongue states (TOT)

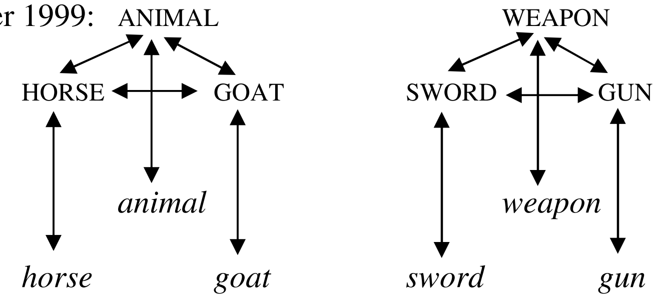
- Lemma is accessed, but then its phonological code is accessed partly or not at all.
  - Should we expect, in this model, to sometimes get activation of just one morpheme—e.g., <ment> but not <assort>?
  - Can we tell the difference between the TOT state that would result and what we'd get from partial access of a whole-word code <assortment>?

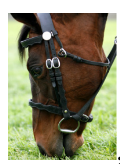
(3) Model's interpretation of semantic interference

Discussion and data from Schriefers, Meyer, & Levelt 1990, with retrospective interpretation from or following Levelt 2001

- Lemmas compete for selection:
  - At each timestep, prob. of selecting a word is its share of total activation
  - *p*(select(HORSE)) = activation(HORSE) / (activation(HORSE) + activ(GOAT) + activ(SWORD) + ...)
  - as that probability gets bigger, it becomes more and more likely that on that timestep the lemma will get chosen (at which point lemma selection stops)

mod. from Levelt, Roelofs, & Meyer 1999:



- Say you're asked to name the picture , but at the same time shown or played the word *sword*.
- HORSE and *sword* get activated
  - from HORSE, activation flows directly to GOAT and *horse*, 1-step removed to *goat*
  - from *sword*, activation flows directly to SWORD, 1-step removed to GUN, 2-steps removed to *gun*
  - activation spreads *according* to:

$$a(k,t+\Delta t) = a(k,t)(1-d) + \sum_n r\, a(n,t),$$

(Levelt & al. p. 36)

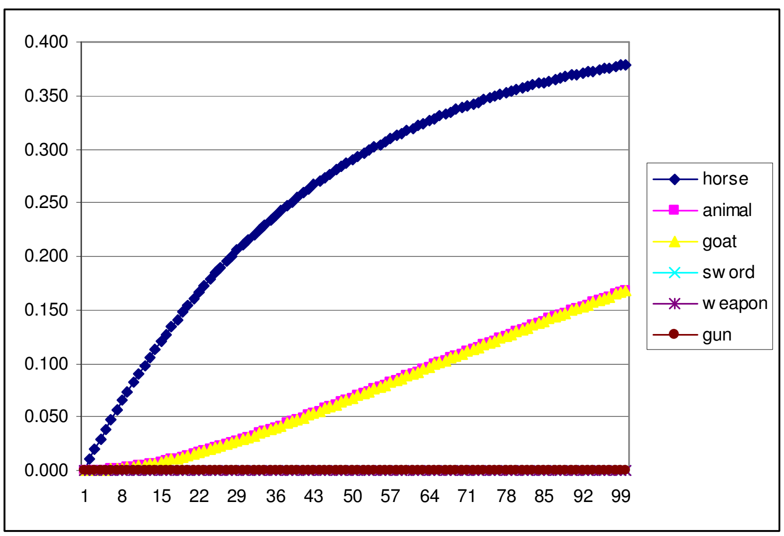
  - with *d* (decay rate) about 0.01, and *r* (spreading rate) =0.024
  - assume that HORSE's activation doesn't decay, because you're still looking at the picture (maybe it should even increase, receiving activation from connected nodes?)

(4) How the numbers might work

- No distracter: *horse* pulls into the lead immediately

(these numbers won't be quite what Roelofs 1997's WEAVER++ model says; I've omitted activation of segments and syllables, and fudged the HORSE issue, and just guessed at starting weights for observed items)

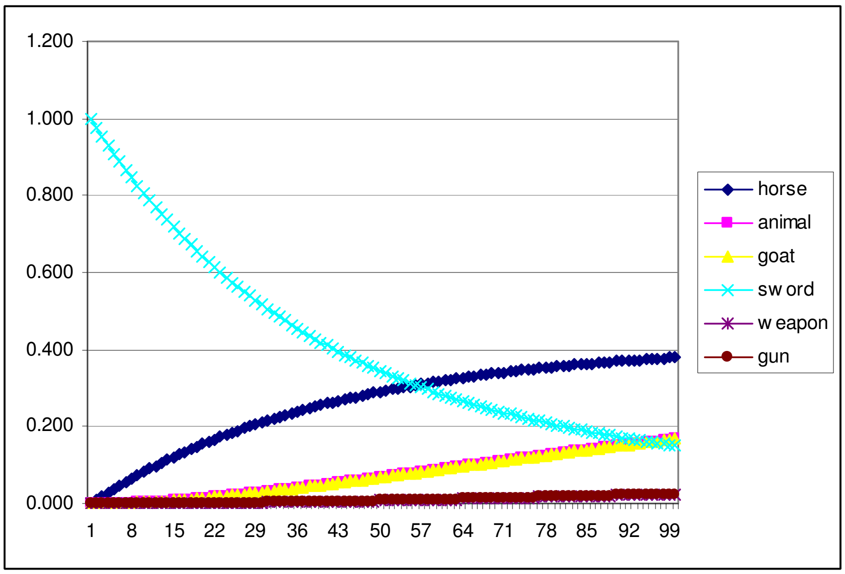
step	***horse***	*animal*	*goat*	*sword*	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)
1	**0.000**	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	
2	**0.010**	0.000	0.000	0.000	0.000	0.000	1.000	0.010	0.010	0.000	0.000	0.000	0.000
3	**0.020**	0.000	0.000	0.000	0.000	0.000	1.000	0.020	0.020	0.000	0.000	0.000	0.005
4	**0.029**	0.000	0.000	0.000	0.000	0.000	1.000	0.030	0.030	0.000	0.000	0.000	0.010
5	**0.039**	0.001	0.001	0.000	0.000	0.000	1.000	0.039	0.039	0.000	0.000	0.000	0.015
6	**0.048**	0.001	0.001	0.000	0.000	0.000	1.000	0.049	0.049	0.000	0.000	0.000	0.019
7	**0.057**	0.001	0.001	0.000	0.000	0.000	1.000	0.058	0.058	0.000	0.000	0.000	0.024
8	**0.065**	0.002	0.002	0.000	0.000	0.000	1.000	0.067	0.067	0.000	0.000	0.000	0.029
9	**0.074**	0.003	0.003	0.000	0.000	0.000	1.000	0.076	0.076	0.000	0.000	0.000	0.033
... 27	**0.195**	0.024	0.024	0.000	0.000	0.000	1.000	0.221	0.221	0.000	0.000	0.000	0.099
28 ...	**0.200**	0.026	0.026	0.000	0.000	0.000	1.000	0.228	0.228	0.000	0.000	0.000	0.102
step	***horse***	*animal*	*goat*	*sword*	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)



- Distracter *sword*: *sword* starts out strong, but *horse* overtakes it

step	***horse***	*animal*	*goat*	***sword***	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)
1	**0.000**	0.000	0.000	**1.000**	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	
2	**0.010**	0.000	0.000	**0.976**	0.000	0.000	1.000	0.010	0.010	0.010	0.000	0.000	0.000
3	**0.020**	0.000	0.000	**0.953**	0.000	0.000	1.000	0.020	0.020	0.020	0.000	0.000	0.000
4	**0.029**	0.000	0.000	**0.930**	0.000	0.000	1.000	0.030	0.030	0.029	0.000	0.000	0.000
5	**0.039**	0.001	0.001	**0.908**	0.000	0.000	1.000	0.039	0.039	0.037	0.001	0.001	0.001
6	**0.048**	0.001	0.001	**0.887**	0.000	0.000	1.000	0.049	0.049	0.045	0.001	0.001	0.001
7	**0.057**	0.001	0.001	**0.866**	0.000	0.000	1.000	0.058	0.058	0.053	0.001	0.001	0.002

8	**0.065**	0.002	0.002	**0.845**	0.000	0.000	1.000	0.067	0.067	0.061	0.002	0.002	0.002
9	**0.074**	0.003	0.003	**0.826**	0.000	0.000	1.000	0.076	0.076	0.068	0.002	0.002	0.003
…													
55	**0.304**	0.078	0.078	**0.313**	0.009	0.009	1.000	0.394	0.394	0.174	0.053	0.053	0.098
56	**0.307**	0.080	0.080	**0.307**	0.009	0.009	1.000	0.399	0.399	0.174	0.054	0.054	0.101
57	**0.310**	0.082	0.082	**0.302**	0.009	0.009	1.000	0.404	0.404	0.174	0.055	0.055	0.103
58	**0.312**	0.084	0.084	**0.296**	0.010	0.010	1.000	0.409	0.409	0.174	0.057	0.057	0.106
59	**0.315**	0.086	0.086	**0.291**	0.010	0.010	1.000	0.415	0.415	0.174	0.058	0.058	0.108
60	**0.317**	0.088	0.088	**0.285**	0.010	0.010	1.000	0.420	0.420	0.174	0.059	0.059	0.110
…													
step	***horse***	*animal*	*goat*	***sword***	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)



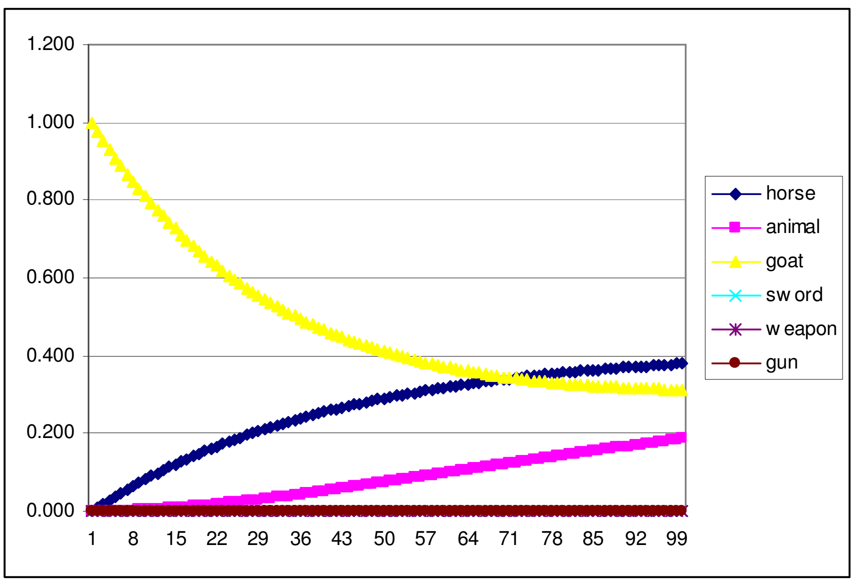
(5) Now the real semantic interference

- Say you're asked to name the same picture, but shown or played *goat*
  - naming should be even slower
  - *goat* gets activation both from the distracter and spread (at one step remove) from HORSE
  - → *goat* remains a strong competitor longer
  - This should work only if the distracter is presented during or just before lemma selection

(6) Numbers again

- Distracter *goat*: *horse* still pulls out front eventually, but it takes longer

step	***horse***	*animal*	***goat***	*sword*	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)
1	**0.000**	0.000	**1.000**	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	
2	**0.010**	0.000	**0.976**	0.000	0.000	0.000	1.000	0.010	0.020	0.000	0.000	0.000	0.000
3	**0.020**	0.000	**0.953**	0.000	0.000	0.000	1.000	0.020	0.039	0.000	0.000	0.000	0.000
4	**0.029**	0.000	**0.930**	0.000	0.000	0.000	1.000	0.030	0.058	0.000	0.000	0.000	0.000
5	**0.039**	0.001	**0.909**	0.000	0.000	0.000	1.000	0.040	0.076	0.000	0.000	0.000	0.001
6	**0.048**	0.001	**0.888**	0.000	0.000	0.000	1.000	0.050	0.094	0.000	0.000	0.000	0.001
7	**0.057**	0.001	**0.867**	0.000	0.000	0.000	1.000	0.059	0.111	0.000	0.000	0.000	0.002
8	**0.065**	0.002	**0.847**	0.000	0.000	0.000	1.000	0.069	0.128	0.000	0.000	0.000	0.002
9	**0.074**	0.003	**0.828**	0.000	0.000	0.000	1.000	0.079	0.144	0.000	0.000	0.000	0.003
10	**0.082**	0.003	**0.810**	0.000	0.000	0.000	1.000	0.088	0.159	0.000	0.000	0.000	0.004
...													
71	**0.341**	0.122	**0.344**	0.000	0.000	0.000	1.000	0.524	0.626	0.000	0.000	0.000	0.152
72	**0.342**	0.125	**0.342**	0.000	0.000	0.000	1.000	0.529	0.629	0.000	0.000	0.000	0.154
73	**0.344**	0.127	**0.340**	0.000	0.000	0.000	1.000	0.534	0.633	0.000	0.000	0.000	0.157
74	**0.346**	0.129	**0.338**	0.000	0.000	0.000	1.000	0.539	0.637	0.000	0.000	0.000	0.159
75	**0.348**	0.132	**0.336**	0.000	0.000	0.000	1.000	0.543	0.640	0.000	0.000	0.000	0.161
76	**0.349**	0.134	**0.335**	0.000	0.000	0.000	1.000	0.548	0.644	0.000	0.000	0.000	0.164
...													
step	***horse***	*animal*	***goat***	*sword*	*weapon*	*gun*	HORSE	ANIMAL	GOAT	SWORD	WEAPON	GUN	p(*horse*)



(7) Experimental results from Schriefers, Meyer, & Levelt 1990

- unrelated distracter interferes, esp. if presented at same time as picture ("SOA" = stimulus onset asynchrony; negative means distracter first, positive means picture first)
- semantically related distracter interferes more

how much slower hearing *goat* makes you

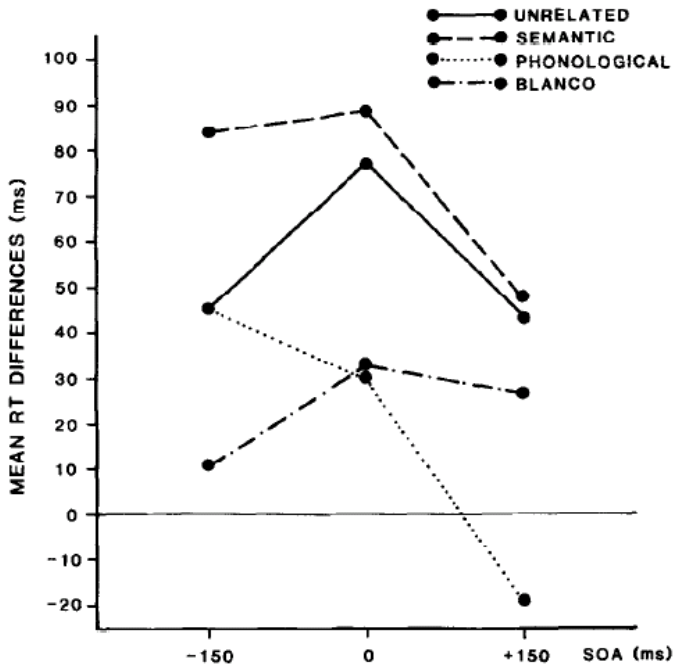


FIG. 2. Results of Experiment 2. Mean reaction time differences (ms) for UNRELATED, SEMANTIC, PHONOLOGICAL, and BLANCO from SILENCE at three SOAs.

Schriefers & al, p. 96

(8) Semantic facilitation

- What if task is not to say *horse* but to say *animal* (vs., e.g., *weapon*)?
  - Then hearing *goat* is helpful, since now both distracter and stimulus help activate *animal*.
  - This should work only if the distracter is presented during or just before lemma retrieval
  - I didn't run the numbers because there are additional assumptions about how the change in instructions affects the numbers that I couldn't figure out exactly how to implement.

(9) Model's interpretation of phonological facilitation

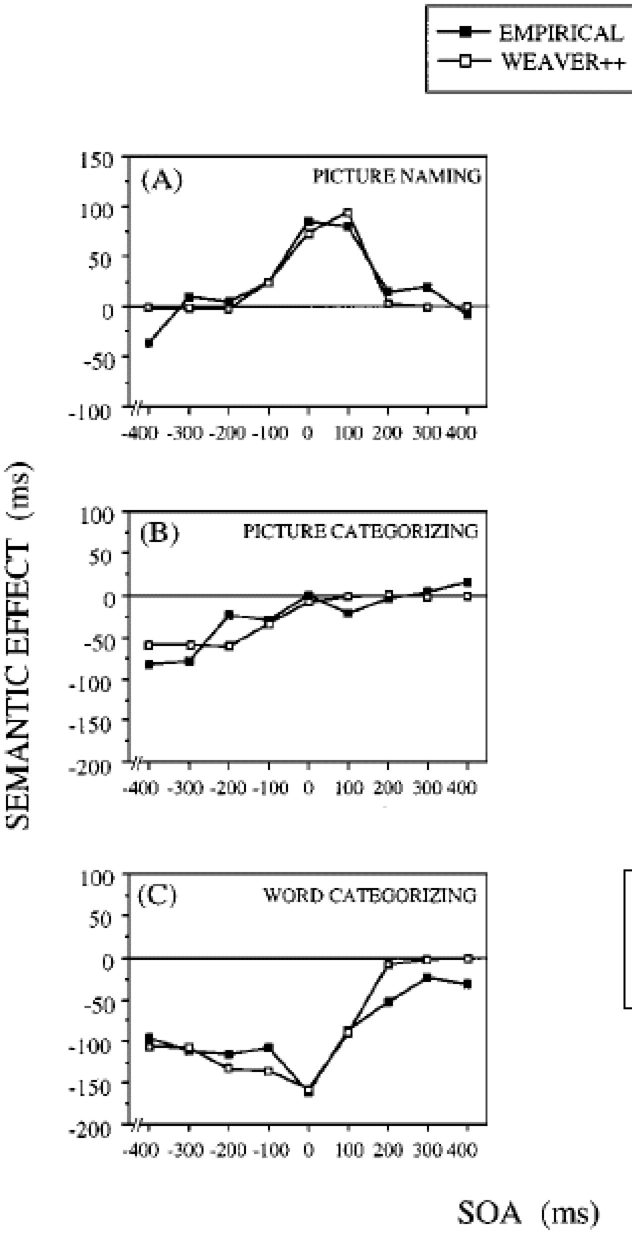
- Imagine same picture-naming task, but this time you hear distracter *hoard* or *course*,
  - speeds up naming (as compared to unrelated distracter *fan*)
  - interpretation: segments belonging to the phonological code get more activation, so it's easier to get from <horse> to *h*, *o*, etc.
  - should work only if distracter presented during or just before lexeme activates segments
- Results (see graph above)
  - with negative SOA, phonologically related distracter produces interference, just like unrelated distracter: too early for a phonological effect, affects lemma selection only, which is blind to phonological content
  - with positive SOA, facilitation: late enough that lemma has already been chosen, so no interference there
  - zero SOA: maybe some of each, cancelling each other out? lemma interference, but segments still have their increased activation by the time they're needed

- Similar effect for non-words: e.g., *mer* facilitates naming a hammer (Levelt, Roelofs, & Meyer 1999 cite then-unpublished results from Roelofs & Meyer)
  - As Levelt & al. 1999 discuss, *hoard* could facilitate at the lemma level—perceiving *hoard* causes activation of the *horse* lemma too; see next week; whether *mer* could do the same depends on your model of speech perception.
  - distracter doesn't have to be a whole syllable of the target
  - interpretation: there's no syllabification at the segment-activation stage, so as long as the segments are more activated, naming will be faster
  - should the order or contiguousness of the segments matter? What about *erm*?
  - might still predict that being a whole syllable increases facilitation (at least if it's the first syllable, assuming one-by-one retrieval of syllables), since there's a subsequent stage of retrieval from the syllabary

(10) How does morphology fit into it?

- After lemma is selected, prepare "morphological target frame", such as *stem+affix+affix*
- Retrieve morphophonological codes to fill slots one by one, left to right
- Frame determines domain of syllabification
  - e.g., in Dutch, syllabify across *stem+affix*, but not *stem+stem* or *prefix+stem*
  - So this part of the model must be language-specific. What do you think of that?
  - not sure where allomorph selection happens

(11) Actual WEAVER++ predictions for distracter effects



"empirical" = data from Glaser & Düngelhoff 1984

word categorizing: instead of seeing a picture, subject sees a word (HORSE) and has to name its category (animal)

(Levelt & al. 1999)[3]

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[3] Glaser & Dungelhoff 1984

3 Dell's model

Discussion here based on Dell & O'Seaghdha 1992

(12) Schematic

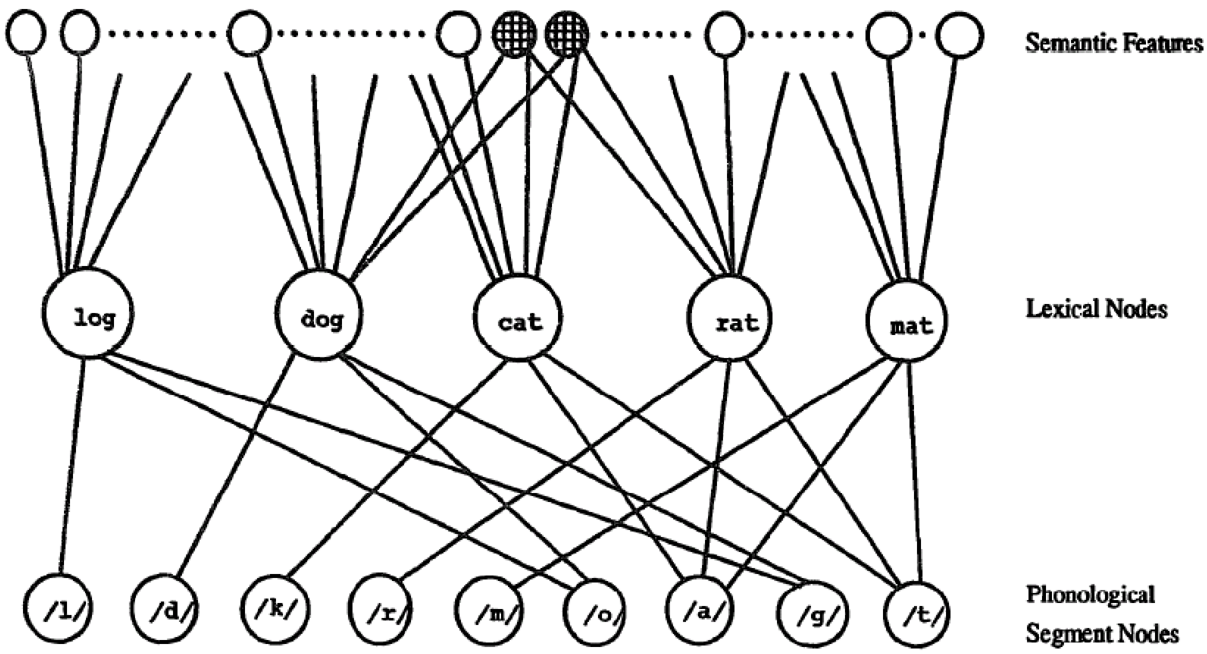


Figure 2. *Lexical network structure in the spreading activation production model. The figure illustrates the case where two features (highlighted) are shared by the three semantically related lexical nodes. The phonological labels are informal. (From Dell & O'Seaghdha, 1991; copyright 1991 by the American Psychological Association.)*

(Dell & O'Seaghdha 1992, p. 294)

- Activation begins flowing from semantic nodes, down and up the network.
- When the syntactic frame is ready for its word, the most highly activated lexical node is given a "triggering jolt of activation" (p. 295).
- This increases the activation of the associated phonological units.

(13) Comparison to Levelt's model

- There's still a distinction between semantic and phonological levels
- Lexical nodes will still start to get activated before phonological material is
- Lexical node is connected directly to semantic features
  - No concept/lemma distinction
- Lexical node is connected directly to phonological features
  - No lemma/lexeme distinction
- Connections are bidirectional
  - Levelt allowed activation to flow from lemma to concept, but not from lexeme to lemma, or from segment to lexeme
  - Here, activation can flow upward, even during production.

(14) Why bidirectionality?

Dell & Reich 1981 discuss speech-error phenomena that seem to require it.

Mixed errors

- Some speech errors are phonological: saying *mat* instead of *cat*
  - In Levelt's terms, lexeme activates wrong segments, or segments activate wrong syllable
- Some are semantic: saying *dog* instead of *cat*
  - In Levelt's terms, concept activates wrong lemma
- Some are mixed: saying *rat* instead of *cat*
- In a corpus, Dell & Reich found mixed errors to be more frequent than expected
  - Not predicted by basic Levelt model: choosing the wrong lemma should be insensitive to phonology; choosing the wrong segments should be insensitive to semantics
  - In Dell's terms, *rat* is getting activation from two sources, and so is more likely to cause an error than *mat* or *dog*

Real-word errors

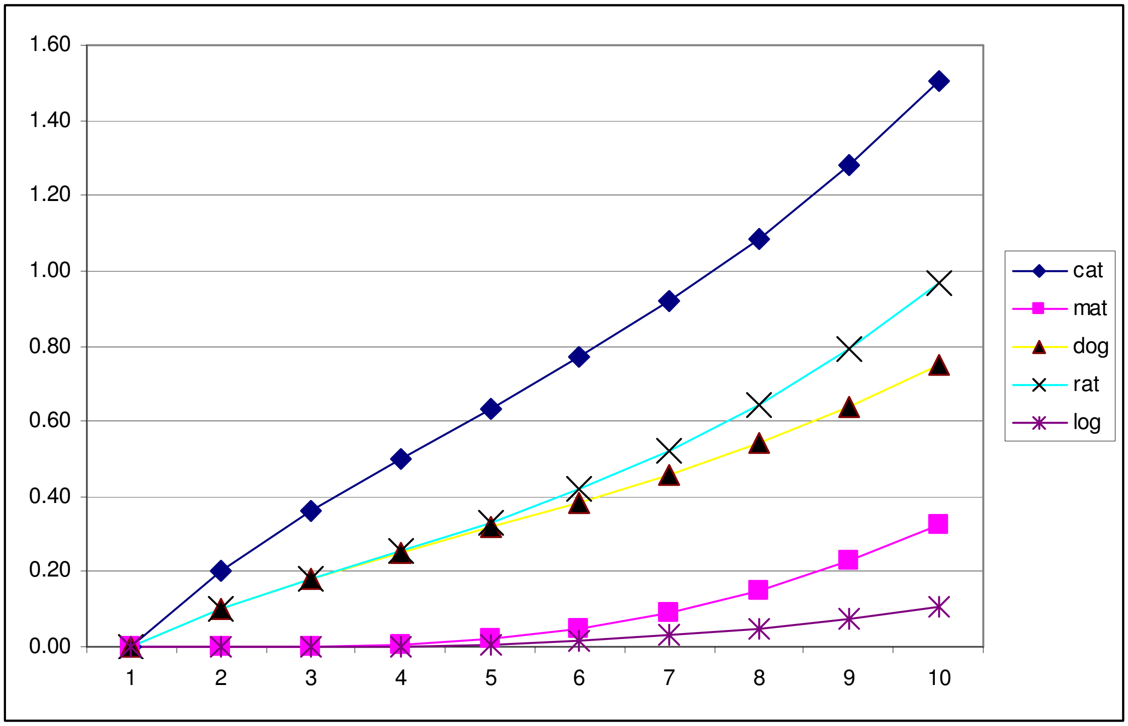
- A speech error can be a real word (*mat*) or not (*zat*)
- Dell & Reich 1981 found that real-word errors were more frequent than expected
  - Not predicted by basic Levelt model: only one lexeme is active at the time of phonological encoding.
  - Errors shouldn't be sensitive to whether they happen to make a real word, though they could be sensitive to whether they form a frequent syllable
  - In Dell's terms, *zat* can only result from activating the wrong segments, but *mat* can result from either *cat* activating the wrong segments or /a/ and /t/ activating the wrong word.

Levelt, Roelofs, & Meyer 1999 propose a checking mechanism whose failures might be able to explain these findings.

(15) Numbers

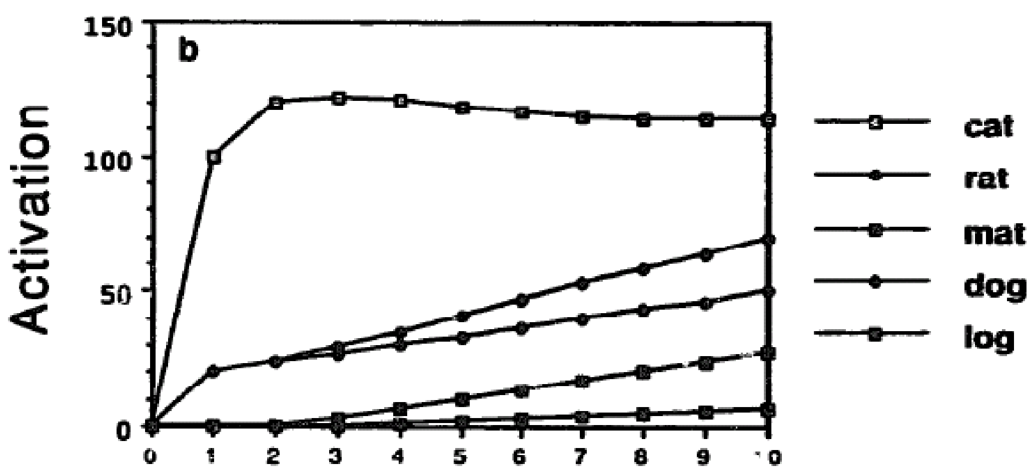
- Updating function is exactly as in WEAVER++
- Difference is in which nodes receive activation from where.
- With just two semantic features, ANIMAL and CAT, we get (decay rate=0.1, spreading rate=0.1)

step	cat	mat	dog	rat	log	k	a	t	m	d	o	g	r	l	animal	cat
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
2	0.20	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.90
3	0.36	0.00	0.18	0.18	0.00	0.02	0.03	0.03	0.00	0.01	0.01	0.01	0.01	0.00	0.85	0.83
4	0.50	0.01	0.25	0.25	0.00	0.05	0.08	0.08	0.00	0.03	0.03	0.03	0.03	0.00	0.84	0.78
5	0.63	0.02	0.32	0.33	0.01	0.10	0.15	0.15	0.00	0.05	0.05	0.05	0.05	0.00	0.85	0.75
6	0.77	0.05	0.39	0.42	0.02	0.15	0.23	0.23	0.00	0.08	0.08	0.08	0.08	0.00	0.90	0.74
7	0.92	0.09	0.46	0.52	0.03	0.21	0.33	0.33	0.01	0.11	0.11	0.11	0.11	0.00	0.96	0.75
8	1.09	0.15	0.54	0.64	0.05	0.28	0.45	0.45	0.02	0.14	0.15	0.15	0.15	0.01	1.06	0.76
9	1.28	0.23	0.64	0.79	0.07	0.36	0.60	0.60	0.03	0.18	0.19	0.19	0.20	0.01	1.18	0.80
10	1.50	0.33	0.75	0.97	0.11	0.46	0.77	0.77	0.05	0.23	0.24	0.24	0.26	0.02	1.33	0.84



→ *rat* is a stronger rival than *dog* or *mat*

(16) With a richer set of semantic features, Dell & O'Seaghdha 1992 **get**



(D&S p. 297)

4 See also

- Goldrick 2006: review of evidence on how much feedback there is, e.g. activation spreading from (in Levelt's terms) lexemes to lemmas—he concludes that it's limited

5 Topic order in flux—new plan for near future

- Today (as planned): models of access in production
- Next week (as planned): models of access in perception, quick overview of methods
- Week 3, paper presentations begin: papers exemplifying some basic positions (access by parts vs. by wholes; role of meaning—pseudo- vs. real morphology)

6 For next time

I'm really behind, but hope to get the reading list for Week 3 at least posted before Monday's class. We can divvy up papers then.

References

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