Sonority and early words: the Sonority Syllable Model applied to an acquisitional project with Danish children

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Syllables play an important role in children's early language acquisition, and children appear to rely on clear syllabic structures as a key to word acquisition (Vihman 1996; Oller 2000). However, not all languages present children with equally clear cues to syllabic structure, and since the specific L1 is known to influence the acquisition rate, it is worth investigating how sonority characteristics in children's linguistic input influence their lexical acquisition. Danish is characterized by having a monotonous sonority envelope compared to other Scandinavian languages. Danish language acquisition therefore presents us with the opportunity to examine how children respond to the task of word learning when the input language offers less clear cues to syllabic structure than usually seen. To investigate the sound structure in Danish children's lexical development, we need a model of syllable structure; and as the theoretical basis for our analyses related to sonority we present Basbøll's Sonority Syllable Model for phonotactics, which is based upon a non-circular version of a sonority hierarchy. We investigate spontaneous child language output in a longitudinal corpus with two children aged 9-29 months. For the two children, the phonetic structure of the first ten words to occur is compared with that of the last ten words to occur before 30 months of age, and with that of ten words in between. Measures related to the sonority envelope, viz. sonority types and in particular sonority rises, are applied to this data.

1. Syllables in children's language acquisition

In children's early language acquisition, the structure of canonical syllables with transitions between consonants and vowels appears to be of major importance to children's parsing of their input and to their own productions. The onset of canonical babbling with well-formed and temporally regular syllables is often regarded as "the most striking production milestone in the first year" (Vihman 1996: 109), and the occurrence, amount and types of CV syllables in babbling is predictive of many later developments in language acquisition (Kent 1992, Stoel-Gammon 1998). Further, children have been found to rely on the specific canonical syllables 'practiced' during babbling in their earliest word productions (Vihman 1992). Oller (2000) suggests that syllables with their relatively consistent timing are fundamental to children's parsing of the input stream because they

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impose rhythmical structure on speech and "provide a frame of focus for perception, allowing the listener to perform analysis on limited chunks of information" (Oller 2000: 91).

We assume that children develop a network of sound-based associations, cross-indexing the words they know regarding for example syllable-count and matching initial or final syllables (Vihman 1981: 247). The stressed syllable seems to be of significant importance – yet we might expect the syllable to be more important in stress-timed languages like English than in more syllable-timed ('weakly stressed') languages like French (Vihman 1981: 254). Danish is expected to be like English in this respect.

2. The Sonority Syllable Model

2.1. Vocoid: the prototypical peak of a syllable

All languages of the world can be described using syllables as structures.[1] All languages have vowel segments which form the peak of a syllable. Some, but not all, languages also have non-vowels (consonants) that can form the peak of a syllable.[2] All languages of the world have non-vowels that do not form the peak of a syllable. Some, but not all, languages also have vowels that do not form the peak of a syllable.[3] Thus the prototypical peak of a syllable is phonetically a vowel segment, a "vocoid", whereas the prototypical non-peak of a syllable is phonetically a consonant, a "contoid" (Pike's terminology 1943).

Basbøll (since Basbøll 1973) has used an equation as the definition of vocoid:

[vocoid] $=_{\text{DEF}}$ [sonorant, –stop, –lateral]

2.2. Universal logic of segment types: independent of time and segment order

All vocoids are, necessarily, sonorant.[4] But some sonorants are not vocoids, viz. prototypical (sonorant) laterals and nasal consonants (which are [sonorant, stop]). Furthermore, all sonorants are, necessarily, voiced.[5] On the other hand, there are non-sonorant sounds (obstruents) that are voiced. Also voiceless segments occur, of course. This universal logic of segment types, built exclusively on existing vs. excluded segment types, can be formulated as an implication and be depicted by a set of (concentric) Euler's circles (Figure 1):

[vocoid] implies [sonorant] implies [voiced]

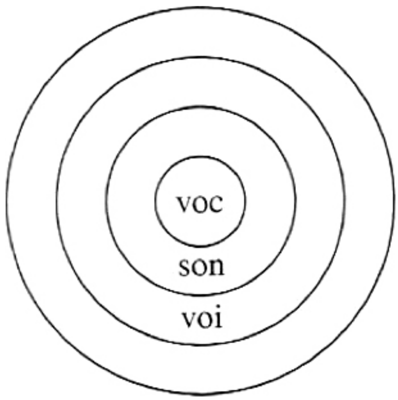

Figure 1. A set of (concentric) Euler's circles depicting the logical relation between vocoids, sonorants and voiced segments independently of any time- or order aspect (from Basbøll 2005: 194).

2.3. Introducing time: a syllable model emerges

When the dimension of time is introduced into the set of concentric circles, a set of relevant order classes of phonotactics follows, predicting the order (up to the peak): voiceless segments, voiced obstruents, sonorant contoids, vocoids; and the mirror-image order in the final part of the syllable. Thus the introduction of the time dimension turns the model into a Sonority Syllable Model (Figure 2):

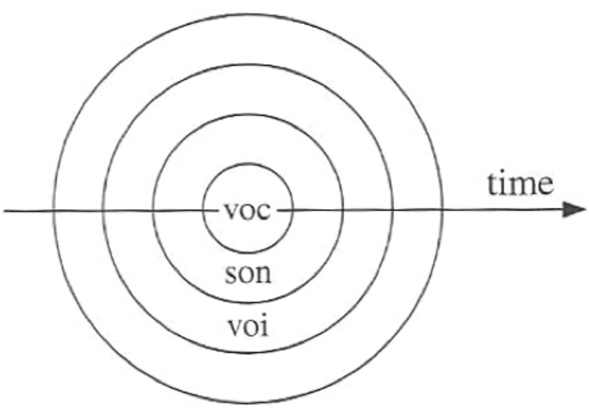

Figure 2. The Sonority Syllable Model. Identical to the set of Euler's circles depicted in Figure 1, but with the addition of the dimension of time which turns the figure into a syllable model (from Basbøll 2005: 184).

2.4. Margins of the Sonority Syllable Model: [spread glottis]

One further phonologically relevant distinctive feature satisfies the criteria for entering into the implication chain underlying the model: [spread glottis], which we understand as meaning 'widely spread glottis'. There are segments that are voiceless but do not have (widely) spread glottis.[6] This means that the maximal version of the Sonority Syllable Model can be based upon the following implication chain:

[vocoid] implies [sonorant] implies [voiced] implies [–spread glottis]

One consequence of this implication chain in the Sonority Syllable Model is that its most marginal segments have the feature [spread glottis]. This makes very good sense phonetically, in our view: the isolated monosyllable, which is the prototypical isolated syllable, starts and ends in rest position which has, obviously, widely open passage through the glottis (for breathing).[7]

2.5. Conclusion on the Sonority Syllable Model

The Sonority Syllable Model predicts that sequences specified in terms of sonority types exhibit 'mirror image' structure initially and finally. This is generally true. But it does not follow from the Sonority Syllable Model that sequences of equal sonority are 'mirror image'-like. On the contrary, they strongly tend to have the same order initially and finally, following separate principles, and the distinction between one and a sequence of two identical segments must be found outside sonority, viz. in prosody and in substitutability.[8]

3. Some phonological differences within Scandinavian: Danish and the sonority envelope

As captured by the Sonority Syllable Model, syllable structure in the languages of the world is fundamentally characterized by rises and falls in sonority. Since the syllable appears to be an important entity in early child language acquisition, we expect clear differences in sonority to facilitate children's parsing of the input stream and their lexical acquisition. However, the languages of the world of course differ widely as to phonotactics, i.e. the concrete syllable structures allowed by the specific languages and the Sonority Syllable Model's circles activated, and also as to which types of reductions characterize spontaneous speech. So, even if children can be generally expected to be highly sensitive to rises and falls in sonority in the input stream during early lexical acquisition, the languages of the world present them with very different cues to syllable structure. Danish is characterized by an unusually monotonous sonority envelope and may therefore present L1 learners with special challenges.

This becomes particularly clear when we compare Danish and its close Scandinavian relatives, in particular its closest relative Swedish (which is also East Nordic).

In Danish, coda lenition, light stressed syllables, schwa elision, /r/ elision, semi-vowel elision and length vacillation are all features causing indistinct sound structure, whereas in most forms of Swedish, word accents, final lengthening and compulsory sentence accent are all strong prosodic cues making sound structure more distinct (Grønnum 2003, 2005), see Table 1. Therefore Swedish is most likely easier for children to grasp.

Table 1. Sound structure in Danish and Swedish (from Basbøll 2012: 24, based upon Grønnum's work, see Grønnum 2003, 2005, 2008).

	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
Tonal word accents	No	Yes
Final lengthening	No	Yes
Compulsory sentence accent	No	Yes
Signal for utterance function	Weak and global	Strong and local

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. There is a combined effect of weakening and schwa-reduction, for example Swedish *gata* [^{2}gɑːta] and *koka* [^{2}k^{h}uːka] vs. Danish *gade* [ˈg̊æ(ː)ð̞(ː)] and *koge* [ˈk^{h}ɔ(ː)w(ː)].[9]

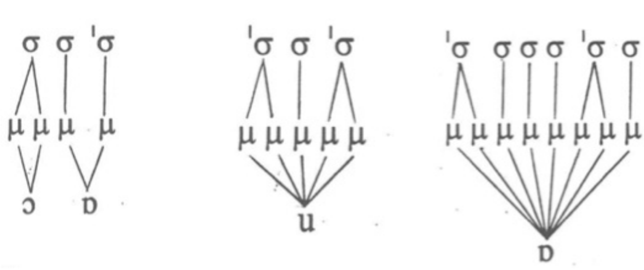

Figure 3. The syllable structure in Danish *koge o(ver)* 'boil over', *(l)uge u(denfor)* 'weed outside', *(h)årdere at åre(lade)* 'harder to bleed' (Rischel 2003: 279).

In Figure 3 Rischel (2003) demonstrates that the structure of the Danish syllable (which he calls 'a national heritage') leads to a syllabic-moraic structure where a single vowel can realize a sequence of morae and syllables.[10]

Table 2 exhibits the past tense forms of a fully regular and fully productive weak verb, viz. Danish *love* 'promise' and its Scandinavian cognates in Norwegian (bokmål[11]), Swedish and Icelandic. The most significant observation comes from the column 'Sonority rises from the stem-final consonant'. In Danish there is no indication whatsoever in the sonority envelope that a syllable (containing the past time morpheme) has been added to the stem, cf. Figure 3. The phonology, in particular sonority and syllable structure, thus makes the morphological structure of such forms in Danish far more opaque than is the case in our close Scandinavian relatives.

Table 2. Weak past tense forms in Scandinavian (based upon the principles of Bleses et al. 2011: 16). Example: past tense of (Danish) *love* 'promise' and its Scandinavian cognates (from Basbøll 2012: 26).

	Spoken form	Number of syllables in suffix (0,1,2)	Number of vowels in suffix (0,1,2)	Number of sonority rises from the stem-final consonant (0,1,2)	Word accent cue for suffix (non-stød/toneme 2) (0,1)
Danish					
-ede	[ˈlɔːʊð̩]	2	0	0	(1)
	[ˈlɔːʊð̩̆]	1	0	0	(1)
Norwegian					
-et	[²lɔːvət]	1	1	1	1
-a	[²lɔːva]	1	1	1	1
Swedish					
-ade	[²loːvadə]	2	2	2	1
-a	[²loːva]	1	1	1	1
Icelandic					
-aði	[ˈlɔːvaðɪ]	2	2	2	0
-aðir	[ˈlɔːvaðɪr̥]	2	2	2	0
-uðum	[ˈlɔːvʏðʏm]	2	2	2	0
-uðuð	[ˈlɔːvʏðʏð̥]	2	2	2	0
-uðu	[ˈlɔːvʏðʏ]	2	2	2	0

4. Hypotheses

In perception canonical syllables with clear transitions between consonants and vowels are privileged units for children to analyze (Oller 2000). For their own production of canonical syllables in pre-linguistic babbling children depend on their ambient language (Oller & Eilers 1988), and these babbling syllables later serve them as bases for their own first words (Vihman 1996). Danish presents children with fewer cues to syllable structure than many other languages do, and this makes early Danish lexical development particularly interesting. The specific sonority characteristics of the input language could be expected to affect children's selection of target words for production, their actual pronunciation of the selected target words and/or acquisition rate. In this study, we focus on the first two issues (with the exclusion, therefore, of acquisition rate) and investigate Danish children's early words across three age stages in terms of segments and syllables per word, sonority types and number of sonority rises, examining both target word selection and actual pronunciation. For all these measures (segments, syllables, sonority types and sonority rises per word), we expect to see a rise at each of our measure points, but we cannot predict whether such expansion will show up in children's selection of words, in their pronunciation of words (e.g. less reduction with age) or in both. We do not consider these measures to be language specific, i.e. we expect a developmental increase in these measures in other languages as well. But we also expect the exact developmental evolution with respect to these measures to be dependent on language type. Further, we will seek to assess whether Danish children prefer words with clear syllable structure to words with vague syllable structure as targets for pronunciation, and whether such potential preference/avoidance patterns are equally active across development within the time window investigated.

5. Method and empirical data

In order to test our hypothesis we have analyzed longitudinal data from the Odense Twin Corpus, a corpus of spontaneous child language input and output. We used data from a dizygotic twin pair, namely the girls Ingrid and Sara in the age of 9-29 months. The children and their family were recorded for about an hour once every month. All recordings are transcribed in CHILDES (MacWhinney 2000 a,b) in Danish standard orthography and coded in OLAM[12], where all words were provided with morphological information as well as their standard pronunciation (cf. Kjærbæk 2013).

We know from earlier studies that children's pronunciations vary more than adults' from one time to the next, and, in their first few months of talking, they may produce multiple versions of the same word (Maekawa & Storkel 2006; Sosa & Stoel-Gammon 2006). In this study we focus on a minor set of words, which we will then follow throughout the time window. This gives us the opportunity to study the development of the specific word during time as well as the child's different pronunciations of the same word in the same recording.

For each child we have registered: 1) the first ten words in the corpus (A-words); 2) the last ten words in the time window (9-29 months) (C-words); 3) ten words exactly in the middle (B-words). All occurrences of the A-, B- and C-words are transcribed phonetically in child speech of the respective child as well as in her parental input (Basbøll et al. 2012a,b), see Tables 3-5.

To decide whether sound strings should be counted as babbling or first words (i.e. A-words), we followed the explicit word identification procedure in Vihman & McCune (1994), evaluating each possible word candidate on the following criteria: Context (determinative context, caretaker identification, multiple use, multiple episodes), Vocalization shape (complex match, exact match, prosodic match), Relation to other vocalizations (imitated tokens, invariant shape, no inappropriate uses).

Table 3. Ingrid and Sara's A-words including standard adult pronunciation and the child's pronunciation.

Ingrid				Sara			
Word	Gloss	Standard	Child	Word	Gloss	Standard	Child
mmm	(tastes-good sound)	[ˈmːmː]	[ˈmːmː]	*mmm*	(tastes-good sound)	[ˈmːmː]	[ˈmːmː]
nam	(tastes-good sound)	[ˈnɑm]	[ˈɑmː]/[ˈnɑm]	*nej*	'no'	[ˈnɑjˀ]	[ˈŋɑˀ]
ja	'yes'	[ˈja]	[ˈja]	*muh*	'moo'	[ˈmuː]	[ˈuːuːu]
op	'up'	[ˈʌb̥]	[ˈɑb̥]	*vov*	'woof/bow-wow'	[ˈvʌw]	[ˈʌw]
nej	'no'	[ˈnɑjˀ]	[ˈnɑːjˀ]	*mam*	(child form for 'food')	[ˈmɑm]	[ˈmɑ]
det	'this/that'	[ˈd̥e]	[ˈd̥e]	*op*	'up'	[ˈʌb̥]	[ˈʌb̥]
der	'there'	[ˈd̥æɐ̯]	[ˈd̥eɛh]	*ah*	(tastes-good sound)	[ˈæː]/[ˈɑː]	[ˈɑːh]/[ˈɑːɑː]
mælk	'milk'	[ˈmɛlˀg̊]	[ˈmɛː]	*uhm*	(tastes-good sound)	[ˈɔm]	[ˈɔmː]
se	'look'	[ˈseːˀ]	[ˈseːeː]	*nam*	(tastes-good sound)	[ˈnɑm]	[ˈnɑm]
mam	(child form for 'food')	[ˈmɑm]	[ˈmɑ]/[mɑːm]	*mælk*	'milk'	[ˈmɛlˀg̊]	[ˈmːɛ]

Table 4. Ingrid and Sara's B-words including standard adult pronunciation and the child's pronunciation.

Ingrid				Sara			
Word	Gloss	Standard	Child	Word	Gloss	Standard	Child
blød	'soft'	[ˈb̥løð̞ˀ]	[ˈb̥lø:ð̞ə]	*spiser*	'eat'	[ˈsb̥i:ˀsɐ]	[ˈg̊ʁisɐ]
drikker	'drink'	[ˈd̥ʁɛg̊ɐ]	[ˈg̊ʁɛja]	*gymnastik*	'gymnastics'	[g̊ymnaˈsd̥ig]	[ˈd̥ekʰθ]
hurra	'hurrah'	[huˈʁɑ]	[o:ˈwɑ]	*bold*	'ball'	[ˈb̥ʌlˀd̥]	[ˈb̥ʌð̞ˀ]
spise	'eat'	[ˈsb̥i:sə]	[ˈb̥is]	*vand*	'water'	[ˈvanˀ]	[ˈvalˀ]
noget	'some'	[ˈnɔ:əð̞]	[nɔ]	*sæt*	'put'	[ˈsɛd̥]	[ˈd̥e]/[ˈd̥ɛ]
gynggang	(child form for 'swing')	[ˈg̊øŋˈg̊aŋ]	[ˈg̊œŋˈg̊aŋˀ]	*kage*	'cake'	[ˈkʰæ:(j)ə]	[ˈkʰæ:æ]
ost	'cheese'	[ˈɔsd̥]	[ˈɒkʰh]	*over*	'over'	[ˈʌwˀɐ]	[ˈʌwˀɐ]/[ˈʌw]
sur	'grumpy'	[ˈsuɐ̯ˀ]	[ˈg̊u:ɑ]/[ˈd̥uɐ̯ˀ]	*skubber*	'push'	[ˈsg̊ɔb̥ɐ]	[ˈg̊ɔg̊ɐ:]
slut	'end'	[ˈslud̥]	[ˈd̥əd̥]	*ur*	'watch'	[ˈuɐ̯ˀ]	[ˈob̥ɑ]
mormor	'grandmother'	[ˈmɒ:ˀˌmoɐ̯]	[ˈmɒ:ˈmɒ:ˀ]	*bog*	'book'	[ˈb̥ɔwˀ]	[ˈb̥ɔwˀ]

Table 5. Ingrid and Sara's C-words including standard adult pronunciation and the child's pronunciation.

Ingrid				Sara			
Word	Gloss	Standard	Child	Word	Gloss	Standard	Child
stadigvæk	'still'	[ˈsd̥æ:ð̞iˈvɛg̊]	[ˈd̥æ:ð̞ˈvɛg̊]	*græder*	'cry'	[ˈg̊ʁæð̞ˀɐ]	[ˈkʰhʁɑjˀɐ]
halsen	'throat'	[ˈhalˀsən]	[ˈhalˀ]	*fjernsyn*	'television'	[ˈfjæɐ̯nˌsy:ˀn]	[ˈvæɐ̯nˌsy:ˀn]
kiks	'biscuit'	[ˈkʰig̊s]	[ˈkʰiç]	*godmorgen*	'good morning'	[g̊oˈmɒ:ɒn]	[g̊oˈmɒ:ɒn]
hvornår	'when'	[vɒˈnɒ:ˀ]	[vəˈnɒ:ˀ]	*hundehvalp*	'puppy'	[ˈhunəˌvalˀb̥]	[ˈhunəˌvalˀb̥]
hiver	'pull'	[ˈhiwˀɐ]	[ˈiwˀ]	*ben*	'leg'	[ˈb̥e:ˀn]	[ˈb̥ẽ:]
avis	'newspaper'	[aˈvi:ˀs]	[aˈvi:ˀs]	*henter*	'fetch'	[ˈhɛnd̥ɐ]	[ˈɛnd̥]
putter	'put'	[ˈpʰud̥ɐ]	[ˈpʰud̥]	*ledningen*	'the cord'	[ˈleð̞neŋ(ˀ)ən]	[ˈleneŋˀ-]
skraldespanden	'bin/garbage can'	[ˈsg̊ʁaləˌsb̥anˀən]	[ˈg̊ɑ:lˌb̥anˀ-]	*køkkenet*	'the kitchen'	[ˈkʰøg̊(ə)nəð̞]	[ˈkʰøb̥əd̥]
hun	'she'	[ˈhun]	[ˈhun]	*glas*	'glass'	[ˈg̊las]	[ˈkʰhlas]
edderkop	'spider'	[ˈeðʔʌˌkʰʌb̥]	[ˈɛʌˌkʰʌb̥]	*saltstænger*	'pretzels'	[ˈsald̥ˌsdɛŋˀɐ]	[ˈsa:ˌd̥ɛŋɐ]

6. Results

6.1. Segments per target word

We now present some quantitative results from comparing Ingrid and Sara's A-, B- and C-words. First, we have counted the number of segments per target word (A-, B- and C-words separately as well as collapsed) in Ingrid and Sara's target words. The results are shown in Table 6. The last column summarizes the measure for all target words taken together.

Table 6. Number of segments[13] per target word (10 A-words, 10 B-words and 10 C-words). Standard pronunciation (I) indicates the standard pronunciation of Ingrid's target words and similarly for Sara: (S).

	A-words	B-words	C-words	Segments per target word (average A+B+C)
Ingrid (I)	2.5	3.7	3.9	3.4
Standard pronunciation (I)	2.6	4.2	5.5	4.1
Sara (S)	2.2	3.3	5.3	3.6
Standard pronunciation (S)	2.5	4.1	6.3	4.3
Children (I+S)	2.4	3.5	4.6	3.5
Standard pronunciation (I+S)	2.6	4.2	5.9	4.2

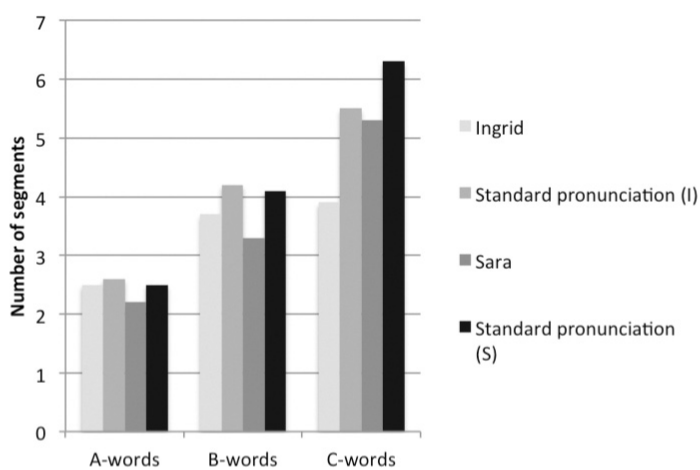

Figure 4. Number of segments per target word (10 A-words, 10 B-words and 10 C-words).

The results of Table 6 are depicted in Figure 4.

The two twin sisters exhibit a different developmental pattern with respect to the measure 'segments per target word': for both sisters, the A-words are simpler than the B- and C-words; but for Ingrid, there is only a small difference between B- and C-words, whereas for Sara, C-words are clearly longer than B-words. The same difference is seen in the standard pronunciation of the target words. Furthermore, we see that Ingrid and Sara's pronunciation of the B- and C-words have fewer segments, i.e. they are shorter, than in the standard pronunciation. We also see a phonetic reduction in child speech when we compare it with the standard pronunciation.

6.2. Syllables per target word

Another possibility, still rather simple but perhaps more interesting in the present perspective, is to count length in terms of syllables rather than segments. The results of this analysis are shown in Table 7.

Table 7. Number of syllables[14] per target word (10 A-words, 10 B-words and 10 C-words). Standard pronunciation (I) indicates the standard pronunciation of Ingrid's target words and similarly for Sara: (S).

	A-words	B-words	C-words	Syllables per target word (Average A+B+C)
Ingrid (I)	1.2	1.6	1.7	1.5
Standard pronunciation (I)	1.0	1.6	2.2	1.6
Sara (S)	1.3	1.5	2.1	1.6
Standard pronunciation (S)	1.0	1.6	2.3	1.6
Children (I+S)	1.3	1.6	1.9	1.6
Standard pronunciation (I+S)	1.0	1.6	2.3	1.6

The results of Table 7 are depicted in Figure 5.

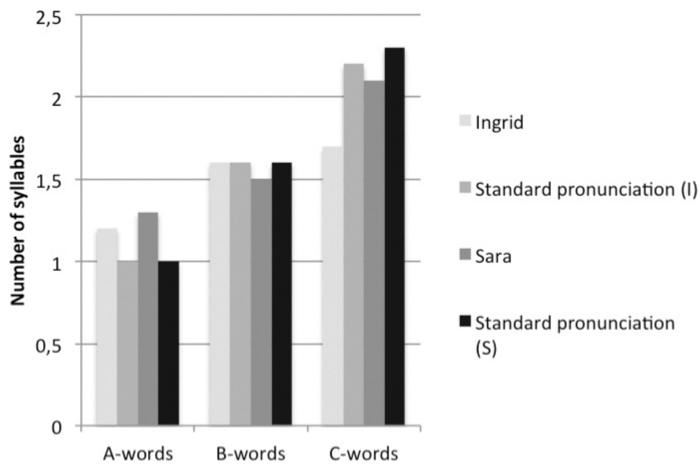

Figure 5. Number of syllables per target word (10 A-words, 10 B-words and 10 C-words).

The two twin sisters exhibit a different developmental pattern with respect to the measure 'syllables per target word', but the pattern is not the same as that found for segments (in Figure 4). For Ingrid, there is a rather small developmental evolution with respect to the number of syllables: B- and C-words are roughly at the same level (with a very slight increase). For Sara, by contrast, there is a big increase in length with respect to number of syllables per target word, from B-words to C-words. As for the pronunciation of the target words, we see a progressive increase for the two girls – Sara with a little higher amount of segments, syllables, sonority types and sonority rises than Ingrid.

The children mainly produce monosyllabic words in the beginning but as they reach the age of 29 months they generally produce disyllabic words. These results are interesting since studies have shown that disyllables dominate the early lexicon of children acquiring most of the other languages in which early word phonology has been investigated (Estonian, Finnish, French, Greek, Hebrew, Hindi, Italian, Japanese, Spanish, Welsh). The Germanic languages, though, generally seem to constitute exceptions, as monosyllables appear to be the most common early words in Dutch (e.g. Elbers & Ton 1985) and German (Leopold 1939; Elsen 1996) as well as English; for Swedish data show that mono- and disyllabic early word forms are in close balance (cf. Vihman & Croft 2013: 20).

A typical example of Ingrid's A-words is the monosyllabic word *ja* 'yes' [ˈja] and a typical example of her C-words is the four syllable word *skraldespanden* 'the garbage can' which she reduces to a three syllable word [ˈg̊ɑːlˌb̥anˀ-]. Generally, the children reduce more syllables in the C-words than in both the A- and B-words which is not surprising since there are more syllables to be reduced in C-words. According to the literature, children acquiring Germanic languages often omit weak or unstressed syllables in initial or final position in their early productions (e.g. Smith 1973). However, the fact that the A-words are very important for the communication since they always carry the whole meaning of the utterance (one word sentences), whereas the C-words are usually part of a longer utterance, and thus relatively less important, could also play a role.

6.3. Different sonority types per target word

The measures in sections 6.1 and 6.2 have given some indication of complexity in the trivial sense of length (measured in terms of number of segments and syllables). However, because of the particular character of Danish as having a monotonous sonority envelope and long vocoidal stretches, this measure needs to be complemented by a measure focusing upon the sonority envelope, i.e. sonority ups and downs. We propose two such measures here, viz. sonority types (in the present section) and sonority rises (in section 6.4; see also Table 2 above for preliminary information). Sonority types and sonority rises are both measures of complexity with respect to sonority, not just measures of length. Both are derived from the Sonority Syllable Model. It follows from this model that there are exactly five sonority types in the sense of major classes having different positions on a sonority hierarchy, neither more nor less: vocoids, sonorant contoids, voiced obstruents, voiceless obstruents with non-spread glottis, and, finally, obstruents with spread glottis.

We have counted the number of different sonority types per target word in Ingrid and Sara's target words. The results are shown in Table 8.

Table 8. Number of different sonority types[15] per target word (10 A-words, 10 B-words and 10 C-words). Standard pronunciation (I) indicates the standard pronunciation of Ingrid's target words and similarly for Sara: (S).

	A-words	B-words	C-words	Sonority types per target word (average A+B+C)
Ingrid (I)	1.9	2.3	2.5	2.2
Standard pronunciation (I)	1.9	2.9	3.2	2.7
Sara (S)	1.7	2.3	3.2	2.4
Standard pronunciation (S)	1.9	2.6	3.5	2.7
Children (I+ S)	1.8	2.3	2.9	2.3
Standard pronunciation (I+S)	2.2	2.8	3.4	2.7
Children (I+ S)	0.1	0.0	–0.35	–0.08
Standard pronunciation (I–S)	0.0	0.15	–0.15	0.0

Ingrid and Sara grew up in the same environment, and we therefore consider the study of their differences and similarities particularly interesting. In order to highlight similarities and dissimilarities, besides individual scores, we have also considered the average scores for their pronunciation (I + S), as well as the difference between their pronunciation and the corresponding standard pronunciation of the two girls (I – S); the largest difference is found for the C-words, where Sara represents the highest number of sonority types whereas Ingrid leads for the A- and B-words, but with a much smaller margin.

The results from Table 8 are depicted in Figure 6.

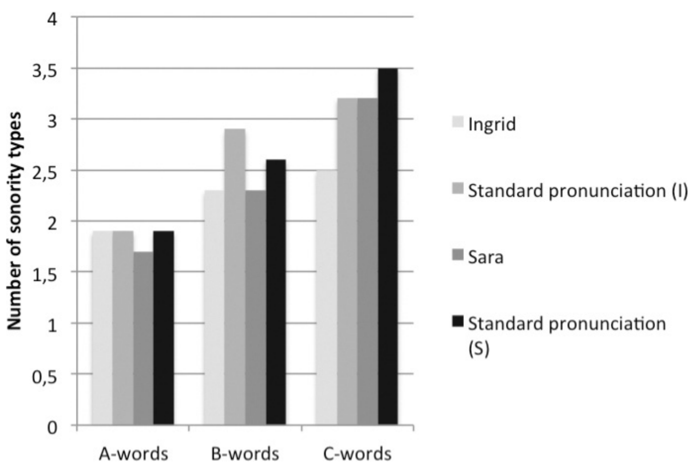

Figure 6. Number of different sonority types per target word (10 A-words, 10 B-words and 10 C-words).

Again we see that the two twin sisters exhibit a slightly different developmental pattern with respect to the measure ‘different sonority types per target word’: for both sisters, the A-words have less sonority types than the B-words which again have less sonority types than the C-words. This measure of sonority thus presents a stronger developmental evolution than the previous measures (number of segments, and of syllables, per target word). There is a small difference between the two twin sisters, however, inasmuch as the increase from B-words to C-words is visibly larger for Sara than for Ingrid. This is perhaps a reflection of the same pattern as in the previous section: at the last stage, Sara produces a few longer words than Ingrid, and this gives her the opportunity to use more different sonority types and (as we shall see in the next section) sonority rises. Since we only analyze ten words per child, we cannot expect this difference between the two sisters’ target C-words to be representative of more general differences, nor can the difference be considered representative of general patterns in Danish children given the limited number of informants. We can be a little more confident in the difference found between age stages because both children exhibit the same development.

6.4. Sonority rises per target word

To obtain a more revealing measure for the diversity in the sonority envelope than the mere number of different sonority types per word (as in section 6.3), we have calculated the number of sonority rises per target word (cf. Table 2) for Ingrid and Sara. The results are shown in Table 9.

Table 9. Number of sonority rises[16] per target word (10 A-words, 10 B-words and 10 C-words). Standard pronunciation (I) indicates the standard pronunciation of Ingrid's target words and similarly for Sara: (S).

	A-words	B-words	C-words	Sonority rises per target word (Average A+B+C)
Ingrid (I)	0.7	1.2	1.2	1.0
Standard pronunciation (I)	0.7	1.8	1.9	1.5
Sara (S)	0.3	1.2	1.8	1.1
Standard pronunciation (S)	0.6	1.3	2.4	1.4
Children (I+ S)	0.5	1.2	1.5	1.1
Standard pronunciation (I+S)	0.7	1.6	2.2	1.5
Children (I+ S)	0.2	0.0	–0.3	–0.03
Standard pronunciation (I–S)	0.05	0.25	–0.25	0.02

The results of Table 9 are depicted in Figure 7.

The two twin sisters exhibit a slightly different developmental pattern with respect to the measure 'sonority rises per target word' (Figure 7): for both sisters, the A-words have less sonority rises than the B-words which again have less sonority rises than the C-words. Examples for Sara are: A-word *mælk* 'milk' [ˈmːɛ] (standard pronun-

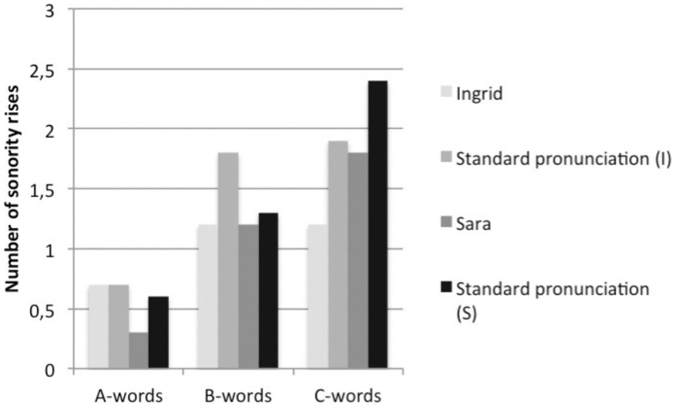

Figura 7. Number of sonority rises per target word (10 A-words, 10 B-words and 10 C-words).

ciation [ˈmɛlˀ g̊]); B-word *spiser* 'eat' [ˈ g̊ʁisɐ] (standard pronunciation [ˈsb̥iːˀsɐ]); and C-word *hundehvalp* 'puppy' [ˈhunəˌvalˀ b̥] (standard pronunciation [ˈhunəˌvalˀb̥]) – all three words represent Sara's maximum in sonority rise among the target words at the three different stages. This measure of sonority thus presents a stronger developmental evolution than the first two measures (number of segments, and of syllables, per target word). There is a small difference between the two twin sisters, however, inasmuch as the developmental increase in this measure (sonority rises per target word) is larger (i.e. the 'curve' would be steeper) for Sara than for Ingrid. As for the standard pronunciation of the target words (Table 3-5), the difference in word length, number of segments, syllables, (different) sonority types and sonority rises is already present in regard to which words the children try to pronounce – even though we are not sure how distinctly they are pronounced by the parents.

7. Discussion and further perspectives

Earlier studies indicate that Danish children are late in their early language acquisition (e.g. lexicon and past tense inflection) compared to children acquiring other languages, but already at the age of 3 years Danish children seem to catch up with other children (Bleses et al. 2008). This could be an indication that the indistinct Danish sound structure is a challenge in the very early language acquisition, i.e. at the stage where the children are to acquire (identify, segment etc.) the speech sounds of the specific language. The Danish sound structure may be a challenge in relation to the acquisition of speech sounds of the Danish language, i.e. already at the early stage where the children are acquiring monosyllables. This is due, we claim, to two (still active) weakening processes which have conspired to make Danish phonetic structure opaque, viz. final obstruent weakening and schwa reduction. As a consequence, it is not always possible to locate the appropriate syllable boundaries within one smoothly developing sonority slope or even to determine the correct number of syllables. This furthermore contributes to the opacity of morpheme boundaries in Danish, much more so than in its closest relative, Swedish. Since clear syllable structure, and the rhythm of sonority rises and falls it imposes on speech, provide children with privileged units for analysis (Oller 2000), Danish L1 acquisition can give us an idea how lexical development proceeds in languages offering less rich cues to syllable structure.

As for children's selection of target words from their ambient language, what we have found is a constant rise from A-words to B-words to C-words for all four measures: The target A-words contain less segments, syllables, (different) sonority types and sonority rises than the target B-words, and these again contain less segments, syllables, (different) sonority types and sonority rises than the target C-words. Turning to children's actual pronunciations of target words, they generally contain fewer segments, syllables, sonority types and sonority rises than the standard pronunciation of the words, but the sonority measures for actual pronunciations follow the same expansion over the twenty months as seen in the selection of target words.

As for the question whether Danish children avoid target words with vague syllable structure in the ambient language, we can say that for the middle and final words in this study (B- and C-words), there is no general avoidance, the children for example selecting *noget* 'something' (standard pronunciation [ˈnɔːəð̩]) and *over* 'over' (standard pronunciation [ˈʌwˀɐ]). If we look at the two children's first words (A-words), however, these are characterized by the absence of words with unclear transition between syllables – because they are all monosyllables. This could be interpreted in different ways: either the children specifically avoid words with unclear syllable structure at this earliest stage of lexical acquisition, or the children in general simply prefer (stressed) monosyllables. In the latter case, according to our sonority measures proposed in this paper, there would not be a clear systematic difference between Danish and Swedish monosyllables. If we include the number of sonority falls (in addition to sonority rises), however, monosyllables in Swedish would be more complex than in Danish with respect to the sonority envelope (compare e.g. Danish *mad*, ending in a vocoid, and its Swedish cognate *mat*, ending in a plosive).

The Danish and Swedish data are not directly comparable (partly due to morphological differences), though, and future studies comparing early lexical acquisition in these two sister languages with more equivalent data sets would be useful for illuminating the influence of sonority characteristics of ambient language on children's first words. Similarly, it would be interesting to compare vocabulary development in Danish with the vocabulary development found in unrelated languages with equal sonority characteristics to assess whether the patterns of lexical selection we find in Danish acquisition are typical of languages with a relatively monotonous sonority envelope or not.

Our conclusions on the development of early Danish vocabulary should be read cautiously for at least two reasons. First of all, we analyzed data from only two children, a pair of twins. This means that we cannot know how representative the patterns found are of early Danish vocabulary development in general, and the analysis should certainly be broadened in future studies. As a first step, we have begun analysis on a second pair of twins of the same age group, and the preliminary results suggest a replication of our findings here. Secondly, it is worth remembering that what we present as target pronunciations here are standard pronunciations as given in Danish dictionaries as norms for distinct pronunciation. As yet, we cannot be sure that children have actually encountered these distinct pronunciations in their input; in principle, what we present as children's reductions compared to input forms could in fact be full forms compared to what they actually hear. However, we have also transcribed all parents' actual phonetic realizations of all A-, B- and C-words; as a consequence, in new analyses we will be able to use those (the most distinct and/or the most frequent forms) as bases of comparison for child pronunciations. For the cases we have already checked, there is no doubt that children *do* reduce compared to input form, for example Ingrid's B-word [ˈ b̥is] (*spise*, 'eat'), which corresponds to [ˈs b̥iːs] in her parental input.

It would be interesting to study further whether the indistinct Danish sound structure has more effect on the acquisition rate than on the children's selection of words. And to conclude, the measures of complexity with respect to sonority presented in this paper – based upon a general and non-circular model of sonority which defines exactly five sonority types – should be applied to other languages with different (genetic and) typological characteristics, as a potential contribution to a typology of sonority changes with respect to L1 acquisition.

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Notes

1 Section 2 is based upon Basbøll (2012), section 3.

2 Such as /l/ in the second syllable of English *little*, or in the only syllable of Czech *vlk* 'wolf'.

3 Semi-vowels or glides, such as the first segment in the French monosyllable *oui* 'yes'. It is a vowel, phonetically, despite its function as non-peak.

4 Sonorants are defined acoustically (following Ladefoged 1971: 58: "a comparatively large amount of acoustic energy within a clearly defined formant structure"; Ladefoged 1971: 93: "greater acoustic energy in the formants").

5 This follows from the definition used here combined with the phonetic (articulatory and acoustic) fact that in order to get great acoustic energy in the formants, the vocal chords must vibrate.

6 It was demonstrated by Frøkjær-Jensen et al. (1971) that in Danish, the aspirated plosives [p^h t^s k^h] have spread glottis, like the voiceless fricatives (e.g. [s f]), whereas the unaspirated plosives [b̥ d̥ g̊] are voiceless but do not have (widely) spread glottis.

7 When the Sonority Syllable Model is applied to a specific language, some of its circles are typically non-active, i.e. they do not predict any specific ordering of segments in that language. This is no violation of the logic of the model: in an implication chain where 'A implies B implies C' it is, by logical necessity, also the case that 'A implies C' – this corresponds to the removal of a circle in the model. Furthermore, different circles can be non-active in either margin of the syllable.

8 The Sonority Syllable Model also predicts that marginal segments in absolute initial and final position have [spread glottis], for example *st-, ts-; -st, -ts*. This accounts for apparent violations of the sonority hierarchy and is testable by observing the glottis (Basbøll & Lambertsen 2014).

9 Danish /b d g/ are realized as voiceless, /p k/ as aspirated, and /t/ as affricated. Vowel qualities are normalized in accordance with Basbøll (2005) and Grønnum (2007).

10 There is no natural way to pronounce a Danish word like *hårdere* 'harder' with any contoids (like [ʁ]) intervening in the vocoidal string after [h].

11 "Dano-Norwegian" in Haugen's (1976) terminology.

12 OLAM is a coding and analyses system for Danish developed by Claus Lambertsen, Hans Basbøll & Thomas O. Madsen.

13 The numbers in Table 6 are based on Table 3-5. Everything marked in the transcription as a segment is counted as a segment (e.g. final [h] even if it could be regarded as a breath). Superscript [^{h}] does not count as a segment, and the same goes for length, stress and stød as well as nasalization; identical segments (as in [ˈmːmː]) are each counted as a segment. The standard forms are very distinct (e.g. *skraldespanden* 'bin' without schwa-assimilation). In for example *kage* 'cake' [ˈk^hæː(j)ə] "[(j)]" counts as a half a segment. Where there are two alternative forms, we count the mean.

14 The numbers in Table 7 are based on Table 3-5. For instance [ˈmːmː] counts as one syllable because there is only one stress and [m] is not an inherently syllabic segment. [ˈseːeː] is counted as two syllables due the two e's (because they are syllabic per definition), and a sequence [eæ] or the like is counted as two syllables. If syllabicity (by schwa-assimilation) is marked by "[-]", it counts as a syllable.
15 The numbers in Table 8 are based on Table 3-5. Here we count the number of different sonority types in the single word. Stød is a prosodic feature and therefore not taken into account here. The transcriptions are followed closely, i.e. a final stop which is transcribed as unaspirated and one which is transcribed as affricated or aspirated, are counted differently. The consonantal [ʁ] is counted as a voiced fricative. Nasals and [l] belong to the same sonority type and vocoids include vowels [ð̞], [w] etc.
16 The numbers in Table 9 are based on Table 3-5. We count one segment at a time, divided into sonority types. For example *blød* 'soft' [ˈ b̥løð̞ˀ]: from [b] to [l] is one sonority rise, from [l] to [ø] likewise. The remaining segments are vocoids and the total number for *blød* is therefore 2.

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