Language acquisition, perception and production

Lecture 4 – Spoken word comprehension

Plan for today

- Spoken word comprehension
- Two models (Cohort & TRACE)
- Evidence
- Auditory perception in the brain

Bottom up vs top-down

- Does knowledge of words influence the way we perceive sounds?

Bottom-up vs top-down

- Phoneme restoration effect (Warren, 1970)
- "The state governors met with their respective legi*latures convening in the capital city"
- * = 0.12 second cough

Phoneme restoration effect

- Put video here

Phoneme restoration effect

- People hear the /s/
- People hear the /s/ even if they know it is missing
- Suggests top-down influence on speech perception

Outline of spoken word comprehension

- Three stages of word identification:

1. Initial contact
2. Lexical selection
3. Word recognition

Initial contact

- Some aspect of sensory input makes contact with stored information in lexicon

- Representations become "activated"

Lexical selection

- Activation accumulates until one representation is "selected"

Word recognition

- Word recognition is the end-point of the recognition phase

- Followed by
  - Lexical access
    - Point where all information becomes available (semantic, syntactic, etc)
  - Integration into higher level discourse processes

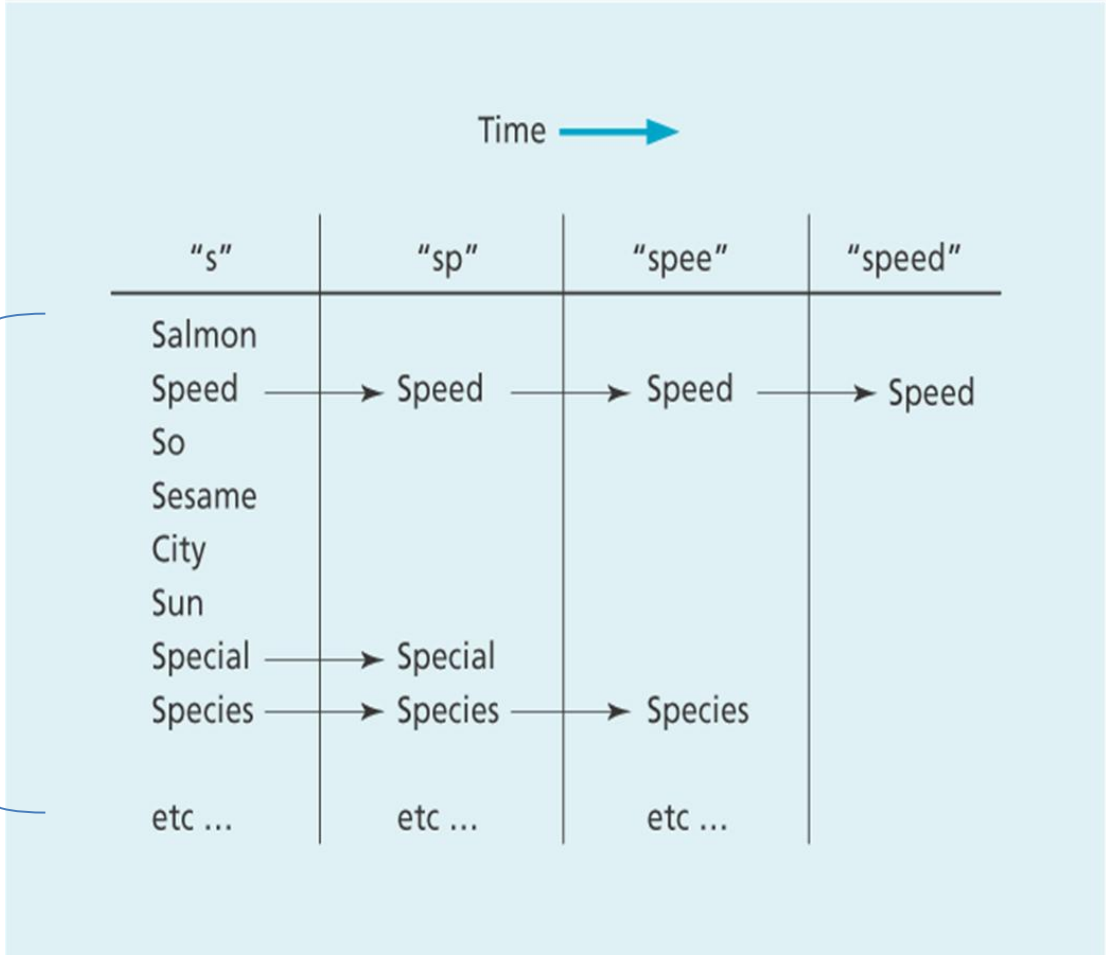
Cohort model

- Marslen-Wilson and Welsh (1978)

- Speech comprehension involves
  1. Access stage
  2. Selection stage
  3. Integration stage

Cohort model

cohort



Cohort model

- Bottom-up information only constrains integration stage; not selection stage
  - Sentence context cannot "slim down" the cohort

- Inclusion in the cohort is not all-or-none
  - "bleasant" is still perceived as "pleasant"
    - Inclusion in the cohort is gradual

Cohort model

- Zwitserlood (1989)
  - Parallel activation of words (the cohort)
  - No early influence of sentence context

- Cross-modal priming task
  - Listen to speech
  - Make lexical decision on visually presented words

  - Participants heard parts of words
  - Then presented with related or unrelated word

Zwitserlood (1989)

- Example 1

- Hear "cap"
  - Cohort = {capital, captain, capsicum, capricorn,...}
- Hear "capt..."
  - Cohort = {captain,...}
- Present 'money' or 'ship'

Zwitserlood (1989)

- Example 2
  - Four contexts
    1. The next word is "cap…"
    2. They mourned the loss of their "cap…"
    3. With damped spirits the men stood around the grave. They mourned the loss of their "cap…"
    4. The player got the ball and scored the winning "goal"

- Present "money" and "ship"

Zwitserlood (1989)

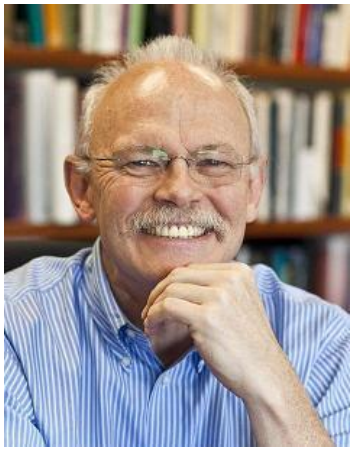
- Results
  - Facilitation to "ship" AND "money" for "cap..."
  - Facilitation to "ship" for "capt..."
  - No influence of context
    - Facilitation also found for "money" in
      - With damped spirits the men stood around the grave. They mourned the loss of their "cap..."

Cohort model

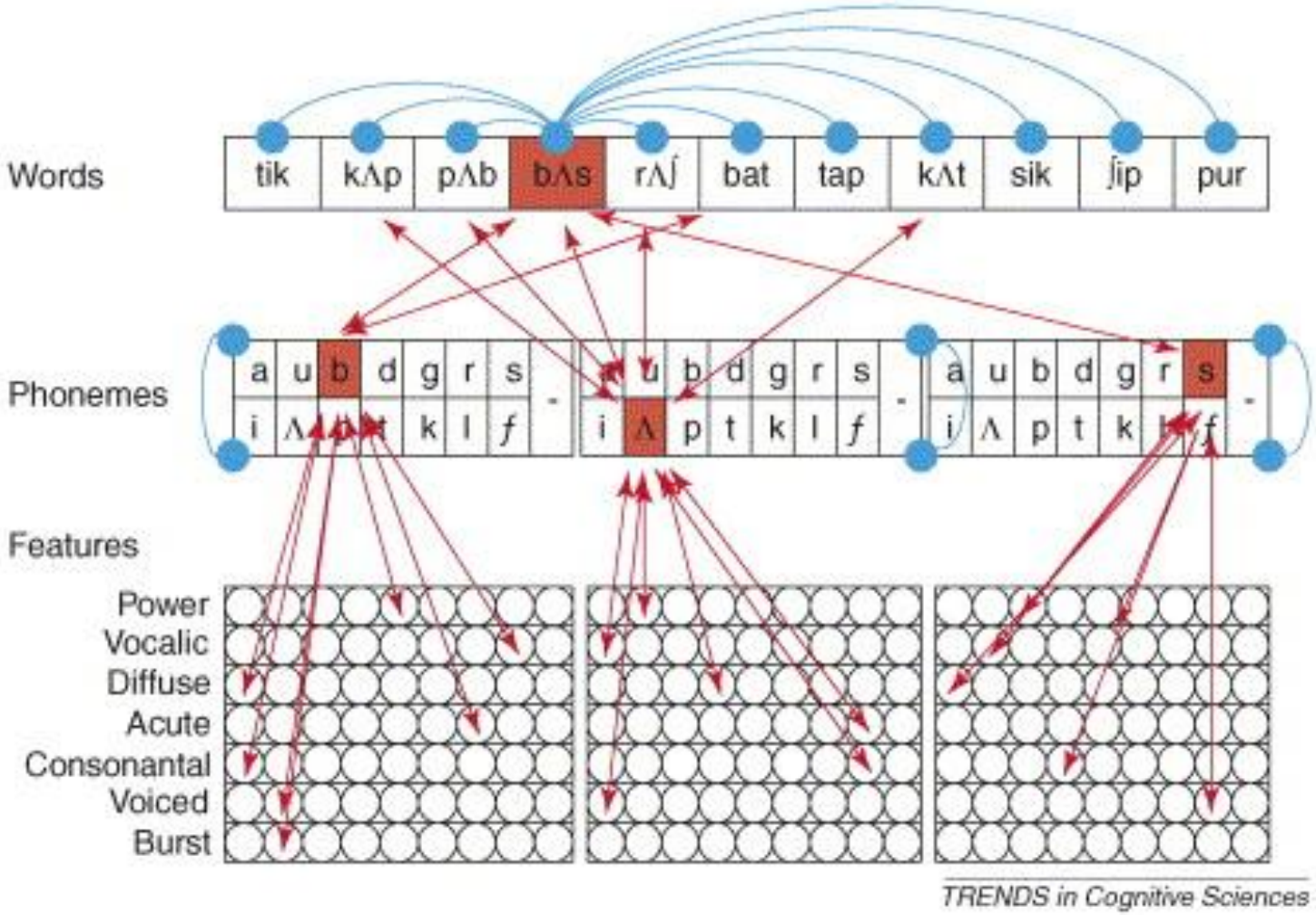
- Effects of phonological neighborhood size (Luce, Pisoni, & Goldinger, 1990)
  - Auditory lexical decision task
  - Words with many neighbors
    - Cat = {cap, cat, cam, can,...}
  - Words with few neighbords
    - Cod = {cod, cop,...}
- Words with many neighbors take longer to identify

TRACE model

- McClelland & Elman (1986)
  - Connectionist model
  - Emphasize role of context on word recognition



TRACE model


Words
tik
kΛp
pΛb
bΛs
rΛʃ
bat
tap
kΛt
sik
ʃip
pur
Phonemes
Features
Power
Vocalic
Diffuse
Acute
Consonantal
Voiced
Burst
TRENDS in Cognitive Sciences

TRACE model

- Important features of the model
  - Three layers of features
    - Input features – phonemes - words
  - Bottom-up and top-down connections
  - Lateral inhibition - competition

TRACE model

- How to recognize ambiguous words?
  - "bleasant"
  - Top-down influence of words

- How does the model do categorical perception?
  - Lateral inhibition leads to categorizing response

Allopenna et al. 1998

- Cohort vs Trace
  - Cohort model assumes competitors mostly share onset
  - Trace assumes competitors also come from rhymes

- Cohort
  - "beaker" → {beetle, beamer, etc}, not {speaker}
- Trace
  - "beaker" → {beetle, beamer, speaker, etc}

Allopenna et al. 1998

Instructions: *"Point to the …"*

-Display contains:
- Target *beaker*
- And <u>at least one</u> of:
  - Cohort competitor *beetle*
  - Rhyme competitor *speaker*
  - Unrelated word *carriage*

-Participants wore head-mounted eyetracker
- People tend to look at objects that are mentioned
  - especially before reaching for them
- How <u>quickly</u> do they look at the objects related to the target word?

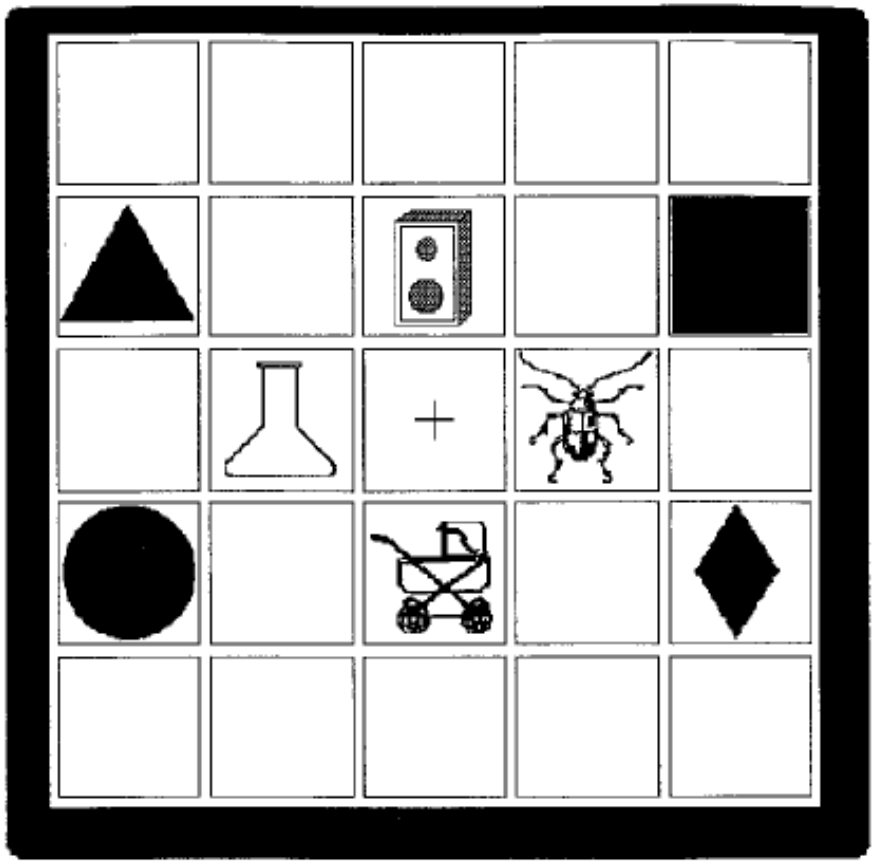


FIG. 3. An example of a stimulus display presented to participants.

Allopenna et al. 1998

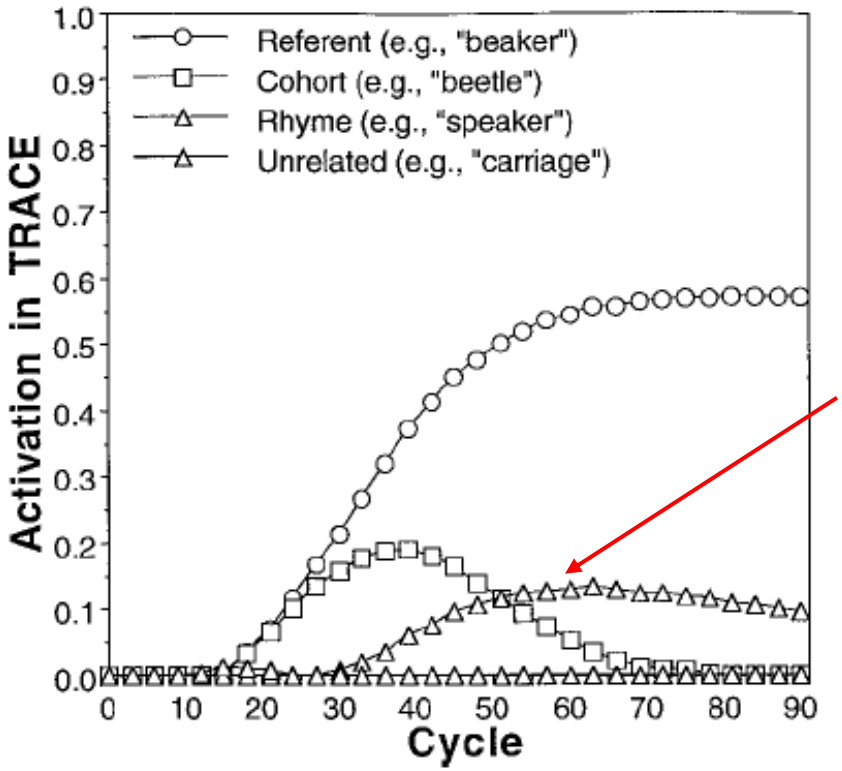
TABLE 1

Items Used in the First Experiment

Pair	Referent	Cohort	Rhyme	Unrelated
A	beaker (2) (6.7) (4)	beetle (0) (7.0) (6)	speaker (49) (−1.0) (3)	dolphin (1) (7.0) (2)
	carrot (1) (6.9) (7)	carriage (11) (7.0) (3)	parrot (1) (7.0) (9)	nickel (7) (7.0) (8)
B	candle (18) (7.0) (8)	candy (16) (7.0) (5)	handle (53) (7.0) (5)	dollar (46) (7.0) (8)
	pickle (1) (7.0) (8)	picture (162) (6.8) (3)	nickel (7) (7.0) (8)	speaker (49) (−1.0) (3)
C	casket (0) (7.0) (3)	castle (8) (6.6) (11)	basket (17) (7.0) (4)	nickel (7) (7.0) (8)
	paddle (1) (7.0) (9)	padlock (2) (7.0) (1)	saddle (25) (6.7) (5)	dollar (46) (7.0) (8)
D	dollar (46) (7.0) (8)	dolphin (1) (7.0) (2)	collar (17) (7.0) (15)	beaker (2) (6.7) (4)
	sandal (0) (6.6) (7)	sandwich (10) (7.0) (1)	candle (18) (7.0) (8)	parrot (1) (7.0) (9)

Note. Different pairs of sets were presented to different groups of participants. The three numbers given below each word are its frequency (per million words in the Kucera and Francis, 1967, corpus), its familiarity (based on 7-point ratings obtained by Nusbaum *et al.,* 1984; values of −1.0 indicate that the item was not included in the rating study), and a count of its (noun) phonological neighbors.

Allopenna et al. 1998



Rhyme competitor *"speaker"* becomes almost as active as cohort competitor *"beetle"*, though later of course

FIG. 1. Average activations from eight TRACE simulations with both cohort and rhyme competitors.

Allopenna et al. 1998

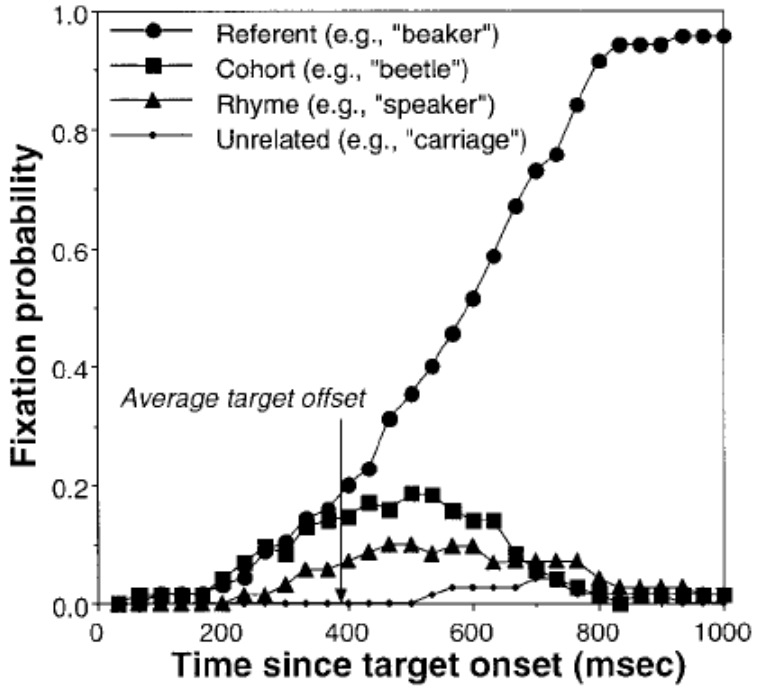
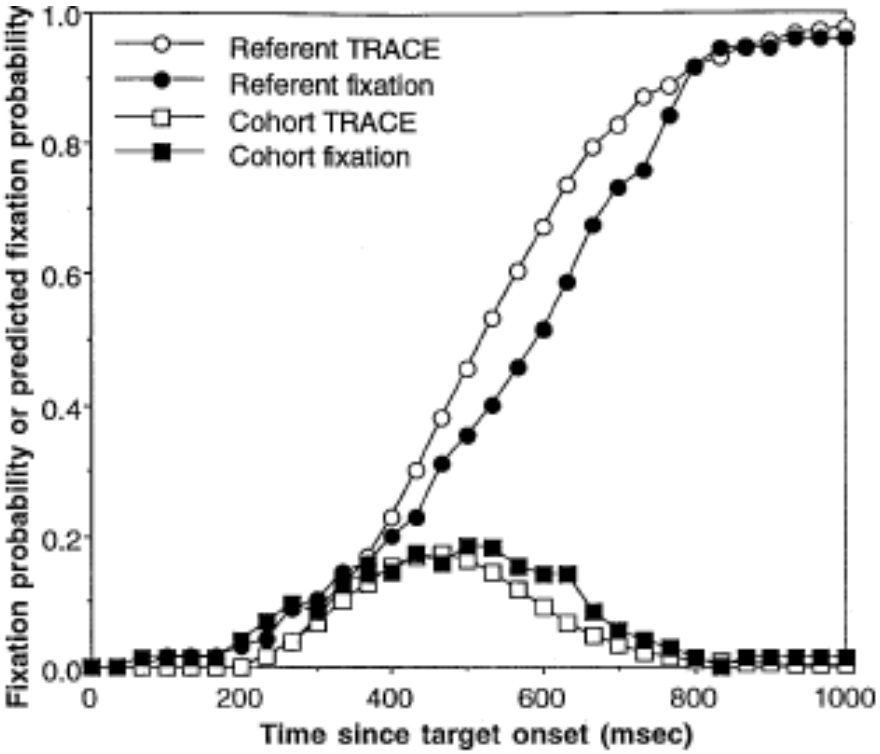


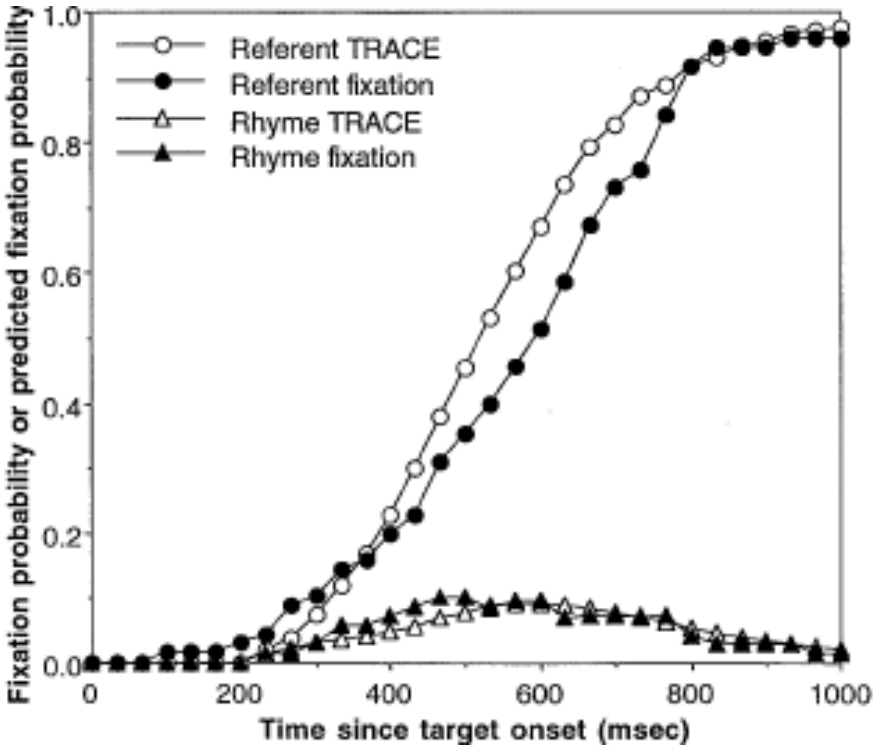
FIG. 4. Probability of fixating each item type over time in the full competitor condition in Experiment 1. The data are averaged over all stimulus sets given in Table 1; the words given in the figure are examples of one set.

Comparison of data to model predictions

Target & Cohort Competitor



Target & Rhyme Competitor



Model slightly overpredicts fixations to Target & slightly underpredicts fixations to both Cohort & Rhyme competitors

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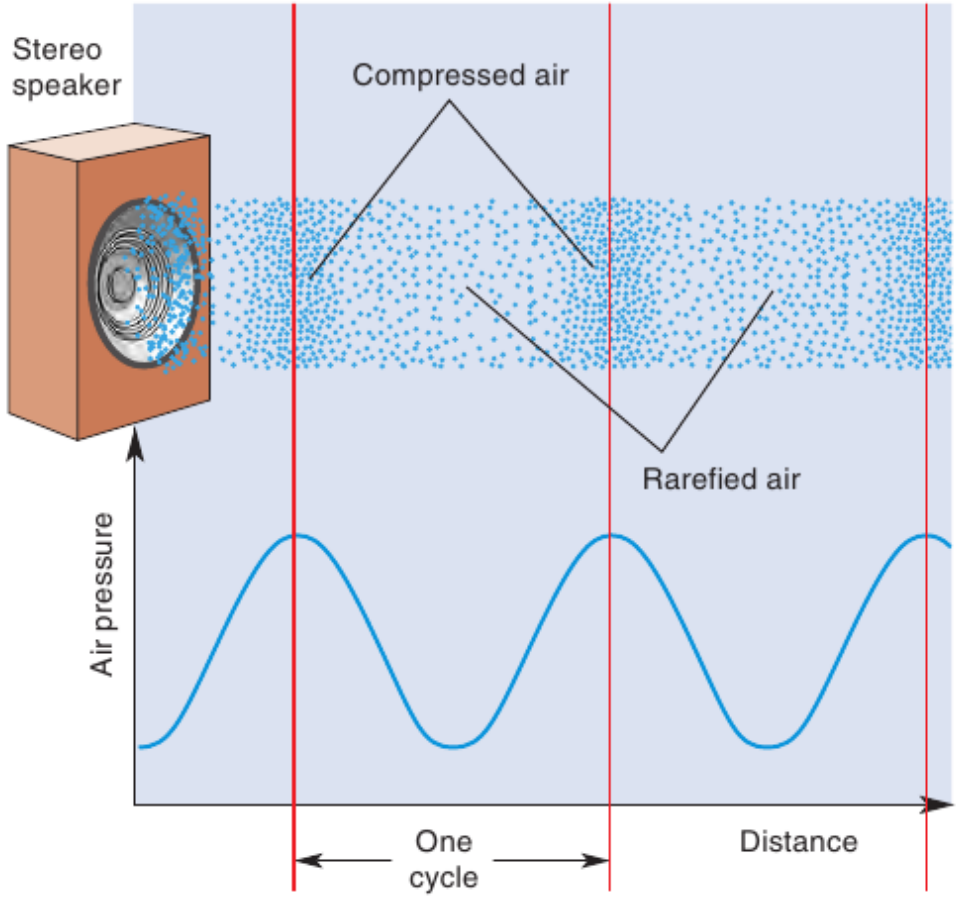
- Trace model more accurately predicts data
- Trace model is preferred over cohort model

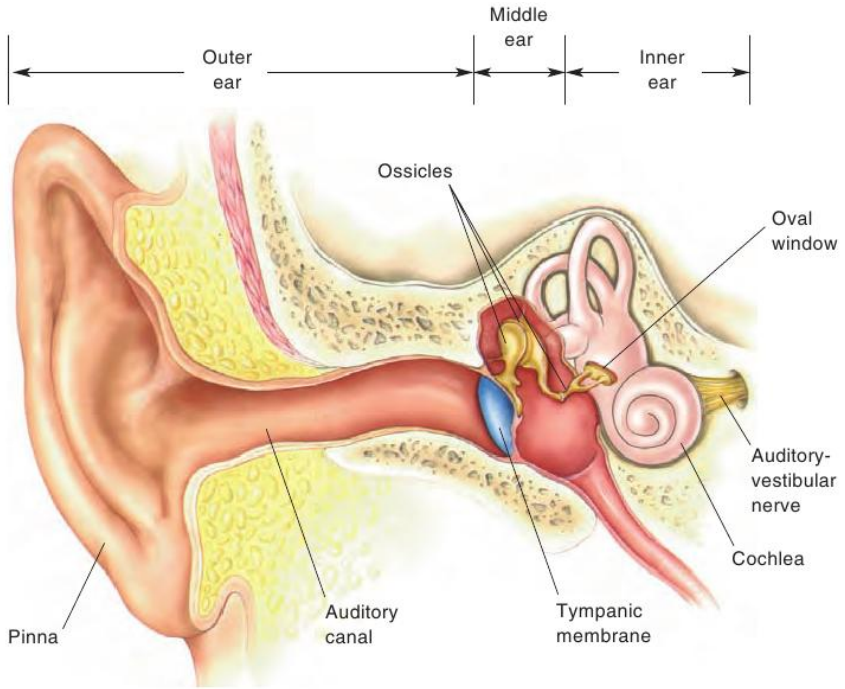
Auditory perception and brain

- What is sound?

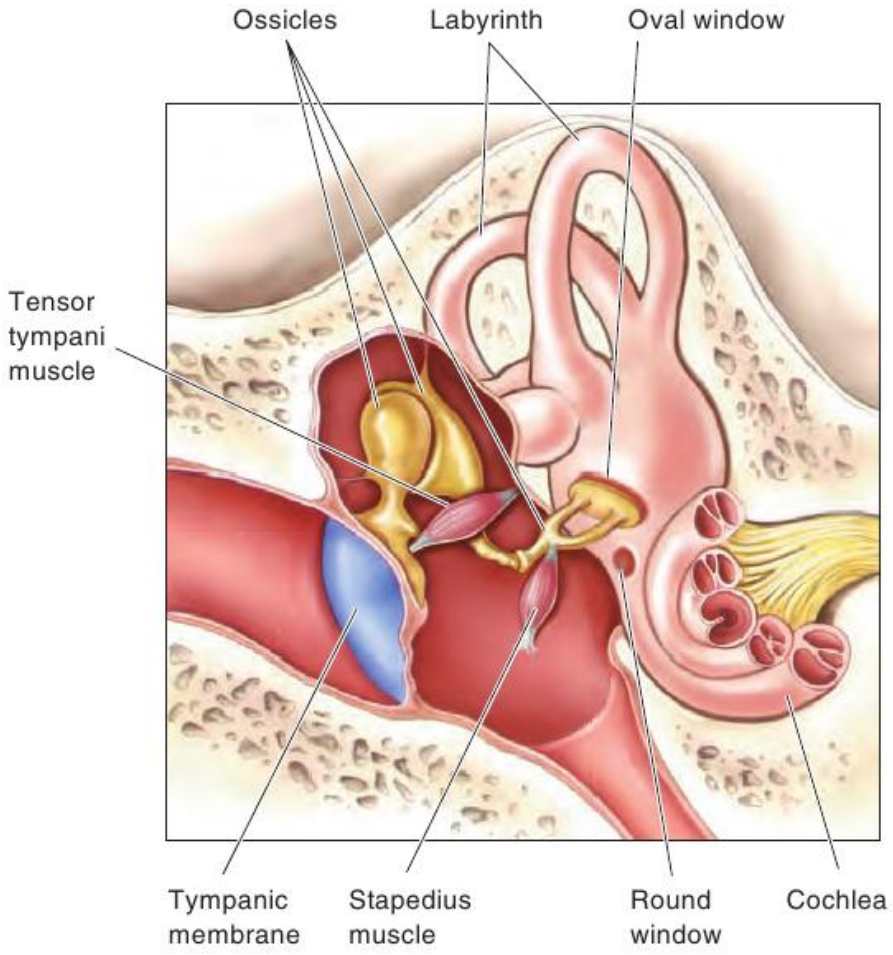


Auditory perception and brain

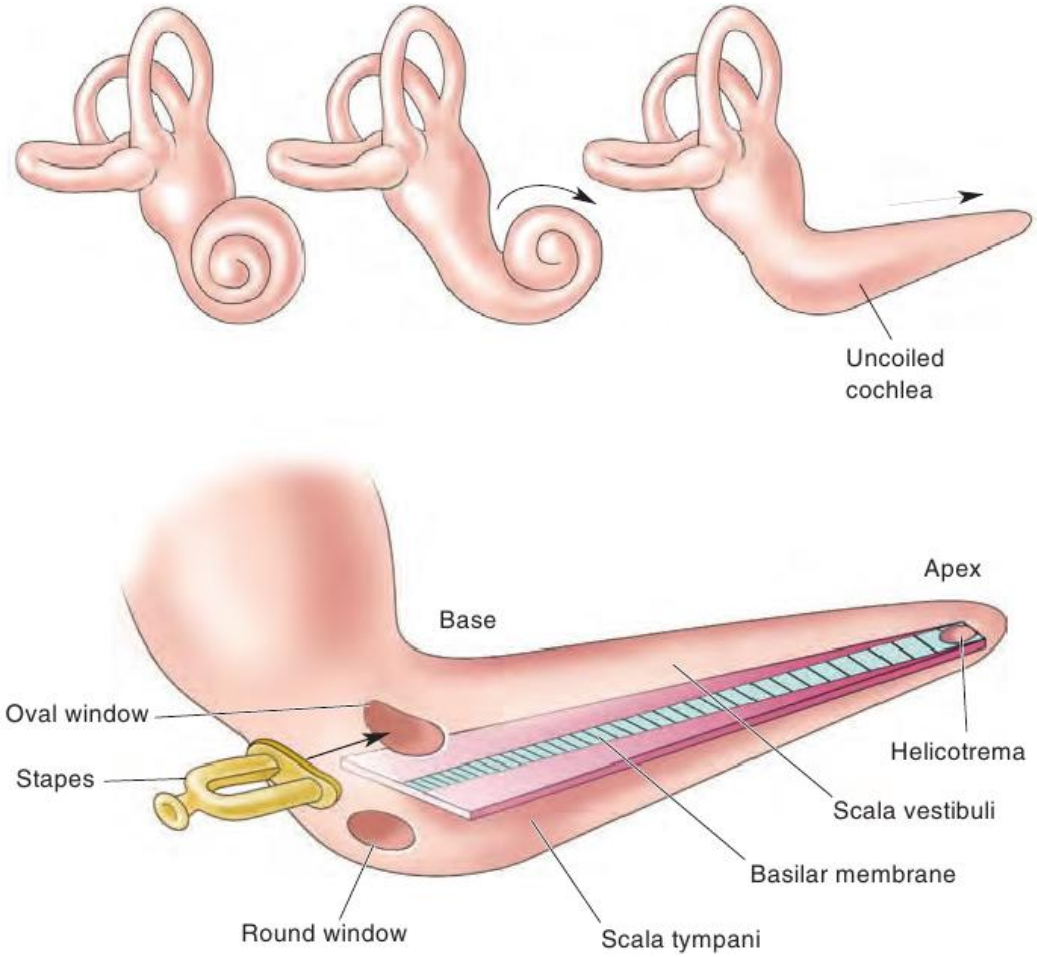
- How does the brain process auditory information?



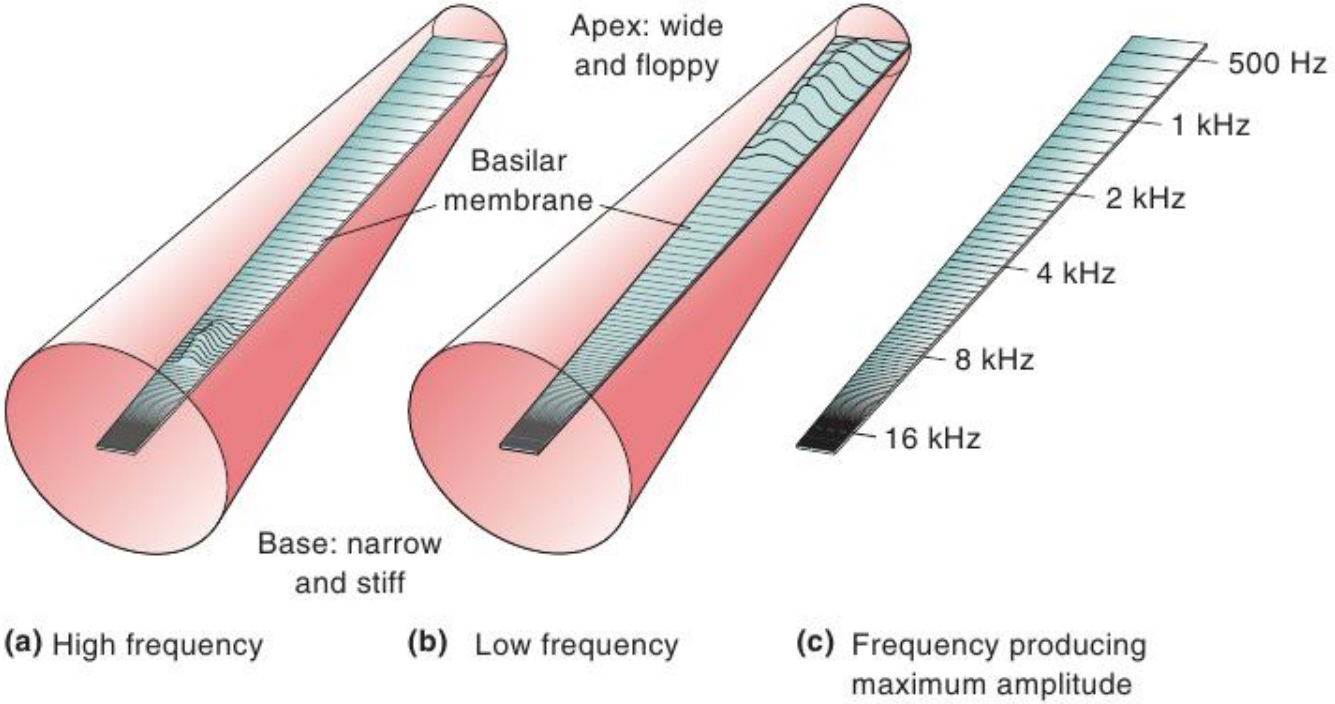
Auditory perception and brain



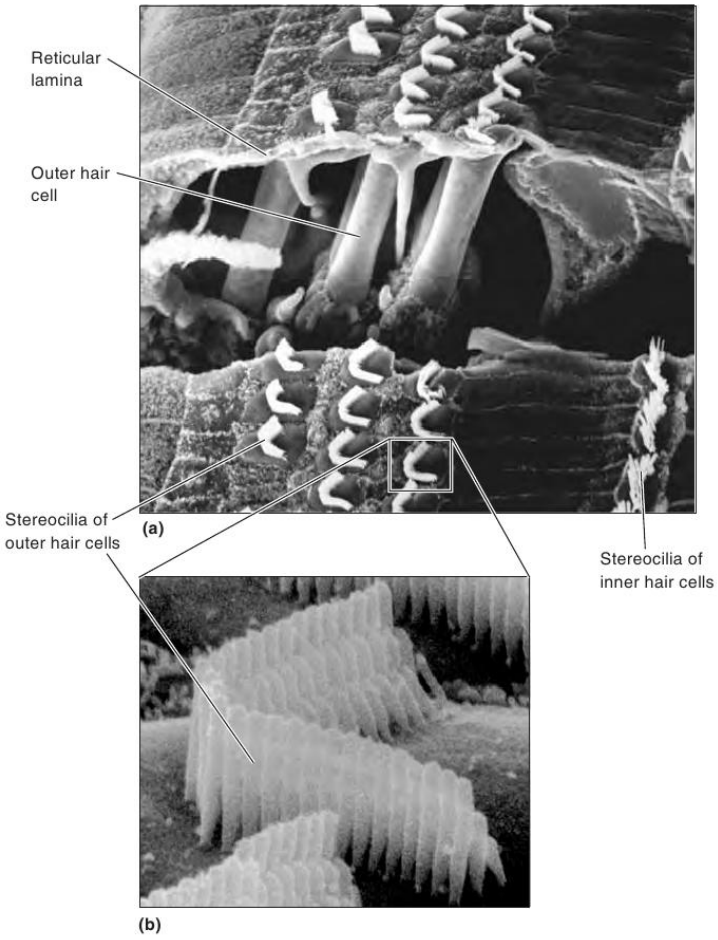
Auditory perception and brain



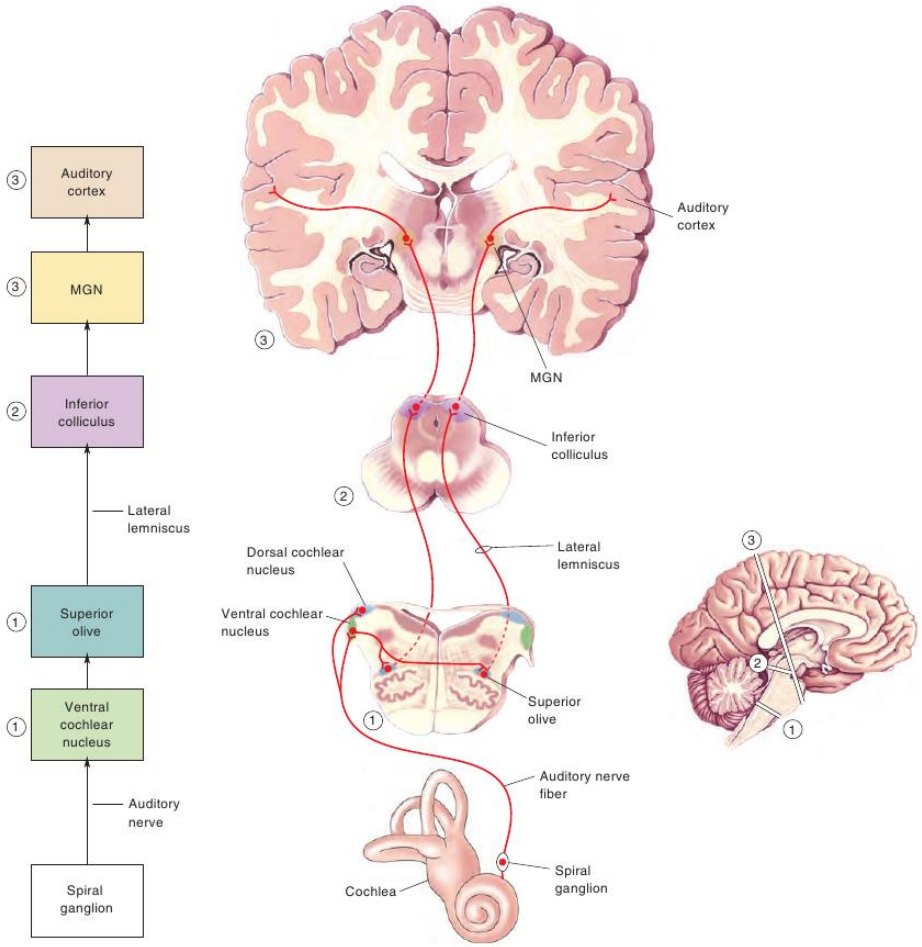
Auditory perception and brain



Auditory perception and brain



Auditory perception and brain



Auditory perception and brain

- Main points here:
  - Sound is pressure waves
  - They are transduced into electrical information in your ear
  - The brain processes this electrical information
  - The brain DOES NOT process sound!

Summary

- Bottom up vs top-down in speech perception
  - Phoneme restoration effect
- Stages in spoken word perception
  - Access stage
  - Selection stage
  - Integration stage
- Cohort and TRACE models
  - Evidence that has been used to distinguish them
- Auditory perception and the brain
  - Brain does not process sound