From sound to words

– an acquisitional project and its relation to a model of phonotactics based on sonority

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English regular inflections

- 1. Is [z] (phonotactically) okay? If yes, choose [z]; if
- no, go to 2.
- 2. Is [s] (phonotactically) okay? If yes, choose [s]; if
- no, choose [ɪz].
- We can illustrate this procedure using *hens, dogs,*
- *cats, buses* as examples:
- 1. [henz] and [dɔgz] are (phonotactically) okay; but
- *[kætz] and *[bʌsz] are not.
- 2. [kæts] is (phonotactically) okay; but *[bʌss] is
- not; so [bʌsɪz]

Basbøll 1972, 2006

English regular inflections

- Because we know that speaker-hearers, including
- small children acquiring the language, are *sensitive to*
- *phonotactical patterns* in the language spoken around
- them, this is an interesting proposal from a psycholinguistic perspective.

- But where does the order [z] before [s] before [ɪz] come from?
-
- A reasonable answer will be: their frequency as plural endings (noun plural allomorphs) in the language. Basbøll 1972, 2006

Hypothesis

- The order of the early words follows the principle of increasing sound complexity. By complexity we mean that:

1. some speech sounds/sequences are more complex than others with regard to articulatory and perceptual features

2. the sound structure complexity furthermore depends on
   a) position of each speech sound (**phonotactic**: initial vs. final and single consonants vs. consonant clusters) and
   b) the word's **prosodic** pattern (stress and stød).

Phonological complexity

- According to the hypothesis, complexity appears in that:

1. words with simple sound structure appear before words with a more complex sound structure

2. the child simplifies the adult pronunciation so that more complex sounds are substituted by more simple sounds – not the other way around.

3. adults adjust their CDS to the child's developmental stage: more complex pronunciations later in CDS

Phonological complexity: metric?

- Measures inspired by Roman Jakobson (1941)
  - For ONE phonetic/phonological form
  - Some (loose!) suggestions
    - Vowels count zero
    - Consonants count 1 (basic)
    - Extra for complexity (e.g. vowels: in the order: a, i, u, e, o, ø)
    - for consonants: fricatives +1 compared to stops, affricates +1 compared to fricatives, etc.

Sonority envelope: metric?

- The sonority envelope is an independent measure (different from complexity)

- Danish is radically different from Swedish (its closest relative): much less diversified sonority envelope:
  - corresponding to Swedish (non-sibilant) obstruents, Danish has (non-lateral) approximants and glides, i.e. segments which belong to the same sonority class as vowels (viz. vocoids) [we use Basbøll's non-circular Sonority Syllable Model]

- We register "sonority sequences" as a measure for this aspect of sound structure (already operational in our system)

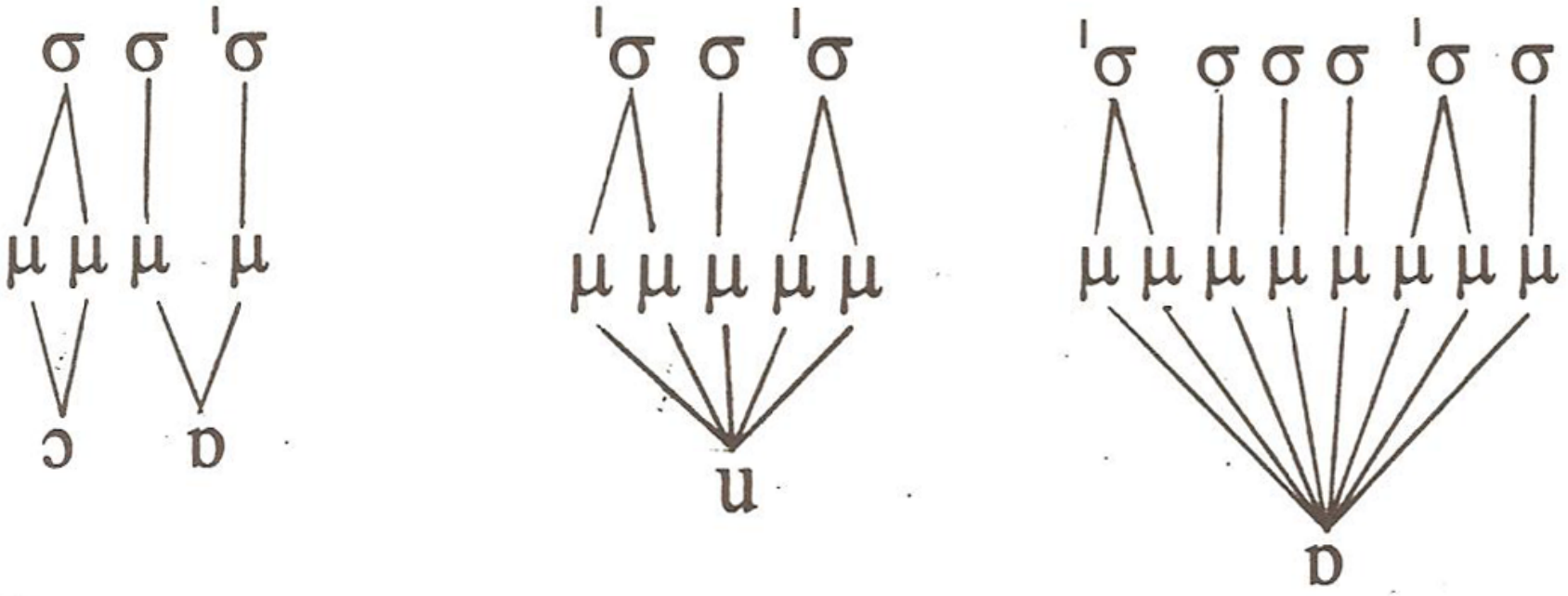
What about Danish (vs. Swedish)?

Combined effect of obstruent weakening and schwa-reduction (processes having started in the middle ages, cf. Swedish and Norwegian)

Gata
Koka
[gɑ:ta,
ku:ka]

Gade
Koge
[gæ(:)ð:,
kɔ(:)w:]

***Koge o(ver), (L)uge u(denfor), (H)årdere at åre(lade)*; Rischel 2003**



Sound structure in Danish||Swedish

Features causing indistinct sound structure	Danish	Swedish
coda lenition	yes	no
light stressed syllables	yes	no
schwa elision	yes	no
/r/ elision	yes	no
semi-vowel elision	yes	no
length vacillation	yes	no
word accents	no	yes
final lengthening	no	yes
compulsory sentence accent	no	yes
signal for utterance function	weak and global	strong and local

Strong prosodic cues making sound structure more distinct

From Nina Grønnum (see www.cphling.dk, cf. Grønnum 2003, 2005)

Weak preterite forms in Scand. (Bleses, Basbøll & Vach 2011)

	Spoken forms	No of syllables in suffix (0,1,2)	No of vowels in suffix (0,1,2)	No of sonority rises from the stem-final C (0,1,2)	Word accent cue for suffix (non-stød/ toneme 2) (0,1)
DANISH					
-ede	[lɔːu̯ːðː]	2	0	**0**	(1)
	[lɔːu̯ːð]	1	0	**0**	(1)
NORWEGIAN					
-et	[lɔːvət]	1	1	1	1
-a	[lɔːva]	1	1	1	1
SWEDISH					
-ade	[loːvɑdə]	2	2	2	1
-a	[loːvɑ]	1	1	1	1
ICELANDIC					
-aði	[lɔːvaðɪ]	2	2	2	0
-aðir	[lɔːvaðɪr̥]	2	2	2	0
-uðum	[lɔːvʏðʏm]	2	2	2	0
-uðuð	[lɔːvʏðʏð̥]	2	2	2	0
-uðu[3]	[lɔːvʏðʏ]	2	2	2	0

Bleses, Basbøll & Vach 2011

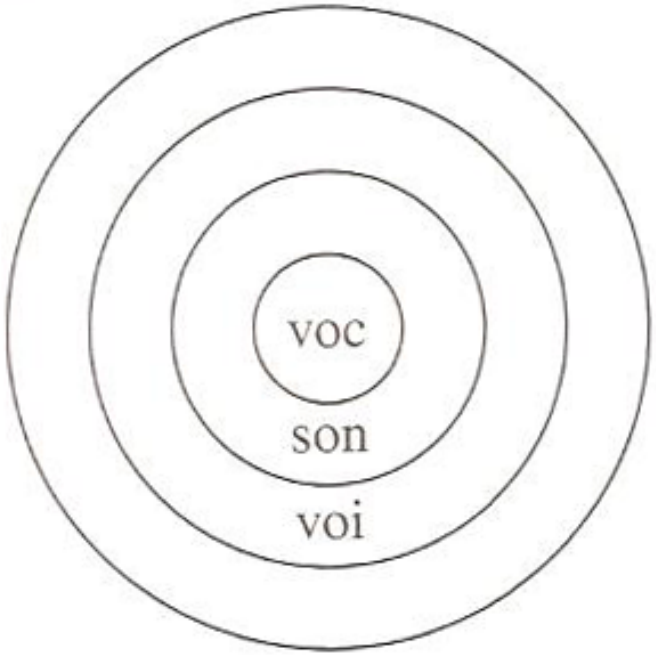
[on the concept of "sonority" and its history, cf. Sievers 1876, Jespersen 1897-99, Laver 1994, Blevins 1995, and many others]

	No. of boundaries	*No. of boundaries within vocalic sequences*	*Percentage of boundaries within vocalic sequences (%)*
Danish distinct	33.381	9.623	28.8
Danish reduced	20.087	6.406	31.9
Simulated Swedish/Norwegian	33.381	2.687	8.0

Note: Material: 47.757 Danish utterances containing 216.829 coded words.

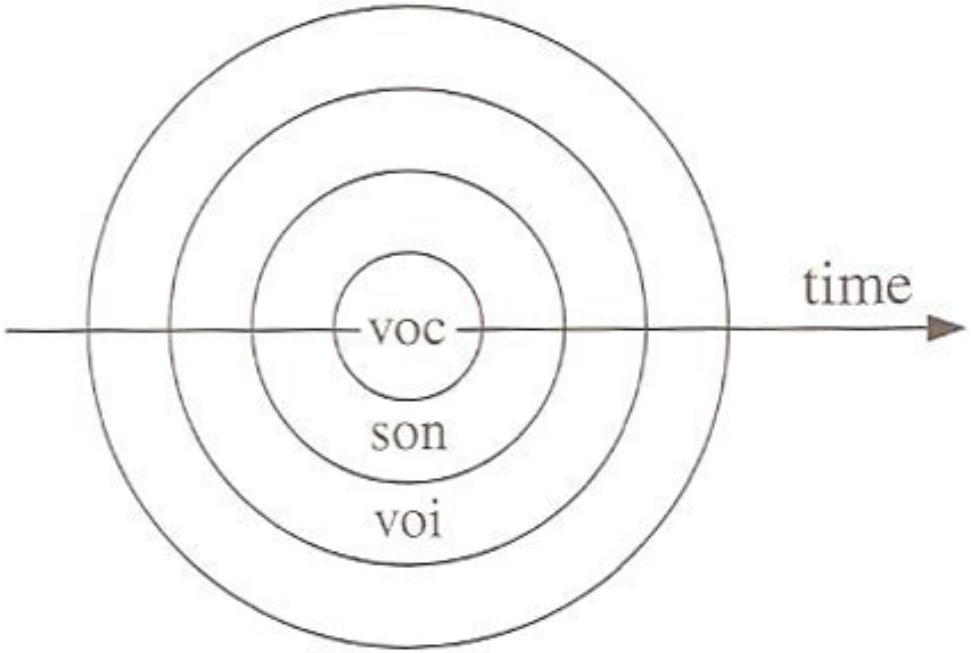
Universal logic of segment types
Basbøll's Sonority Syllable Model (SSM)

- Universal logic of segment types (general phonetics)
- Vocoids as the starting point (peaks universally)



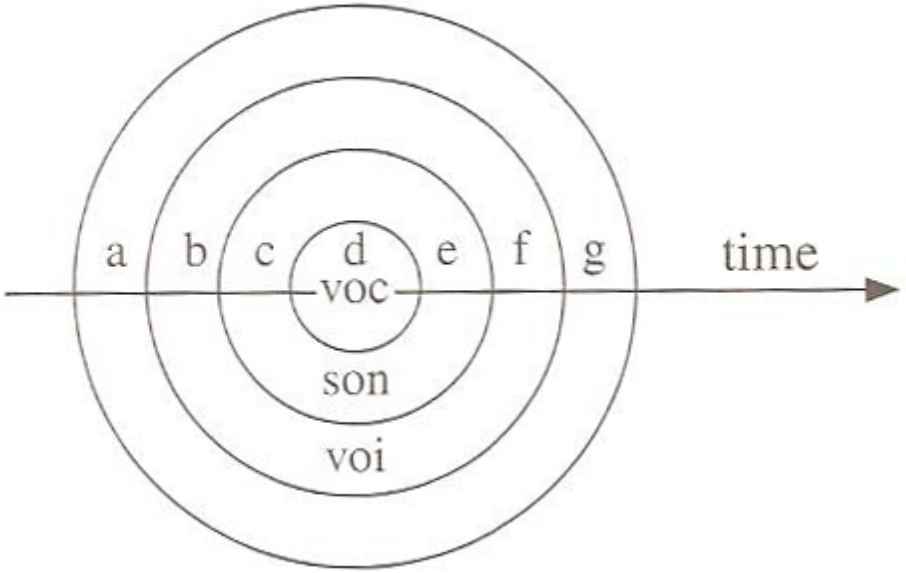
Introduction of time
Basbøll's Sonority Syllable Model (SSM)

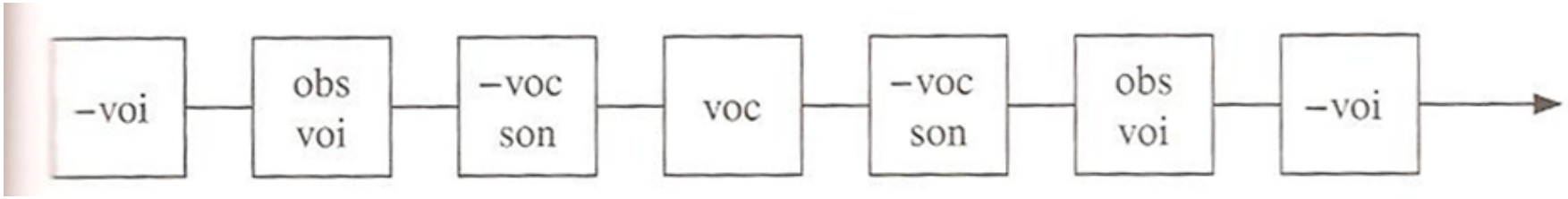
- Introduction of the time dimension turns the model into a Sonority Syllable Model (the logical force of the model)



Introduction of time: order classes

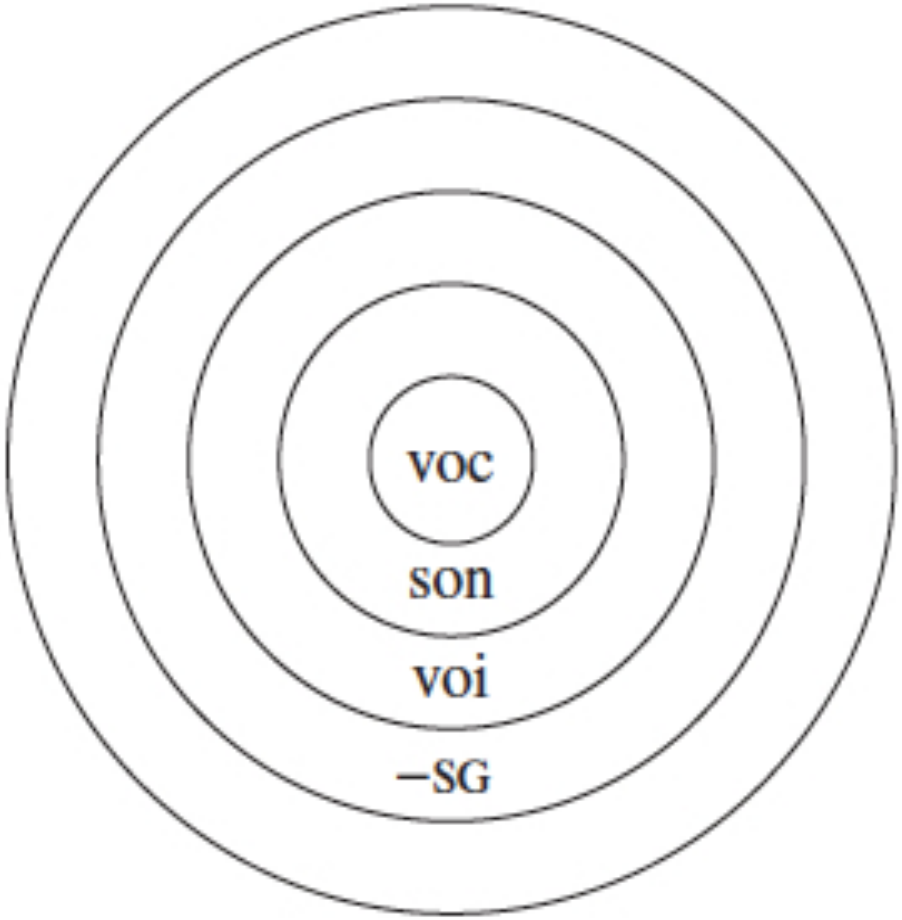
Basbøll's Sonority Syllable Model (SSM)





Logic of Segments: maximal model

- The outermost circle ring
- (viz. what is outside the
- circle with [-SG]segments
- contains the comple-
- mentary class of [-SG],
- viz. the segments having
- spread glottis



Conclusion on the SSM

1) The SSM is *unique*, I think, in its *non-circular and non-inductive* foundation – not building upon innateness postulates – residing in general phonetic and phonological categorizations, including the *definition* of [vocoid]. The approach with SSM can be applied to *all languages*.

- 2) The SSM is based upon phonological segments classified with respect to specific general phonetic dimensions (the five sonority types); but the distinction between one and two identical segments must be found outside sonority, viz. in *prosody* and in *substitutability*.
- 3) It follows from the SSM that segments with *spread glottis* occupy the marginal position of the word. This agrees with the fact that an isolated word begins and ends with resting position (breathing!). A prediction from the model is that e.g. an initial plosive before /s/ (cf. Greek *ps*-), or a final plosive after /s/, will have a spread glottis (*testable* by direct observation of the glottis!)

Conclusion on ”mirror image”

1) The SSM predicts that sequences specified in terms of sonority types (SonSeq) exhibit *mirror imag*e structure initially and finally. This is generally true.

- 2) But it does not follow from the SSM that sequences of equal sonority are *mirror imag*e-like. On the contrary, they strongly tend to have the *same order IN and FI*, following separate principles (including morphology, cf. Fr. *r(e)-*).
- 3) The SSM predicts that marginal segments in absolute initial and final position have [spread glottis], e.g. *st-, ts-; -st, -ts* (this agrees with final devoicing e.g. in Fr. *–fl* (*gifl*e)). This accounts for apparent violations of the sonority hierarchy and is testable by observing the glottis. Basbøll & Lambertsen fc

Distance: metric?

- The following measures all involve **comparison between phonetic forms** (in a well-defined notation)
- Example: a distinct target form and a reduced form
- This presupposes that the two forms are both segmented in positions and ordered so that corresponding segments are in the same position (our system allows that)
- Reduction: one or more segments in the distinct form corresponds to a non-segment (e.g. zero, or a hyphen (for schwa-assimilation), or length); or: a stronger segment corresponds to a weaker segment – not inversely

Distance: metric?

- The following measures all involve comparison between phonetic forms (in a well-defined notation)
- Example: a distinct target form and a reduced form

- *Smil* 'smile', target form: s__m__i___:_?__l
  | | | | | |
- reduced form: Ø_m__i___:_Ø_l

- *Pande* 'pan', target form: p_a_n_ë (e-schwa)
- reduced: p_a_n_- (schwa-assimilated)

Phonetic variation: metric?

- Can be calculated from **the whole set of phonetic forms corresponding to one target form**:
- Simple measure: number of **phonetic forms (types and tokens)**
- More interesting measure (presupposes that all phonetic forms corresponding to one target form are segmented in positions (cf. the ”distance metric”)):
- For every position of the phonetic target form, the number of different ”fillings” (segments or non-segments) is registered.
- The sum of such numbers is a measure of the variation (this can be seen in relation to word length, ”variation per target segment”)

Phonetic variation: metric?

- This can be used for analyses of variations such as:
  - variations of vowels compared to consonants
  - variations of clusters (cf. single consonants)
  - variations of long vs. short vowels (e.g. V(:)Co)

- Examples of stronger segments being substituted by:
  - Full vowel > neutral vowel
  - Aspirated stop > unaspirated stop
  - Obstruent > semivowel or (non-lateral) approximant

From sounds to words (a project)

- Longitudinal study (from the Odense Twin Corpus)
- Spontaneous speech (input vs. output)
- Two twin pairs (girl/girl – girl/boy) fraternal (dizygotic)
- Age 0;10-2;5 years
- Recorded every month
- Transcribed in CHILDES
- Coded in OLAM

Basbøll, Kjærbæk, Lambertsen & Boeg Thomsen (2012)

Basbøll et al. (2012)

- **For each child:**
  - First ten words registered (A-words)
  - Last ten words in the time window (9-30 months) (C-words)
  - Ten middle words (exactly in between) (B-words)
  - A-words compared to the children's babbling

For each of the parents:

all target words (A, B, C, of their twin children) transcribed

distinction between CDS and ADS

Ingrid's first words (A-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*mmm*	['mːmː]	['mːmː]	(tastes-good-sound)	0;10
2.	*nam*	['nɑm]	['ɑmː]/['nɑm]	(tastes-good-sound)	0;10
3.	*ja*	['ja]	['ja]	'yes'	0;11
4.	*op*	['ʌb̥]	['ɑb̥]	'up'	1;0
5.	*nej*	['nɑjˀ]	['nɑːjˀ]	'no'	1;2
6.	*det*	['d̥e]	['d̥e]	'this/that'	1;2
7.	*der*	['d̥æɐ̯]	['d̥eɛh]	'there'	1;2
8.	*mælk*	['mɛlˀg̊]	['mɛː]	'milk'	1;2
9.	*se*	['seːˀ]	['seːeː]	'look'	1;2
10.	*mam*	['mɑm]	['mɑ]/[mɑːm]	(child form for food)	1;3

Sara's first words (A-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*mmm*	['mːmː]	['mːmː]	(tastes-good-sound)	0;10
2.	*nej*	['nɑjˀ]	['ŋɑˀ]	'no'	1;0
3.	*muh*	['muː]	['uːuːu]	'moo'	1;2
4.	*vov*	['vʌw]	['ʌw]	'woof/bow-wow'	1;2
5.	*mam*	['mɑm]	['mɑ]	(child form for food)	1;2
6.	*op*	['ʌb̥]	['ʌb̥]	'up'	1;2
7.	*ah*	['æː]/['ɑː]	['ɑh]/['ɑːɑː]	(tastes-good-sound)	1;2
8.	*uhm*	['ɔm]	['ɔmː]	(tastes-good-sound)	1;3
9.	*nam*	['nɑm]	['nɑm]	(tastes-good-sound)	1;3
10.	*mælk*	['mɛlˀg̊]	['mːɛ]	'milk'	1;3

Parent pronunciation of *mælk* 'milk'

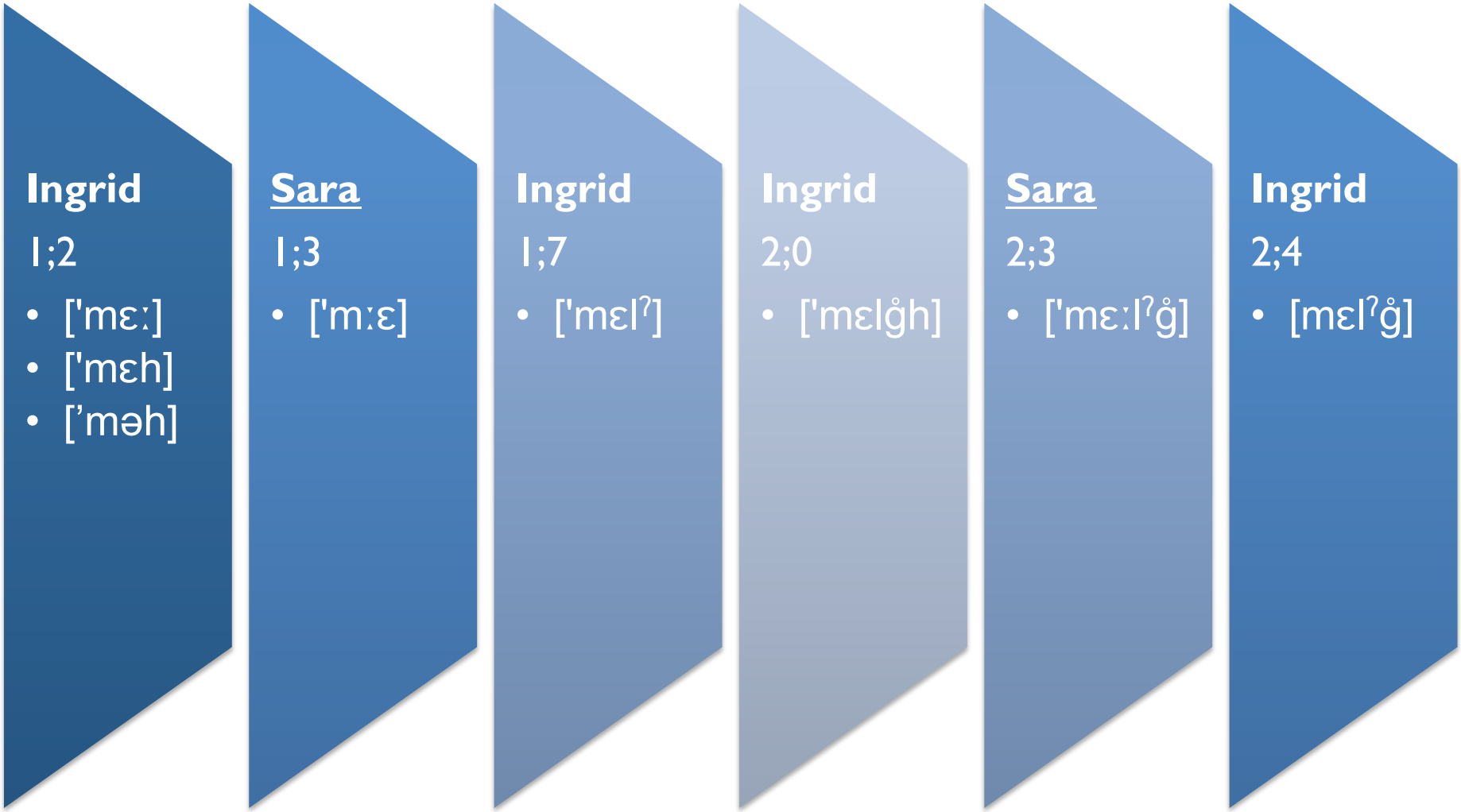
Mother

- ['mɛlˀg̊]
- ['mɛlg̊]

Father

- ['mɛlˀg̊]

The development of *mælk* 'milk'



Mother: *ja* 'yes'

ADS

- ˈja ˈjaː ˈjaːˀ
- ˈjæ ˈjæːˀ
- ˈjæɐ̯ ˈjæɐ̯ˀ
- ˈjə
- ˈæɐ̯
- ˈa

CDS

- ˈja
- ˈjɑ ˈjɑː
- jæː

Father: *ja* 'yes'

ADS

- 'ja
- 'jæɐ̯
- 'a:'a
- 'a
- 'æh
- 'æɐ̯
- jə

CDS

- 'ja 'ja:
- 'jæɐ̯
- 'jɑ
- 'jə
- 'a:

Ingrid: *ja* 'yes'

0;11

- 'jah
- 'ja 'ja:

Parents: *op* 'up'

Mother

- ˈʌb̥ ˈʌb̥h
- ˈɑb̥

Father

- ˈʌb̥

Children: *oƥ* 'up'

Ingrid 1;0

- 'ʌb̥
- 'ɑb̥h
- 'ʌpʰe
- 'ɑb̥
- 'ɔb̥ 'ɔb̥

Sara 1;2

- 'ʌb̥

Ingrid's middle words (B-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*blød*	['b̥løðˀ]	['b̥løːðə]	'soft'	1;7
2.	*drikker*	['d̥ʁɛg̊ɐ]	['g̊ʁɛjɑ]	'drink'	1;7
3.	*hurra*	[hu'ʁɑ]	[oː'wɑ]	'hurrah	1;7
4.	*spise*	['sb̥iːsə]	['b̥is]	'eat'	1;7
5.	*noget*	['nɔːəð]	[nɔ]	'some'	1;7
6.	*gynggang*	['g̊øŋ'g̊ɑŋ]	['g̊œŋ'g̊ɑŋˀ]	(child form for swing')	1;8
7.	*ost*	['ɔsd̥]	['ɒkʰh]	'cheese'	1;8
8.	*sur*	['suɐ̯ˀ]	['g̊uːɑ]/ ['d̥uɐ̯ˀ]	'grumpy'	1;8
9.	*slut*	['sluḍ]	['d̥ɔḍ]	'end'	1;8
10.	*mormor*	['mɒːˀˌmoɐ̯]	['mɒː'mɒːˀ]	'grandmother'	1;8

Sara's middle words (B-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*spiser*	['sb̥iːˀsɐ]	['g̊ʁisɐ]	'eat'	1;7
2.	*gymnastik*	[g̊ymna'sd̥ig]	['d̥ekʰθ]	'gymnastics'	1;7
3.	*bold*	['b̥ʌlˀd̥]	['b̥ʌðˀ]	'ball'	1;7
4.	*vand*	[vanˀ]	['valˀ]	'water'	1;7
5.	*sæt*	['sɛd̥]	['d̥e]/['d̥ɛ]	'put'	1;7
6.	*kage*	['kʰæː(j)ə]	['kʰæːæ]	'cake'	1;8
7.	*over*	['ʌwˀɐ]	['ʌwˀɐ]/ ['ʌw]	'over'	1;8
8.	*skubber*	['sg̊ɔb̥ɐ]	['g̊ɔg̊ɐː]	'push'	1;8
9.	*ur*	['uɐ̯ˀ]	['ob̥ɑ]	'watch'	1;8
10.	*bog*	['b̥ɔwˀ]	['b̥ɔwˀ]	'book'	1;8

Ingrid's last words (C-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*stadigvæk*	['sd̥æːði'vɛǥ]	['d̥æːð'vɛǥ]	'throat'	2;4
2.	*halsen*	['halˀsən]	['halˀ]	'biscuit'	2;4
3.	*kiks*	['kʰiǥs]	['kʰiç]	'when'	2;4
4.	*hvornår*	[vɒ'nɒːˀ]	[və'nɒːˀ]	'pull'	2;4
5.	*hiver*	['hiwˀɐ]	[iwˀ]	'first'	2;4
6.	*avis*	[a'viːˀs]	[a'viːˀs]	'newspaper'	2;5
7.	*putter*	['pʰud̥ɐ]	['pʰud̥]	'put'	2;5
8.	*skraldespanden*	['sǥʁɑlə¸sb̥anˀən]	['ǥɑːl¸b̥anˀ-]	'bin/garbage can'	2;5
9.	*hun*	['hun]	['hun]	'she'	2;5
10.	*edderkop*	['ɛðˀʌk̥ʰʌb̥]	['ɛʌ¸kʰʌb̥]	'spider'	2;5

Sara's last words (C-words)

	Word	Target pronunciation	Actual Pronunciation	Translation	Age
1.	*græder*	['g̊ʁæðˀɐ]	['kʰhʁ̥ɑjˀɐ]	'cries'	2;4
2.	*fjernsyn*	['fjæɐ̯nˌsyːˀn]	['væɐ̯nˌsyːˀn]	'television'	2;4
3.	*godmorgen*	[g̊o'mɒːɒn]	[g̊o'mɒːɒn]	'good morning'	2;4
4.	*hundehvalp*	['hunəˌvalˀb̥]	['hunəˌvalˀb̥]	'puppy'	2;4
5.	*ben*	['b̥eːˀn]	['b̥ẽː]	'leg'	2;4
6.	*henter*	['hɛnd̥ɐ]	['ɛnd̥]	'fetch'	2;5
7.	*ledningen*	['leðneŋ(ˀ)ən]	['leneŋ'-]	'cord'	2;5
8.	*køkkenet*	['kʰøg̊(ə)nəð]	['kʰøb̥əd̥]	'kitchen'	2;5
9.	*glas*	['g̊las]	['kʰl̥as]	'glass'	2;5
10.	*saltstænger*	['salˌsdɛŋˀɐ]	['saːˌd̥ɛŋɐ]	'pretzels'	2;5

Early words and sonority

	A-words	B-words	C-words	A + B + C
Ingrid	0.65 (0.7) 1.9 (2.2)	1.1 (1.4) 3.0 (3.8)	1.3 (1.7) 3.7 (4.8)	1.02 (1.27) 2.87 (3.60)
Sara	0.4 (0.6) 1.7 (2.2)	1.1 (1.2) 2.8 (3.4)	1.8 (1.85) 4.5 (5.2)	1.10 (1.22) 3.00 (3.60)
Ingrid + Sara	0.53 (0.65) 1.80 (2.20)	1.10 (1.30) 2.90 (3.60)	1.55 (1.78) 4.10 (5.00)	1.06 (1.25) 2.94 (3.60)
Ingrid – Sara	0.15 (0.10) 0.20 (0.00)	0.00 (0.20) 0.20 (0.40)	–0.50 (–0.15) –0.80 (–0.40)	–0.08 (0.02) –0.13 (0.00)
Numbers (per word) *above in each cell:* sonority rises;	*Numbers (per word)* *below in each cell:* son-types		*Numbers without parentheses: child lg. output*	*Numbers in parentheses: child lg. input*

Early words and sonority

	A-words	B-words	C-words	A + B + C
Ingrid	24	37	39	33.3 (100)
Ingrid's mother	23	42	44	36.3 (109)
Sara	22	33	51	35.3 (106)
Sara's mother	25	40	60	41.7 (125)

Number of segments (10 words)

Early words and sonority

	A-words	B-words	C-words	A + B + C
Ingrid	13	16	17	15.3 (46)
Ingrid's mother	10	15	20	15 (45)
Sara	13	15	21	16.3 (49)
Sara's mother	12	16	22	16.7 (50)

Number of syllables (10 words)

Early words and sonority

	A-words	B-words	C-words	A + B + C
Ingrid	19	29	36	28 (84)
Ingrid's mother	19	36	41	32 (96)
Sara	18	27	47	30.7 (92)
Sara's mother	20	31	51	34 (102)

Sonority types (10 words)

Early words and sonority

	A-words	B-words	C-words	A + B + C
Ingrid	6	12	12	10 (30)
Ingrid's mother	6	17	16	13 (39)
Sara	3	12	19	11.3 (34)
Sara's mother	5	12	22	13 (39)

Sonority rises (10 words)

Early words and sonority

- In view of the description of Danish as a language with a less diversified sonority slope than e.g. Swedish (otherwise closely related to Danish), in particular with long vocoidal sequences, the following questions seem pertinent:
- Do Danish children select target words with a clear syllable structure, i.e. with salient changes in sonority? This would seem easier perceptually.
- Or do Danish children select target words with few changes in sonority slope, i.e. with few changes in sonority (e.g. few sonority rises)? This might be easier to produce.
- To answer these questions, further research is needed!

Babbling and first words

Analysis in progress:

Counting all the children's babbling syllables in the first sessions, e.g. *va, mo, du*.

The structure of these syllables are compared to the structure of the syllables in A-words.

Babbling and first words

Individual patterns (from the other pair of twins)

Girl:

6 of 10 A-words begin with an alveolar (*det, nam, tryk, nej, sidde, se*)

32 % of her babbling syllables begin with an alveolar

(her own name contains three alveolar sounds)

Boy:

3 of 10 A-words begin with an alveolar (*nej, det, tak*)

12 % of his babbling syllables begin with an alveolar

Babbling and first words

The pattern of the preceding slide seems to be reversed:

Boy:

4 of 10 A-words begin with a labial (*mam, mælk, hvad, pille*)

89 % of his babbling syllables begin with a labial

Girl:

1 of 10 A-words begins with a labial (*mam)*

17 % of her babbling syllables begin with a labial

Preliminary conclusions

- There is an interesting *evolution in the phonetic and phonological structure* in the children's first words until the last words (within the time window: up to 30 months) that can be analysed using our OLAM-system in ways suggested here.
- The *target A-words* are simpler (both with respect to complexity and to sonority slope) – measurably – than the *target B-words*, and these are again simpler – measurably – than the *target C-words*.
- The *child's pronunciation of the target words* can be compared to the *target pronunciations* (defined as the most distinct, or the most frequent, or the first pronunciation used by the parents) using our measures for *reductions* and *distance*.

Preliminary conclusions

- The *target pronunciations* (still defined as the most distinct, the most frequent, or the first pronunciation used by the parents) can be analysed with respect to *variation* (in Child Directed as well as in Adult Directed Speech). It is a hot scientific issue to which degree and how the caregivers adapt their speech to the different stages of development of their children, and this can be analysed in our OLAM-system.
- *Stød* seems in the process of being acquired within the time window (and the twins do not seem to take on their mother's wrong – and unsystematic – stød distribution).
- There is a *clear correlation between the children's first words and their babbling*, concerning *place* of initial segments.

Thank you!

Merci!

Ta(c)k(k)!

(*Tackk!)

Grazie!!!

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