Spoken word recognition

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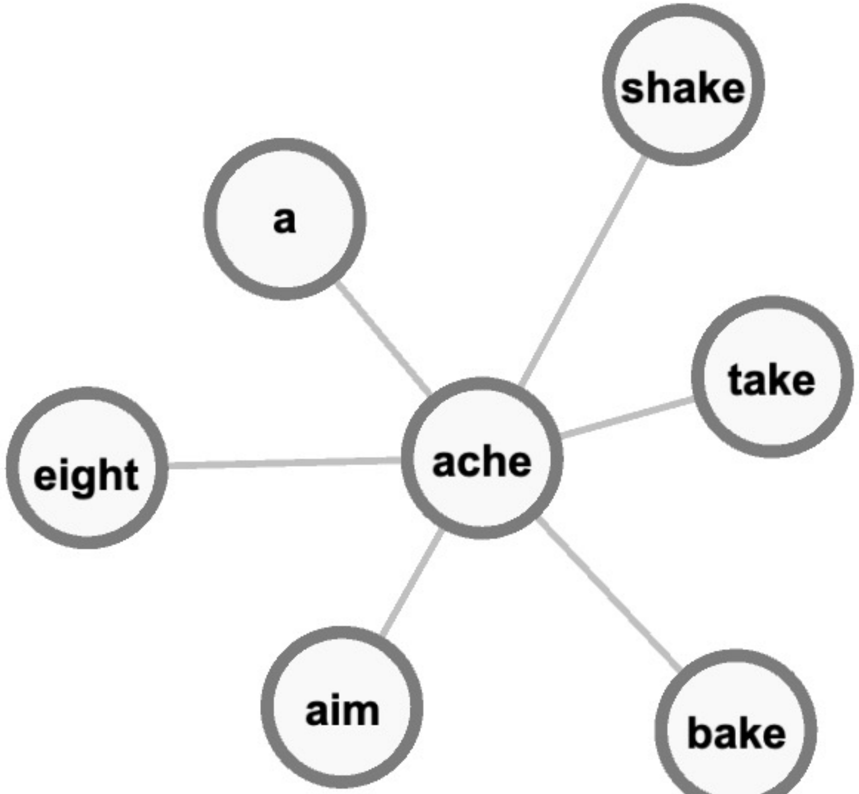
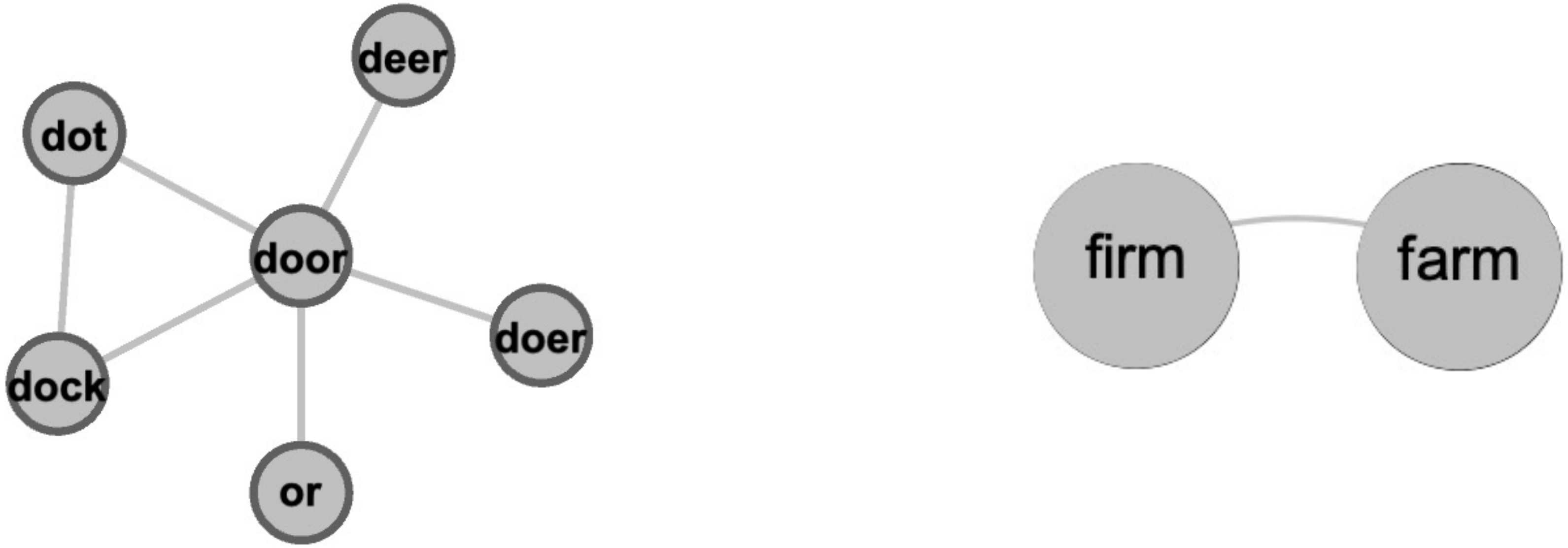
SS 2026

Phonologial neighborhood



k=6

Sparse and dense neighborhoods



Density is relative

In English, dense neighborhoods >50 members (e.g., cats)

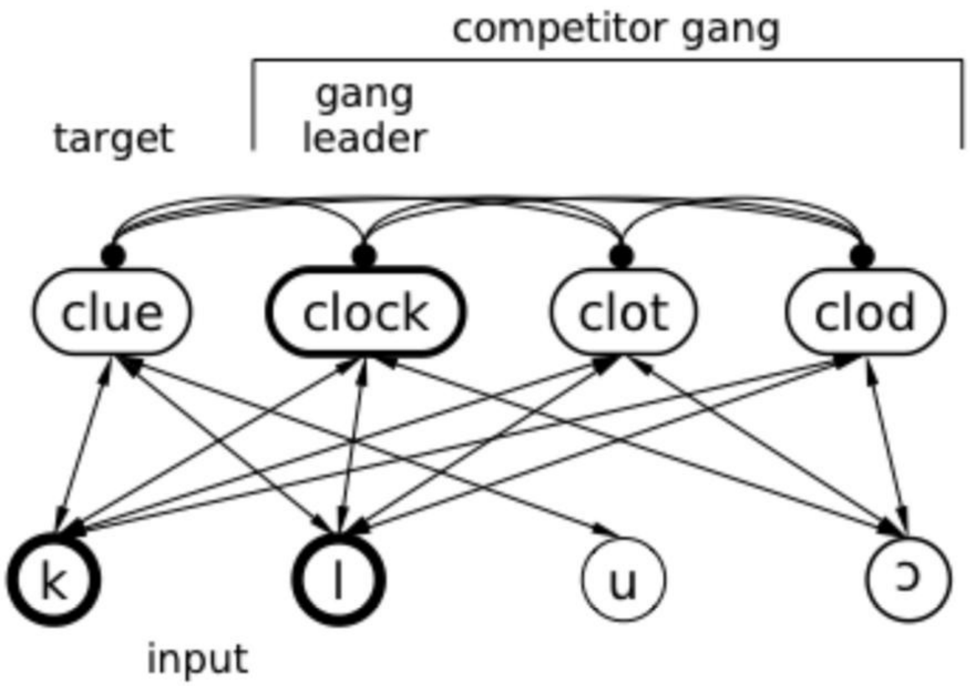
Lexical processing of neighbors

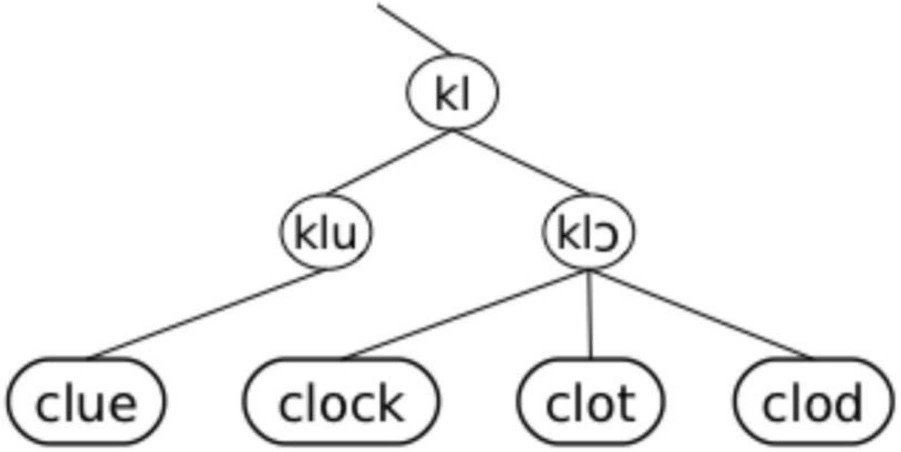
- Co-activation spreads through shared phonemes
  - the more phonemes are shared within a neighborhood the more activation spreads within the neighborhood
  - “phonological neighborhood effect” (Vitevitch & Luce, 2016)
- Consequences of of lexical coactivation is **competition for activation** between segments and phonological neighbors
  - competitor words

The word that ends up receiving the majority of the activation will be selected

→ In speech perception

Lexical competitors





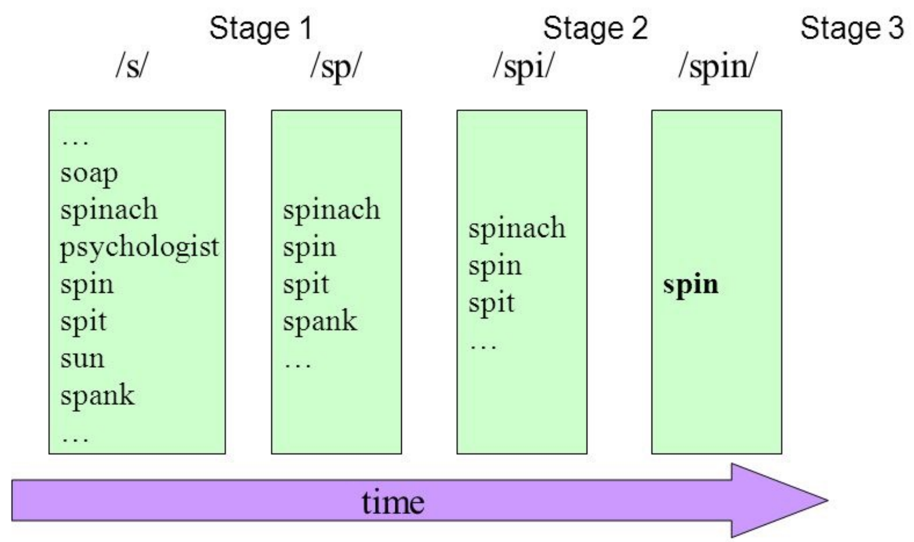
Psycholinguistic models of speech recognition

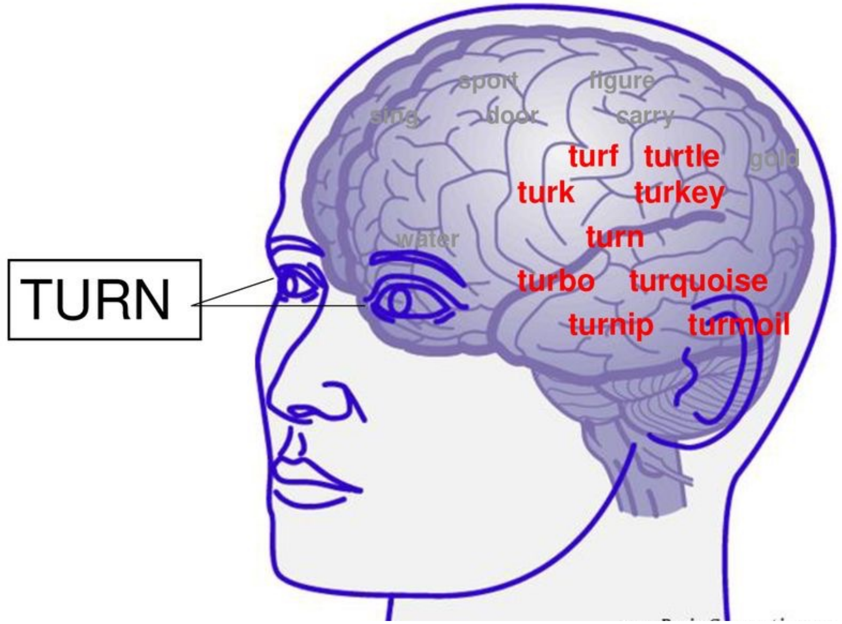
- Models of spoken word recognition rely on various notions of phonological neighbors
- One of the earlier models – Cohort Model of Lexical Access
  - focusses on word-initial segments (Marslen-Wilson, 1987; Marslen-Wilson & Warren, 1994)
- Model predicts co-activation based on temporal phonemic overlap starting at the initial phoneme and proceeding with each successive, similar phoneme in a serial manner when speech unfolds in time
- Phonological neighbors share onset segments
- Non-onset phonological neighbors are excluded as lexical candidate words in chronological phonemic perception

Cohort Model

- Marslen-Wilson, 1987
  - co-activation based on temporal phonemic overlap starting at the initial phoneme
    - are-arm-army   bra-brow-browse-browser

  - words will be recognized once they have
reached a unique identifying phoneme



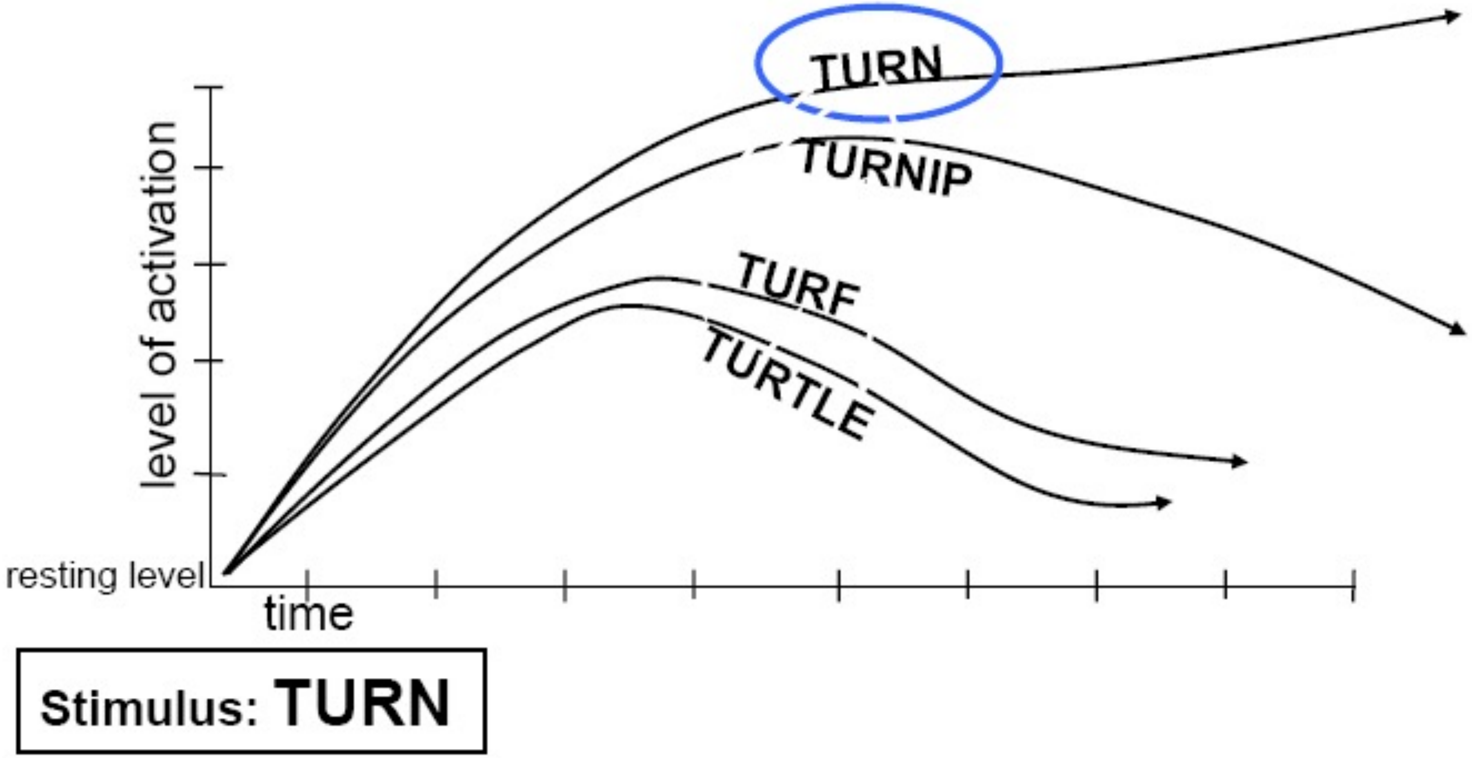


Cohort neighborhoods

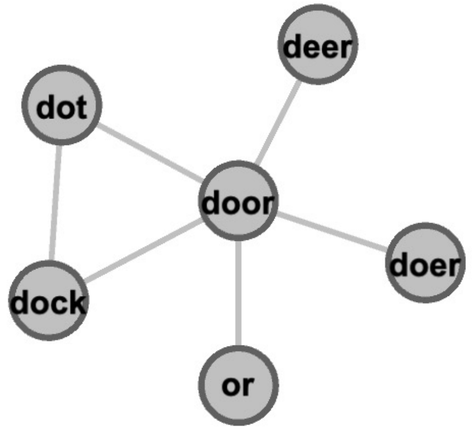
- cohorts are formed with the initial phoneme
  - each word-initial phoneme in a language would constitute the first layer of cohort
- word-initial biphones, triphones, and so forth, all constitute their own cohorts
  - /kɪ/ - /kɪl/- /kɪlt/

- Cohort II (Marslen-Wilson, 1990; Marslen-Wilson, Brown, & Tyler, 1988)
- account for lexical frequency of words
  - high-frequency words are recognized faster than low-frequency ones
- and to consider phonological confusability
  - for instance *nobility* being activated by *mobility*
    - Temporal order glitches

Activation Competition Selection



Neighborhood Activation Model



- NAM (Luce & Pisoni, 1998)
  - co-activation spreads in words that differ in by one phonological segment
  - neighborhoods are established through segmental links in a word
    - *sat-mat*
    - *coast – ghost*
  - acoustic-phonetic patterns receive activation levels proportional to their similarities to the stimulus input
- NAM states that increasing the number of acoustic-phonetic patterns activated in memory by the stimulus input will slow processing and reduce identification accuracy

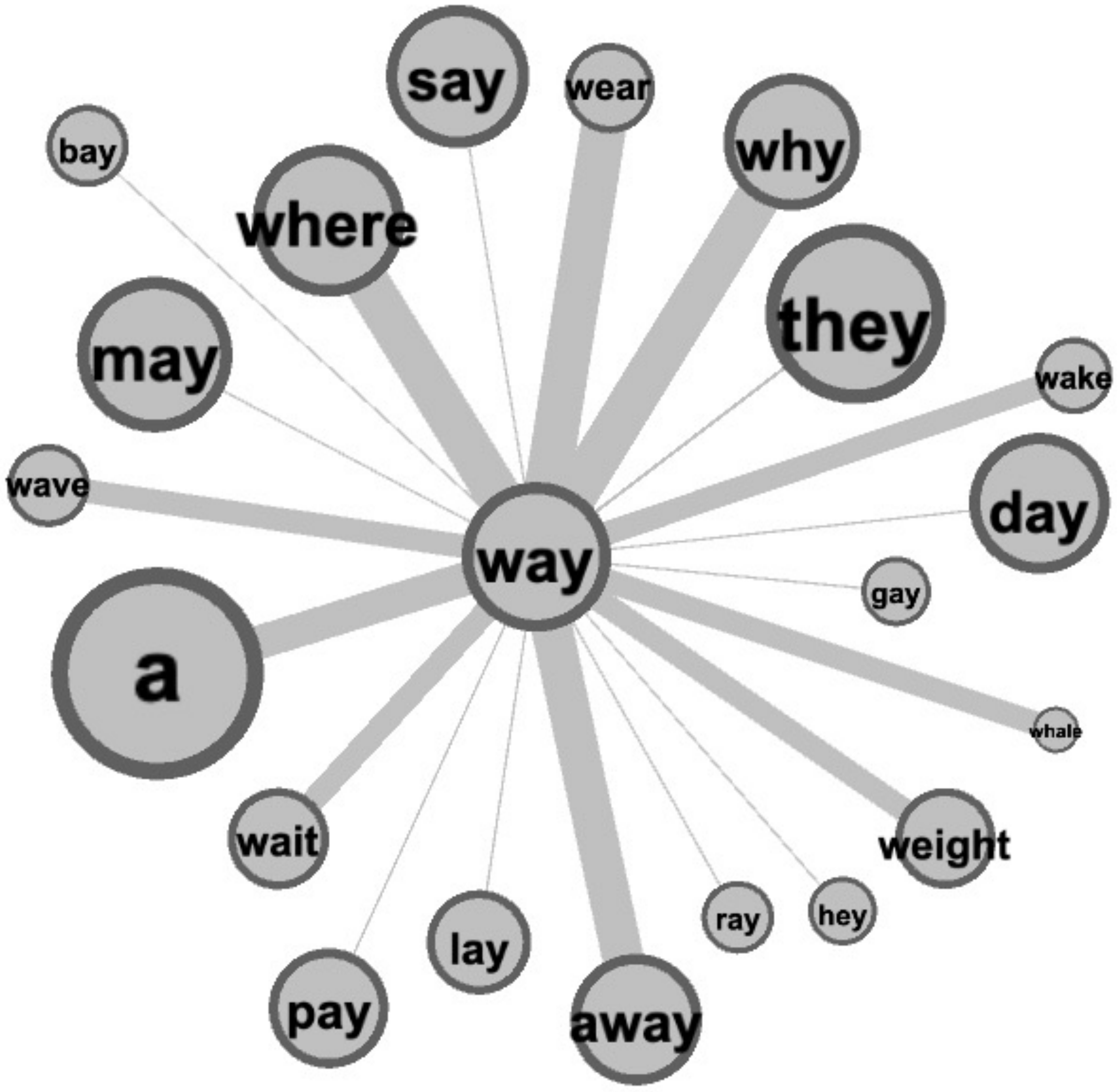
NAM

- in the original NAM model: neighborhoods established through any segmental position in a word
  - initial, medial, final
  - differences in neighborhood formation do not impact on the strength of a neighborhood

- phonetically close neighbors have an amplified effect on phonemic competition by inhibiting word recognition in NAM (Goldinger, Luce and Pisoni, 1989; Gahl et al., 2012; Scarborough, 2013)
  - competition effects mediated by word frequency and phonetic distance
    - *cap* and *cab* are more influential neighbors and share more activation (and competition), as opposed to *cab* and *fab*

Phonological neighborhood of "way"

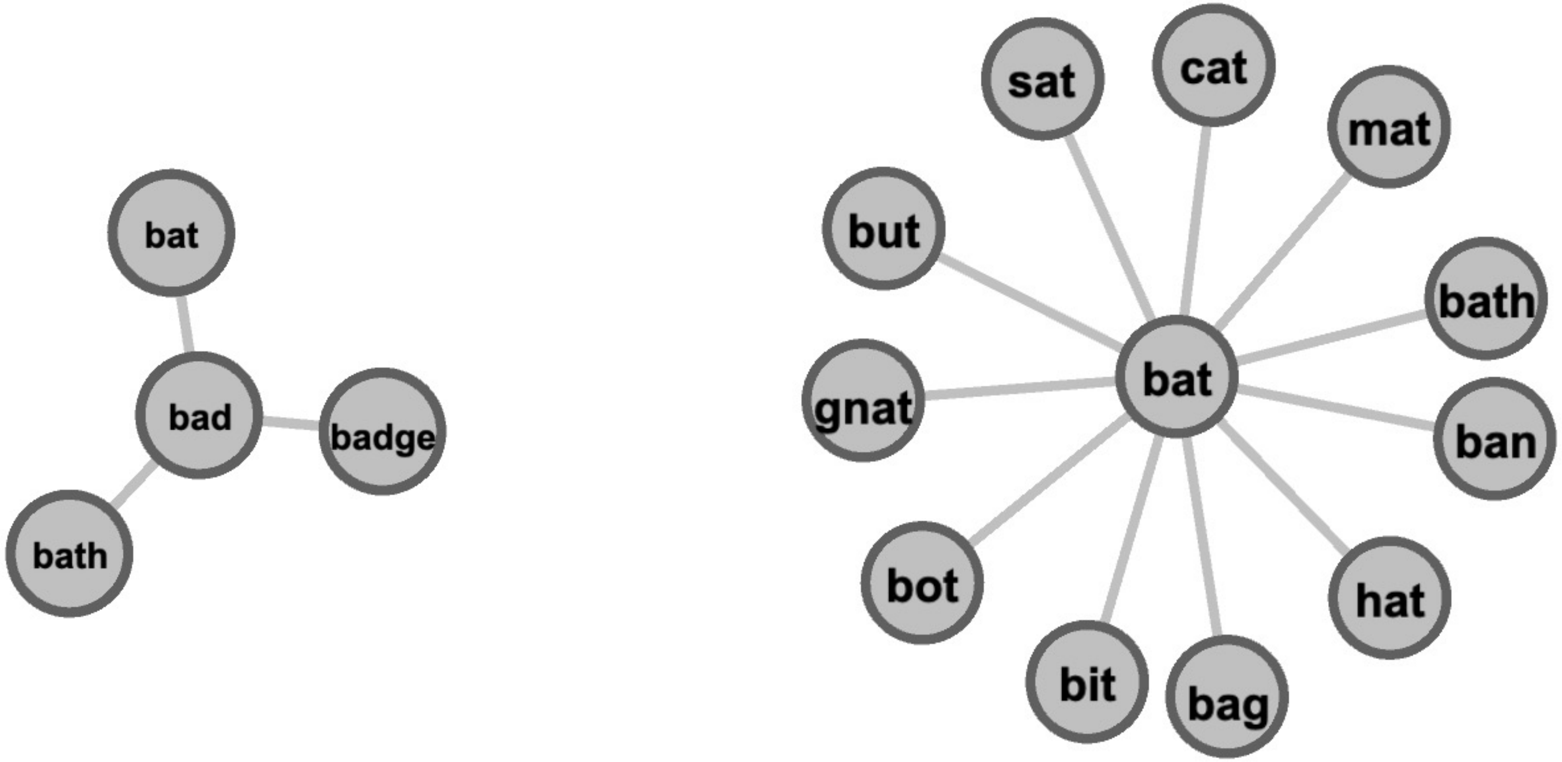
Larger nodes = higher lexical frequency
Thicker edges = closer phonetic distance



NAM prediction

- Low-density neighborhoods (i.e., words that have few neighbors) experience less competition and thus faster target word recognition rates,
  - leads to those words being responded to and recognized more quickly as opposed to words with a high number of neighbors
- Numerous studies have confirmed the NAM predictions for word recognition (e.g., Goh, Suarez, Yap, & Tan, 2009; Luce et al., 2000; Vitevitch, 2002c; …)
  - earning it its prominent place in spoken word recognition
- Luce and Pisoni (1998: p. 1) explicitly acknowledge a “structural organization of the lexicon” based on “similarity relations among the sound patterns of spoken words”
  - all neighbors of “way” also have neighbors of their own
  - a large number of words in a lexicon could be interlinked in one large web

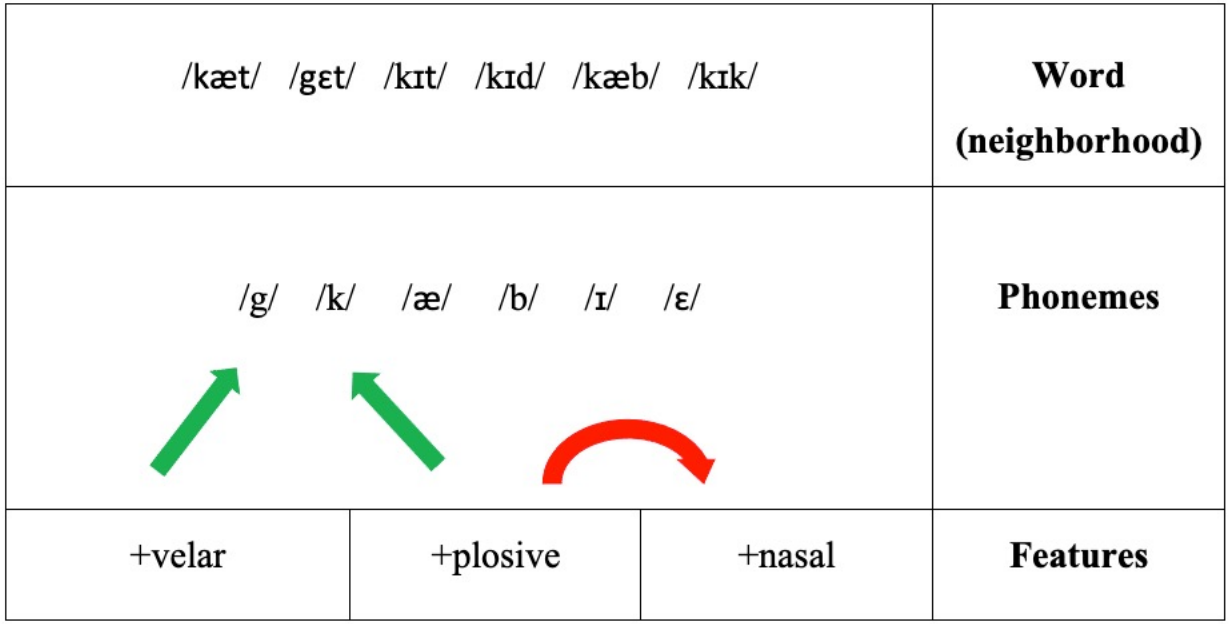
Retrieval efficiency (speed)



What are your expectation regarding retrieval speed (e.g. reaction-time measurements) concerning the words in the two neighborhoods?

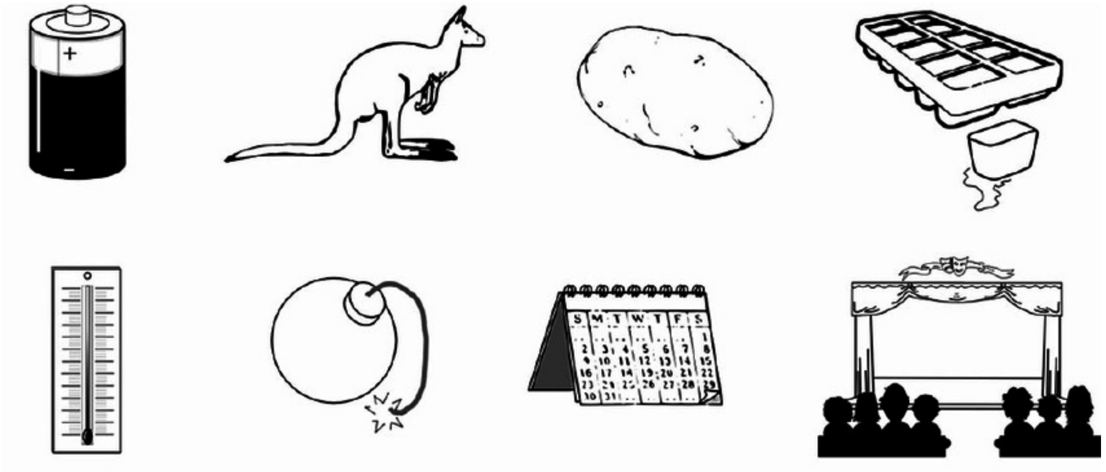
Other models of spoken word recognition

- TRACE (McClelland & Elman, 1986)
  - multidimensional features of phonemes serve as the input (e.g., frication, nasality, back vowel, front vowel), are then channelled up to the next layer, the phoneme layer
  - due to focus on phonetic features rather than phonemes, TRACE can account for underspecification, phonological variation (e.g., dialects), and mispronunciation of target words
  - special weighting is assigned to higher frequency units in the model



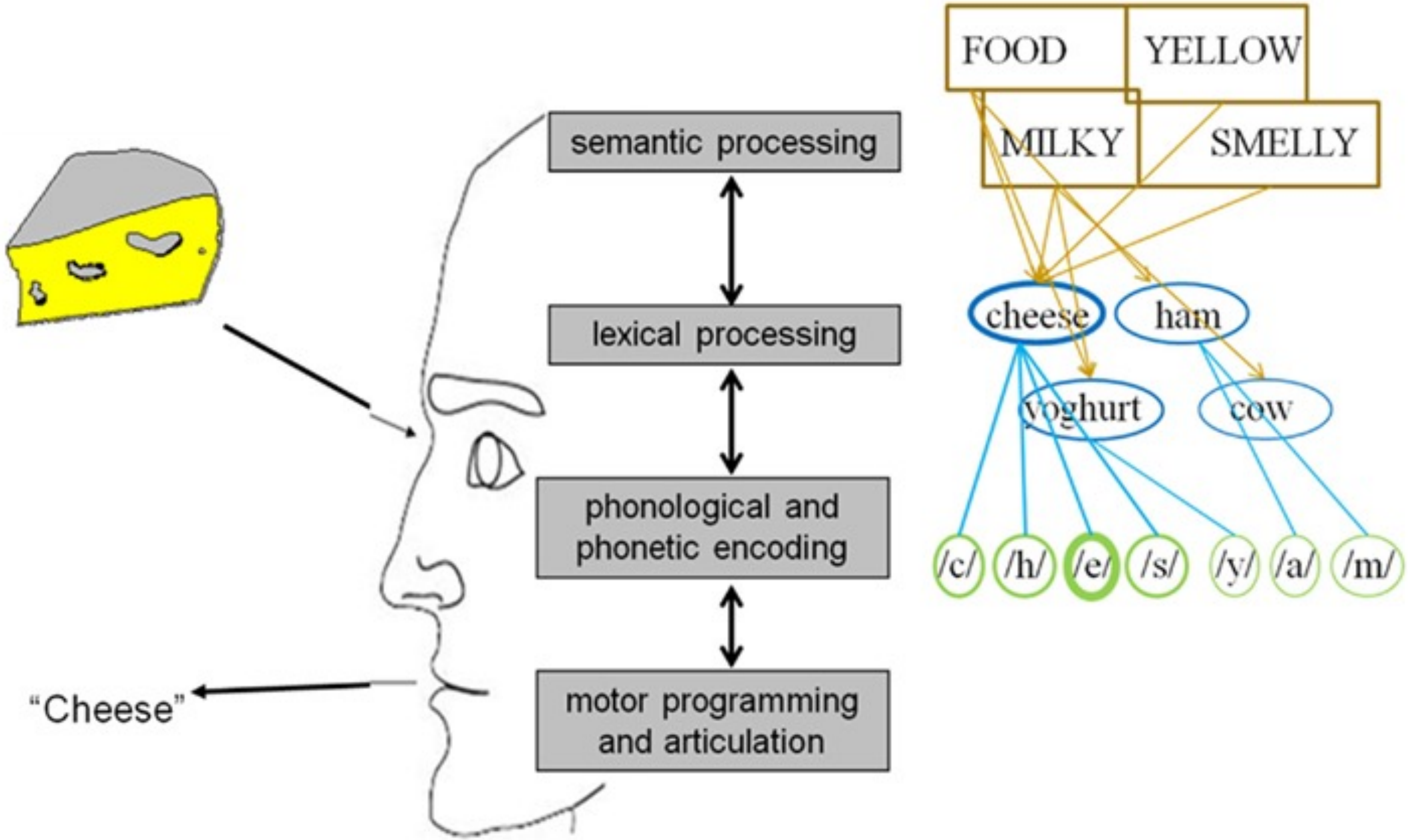
→ How are phonological neighbors defined in this model?

Speech production



- Dual functions of phonological neighborhood effects
- In speech production the opposite is observable, and words from competitive neighborhoods are produced faster and more accurately (Chen & Mirman, 2012; Dell & Gordon, 2003)
  - more practiced motor articulation program
  - this practice is transferred onto neighboring words
- Whereas in perception: competition among lexical candidates leads to slower access of the target word (Luce & Pisoni, 1998)
  - E.g., lexical decision tasks

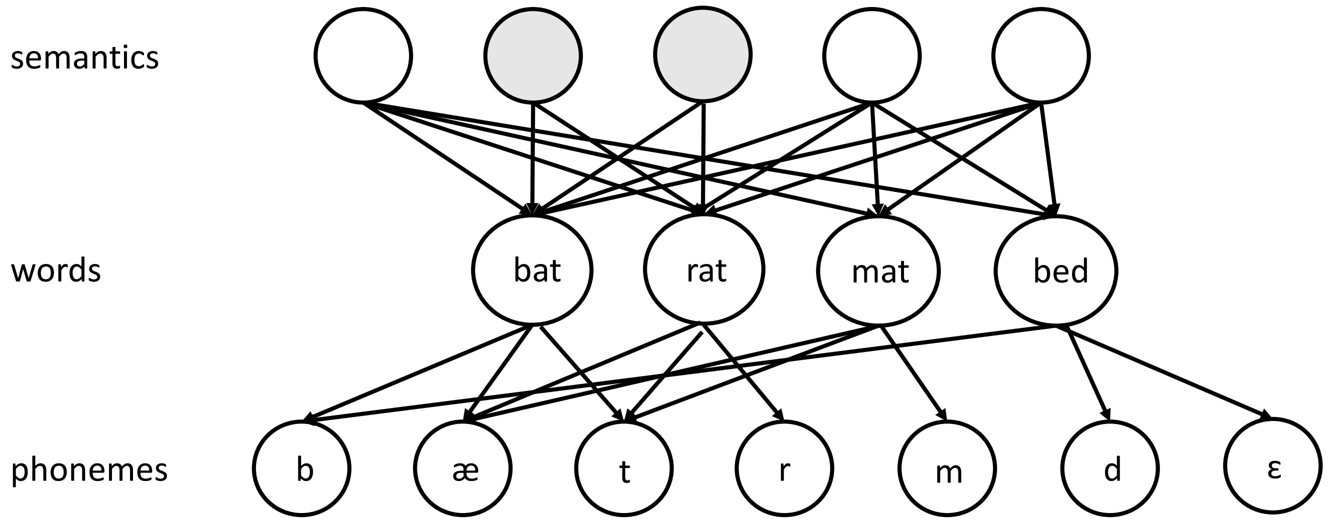
Picture naming experiment



Dell's interactive two-step model of lexical access and retrieval

- lexical and phonological retrieval are distinct and ordered categories but *interact* through *bi-directional spreading of activation* (Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997)
    - semantic information (semantic features) can influence phonological retrieval and phonological information can affect semantic retrieval (Dell, Martin, & Schwartz, 2007)
- the first step is lexical selection and maps the conceptual representation of a word to a lemma
    - phonological information is not required at this point
- next, phonological encoding is initiated and the phonemes used for building the target word are retrieved

Interactive feedback model (Dell, 1986)



In **word production**, the initial semantic activation provides a baseline activation, which is then further boosted by activation of phonological neighbors

Word recognition begins with the activation of phonological segments and boosts activation of all phonological neighbors, including the target word, and thus activation spreads more evenly within the phonological neighborhood and is less focused on the target word

→ *Competition for activation is greater in recognition*

Flow of semantic and phonological information

- unresolved question in speech production models concerns the flow of information from the semantic to the phonological domain (Schriefers & Vigliocco, 2015)
  - has direct implications for neighborhood activation
- Discrete serial models
  - target lemma and a set of semantically related other lemmas are initially activated.
    - After exclusion of the non-target lemmas, phonological encoding of the target is initiated, and non-targets are not phonologically encoded
- Cascading models
  - activated set of initial lemmas send some activation to phonological encoding before the final target lemma has been selected
    - thereby spreading phonological activation among competing lemmas

Flow of information…

- Fully interactive models (Dell)
- assume feedback spreading between the phonological and the lemma level → activation will be spread among competitor lemmas at the lemma stage
- in addition to the phonological forms sending activation back to the lemmas and thus spreading co-activation among phonologically similar forms
- evidence that semantic competitors receive co-activation (as predicted by cascading and interactive models)
  - for instance phonological activation spreads between near-synonyms like ‘couch’ and ‘sofa’ (Jescheniak & Schriefers, 1998)
- assumption of feedback from the phonological to the lemma level has been supported by the ‘lexical bias effect’
  - = phonemic errors tend to lead to existing rather than non-words (Nooteboom, 2005)
  - can be explained by feedback spreading from the level of the phonological segments to the higher lemma level
    - discrete serial models predict independence of phonological errors from an existing word

Phonological neighborhood effect

- Well-documented phenomenon in psycholinguistic research
- Can be observed in different languages and populations (e.g., Gordon, 2002; Marian & Blumenfeld, 2006)
- But some languages show opposite neighborhood effects
  - Faster retrieval in dense neighborhoods, rather than slower as in English
    - Spanish (Vitevitch & Rodrıguez, 2005)
    - Russian (Arutiunian & Lopukhina, 2020)

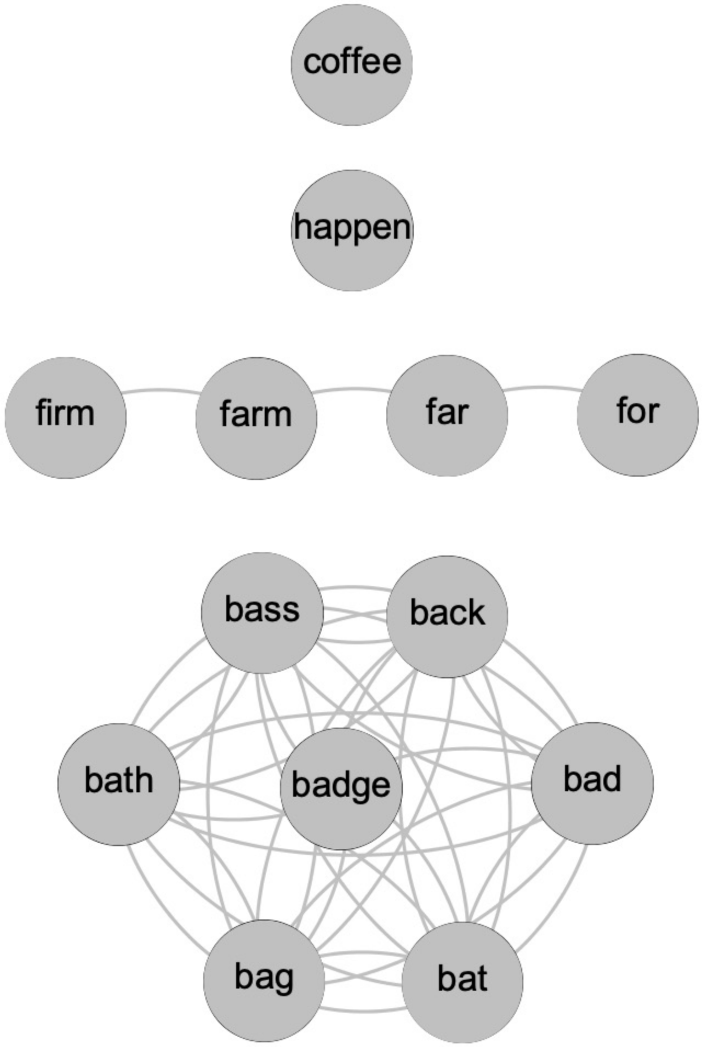
- Differences raise interesting questions for bilinguals and L2 learners
  - e.g., Spanish learners of English
  - in addition: L2 learners have different word knowledge and consequently phonological neighborhood relationships than L1 users

Spreading activation/ diffusion

- Activation spreads to neighbors
  - and to neighbors of neighbors

- Activation restriction
  - fewer connections
- Activation propagation
  - dense, interconnected neighborhoods

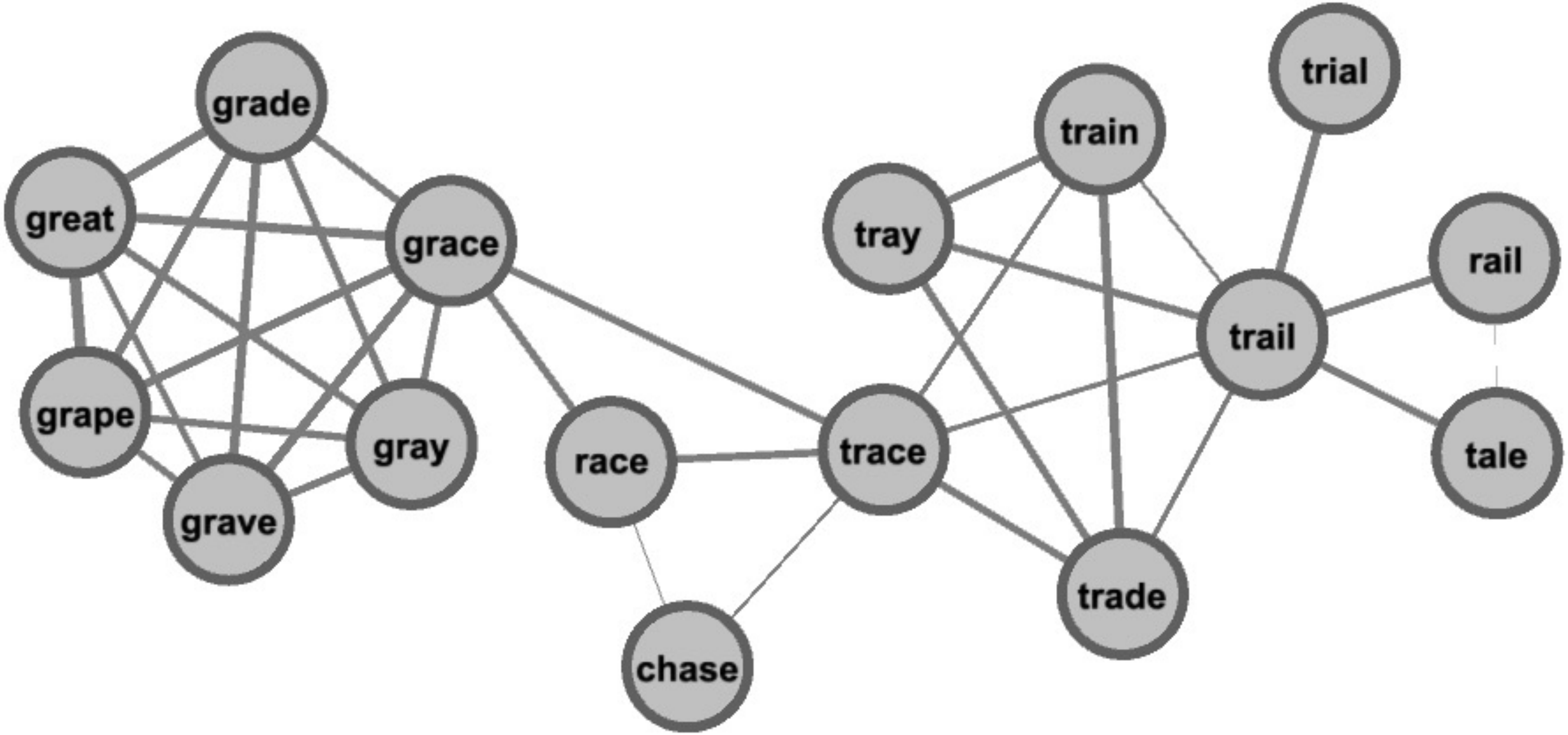
- Words residing in interlinked neighborhoods: delay in lexical retrieval (Siew & Vitevitch, 2016)
- Lexical hermits have clear retrieval advantage (Vitevitch and Castro, 2015)



“Neighborhood effects without neighbors”

- Co-activation extends to the wider neighborhood separated by more than one phoneme distance, and even when no one-phoneme neighbors exist (Suarez, Tan, Yap, & Goh, 2011; Chan & Vitevitch, 2009)
  - *PLD-20* → gives the mean number of steps that are required to transform a word into its 20 closest neighbors
  - *75% neighborhood metric* - quantifying phonological similarity by 75% phonemic overlap (Kapatsinski, 2006)
- Demonstrate the influence of the wider neighborhood on target words
- Underscores the importance of extended neighborhood analysis

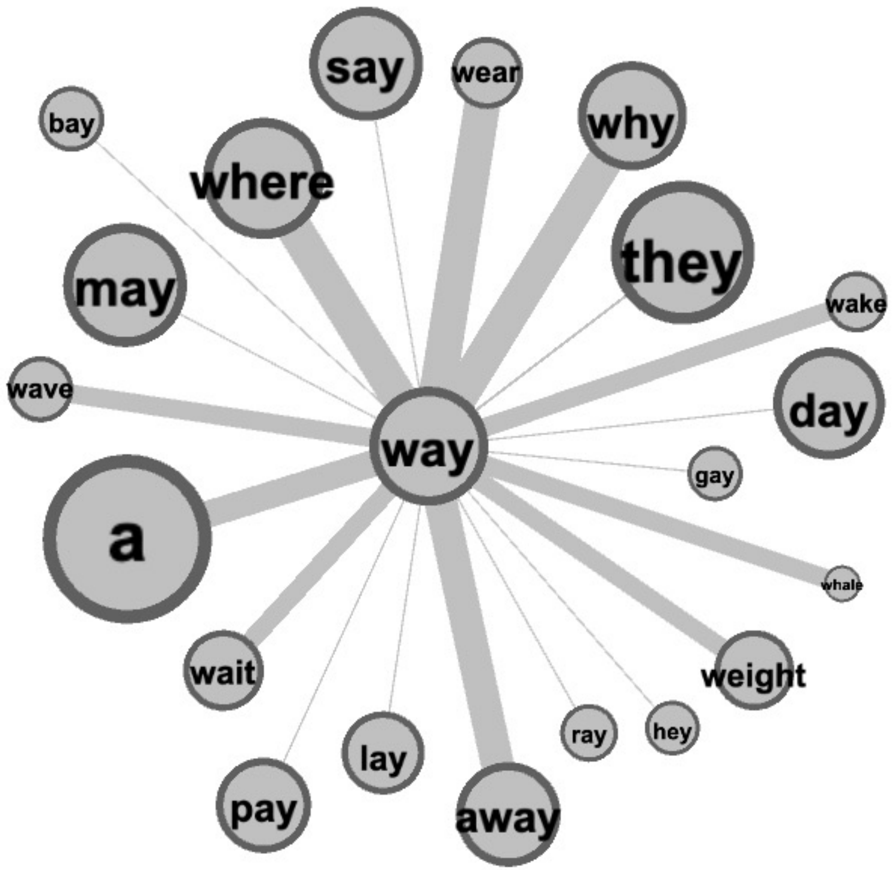
Extended neighborhoods



English C1

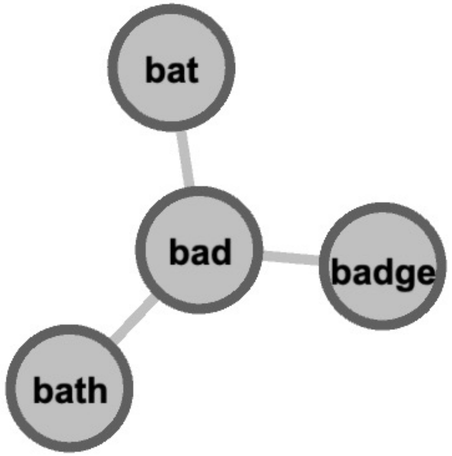
Spoken word recognition

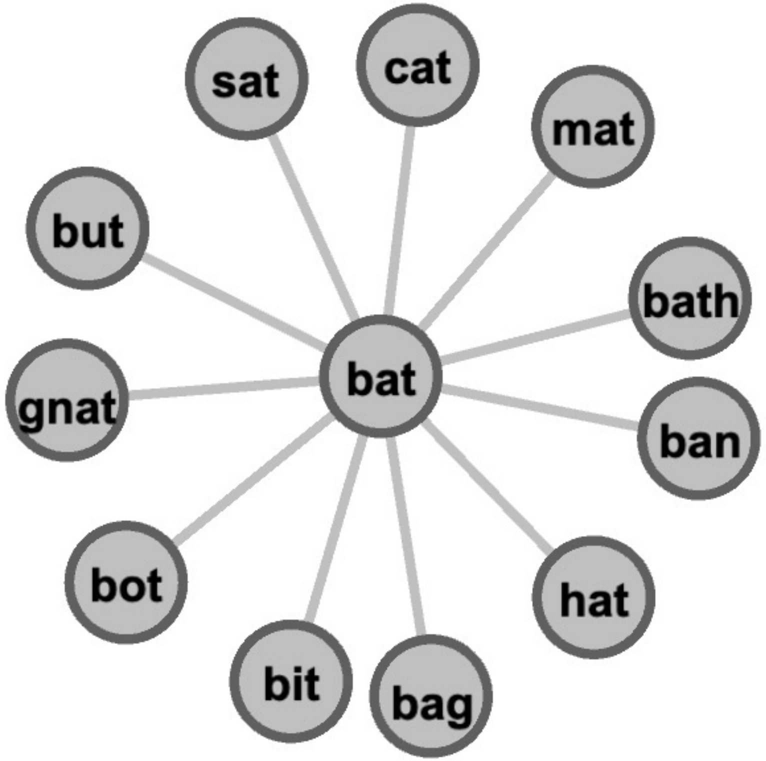
- Relies on phonological neighborhoods
  - “One-segment neighbors”
- Models of spoken word recognition
  - *Neighborhood Activation Model* (Luce & Pisoni, 1998)
  - *Cohort Model* (Marslen-Wilson, 1987)
  - *TRACE* (McClelland & Elman, 1986)
  - …
- Core tenet of word recognition mechanisms:
  - Phonological similarity between words
    - Lexical frequency
    - Length of words



Lexical competition

- Word recognition facilitated when few neighbors are present in neighborhood
  - Takes longer to recognize words if many neighbors
- Co-activation spreads through shared segments
  - The more segments are shared within a neighborhood the more activation thins out
  - "Phonological Neighborhood Effect" (Vitevitch & Luce, 2016)

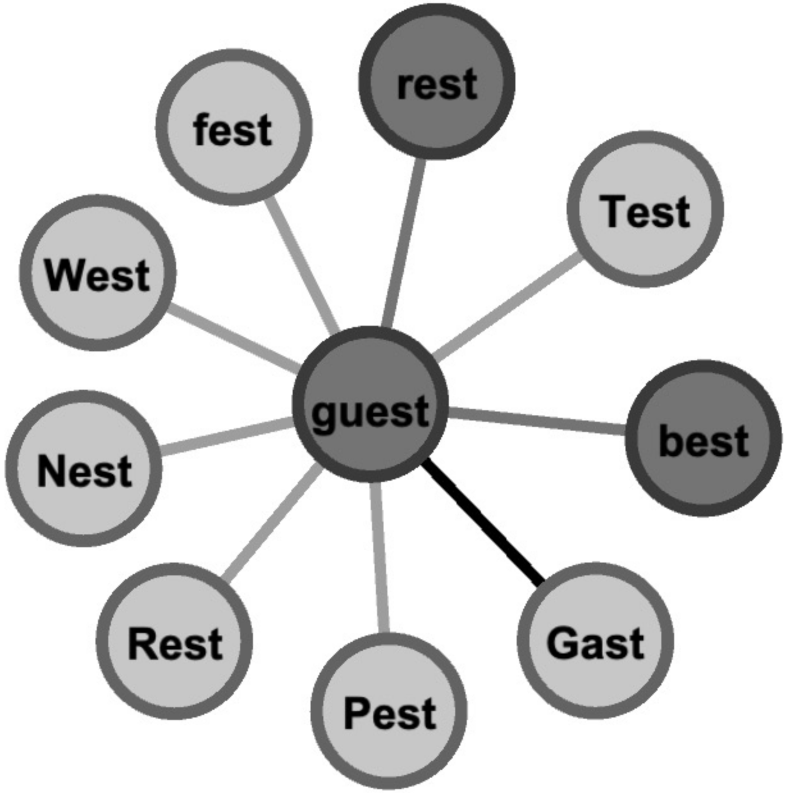




Bilingual phonological neighborhoods

- Bilinguals accrue more phonological neighbors
  - Cross-language neighbors delay word recognition
    - Visual word recognition
    - Brysbaert, Van Dyck, & Van de Poel, 1999; Van Heuven, Dijkstra, & Grainger, &, 1998; Dijkstra et al., 2010, Van Hell & Dijkstra, 2002…

- Cross-language interference of cognates, homophones
  - “Bilingual Processing Disadvantage”
    - Blumenfeld & Marian, 2007; Canseco-Gonzalez et al., 2010; Ju & Luce, 2004; Marian & Spivey, 2003a, 2003b; Shook & Marian, 2012; Weber & Cutler, 2004
  - Cross-language phonological neighbors
    - Luef, Resnik, & Graf, 2023; Luef, 2023; Luef, 2024; Marian, Bartolotti, Chabal, & Shook, 2012; Marian et al., 2008; Shook & Marian, 2013; Vitevitch, 2012



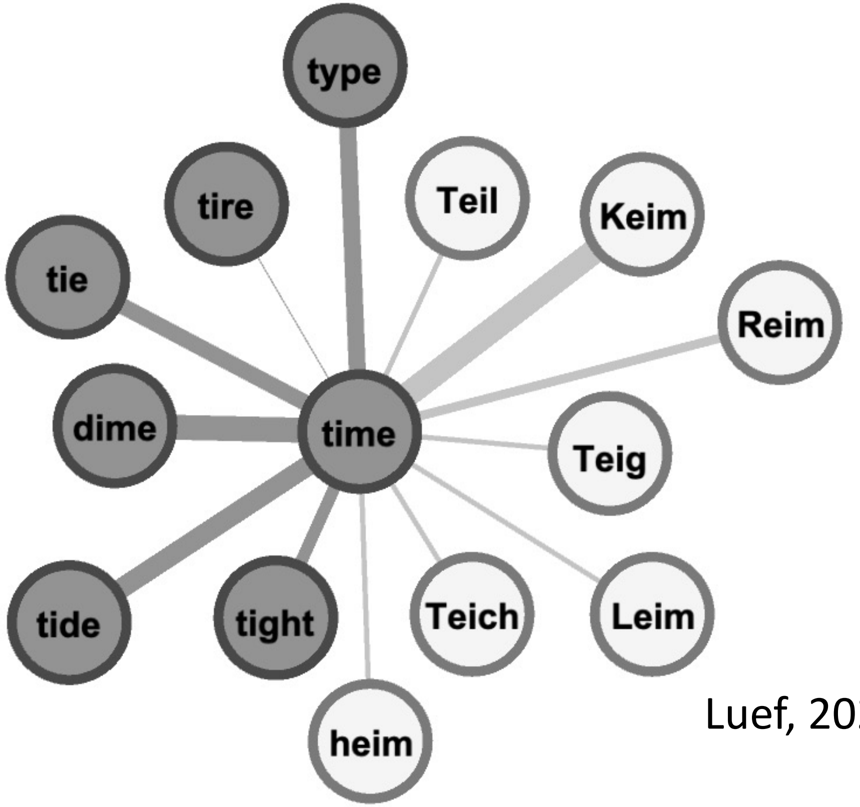
Bilingual lexical access

- Bilingual lexical access is non-selective
  - Integrated lexicon
    - Bartolotti & Marian, 2012; Costa, Pannunzi, Deco, & Pickering, 2016; Costa & Santesteban, 2004; de Groot, Delmaar, & Lupker, 2000; Dijkstra et al., 1999; Jared & Kroll, 2001; Lemhöfer, Dijkstra, & Michel, 2004; Luef, 2022, 2024; Marian & Spivey, 2003a, 2003b; Van Hell & Dijkstra, 2002…

- *BLINCS* "Bilingual Language Interaction Network for Comprehension of Speech"
  - Shook & Marian, 2013
    - Phonological features activated across languages
  - BIMOLA Model: phonetic features activated first
  - Strength of activation (L1, L2)

Activation spreads along phonological similarity

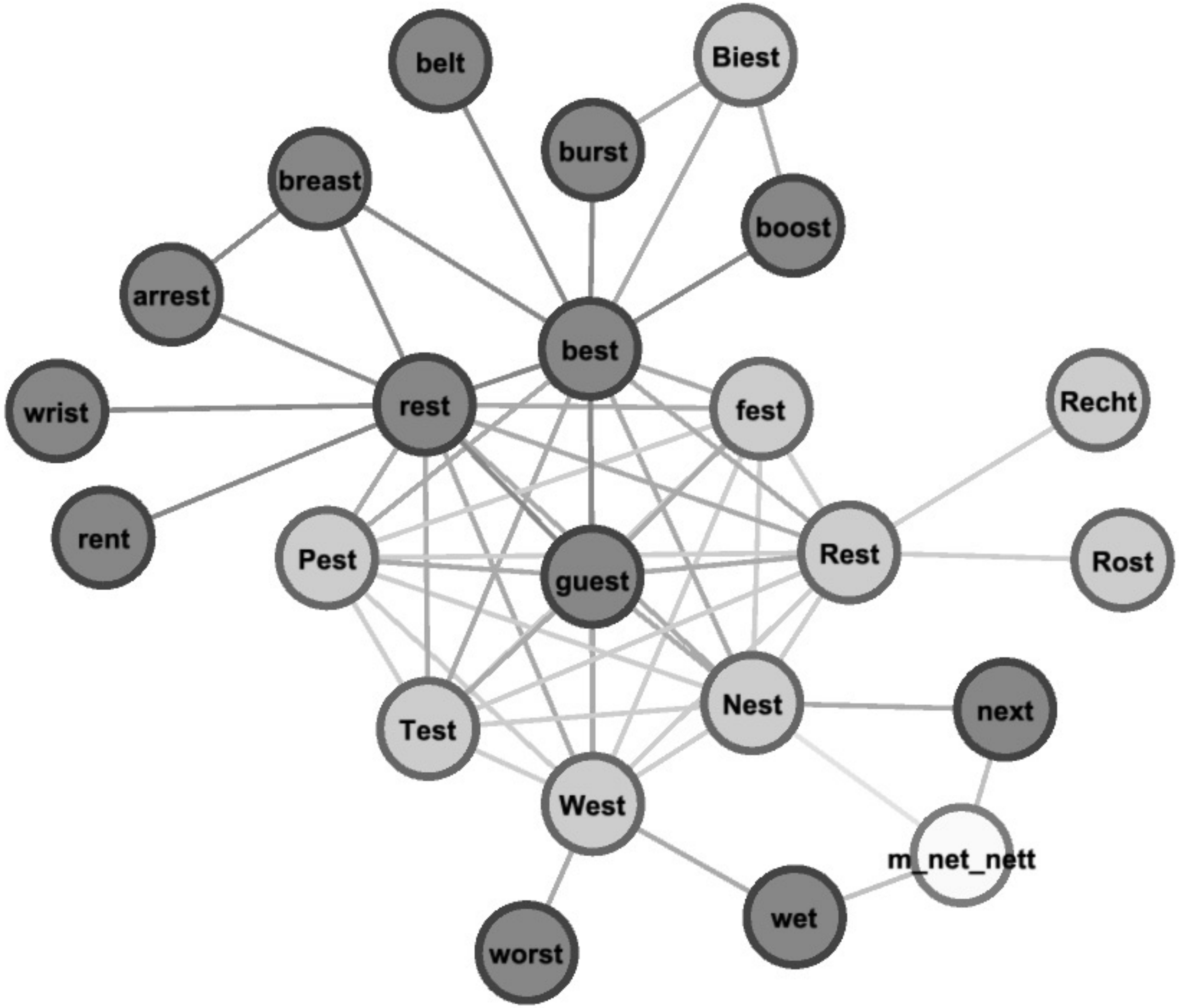
- Phonological similarity: ALINE algorithm
  - Phonological feature comparison
    - Backness, roundedness, place of articulation, manner of articulation …
    - ALINE score between 0 and 100
- Word recognition delayed by close phonological similarity in neighborhood
  - not number of neighbors
  - in line with BLINCS predictions
- Segmental and feature activation predicts spreading patterns
- More similar languages (phonologically) means more activation spreading between them



Luef, 2024

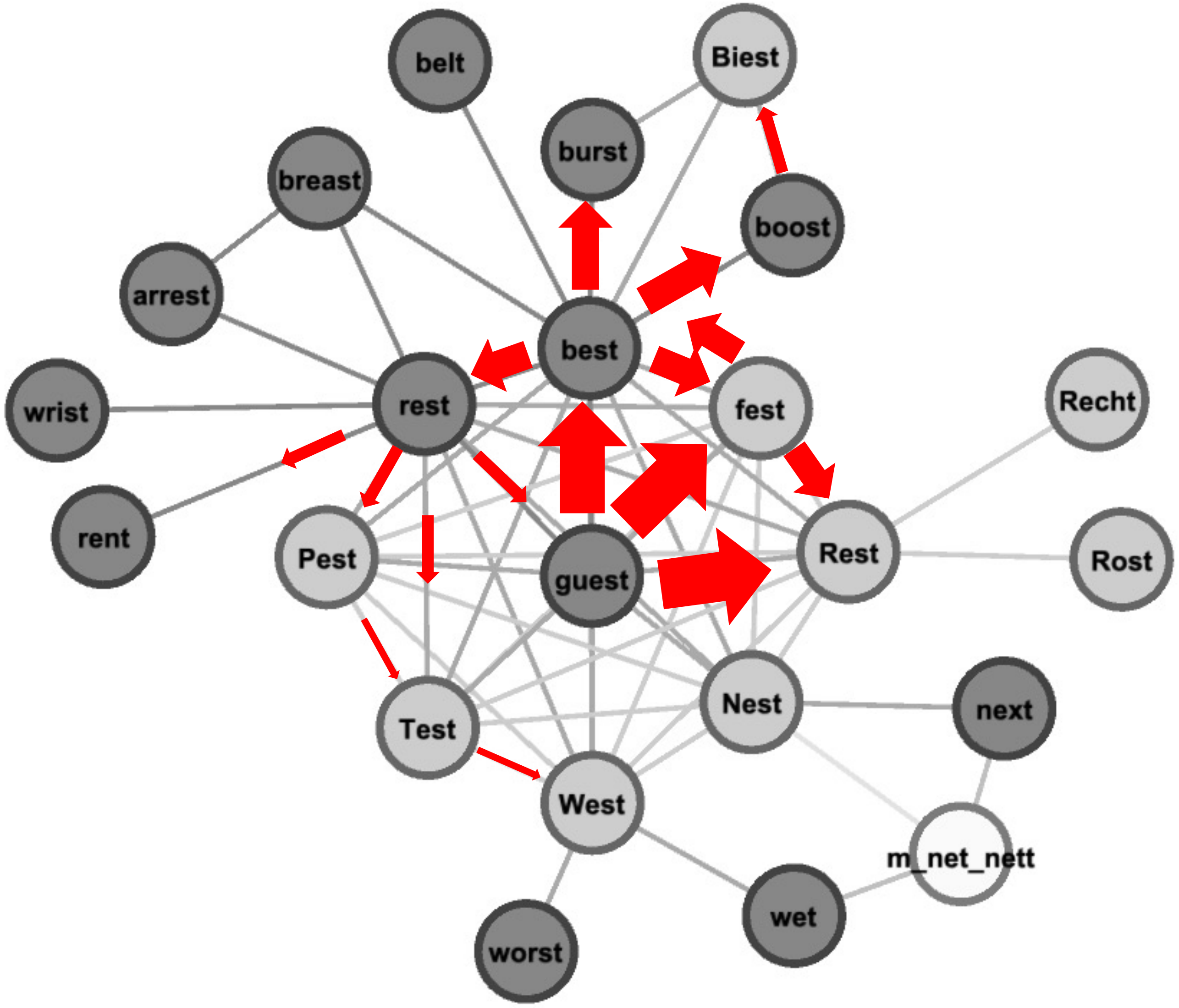
Word “cheese”	Neighbor	Phonological similarity
"ʧiz"	"ʧuz" (choose)	88
"ʧiz"	"tiz" (tease)	84
"ʧiz"	"ʧik" (cheek)	65

Neighborhoods of neighbors



- Densely connected vs. sparsely connected regions
  - How embedded is a word in the word form lexicon?
    - Unequal distribution of denseness across lexical network
  - More activation spreading in denser areas of lexicon
    - More difficult word retrieval
    - Suarez et al. ”Neighborhood effects without neighbors”
      - Lexical activation spreads from lexical hermits to 2- and 3-segment neighbors

Neighborhoods of neighbors



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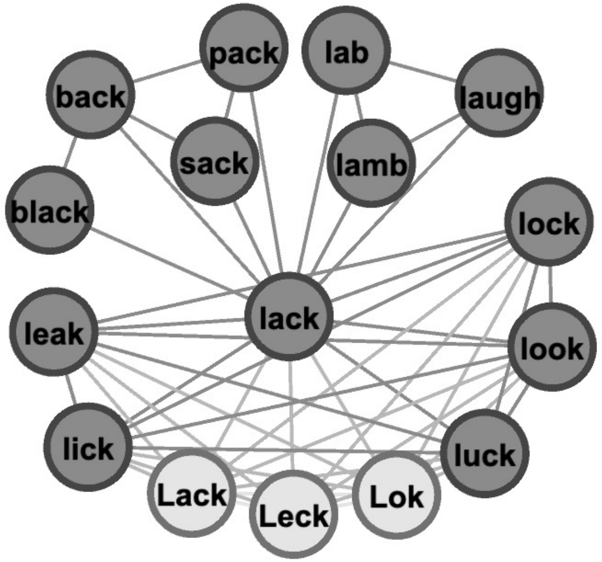
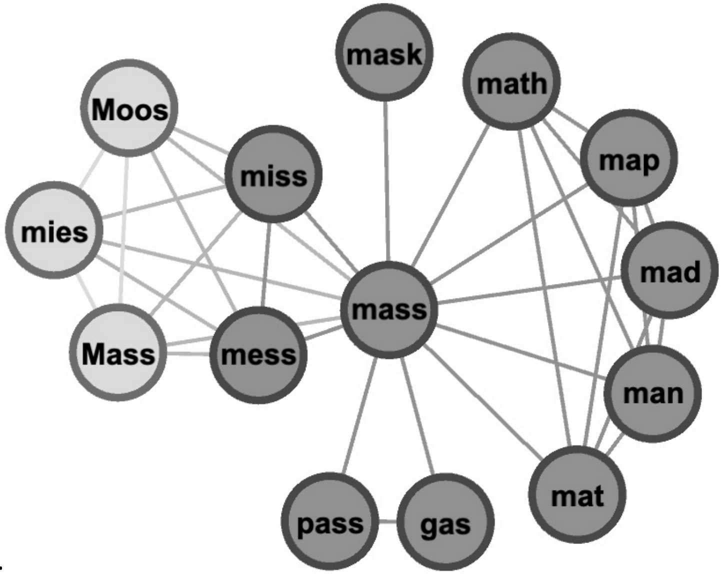
Neighborhood characteristics

- Linking of neighbors thins out activation (neighborhood clustering)
    - Network statistic: clustering
  - Not captured by traditional accounts of lexical processing
  - L1-English monolingual lexicon: clustering delays target word recognition
    - Activation bounces back and forth in clustered neighborhoods (Chan & Vitevitch, 2008, 2009; Yates, 2013)

Clustering = $2e_n/(k_n(k_n-1))$



Luef, 2024



- German neighbors may increase clustering in L2-English neighborhoods
  - and delay word recognition
    - Luef (2024)

L1-German, L2-English bilingual lexicon

Separated vs. integrated lexica

- many studies use **cognate** materials
  - palace – palacio in English-Spanish,
  - pyramid – pyramida in English-Hebrew
  - πόρτα /'porta/ – porte ‘door’ in Greek-French
- cognate effect is the fact that a cognate word (e.g., palacio) will significantly facilitate the recognition of its translation in the other language (e.g., palace in English)
- one of the best-studied and most robust bilingual effects
- found not only when both prime and target words are written in the same alphabet, but also when they are written in different scripts (cross-script priming task):
  - e.g., κέντρο /'kendro/ – centre in Greek-French (Voga and Grainger 2007; Gollan, Forster, and Frost 1997)
- cognate effect provides the basis for several applications in second language learning, especially related to vocabulary in a second language.
  - Sheng et al. (2016), children from 4 to 7 (English-Spanish and Mandarin-English) → demonstrated that cross-linguistic similarities at the phonological level allow bootstrapping of vocabulary learning/ facilitate vocabulary learning

Cognate studies

- term ‘cognate’ is used in different ways in psycholinguistics and historical linguistics
  - in historical linguistics → cognates are words that are etymologically linked
  - etymological link can be either directly inherited from a common ancestor or borrowed via language contact
    - the numerals English *ten*, Dutch *tien*, and German *zehn* are cognates via inheritance, as they stem directly from reconstructed Germanic **tehun*
- according to an etymological approach, Spanish “diez” and English “ten” are cognates

Cognate definitions

- English “*curtain*” and German “*Gardine*” are also cognates
  - → not via inheritance but via language contact, both borrowed from French *courtine*
- in psycholinguistics, notion of cognate is based on the criterion of perceptual recognizability
  - requires formal similarity under the exact conditions of a given experiment
  - e.g., orthographic overlap is measured in an objective way
  - psycholinguistic logic: two words match each other formally, irrespective of any etymological relation of inheritance or borrowing between them
  - *Formal match* in terms of acoustic (i.e., phonetic) or visual (i.e., orthographic) overlap
  - ‘cognateness’ can be a matter of degree in psycholinguistics

Cognats in bilinguals

- for most psycholinguists, cognates are translation equivalents sharing significant formal overlap
  - English “rain”, German “Regen”
- bottom-up approach to bilingual lexical access
  - written word recognition starts at the level of visual features (letters) and activation spreads up to the lexical level (e.g., in the Bilingual Interactive Model, BIA, of Dijkstra, van Heuven, and Grainger 1998)
  - in bottom-up protocols, maximal formal overlap is crucial → constitutes the necessary condition in order to attribute the cognate status to a pair of words
    - For instance, *hotel* or *sport* in English, French and Dutch (e.g., Dijkstra et al. 1999)
    - “gat” and “gato” ‘cat’ in Catalan and Spanish (Costa, Caramazza, and Sebastien-Gales 2000)

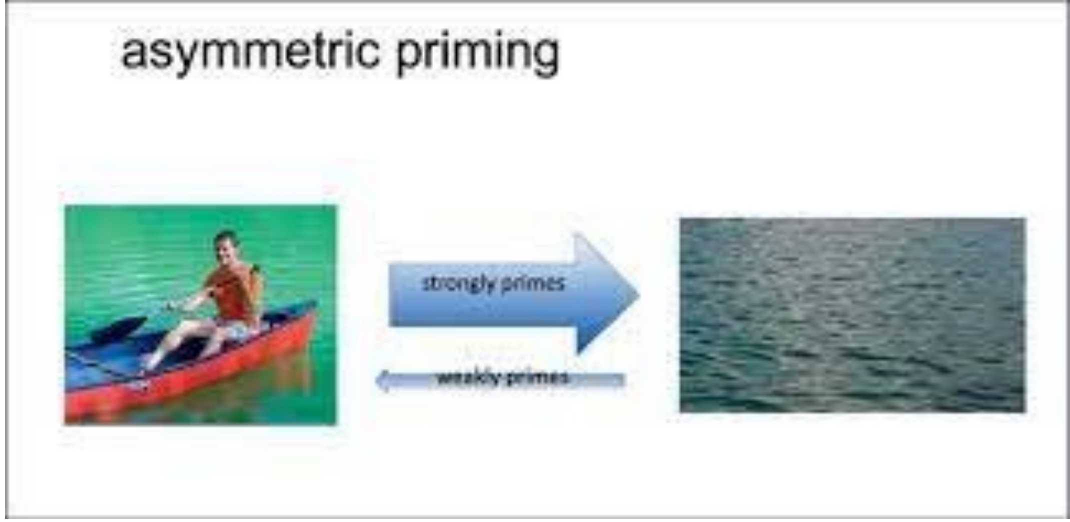
Interlingual homonyms

- words that share spelling but not meaning within or across languages
  - E.g., *boot* in English (meaning footwear) and *Boot* in German (i.e., ship)
  - homographs (words that are typographically similar)
  - homophones (words that are phonologically similar)
- In contrast, cognates are words that share form (completely or predominantly) and meaning across languages, such as the German and English word *film*.
- cognate facilitation effect
  - cognates are read, heard, and spoken faster than non-cognates by bilinguals speaking those specific languages (Cop et al., 2017; Blumenfeld & Marian, 2007; Costa et al., 2000)
  - whereas cross-linguistic homophones interfere with bilingual language processing, in listening and reading (e.g., Lagrou et al., 2011 & 2015; Dijkstra et al., 1999 & 2000; Jared & Szucs, 2002)
- show that words of each language can be activated in both first (L1) and second (L2) language processing
  - Facilitates (when shared meaning) or impedes (different meanings) processing

To sum up…

- the implications of cross-script cross-language priming for the questions of *selective vs. non-selective access*, *independent lexica vs. integrated lexicon* are quite straightforward.
- First, the non-target language, at least when it is L1 (Gollan, Forster, & Frost 1997; Voga & Grainger 2007) <u>cannot</u> be suppressed and exerts its influence
    - even when the duration of the prime is below the conscious perception threshold (masked priming)
- Second, transfer of activation from one language to another also in cases of null orthographic overlap (Greek, Russian, Hebrew… with English)
    - cognate effect can survive reduced phonological overlap combined with largely reduced orthographic overlap, as demonstrated in the case of Greek-French cognates (κέντρο /'kendro/ – centre

Priming asymmetries



- two priming directions
- E.g., Keatley, Spinks, & de Gelder (1994): the L2 to L1 direction does not induce significant cognate priming, neither for Chinese-English nor for French-English bilinguals.
- Gollan, Forster, & Frost (1997), Hebrew-English, obtained a 53ms cognate priming effect in the L1 to L2 direction, but a non-significant effect in the opposite direction (9ms)
- This asymmetry is found in other studies (e.g., for Chinese-English: Jiang and Forster 2001; Chen et al. 2014; Allen, Conklin, and van Heuven 2015, for Japanese-English cognates)
- If integrated lexica, cross-language facilitation should be found in both priming directions, and not only in the L1 to L2 direction

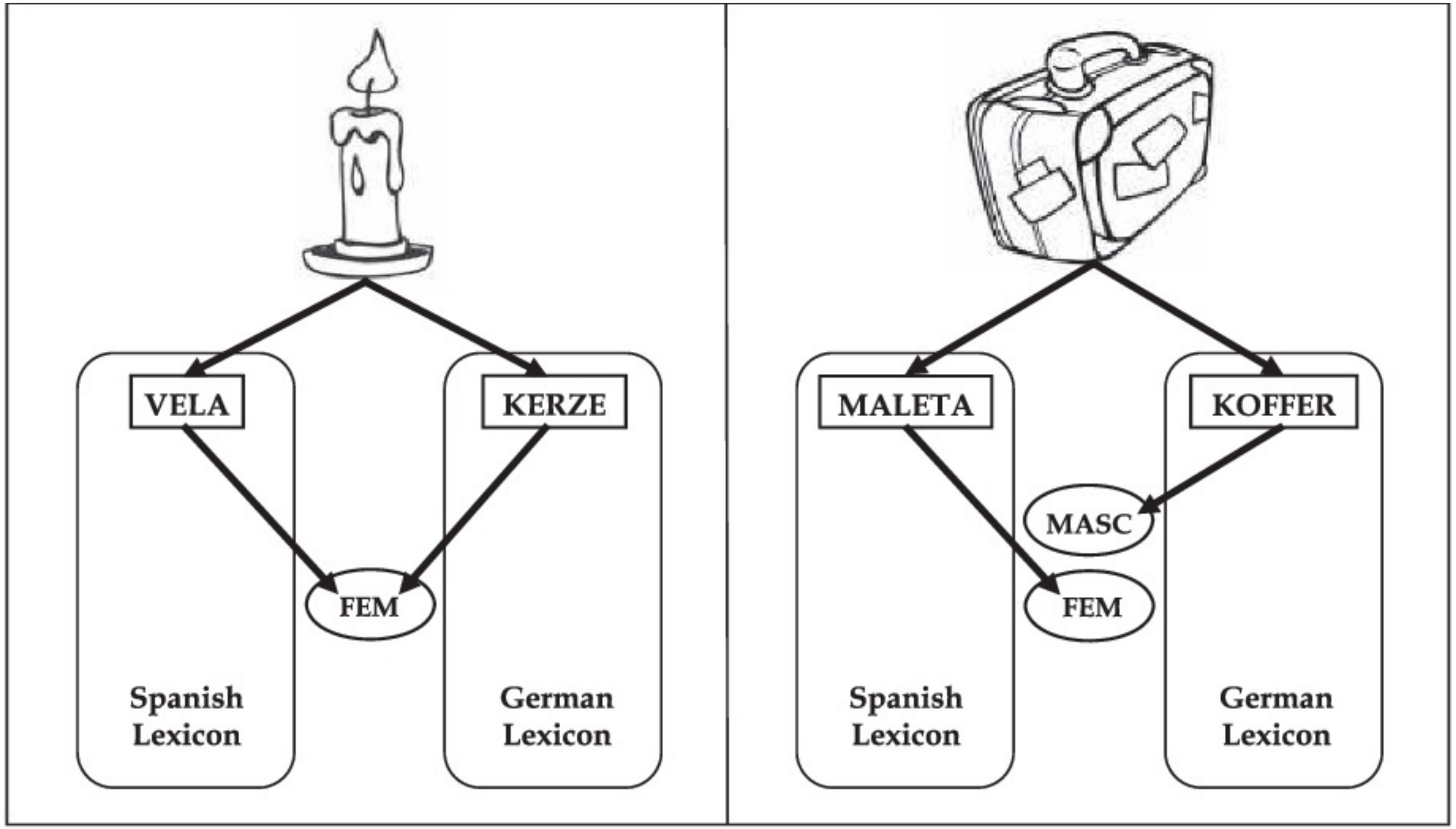
Priming asymmetries

- Not all studies report asymmetrical effects (see, e.g., Duyck and Warlop 2009, for Dutch-French non-cognates)
- Sometimes asymmetry is found for one type of cognate stimuli but not for the other
  - Greek-French bilinguals (Voga 2014), having lived for several years in the L2 country: cognates of Greek etymology, e.g., ιδέα /i'ðea/ – idée ‘idea’
  - priming direction L1 to L2 gives a 56ms cognate effect and the opposite direction gives a 24ms significant effect → not a clear asymmetry
  - etymologically French (Latin) cognates, e.g., role – ρόλος /'rolos/ ‘role’ or cuisine – κουζίνα /ku'zina/ ‘kitchen’ fail to induce any significant effect in the L2 to L1 direction, despite the fact that they manage to prime in the L1 to L2 direction

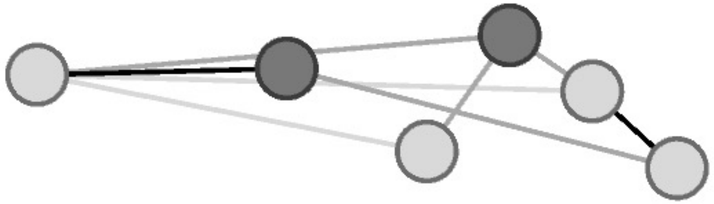
Asymmetry factors

- i) Nature of the task
  - tasks explicitly relying on the semantic component such as semantic categorization, vs. those in which perceptual factors are more implied, such as the lexical decision task (Finkbeiner et al. 2004, with non-cognates)
- ii) Participants' level of proficiency
  - low-proficient bilinguals perform worse than more proficient bilinguals in tasks requiring lexico-semantic activation of L2 items (e.g., Kroll et al. 2010)
- iii) Language environment (e.g., Finkbeiner et al. 2004)
  - participants living in the L2 country represent the type of bilingual who has the greatest chances to exhibit L2 to L1 priming effects
- iv) The types of materials used or features of the materials
  - e.g., cognates of L1 vs. L2 etymology (Voga 2014)
    - German-English "Gardinen-curtains", "Film-film"
  - the question of priming asymmetries could be related to the morphological organization of the bilingual lexicon and the reliance of historical linguistics on factors such as etymology can have a psychological reality

The integrated bilingual lexicon



References



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