Voice less, front more.
On the development of knowledge of voicing and vowel alternations in German
nouns by 5 year-olds, 7 year-olds and adults

Morphemes are realized differently in different contexts. Knowledge of such alternations involves the ability to extend them to novel items (Pierrehumbert, 2000; Ernestus & Baayen, 2003). Not much is known about the development of this knowledge in children (see Kerkhoff, 2007, for a recent study). German has a voicing and a vowel alternation in singular - plural pairs and is therefore an appropriate language to study this issue.

We present the results of three wug tests (Berko-Gleason, 1958), one with twenty 5 year-olds, one with twenty 7 year-olds and one with twenty adults, to study the extension of voicing and vowel alternations to nonces in each age group. Our finding is that the proportion of voicing alternations in nonces decreases with age, while the proportion of vowel alternations increases. We conclude that: First, the role of phonetic substance decreases over time and the role of input statistics increases. Second, phonetically arbitrary patterns are learned (Hayes, Zuraw, Siptár & Londe, 2009; Zuraw, 2010)(but see Becker, Ketrez & Nevins, 2011).

In a voicing alternation a voiceless stem-final obstruent of a singular may correspond to a voiced one in the plural, as in the pair [fjɔrt] - [fjɔrdə] "fjord". This alternation is phonetically probable; it is common cross-linguistically to voice obstruents intervocallically and doing so is phonetically grounded (Westbury & Keating, 1980). In a vowel alternation a back vowel in the singular may correspond to a front vowel in the plural, as in [kuː] - [kyːə] "cow". The majority of singular - plural pairs does not alternate, for example [ɔrt] - [ɔrtə] "place" and [ʃuː] - [ʃuːə] "shoe".

In the wug tests we asked our participants to form the plural of 39 singular nonces. We found that the proportion of voicing alternations decreases from 5 year-olds to adults, whereas the number of vowel alternations increases from 5 year-olds to adults (see table 1 and figure 1).

Alternations in nonces are the consequence of markedness constraints. These constraints can be derived from phonetic substance (Boersma, 1998; Hayes & Steriade, 2004) or input statistics (Bybee, 2001). Constraints derived from phonetic substance are based on the child's knowledge of its production experiences (Hayes & Steriade, 2004). Statistical markedness constraints are based on pairs of specific lexical items (Pater & Coetzee, 2005). The child's experience of the difficulty of producing voiceless intervocalic obstruents will result in general constraints against such sequences. Such a constraint will affect all relevant sequences and result in more alternations than found in the input. This overgeneralization will be countered by ranking the statistical constraints higher; many more words do not alternate and each violation of the phonetically based constraint will demote it. This scenario predicts a decrease of phonetically probable alternations over time, due to the higher ranking of statistical constraints. The vowel alternation has no phonetic basis and there are no phonetically based constraints to boost its production. The amount of vowel alternations increases therefore steadily over time, which also shows that arbitrary alternations can be learned.

word count: 495

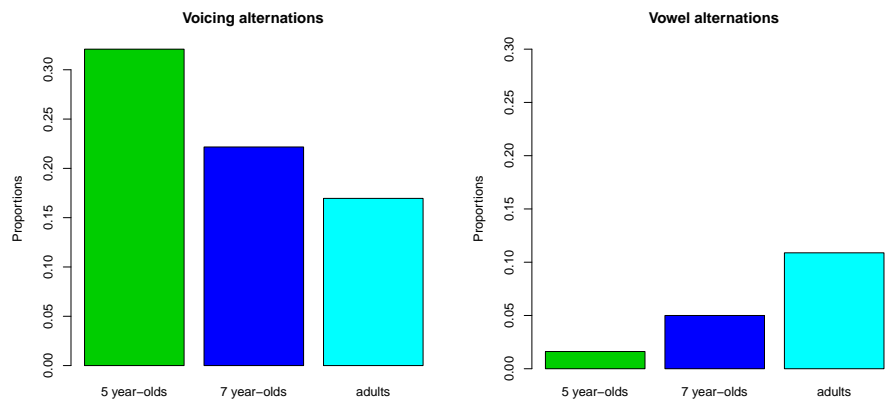| Voicing alternations		
	Alternations	No alternations
5 year-olds	43 (32%)	91 (67%)
7 year-olds	47 (22%)	165 (77%)
adults	49 (17%)	240 (83%)
Vowel alternations		
	Alternations	No alternations
5 year-olds	11(1%)	669 (98%)
7 year-olds	34 (5%)	646 (95%)
adults	74 (11%)	606 (89%)

Table 1: Alternations produced across ages

Figure 1: A comparison of the development of voicing and vowel alternations across ages.

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