Categorization and abstraction in perception

LING611 Spring 2021

Brian Dillon
Shota Momma

University of Massachusetts, Amherst
Department of Linguistics

2/3/2021

Today's goals

Our discussion today will touch on:

- Subcategorical detail in perception
- Acquisition of categories and distributional learning

Scene setting

⇒ This is Loki, an expert, probability-matching treat forager. He knew you do better finding treats if you know not just *where* they are, but *how likely* it is for a treat to be someplace. Tracking probabilities helps deal with uncertainty (i.e. *where are the treats??*).

Scene setting

Dealing with uncertainty is arguably a central problem in language processing. Do language users manage uncertainty about linguistic structure in the input like Loki managed uncertainty about treat locations?

- Do we track subcategorical (probabilistic) cues to linguistic categories?
- Do we exploit these cues in processing linguistic input?
- Do learners exploit ‘structured variation’ to discover categories in their experience?

Tracking activation in real-time: The visual world

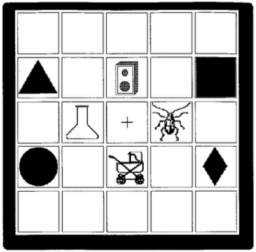
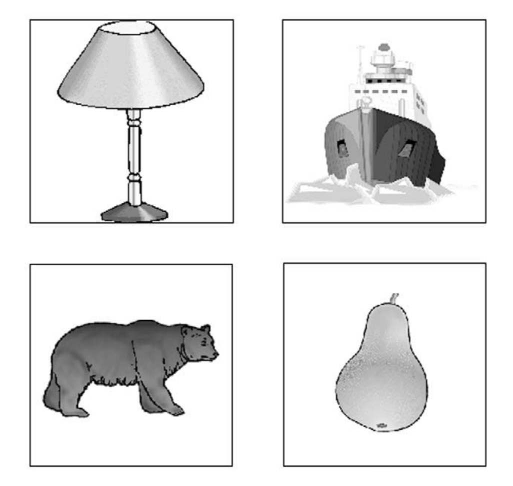


FIG. 3. An example of a stimulus display presented to participants.

Allopenna et al., 1998

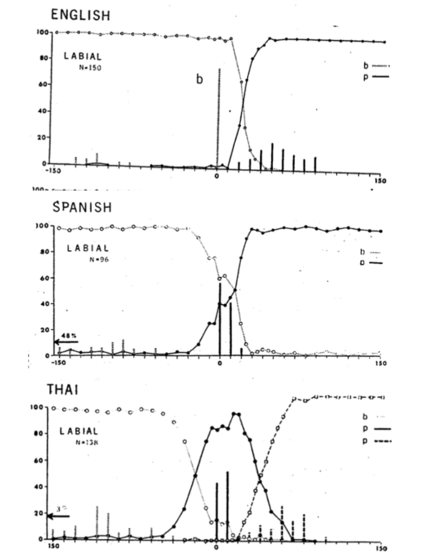
⇒ **Eye-mind hypothesis** (Just & Carpenter, 1980): Eye movements (probabilistically) reflect contents of active attention (cf Magnuson, 2019). A hypothesis about how cognitive events are related to observable measures is called a *linking hypothesis*.

McMurray et al (2002)



⇒ /bɛɹ/ vs /pɛɹ/ are (categorically) distinguished by voicing. But are listeners sensitive to subcategorical *degree* of voicing?

Distribution of VOTs by language



McMurray et al (2002)

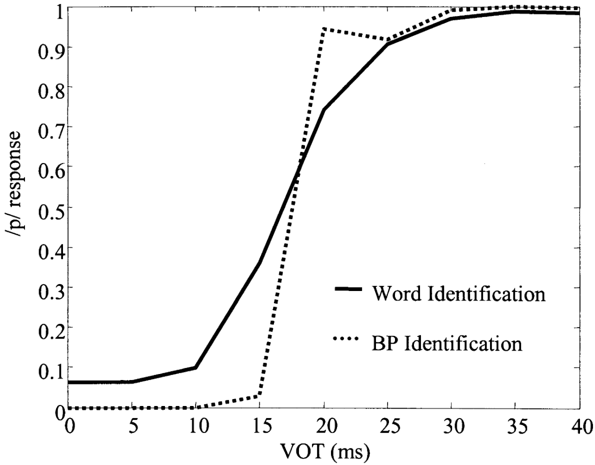


Fig. 2. Identification curves (from mouse clicks) pooled across all subjects for the word and BP identification tasks. Shown is the proportion of trials in which the p-item was selected as a function of VOT.

McMurray et al (2002)

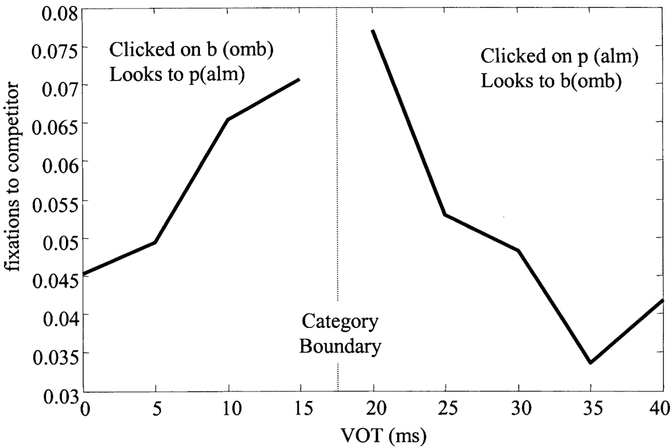


Fig. 3. Mean proportion fixation to the competitor picture as a function of VOT. The left panel displays trials in which the subject responded /b/- (and the competitor was the p-item). The right panel displays trials in which the subject responded /p/- (and the competitor was the b-item). A clear gradient effect of VOT can be seen.

McMurray et al (2002)

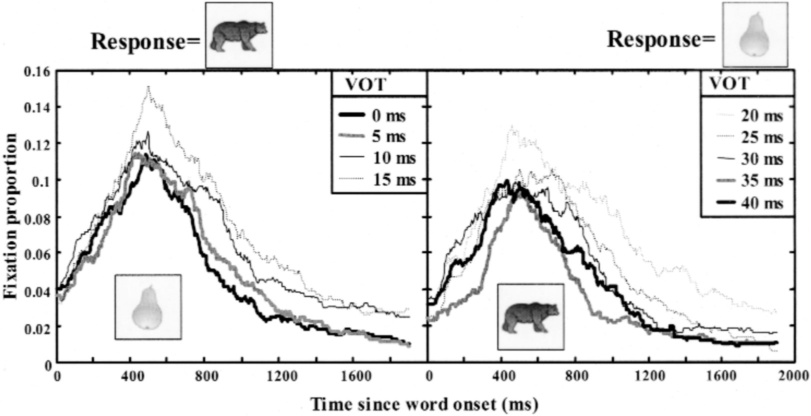


Fig. 7. Effect of VOT and time on fixations to the competitor. A clear gradient effect of VOT can be seen. Importantly, the effect of VOT is primarily on the duration of activation.

Key takeaways

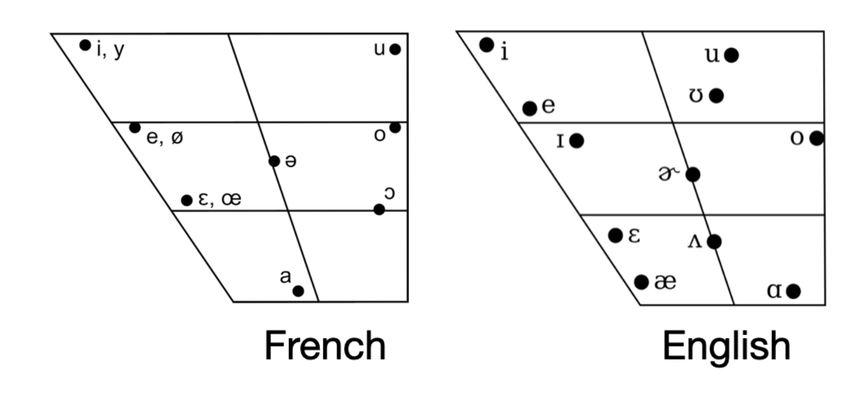
- Lexical competitors activated as a gradient function of VOT: As you approach the category boundary, the activation of the competitor increases.
- Activation of the competitor was not short-lived: Competitors seem to remain active in proportion to their likelihood for upwards of a second after the ambiguous segment.
- McMurray et al's hypothesis: Subcategorical distinctions are preserved and maintained by listeners to deal with ambiguity / uncertainty. Listeners track what VOTs make a good instance of /p/ or /b/ and exploit this information 'online' during language comprehension.
- **Example:** The /d̥/ent in the fender/woods (Connine, Blasko & Hall, 1991).

Scene setting

- Do we track subcategorical (probabilistic) cues to linguistic categories?
- Do we exploit these cues in processing linguistic input?
- Do learners exploit ‘structured variation’ to discover categories in their experience?

The adult state

How do learners discover phonetic / phonological categories? Consider the target of acquisition: Languages vary not just in the number and character of phonetic / phonological categories, but also the fine phonetic details of those categories:



The conditioned head turn procedure

What do pre-verbal infants know about phonetic categories? The **conditioned head turn procedure** provides one tool. One standard use: Condition infants to turn their head and look at a 'reinforcer' when there is a change in a stream of speech stimuli (Werker et al., 1997).

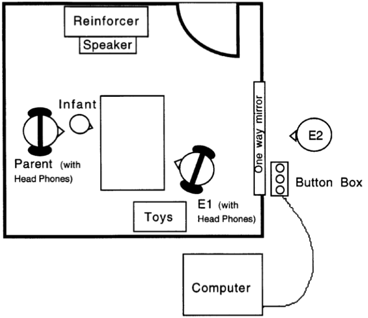
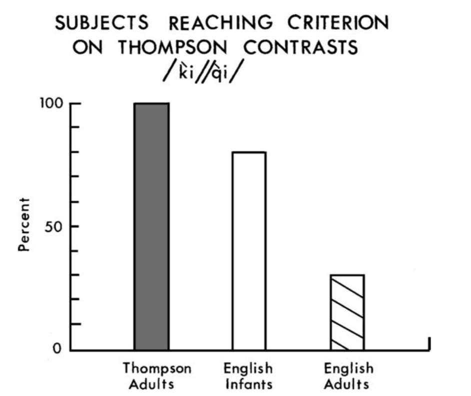


Figure 1. A schematic diagram of the Conditioned Head Turn procedure.

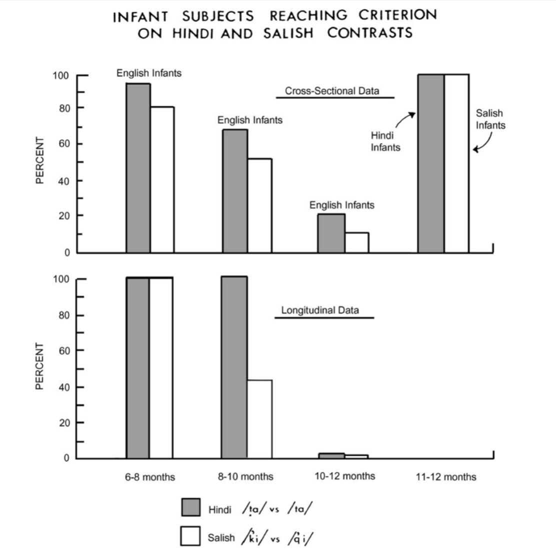
Werker & Tees (1984)

How well can adult English speakers distinguish place of articulation in a /k'/ - /q'/ contrast (e.g. Thompson Salish)? Or in a /t̪/ - /ʈ/ contrast (e.g. Hindi)?



Werker & Tees (1984)

What about infants?



Habituation paradigm

- Orient infant to visual display; play stimulus until looking time drops to pre-determined threshold (e.g. they 'get bored'.
- At habituation, continue play same stimulus on **same** trials, or change stimulus on **change** trials
- If infants detect a change, they will dishabituate and look more at the display. Increase in looking times for **change** trials compared to **same** trial baseline indicates discrimination.

Narayan et al. (2010

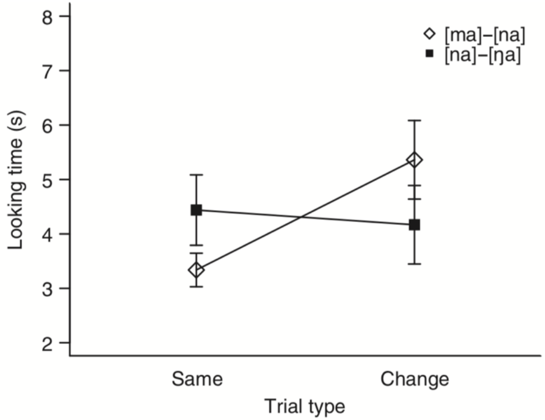


Figure 4 *English-hearing infants' (at 4–5 months) looking time to same vs. change trials for the native [ma]–[na] and non-native [na]–[ŋa] contrasts. Error bars represent standard error.*

Distributional learning

Do learners exploit 'structured variation' to discover categories in their experience?

Distributional learning: A hypothesized learning procedure that leverages structured variation in the input to 'infer' the latent structure of the input. Common examples:

- The number of 'peaks' in a VOT distribution may signal number of voicing categories.
- Dips in transitional probability between syllables in a word may signal a word or morpheme boundary.

Maye et al (2002)

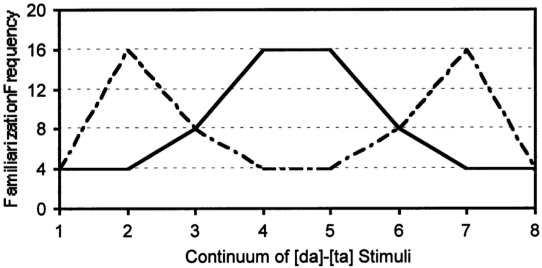


Table 1
Mean (SE) looking times for infants in each age group and familiarization condition on Alternating and Non-Alternating trials

	Alternating trials (s)	Non-Alternating trials (s)
6 months Unimodal	4.85 (0.47)	4.53 (0.51)
8 months Unimodal	4.98 (0.63)	5.20 (0.56)
6 months Bimodal	5.66 (0.44)	6.41 (0.32)
8 months Bimodal	5.45 (0.52)	6.15 (0.56)

Novelty preference

Stepping back

- Listeners recover abstract linguistic categories during perception...
- ... but are sensitive to, and maintain information about, subcategorical or probabilistic cues to those categories.
- The distributional structure of the input may also be used by learners to detect hidden structure.