Language-specificity in processing, and its origins

Anne Cutler

ARC CENTRE OF EXCELLENCE FOR THE DYNAMICS OF LANGUAGE

MAX PLANCK INSTITUTE FOR PSYCHOLINGUISTICS

WESTERN SYDNEY UNIVERSITY

The MARCS Institute for Brain, Behaviour and Development

1970s: Language-specificity in processing?

RT to phoneme targets was slower after an ambiguous word (1).
It turned out that the ambiguous word in such experiments was often shorter than its unambiguous control (2).
With ambiguity & control of equal length (3), RTs did not differ; after an ambiguous word that was longer (4), RTs were faster.

1. The men started to drill/march before the order to do so
2. Paul took a pipe/cigar down from the rack in the store
3. La dame a acheté une glace/dinde pour offrir à sa fille
4. Le film s'appelle 'L'héroïne/Le tigre disparut à Hong-Kong'

Might the language difference have affected the results?

(Foss, *JVLVB*, 1970; Foss & Swinney, *JVLVB*, 1973; Foss & Jenkins, *JVLVB*, 1974; Cairns & Kamerman, *JVLVB*, 1975; Swinney & Hakes, *JVLVB*, 1976; Mehler, Segui & Carey, *JVLVB*, 1978)

Language-specificity in processing?

- *A strong claim about human sentence comprehension is that the processing mechanism is fully innate and applies differently to different languages only to the extent that their grammars differ.* 1998
- *The HSPM:*
- *Does the HSPM compute syntactic structures always in an incremental manner, or is incremental parsing restricted to certain structures?* 2019
- *One of the most impressive features of the HSPM is that it takes the continuous speech stream and segments it into separate words.* 2013

Speech segmentation

Spoken messages consist of words in a continuous stream.
To understand messages, listeners must find the component words – i.e., segment the speech stream.

Segmentation is the core of adult speech recognition

In adults it is a language-specific process, drawing inter alia on rhythmic structure:

- ❖ STRESS-based in English and in Dutch
- ❖ SYLLABLE-based in French and in Korean
- ❖ MORA-based in Japanese and in Telugu

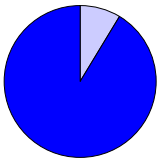
(Mehler et al., 1981; Cutler et al., 1983, 1986, 1987, 1989, 1992; Cutler & Carter, 1987; Cutler & Norris, 1988; Otake et al., 1993; Cutler & Otake, 1994; Vroomen et al., 1996; Murty et al., 2007; Kim et al, 2008)

1. Language-specificity in segmentation

- Language-specificity in speech segmentation is indisputable. The phonology demands it.

Infants also receive continuous speech

Speech to an infant 6-9 months



(Van de Weijer, 1999)

So infants must also learn to segment speech

(luckily, they are sensitive to speech rhythm)

(Nazzi, Bertoncini & Mehler, 1998, Christophe & Morton, 1999)

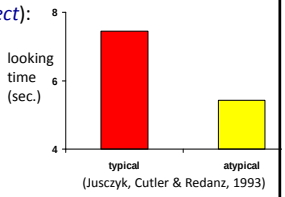
Speech segmentation in the 1st year of life

Using HPP: 9-month-old AmEng-learners prefer typical words (*pliant*, *rector*) over atypical words (*imply*, *correct*):

They can only have learned this by successfully segmenting speech.

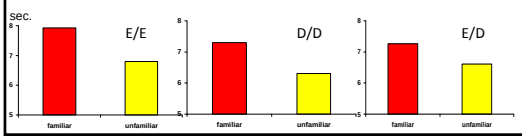
With HPP used as a direct test of continuous-speech segmentation,

(Jusczyk & Aslin, 1996; Jusczyk, 1998)



(Jusczyk, Cutler & Redanz, 1993)

9-month-olds learning either AmEng or Dutch proved to segment speech similarly:



(Jusczyk, 1998; Kuijpers, Coolen, Houston & Cutler, 1998; Houston, Jusczyk, Kuijpers, Coolen & Cutler 2000)

Speech segmentation in infant brains

Infants first hear words (in isolation or in sentences), then continuous sentences containing either the familiar words, or other words. ERPs are recorded.

At test, familiarized words evoke a significantly more negative response than unfamiliar words, appearing left frontally in the brain, ca. 500ms post word onset.

10 months

It is like the adult negative-going response to repeated items.

In bisyllabic Dutch words, the infant brain responds to the stressed syllable (*tijger, getij*; cf. Eng. *target, guitar*); measuring from word onset, the response does not look like a recognition response, but if measured from stressed syllable onset, it does.

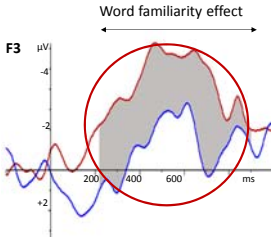
(Kooijman, Hagoort & Cutler, 2005, 2009)

Infant segmentation with only continuous speech

10-month-old infants hear sentences all containing a given word, e.g., *drummer*. Then they hear sentences either with the same familiarized word or another word:

Hij was drummer van een band
Een goede drummer heeft werk
De grote trom was van een drummer
De populaire drummer zong graag
Veel fans waren gek op de drummer
Elke band heeft een drummer nodig
Voor de drummer stond alles klaar
De leuke drummer hield van slagroom

De mus heeft een drummer gehoord
Een leeuw maakt fakirs bang
Die enge fakirs zijn magisch
Meteen sloeg de drummer zijn slag



Difficult task – more variability – but overall, negative response in familiarization AND test

(Junge, Cutler, & Hagoort, 2014)

The *CLCL*: achieving lexical segmentation

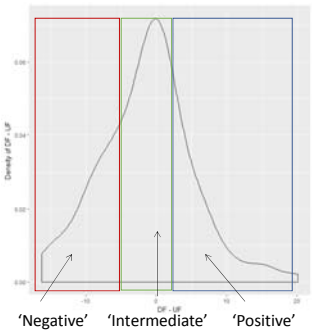
113 Australian 9-month-olds

The *Canberra Longitudinal Child Language* project: a group of 100+ children, from 9 months to age 5.

At 9 months we test their ability to extract word-forms from speech.

We used only continuous-speech exposure (as in Junge et al. 2014); this task is hard, and so we found considerable individual variability in the response patterns (QED).

Approximately one-third showed a negative-going response to the familiarized word.

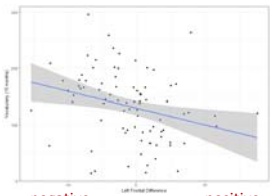


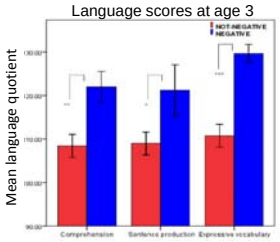
(Kidd, Junge, Spokes, Morrison & Cutler, 2018)

Segmentation ability predicts later language skills (1)

In the CLCL, relative ERP negativity at 9 months predicts vocabulary size (parent reports by standard questionnaires) at 15 months.

This replicates the finding by Junge for Dutch: presence and strength of ERP response predicted language skills, up to 3 years of age.





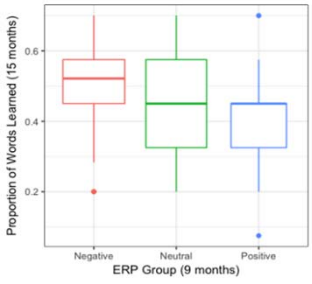
(Kidd, et al., 2018; Kooijman, Junge, Johnson, Hagoort & Cutler, 2013; Junge, Kooijman, Hagoort & Cutler, 2012; Junge, Cutler & Hagoort , 2014; Junge & Cutler, 2014)

Segmentation ability predicts later language skills (2)

Relative ERP negativity at 9 months also predicts CLCL participants' cross-situational word learning scores at 15 months:

32 training trials: 2 named objects

16 later test trials: 2 objects, only one named – do infants look at the object that was previously given that name?



(Donnelly, Kidd, Mulak & Escudero, 2017; Kidd et al., 2018)

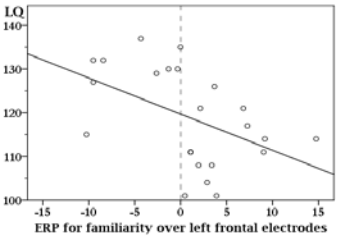
CLCL segmentation ability does not predict all skills

Relative ERP negativity at 9 months is however not related to CLCL children's later production vocab. (or its growth, from 9-30 months).

Social communication measures including adult vocabulary count are related to child production vocabulary growth. (Kidd et al., in prep.)

This suggests some interesting new paths to explore.

For instance, it contrasts with results from the Dutch studies, including word production at 3 years:



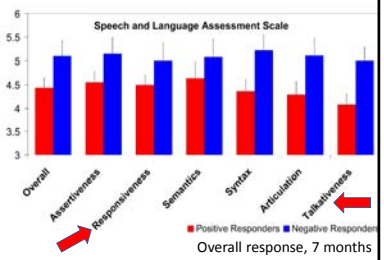
Negativity at 7 months

(Kooijman, Junge, Johnson, Hagoort & Cutler, 2013)

Dutch segmentation ability predicts more

As well as the Speech and Language Assessments (by parents) at 3 yrs:

Further, using again a harder task (initial exposure in continuous speech), the Dutch findings showed correlation between 10-month-olds' segmentation ability and their production vocab. at 24 months.

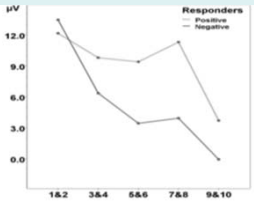


Overall response, 7 months

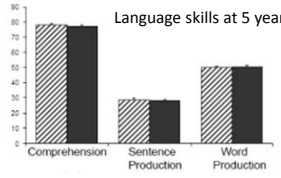
(Kooijman, Junge, Johnson, Hagoort & Cutler, 2013)

Junge, Kooijman, Hagoort & Cutler, 2012)

Though the Dutch results also do not predict forever

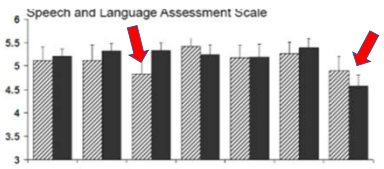


Groups at 10 months



NO significant relationships between the 10-month-old response pattern and the 5-year-old performance measures or (most) ratings

(Junge & Cutler, 2014)



= responsiveness; talkativeness

2. Language-specificity in the predictive power of early speech segmentation ability?

- The phonological structures of English and Dutch demand the same segmentation response. The lexical asymmetry (strong-initial words are way more likely than weak-initial) is especially clear in the input that infants receive:

Lexical Words:	S-initial	W-initial
English lexical data	.902	.098
English infant input	.968	.032
Dutch lexical data	.883	.117
Dutch infant input	.971	.029

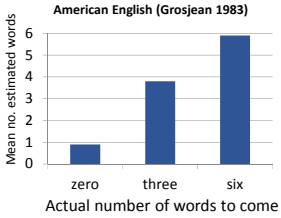
- Why should picking up on this asymmetry correlate (or not) with language production a few years later? A language-based explanation may not be required.

3. If not language-specificity, then what?

- There are multiple sources of variability
- In the case of infant environments, the variability may run from individual differences through community factors (SES? Work/parenting patterns? Interlocutor availability?) to cultural expectations.
- Such factors may accidentally co-vary with language
- Or indeed with language variety
- Varieties can also differ phonologically in a way that might affect processing. In that case, such a claim is worth checking

Testing a possibly variety-specific processing claim

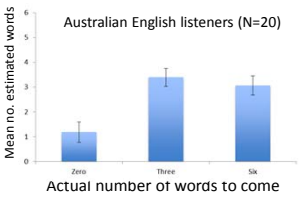
- Are there speech cues to how long an utterance will be?
- *Yesterday James fixed the lock on the door of his car*
- 1983: At the first phrase boundary (*lock*) AmEng listeners could tell whether 0 or 3 or 6 words were coming
- This result could not be replicated in French
- Or in German
- Or in several L2 groups (with L2 English or German)
- The response was always: It's finished, or it isn't



(Grosjean, 1983; Grosjean & Hirt, 1996; O'Brien, Jackson & Hendricks, 2013; Jeske, Kember & Cutler, 2016)

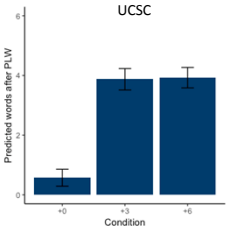
How long is an Australian English sentence?

- What about another variety of English?
- Again, it is either finished or not finished
- Could there be a variety-specific pattern?
- E.g.: Australian English has "uptalk" – final pitch rises
- Could this make syntactic boundary cues less reliable?
- (A plausible effect of such a difference)
- So how about US listeners, more than 3 decades on?



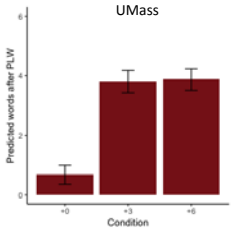
Sentence length: p < .001
0 vs. 3, 0 vs. 6: p < .001
3 vs. 6: n.s.

How long is an (Am)English sentence (in 2019)?



32 listeners (U. Calif. Santa Cruz); same materials; male talker. Acoustic realizations as in 1983 (Boston) and 2018 (Sydney)

0 vs. (+3 and +6)	p<0.001
+3 vs. +6	p =0.78



Ditto, except at Univ. Massachusetts

0 vs. (+3 and +6)	p<0.001
+3 vs. +6	p =0.63

(Rysling, Clifton, Van Handel, Geguera, Choi & Cutler, 2019. *CUNY Sentence Processing Conference*)

4. Variety-specificity?

- The "how long is the sentence?" effect probably wasn't variety-specificity after all
- There may be no telling what it was in 1983 (the original recordings have been destroyed)
- (My colleagues are still trying some idiosyncratic individual-based explanations; watch this space)
- Listener adaptability is extensive, and individual-specific cues are actually common

Consider the "predicted-accent" effect

Target: /b/

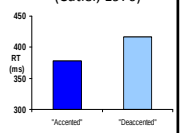
The couple had quarrelled over a book they had read

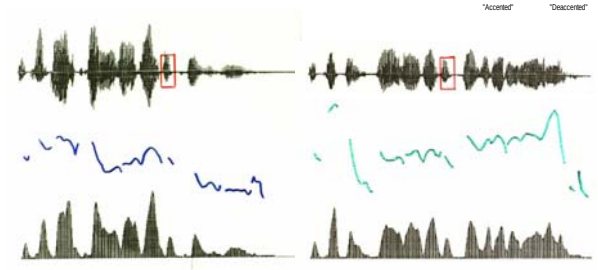
The couple had quarrelled over a book they hadn't even READ

book

The couple had quarrelled over a book they had read

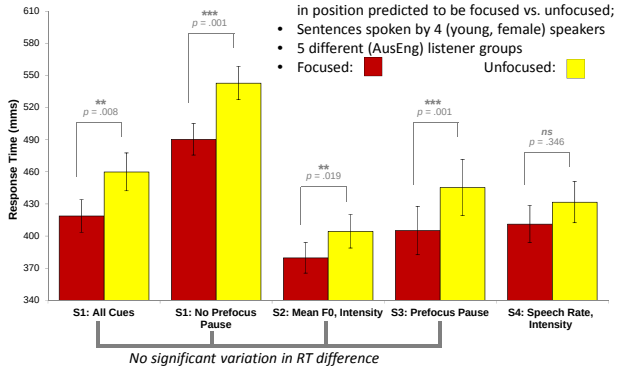
(Cutler, 1976)





Speakers of English: Different cues to focus placement

- Same task: phoneme detection on same word in position predicted to be focused vs. unfocused;
- Sentences spoken by 4 (young, female) speakers
- 5 different (AusEng) listener groups
- Focused: Unfocused:



(Ip & Cutler, *SST* 2018; 2019 submitted)

5. Specificity in processing?

- Not all processing differences across languages are signals of language-specificity, and not all processing differences across language varieties are signals of variety-specificity.

The role of IDS in lexical segmentation

Junge et al., 2014

Elke band heeft een drummer nodig

Voor de drummer stond alles klaar

De leuke drummer hield van slagroom

Meteen sloeg de drummer zijn slag

He held the trident high above

A brown beaver is hiding there

They always feed the sparrow seeds

He saw a wild eagle up there

Kidd et al., 2018

The role of IDS in lexical segmentation

Lexical segmentation by adult listeners shows the same pattern in British, American and Australian English, and in Dutch

Lexical segmentation by infant listeners shows the same pattern in American and Australian English, and in Dutch

Some researchers have failed to find infant segmentation for British English (though others have succeeded); the failure has been ascribed to use of exaggerated IDS by others

But the AusEng & Dutch studies had no exaggerated IDS

The language-specific segmentation patterns are based on the lexicon, which shows the same skew for all varieties of English

Infants themselves induce IDS from interlocutors

What variety-specific factors might control infants' desire for IDS, or for words?

(Smith & Trainor, 2008; Lam & Kitamura 2010, 2012; Kalashnikova et al., 2016)

Conclusion

- Language-specificity in speech segmentation is indisputable. The phonology (embodied in the lexicon) demands it.
- Is there language-specificity in the predictive power of early speech segmentation ability? A language-based explanation may not always be required.
- If not language-specificity, then what?
- Listener adaptability (extensive); individual-based cues (common)?
- Not all processing differences across languages are signals of language-specificity, and not all processing differences across language varieties are signals of variety-specificity.
- There is much more to be learned about the extent of variability, but let's ensure claims about specificity are plausibly motivated