An acoustic comparison of vowel systems in adult-directed-speech and child-directed-speech: Evidence from French, English & Japanese

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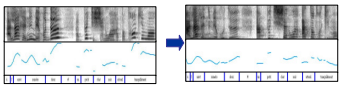
THEORETICAL ISSUES

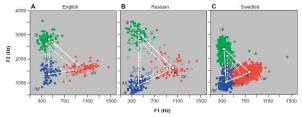
In child-directed speech (CDS), extreme simplification of syntax, semantic and phonological levels, but dramatic exaggeration of the prosodic level [1], [2], [3].



In particular, dramatic slow down of the speech rate which vary in function of the attentional state of the baby [2]**: Hyper-articulation (Lindblom's H&H theory** [4]**).**

In Kuhl & al. [5]**, mothers produce more extreme vowels in CDS than in adult-directed speech (ADS): Hyper-articulation of the 3 point vowels /i/, /a/ and /u/ in English, Swedish and Russian.**

Expansion of the vowel triangle from ADS to CDS on two axes, the high-low dimension (F1) and the front-back dimension (F2).



Questions

1) English, Swedish and Russian belong to the same rhythmic class, stress-timed languages.
What happens in languages from different rhythmic classes as moraic and syllable-timed languages?

2) In Kuhl's study, mothers had to produce specific CVC words during a 20 minutes conversation. This constraint could influence them to produce more hyper-articulated words.
What happens in a less constrained speech condition as reading a story to a child?

The present study examined if vocalic systems are extended in CDS in three rhythmically different languages (English, French & Japanese). To compare ADS and CDS, we use a less constrained speech condition, telling the same story to a child and to an adult.

METHOD

15 speakers

-5 English mothers.

-5 French mothers.

-5 Japanese mothers.

-All mothers recorded in France, but they spoke to their babies in their native language since birth.

-Age of babies ranged between 6 and 22 months (mean age: 13 months +/- 5 months).

Recordings

-Minidisk recorder (Sony MZN-910S) and unidirectional Philips SBC-MD695 microphone.

-Story taken from a French child story book and translated in English and Japanese.

-Mothers had to read this story to a familiar adult (ADS modality) and to their child (CDS modality).

-Recordings were dissociated in time in order for modalities to be much more differentiated and made at home, by father or a familiar person in order to obtain the most natural speech condition.

Acoustic and statistic analyses

Acoustic analyses

Number of vowels (965) per language and per vowel:

	ADS			CDS		
	i	a	u	i	a	u
English	119	40	25	120	40	23
French	119	125	60	133	144	80
Japanese	151	233	93	175	249	107

1) Sentences sampled at 22 kHz, 16 bits, mono;
2) Automatic extraction of F1, F2, F3 with "Burg" Praat algorithm (12.5 ms Gaussian window, 5 ms step) at the temporal mid-point for /i/, /a/ and /u/;
3) Conversion of formant frequencies to Barks for normalization;
4) Automatic extraction of *ƒ0* for all segments.

Statistical analyses

-MANOVAs on each formant:

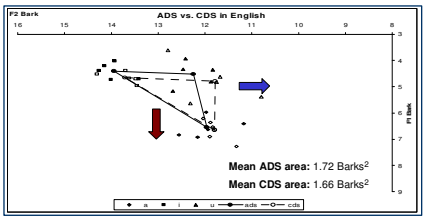
1) Speech's modality (ADS vs. CDS);
2) Language (French vs. English vs. Japanese);
3) Speaker (15 mothers).

-Student T-Test on F1-F2 and F1-*ƒ0* on each vowel.

-Convex Hull method for Vowel dispersion areas.

RESULTS

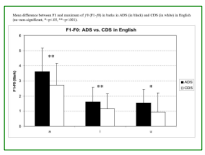
1) English ADS vs. CDS



-**Slightly reduction of the vowel triangle area in CDS** in a proportion of 3.49 % from ADS to CDS (ns).

-**High-low dimension (F1):** Downward shift of the vowel space from ADS to CDS (/i/ is more opened in CDS, higher F1 value, p<.05).

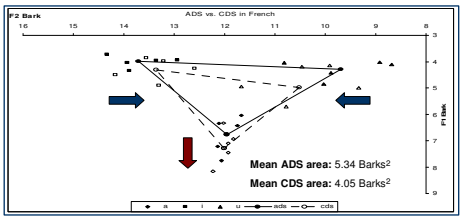
-**Front-back dimension (F2):** /i/ is backed (lower F2 value, p<.05), but no significant effect for /a/ and /u/.



-**F1-*ƒ0* difference more reduced in CDS for the 3 vowels** because of an important increase of *ƒ0* from ADS to CDS in English: + 4 semi-tones).

-**High correlation degree between the children age and vowels area** (r=0.94). Vowel area size increases as the child age increases.

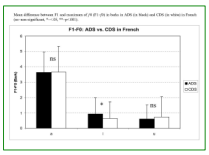
2) French ADS vs. CDS



-**Larger vowel triangle area in French for both modalities and greater reduction in CDS** in a proportion of 24.35 % from ADS to CDS (ns).

-**High-low dimension (F1): Downward shift of the vowel space from ADS to CDS** for the 3 vowels (higher F1values, p<.01 for /i/, p<.001 for /a/ and p<.0001 for /u/).

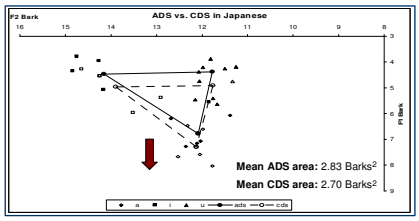
-**Front-back dimension (F2):** /u/ is fronted (higher F2 value, p<.0001), /i/ is backed (lower F2 value, p<.01) in CDS. No significant differences for /a/.



-**F1-*ƒ0* difference is reduced in CDS for /i/, but not for /a/ and /u/.**

-**High correlation degree between the children age and vowels area** (r=0.72): Vowel area size increases as the child age increases.

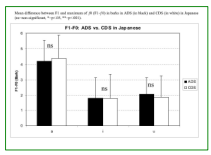
3) Japanese ADS vs. CDS



-**Slightly reduction of the vowel triangle area in CDS** in a proportion of 4.6 % from ADS to CDS (ns).

-**High-low dimension (F1): Downward shift of the vowel space from ADS to CDS** for the 3 vowels (higher F1values, p<.001 for /i/, p<.0001 for /a/ and p<.001 for /u/).

-**Front-back dimension (F2):** /i/ is slightly backed (lower F2 value, p<.05), /i/. No significant difference for /a/ and /u/.



-**F1-*ƒ0* difference is not reduced from ADS to CDS.**

-**Negative correlation degree between the children age and vowels area** (r=-0.49): Vowel area size decreases as the child age increases.

1) No expansion, but rather a reduction of vowel triangle and a shift on the high-low dimension (F1) in CDS: Closed vowels are more opened (higher F1) in CDS than in ADS in English, French and Japanese.

Nevertheless, F1 values could be affected by increase of *ƒ0* values from ADS to CDS, particularly strong in English [6].

2) On the front-back dimension (F2), variability could be explained by consonantal influences [7]**. /u/ was less extreme on this dimension.**

Vowel dispersion area differences across languages could be explained by the different position of "point" vowels across the 3 languages.

DISCUSSION

Why do mothers tend to produce more opened vowels when they address to their child, resulting in a downward shift of the vowel space on the high-low dimension (F1)?:

- **Babies need to match sounds and articulatory gestures produced by their mother.**
  Gestures carried out to produce more opened sounds, could be much more visually salient and easier to extract for the babies.
- **With a smaller vocal tract, babies produce more opened (higher F1) and more fronted (higher F2) vowels** [8].
  Mothers could try to match the productions of their babies, in an imitation play.

In English and in French, there is an effect of the babies' age on vowel area size which increases as the child age increases. *CDS characteristics seem to evolve with the age and abilities of the child* [9]**. Nevertheless, the "age" variable cannot validly been discussed, as the babies' age ranged between 6 and 22 months.**

CONCLUSION

Further investigations is needed to explore:

- **The effect of the babies' age on the vowel area size of their mothers. In fact, vowels and consonant could be pronounced more distinctively when the child begins to speak than when he is younger or older.**
- **If mothers tend to produce more opened or hyperaticulated vowels in spontaneous speech (natural child-mother conversations in longitudinal datas).**

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