General Session, June 11th
Do bilingual children begin with one system or two? The question has generated controversy for over 30 years, with regards to phonology as well as lexicon and morphosyntax (e.g., Volterra & Taeschner, 1978; Pearson et al., 1995; Paradis & Genesee, 1996; DeHouwer, 2005). Attempts have been made to settle the question for phonological development based on production studies, with respect to phonetic inventories (Schnitzer & Krasinski, 1994, 1996), process use (Berman, 1977), acoustic analyses (Deuchar & Clark, 1996; Kehoe, 2002; Kehoe et al., 2004), and phonotactic (Ingram, 1981) or prosodic structures (Lleó, 2002). The dominant current view is that there are two systems from the start, but with some interaction (Lleó & Kehoe, 2002). The position is more programmatic than empirical, as it is difficult to demonstrate definitively that a child has one system or two at any given point in a dynamic period of change; allowing for ‘some interaction’ effectively renders the question moot.

Taking an emergentist approach, Vihman (2002) proposed that infants begin with a vocal repertoire of familiar segments, sequences and structures whose match to the input provides a starting point for word production. On this item-learning account no phonological system need be posited for the earliest stages of bilingual (or monolingual) development. Once the child has produced a number of words, preferred word patterns or templates are abstracted from the existing forms and applied to less easily assimilated adult-word targets (Vihman & Croft, 2007), initiating the first systematic organization.

Based on one child each acquiring English along with French, Hebrew and Estonian Vihman (2002) showed that in each case templates were used to adapt words from both of the child’s languages (cf. also Brulard & Carr, 2003). This paper extends the illustrative template data, supplemented by quantitative analyses, to five children bilingual with English, one each learning German or Spanish and three learning Estonian. Although the children vary in the extent to which they differentiate prosodic structures in their two languages, every child has templates to which she adapts words from both.

The findings suggest a paradox. Perceptual studies have made it clear that infants differentiate their languages within the first six months (Mehler et al., 1988; Bosch & Sebastián-Gallés, 1997). Additionally, according to exemplar theory lexical representations will initially include the voices of familiar speakers. Why then would a single template be extended to words in both languages? We argue that this generalization, rather than reflecting a ‘unitary system’ (following the earlier models), is mediated by the child's experience of his own production, which is much the same (given articulatory limitations) for words in either language, and likely also by hearing some words used by (bilingual) speakers of both languages. Such a production effect would not be apparent in the child’s first word uses, whose simple form often makes it difficult to identify the linguistic source (the period of ‘no system’), but should be observable as lexical production increases and the typological differences seen in cross-linguistic studies emerge along with greater systematicity (Vihman, 2012).
References

Interaction in Spanish-English Bilinguals’ Acquisition of Segments and Syllable Types

[1] UCSD (USA); [2] SDSU (USA)

Keywords: frequency, complexity, syllable structure, bilingualism, interaction, Spanish, English

When monolinguals acquire phonology, they must master the set of sounds used, and how sounds interact within the system and organize into syllables. Bilinguals face the same task, but for two languages in the time monolinguals take to acquire one. However, the source of this efficiency in bilingual acquisition is not well understood.

Research has shown growing evidence of interaction in bilingual acquisition (Paradis & Genesee, 1996), where acquisition of one language influences acquisition of another. For instance, Lleó et al. (2003) found acceleration in Spanish-German simultaneous bilinguals’ (1-3 yrs.) acquisition of Spanish codas: bilinguals produced target codas with greater structural accuracy than Spanish monolinguals. They argued that acceleration resulted from bilinguals’ exposure to German, which uses singleton codas more frequently than Spanish. While Lleó et al. found evidence of bilinguals’ higher structural coda accuracy, segmental accuracy remains unknown. Less frequent exposure to each type of coda could result in deceleration. Additionally, exposure to more complex kinds of a given syllable type could aid structural or segmental acquisition.

Our study addresses structural and segmental acquisition of singleton codas and onset clusters by Spanish and English mono- and bilingual children. We hypothesize that frequency of exposure is tied to acceleration and deceleration, while complexity is tied to acceleration. In English, codas are more frequent and more varied compared to Spanish. We therefore predict bilinguals will show accelerated acquisition of singleton codas compared to Spanish monolinguals, but decelerated acquisition compared to English monolinguals due to less frequent exposure. Onset clusters are similarly frequent, but differently complex in each language; English allows 3-element clusters, and Spanish approximant-liquid clusters (Barlow, 2003) have smaller sonority distances. We therefore predict accelerated bilingual acquisition of onset clusters compared to monolinguals within each language.

Participants were 15 children (5 monolingual English, mean: 38.6 mo; 5 monolingual Spanish, mean: 39.1 mo.; 5 early bilingual Spanish-English, mean: 44.1 mo.) from the Southern California area. Data were transcribed participant productions of target singleton codas and onset clusters, elicited using phonological probes targeting all consonants in all positions (onset clusters: 77 English, 41 Spanish; singleton codas: 187 English, 94 Spanish). Analysis comprised structural and segmental production accuracy rates, where structural accuracy counted consonant substitutions as hits and segmental accuracy counted them as misses.

Mixed models showed significant differences between bilinguals’ and monolinguals’ production accuracies in both analyses for both positions (Table 1-2). Bilinguals’ onset cluster productions were more accurate than monolinguals’ in both languages, while their coda productions were less
accurate than English monolinguals’. Bilinguals’ and Spanish monolinguals’ coda production accuracies did not differ.

As predicted, bilinguals exhibited decelerated singleton coda acquisition compared to English monolinguals due to less frequent exposure. However, bilinguals’ acquisition of codas was not accelerated compared to Spanish monolinguals, unlike Lleó et al.’s findings, possibly due to differences in participant age or language background. Finally, bilinguals showed accelerated acquisition of onset clusters in both languages due to exposure to more complex types of onset clusters, suggesting that frequency and complexity are both sources of interaction in bilingual acquisition.

<table>
<thead>
<tr>
<th>Language: English</th>
<th>Syllabic Position</th>
<th>Participant Background</th>
<th>Mean Production Accuracy (Percent)</th>
<th>Standard Deviation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset Cluster</td>
<td>Monolingual</td>
<td>0.57</td>
<td>0.498</td>
<td>*</td>
<td>(F=6.275, p&lt;.05)</td>
</tr>
<tr>
<td>Coda</td>
<td>Bilingual</td>
<td>0.68</td>
<td>0.468</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Segmental Analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton Cluster</td>
<td>Monolingual</td>
<td>0.66</td>
<td>0.473</td>
<td>*</td>
<td>(F=4.892, p&lt;.05)</td>
</tr>
<tr>
<td>Coda</td>
<td>Bilingual</td>
<td>0.57</td>
<td>0.495</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Structural Analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton Cluster</td>
<td>Monolingual</td>
<td>0.86</td>
<td>0.347</td>
<td>*</td>
<td>(F=30.471, p&lt;.001)</td>
</tr>
<tr>
<td>Coda</td>
<td>Bilingual</td>
<td>0.67</td>
<td>0.469</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. English Segmental and Structural Analysis Results

<table>
<thead>
<tr>
<th>Language: Spanish</th>
<th>Syllabic Position</th>
<th>Participant Background</th>
<th>Mean Production Accuracy (Percent)</th>
<th>Standard Deviation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset Cluster</td>
<td>Monolingual</td>
<td>0.33</td>
<td>0.495</td>
<td>*</td>
<td>(F=10.969, p&lt;.01)</td>
</tr>
<tr>
<td>Bilingual</td>
<td>0.58</td>
<td>0.471</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Segmental Analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton Cluster</td>
<td>Monolingual</td>
<td>0.59</td>
<td>0.493</td>
<td>NS</td>
<td>(F=2.271, p=.132)</td>
</tr>
<tr>
<td>Coda</td>
<td>Bilingual</td>
<td>0.72</td>
<td>0.448</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Structural Analysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton Cluster</td>
<td>Monolingual</td>
<td>0.4</td>
<td>0.492</td>
<td>*</td>
<td>(F=51.745, p&lt;.001)</td>
</tr>
<tr>
<td>Bilingual</td>
<td>0.84</td>
<td>0.369</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singleton Cluster</td>
<td>Monolingual</td>
<td>0.67</td>
<td>0.472</td>
<td>NS</td>
<td>(F=.725, p=.395)</td>
</tr>
<tr>
<td>Coda</td>
<td>Bilingual</td>
<td>0.78</td>
<td>0.415</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Spanish Segmental and Structural Analysis Results

References


Effects of linguistic structure and ambient language in the prosodic development of Spanish-English simultaneous bilinguals compared to monolinguals

Brechtje Post[1], Elaine Schmidt[1], & Elinor Payne[2]

While a number of studies have analysed rhythm development based on the complexity of consonant clusters and vowel reductions, and quantified it with the help of rhythm metrics, relatively little is known about the development of the marking of prosodic heads and edges, although this has been shown to contribute significantly to rhythm (Prieto et al.2012). For prosodic heads, it has been established that young children struggle to produce the consistent durational distinctions between stressed and unstressed syllables characteristic of English but it is unclear to what extent durational distinctions for prosodic edges are problematic, and whether and how durational marking for heads and edges interact in child development.

Bilinguals are faced with the additional difficulty that the two languages realise heads and edges differently. Comparing monolingual and bilingual development here enables us to isolate problems in the acquisition that are inherent in the feature to be acquired or in the acquisition process more generally.

In this paper we report a semi-structured-elicitation task-based study investigating the development of marking of prosodic heads and edges in Spanish-English bilingual 2-,4-, and 6-year-old children in the UK (UKBL) and Spain (SPBL) and monolingual (ML) control groups. We asked at what age children master length distinctions between different stress (unstressed, accented, nuclear accented) and boundary (Intonation Phrase vs. word) conditions and whether bilingual children follow the same developmental path as monolingual children, or whether acquisition of pre-boundary lengthening and accentuation in one will facilitate the acquisition in the other language. We also analysed how children’s realisations of prosodic heads and edges affect their rhythm overall by applying a set of rhythm metrics that have been found to be discriminative for child speech cross-linguistically (%V, nPVI-V, ΔC, rPVI-C; Payne et al.2012).

Initial findings show that UKBL and monolinguals already produce durational distinctions between different syllable types in English from age 4. Interestingly, SPBL fail to make a distinction between accented and final syllables in English and follow the Spanish pattern. This suggests that the ambient language is an important factor in determining developmental progression.

Vocalic rhythm metric scores in Spanish reveal that 4-year-old BL and ML have adult-like proportions of vocalic material in their speech. However, in English the variability of vocalic intervals is significantly lower in the SPBL group, again highlighting the importance of ambient language. Unlike ML, who show off-target variability in consonantal variations in both English and Spanish, all BL have adult-like rPVI-C scores at 4.

We conclude that the marking of prosodic heads and edges is a decisive factor in rhythm development of children of all language backgrounds. Additionally, in bilinguals, the two languages interact, leading to faster acquisition of certain prosodic features. Finally, the ambient language is of crucial importance, since bilinguals with the same language backgrounds but from different countries follow slightly different developmental paths. Our consonantal findings in particular suggest that BL may be benefitting from more advanced motor control due to the
production of a greater variety of structures which allows them to coordinate complex articulatory gestures at an earlier age.
A bilingual early advantage in the broad cognitive domain has been reported (Kovács & Mehler, 2009a), whereas mixed findings are found in language domain. It remains unclear whether mono- and bilingual infants follow the same developmental trajectory in early language acquisition. Some studies found (temporary) delays in bilingual early consonant (Garcia-Sierra et al., 2011) and vowel perception (Sebastián-Gallés & Bosch, 2009), whereas others showed no such delay (Burns et al., 2007; Sundara et al., 2008; Albareda-Castellot et al., 2011). A recent study reveals a bilingual early advantage for non-native tone perception, as an indication of their enhanced acoustic sensitivity (Liu & Kager, 2013).

Specifically in the vowel domain, two patterns have been reported regarding early bilingual vowel perception: (i) bilingual infants keep the same pace as their monolingual peers (Albareda-Castellot et al., 2011, Sundara & Scutellaro, 2010), and (ii) a temporary delay may occur in the first year of life, leading to a U-shaped perceptual pattern (Bosch & Sebastián-Gallés, 2003b, Sebastián-Gallés & Bosch, 2009). The potential influential factors for the latter pattern are argued to be statistical regularities / relative frequency across languages, overlapping vowel categories in the perceptual space, rhythmic similarity between the target languages, etc.

The current study asks whether monolingual and bilingual infants follow the same developmental trajectory in vowel perception in the first year of life.

200 monolingual Dutch and 104 bilingual infants with Dutch as one L1 aged 5-6, 8-9, 11-12 and 14-15 months were tested on their perception of the Dutch /i/-I/ vowel contrast, in which the major acoustic cue resides in spectrum but not duration. A visual habituation procedure was adopted: after being habituated on one category, infants were dishabituated on the other. Discrimination was shown by the increase of looking time when infants regained their attention towards the acoustic stimuli.

Results show that neither monolingual nor bilingual infants discriminate the contrast at 5-6 months. Monolingual infants discriminate the contrast at around 11-12 months (FIG1, p < .001), whereas bilingual infants show discrimination 3 months earlier, at 8-9 months (FIG2, p = .007). The looking time difference between mono- and bilingual infants at 8-9 months is significant (p = .018).

The initial failure to discriminate a native contrast reveals the relative acoustic difficulty of the Dutch /i-/I/ contrast. This was previously found for a less-salient native consonant contrast (Tagalog /na/-/ŋa/, Narayan et al., 2010). The current research extends this scenario to the vowel domain.

The finding that bilingual infants are ahead of monolinguals in discriminating a native contrast has not been previously reported in the speech domain. This distinct perceptual pattern may be
caused by the complexity of bilingual infants' language environment. In addition, thresholds of absolute and/or relative frequency in the bilingual's input may exist in order for infants to command native phonetic categories.

Future studies will look into potential difference among bilingual infants with different language backgrounds, and into the correlation between infants' degree of exposure and their discrimination ability.

References


Studies have shown that, before 17 months of age, children have substantial difficulty in learning to associate novel words to their picture referents when the novel words form phonologically minimal pairs, i.e., when they differ in a single consonant (e.g. *bin* versus *din*).

It has also been shown that children under 17 months can associate objects’ referents to some novel minimal pairs involving vowels: when learning to associate *deet* and *dit* to objects A and B, children looked longer when *deet* was presented with the object that had been associated with *dit* and vice versa, than when these words were presented with their corresponding objects, while they did not look longer to this switch of word-object referent when the words were *deet* and *doot*. This suggests that the difficulty in early word learning depends on the type of phoneme contrast presented to the learner.

Previous studies present toddlers with novel words spoken by native speakers of their own dialect (often Canadian or American English). Here, we examine whether dialectal differences in the production of novel minimal vowel pairs affect early word learning success. From a phonological/phoneme-based perspective, dialectal variation should not yield differences in word learning performance. However, an experience-based attunement perspective would predict higher levels of success for native than non-native dialects, while an acoustic/articulatory perspective would predict that the dialect with the largest phonetic differences would yield more success regardless of nativeness.

Two groups of Australian English 15-month-olds (N = 24 each) were presented with the novel words *deet, dit* and *doot* produced by either an Australian English (native dialect) or a Canadian English (non-native, but has larger acoustic-phonetic differences among these vowels) female speaker. Across dialects, stimuli were matched for IDS contours and voice quality, and a phonetically-trained listener reported that there was a clear difference in the vowels, while the consonant frames sounded very similar. Toddlers in the two stimuli groups were presented with learning trials where they saw a moving object on the screen and heard *deet*. After habituation, they were presented with three test trials, all of which showed the same moving object but played different words (*deet, dit* and *doot*). Test trial order was counterbalanced across infants, with the *deet* test appearing first, second or third.

A repeated-measures ANOVA with word as within-subject factor and dialect (Canadian versus Australian) and order (*deet* in three different positions) as between-subjects factors revealed a main effect of word, qualified by a word x dialect interaction. Paired t-tests showed that the Australian toddlers exposed to Canadian stimuli looked longer at the switch (*dit* and *doot*) than at the same trials (*deet*), while no effect of test trial was found for the toddlers exposed to Australian stimuli.

Thus, dialectal differences in the stimuli indeed affect early word learning. Moreover, novel words produced in the learners’ native dialect are not always easiest to learn. Rather, the
acoustic/articulatory properties of the stimuli and how they compare to the learners’ phonetic categories appear to be the strongest predictors of early word learning success.
In human speech, the same word can be produced in various ways while the meaning of the word is not affected. Similarly, one single phoneme can have multiple different realizations. As adults, we can easily normalize the different realizations of the same phoneme, and ignore the irrelevant variations that do not affect meaning. However, for infants, to build up abstract phonological categories based on multiple different realizations is not an easy task. When and to what extent infants succeed in normalizing speech sounds remains unclear (Singh, Morgan & White 2004; Houston & Jucszyk 2000; Singh, 2008; Kuhl 1979, 1983).

These aforementioned studies focused on infants’ perception of native words or native vowels. However, the normalization of native sounds may simply reflect the native language knowledge accumulated in the long term, and the frequency of the tested sounds in the native input may have influenced the results. Hence, to pinpoint how the ability of normalizing speech sounds develops, we trained infants with a non-native contrast. 149 Dutch infants aged 4 (N=29), 6 (N=60), and 11-12 (N=60) months were tested with a lexical tone contrast, which is absent in their native language. In the experiment, the infants were first trained with one tone until they got habituated. In the following test phase, they were tested with one “old trial”, where they were presented with one different token of the tone as they have heard in the test phase, and one “novel trial”, presenting a new tone that they had not heard yet. If the infants were able to normalize the training tone, then they should be able discriminate the novel tone from it. In this way, we simulated a language learning situation. Importantly, we controlled the amount of token variations in the training phase: the infants were trained with either one single token (ST), or multiple tokens produced by one single speaker (MT), or multiple tokens produced by two speakers (TS). The three conditions differed in terms of inter-token variability. The tones used in the experiment were the Mandarin rising tone (T2) and dipping tone (T3), which are the most difficult tonal contrast for both native and non-native listeners (Huang 2001). We chose this difficult contrast to prevent possible ceiling effect (Liu & Kager 2012). The training tone (either T2 or T3) was counter-balanced among the infants.

The 4-month-old infants were trained under both ST and MT condition. In neither case did the infants succeed in discrimination. The 6-month-old and 11-12-month-old infants were trained under all ST, MT, and TS conditions. At 6 months, only those trained in MT showed a significant discrimination effect; at 11-12 months, the infants succeeded in all three conditions. We conclude that, after a very short training phase, infants’ are able to normalize variable tokens of speech sound, and their normalization ability mainly improves between 6 and 9 months. Cross-speaker normalization occurs later than within-speaker normalization.
References


A deep look into the developing lexicon: revelations from covert picture-naming

Céline Ngon & Sharon Peperkamp
Laboratoire de Sciences Cognitives et Psycholinguistiques (France)

Infants store word-forms with phonological detail from an early age: French-learning infants, for instance, recognize familiar words at 11 months, and have phonologically detailed representations in their receptive lexicon from 12 months. Productive capacities, by contrast, develop more slowly, with words being incorrectly articulated until well into school age. However, there is evidence that infants can internally generate correct phonological word forms from an early age. For instance, a phonological priming study found that word recognition in 18-month-olds is facilitated by the prior silent presentation of a known object which name is phonologically related to the name of the target object (e.g., cat-cup). This priming effect shows that infants covertly produced the prime object’s name. Is it likely, however, that infants in this study could produce several prime and target words overtly. Here, we focus on known words that are not yet produced overtly, and show that infants can 1. covertly produce those word-forms, and 2. categorize them on the basis of their length.

Two groups of 21-month-old French-learning infants are tested in an anticipatory eye-movement procedure (see Fig. 1); one group is presented with mono- vs. trisyllabic words and the other with mono- vs. disyllabic words. The experiment starts with a learning phase, where trials begin with the central presentation of an object, while its auditory label is played simultaneously. The offset of the image is followed by two white squares appearing on each side of the screen and finally, the object reappears after 1.5 seconds in one of the squares. For half of the infants in each group, it reappears in the left square if its name is monosyllabic and in the right one if it is multisyllabic; for the other half, it is the reverse. The 1.5 seconds time delay allows infants to anticipate the location of the object’s reappearance, by inferring the association between the length of the object’s label and the side of its reappearance. The following test phase contains similarly designed trials with the presentation of new objects, but without their auditory label. Thus, the only way for infants to anticipate the object’s reappearance is to internally generate its name themselves and inspect its length. Crucially, each infant is tested on words s/he comprehends but does not yet pronounce according to parental report. So far we have tested 45 infants divided over the two groups, and found that in the test phase, infants’ first looks were significantly more often oriented towards the correct side than the incorrect side for the mono- vs. trisyllable group ($t(22) = 3.29; p = 0.003$) but only marginally so for the mono vs. disyllable group ($t(21) = 1.48; p = 0.077$).

These results show that infants can covertly produce word-forms that they do not yet produce overtly, and categorize them as mono- vs. trisyllabic. Testing additional infants will determine whether successful categorization holds for words with a smaller phonological difference.

---

Figure 1. Timeline of two typical learning trials (a) and one test trial (b).
The interaction of phonetic variability and whole-word systematicity in child phonology

Marta Szreder
University of York (UK)

Several factors have been mentioned in phonological development literature as possible sources of the phonetic variability observed in child data. Firstly, variability can be attributed to underdeveloped motor control (Smith & Goffman 1998, Goffman & Smith 1999). Secondly, variability at early stages could be due to small vocabulary, which does not allow for the emergence of stable phonetic categories (Lindblom, Studdert-Kennedy & MacNeilage, 1983; Walley & Metsala, 1990; Lindblom, 1992; Walley, 1993). Thirdly, variability might result from the difficulty of targets (Leonard et al 1980.) However, Sosa & Stoel-Gammon (2006) report patterns of variability which do not confirm the predictions of any of the above hypotheses. In this study, we had two research objectives:

1) To examine patterns of variability and their relationship with the previously proposed factors using a variability measure different from Sosa & Stoel-Gammon’s in that it is based only on words with multiple recorded tokens (percent words with >1 different phonetic form in words with >1 token.) This measure allows to control for the fact that single-token words do not exhibit variability by definition.

2) To investigate the possibility that phonetic variation in early phonological acquisition can be linked to whole word systematicity, which has been mentioned in the literature (Ferguson & Farwell, 1976, Vihman, 2009) but not sufficiently studied. Specifically, our hypothesis was based on the study of complex systems (Thelen & Smith 1994, Kelso 1995), in which periods of variability are expected to precede the transition to and from a stable state. Under this view, variability could be the sign of the phonology undergoing a transition to and from a stable templatic organisation.

Longitudinal data from three children acquiring English were analysed, from the 25 word point onwards for six months. We examined the interdependencies between variability and chronological age ($r=0.14$), lexicon size ($r=0.11$), and challenging targets ($r=0.07$), as well as between variability and T score, a measure of whole word systematicity developed by Vihman et al (in prep.) Variability did not correlate with any of the three factors mentioned in the literature, thus mirroring the findings of Sosa & Stoel-Gammon (2006) despite the modified measure of variability. Motor skills could explain part of variability observed, as apparent in variability being present even at higher levels of accuracy in one subject who did not develop templates. Nevertheless, in the two children who developed strong templates, variability increased along with emerging systematicity, then decreased when systematicity reached its peak, to increase again when systematicity was disappearing. In consequence, the highest variability was observed for medium T score (either decreasing or increasing) (Fig. 1). Although the two variables did not correlate linearly, they were interdependent.

We conclude that variability should not be considered solely a deviation from target, a side effect which reflects underdeveloped cognitive or articulatory competence, but instead an important sign of transition from one stable stage of phonological organisation to another in a dynamically self-organising complex cognitive system.
Figure 1. Word shape systematicity score (T score) and variability in the two subjects who developed word templates.
References


The role of French loan word adaptation in the acquisition of consonant length in Lebanese Arabic

Ghada Kattab & Jalal Al-Tamimi
Newcastle University (UK)

Lebanese Arabic has long exhibited influence from French and more recently English due to its colonial past. Code-switching between Arabic, French, and English is very common but the base language tends to vary across Lebanese communities according to social factors such as religion, education, and social class. While many French words have over time been adapted to Arabic phonology, their production varies from French-like to Arabic-like, also according to the above social factors, which makes it difficult to draw a line between guest words and loanwords (e.g. portproduced as [pɔʁ] or [boɾ], the latter reflecting the lack of /p/ from the Arabic consonant inventory and the final rhotic being realised as an Arabic tap). Words with an iambic disyllabic structure and spelling which reflects historical medial gemination in French (e.g. appelle, casse etc.) are often realised with a long/doubled medial consonant ([appɛl] and [kasse] respectively) by some speakers, and this extends to other iambic stressed disyllables (e.g. papa [pappa], maman [mamma]). No phonetic study has so far established the duration of these medial consonants in relation to medial geminates in Arabic and the role they play in the acquisition of contrastive consonant length by Lebanese-speaking children.

This study builds on earlier work which looked at the acquisition of gemination by Lebanese-speaking children (Al-Tamimi & Khattab, 2011; Khattab, 2007; Khattab & Al-Tamimi, 2013, 2009), and found a tendency for children to lengthen target medial singletons in Arabic in the process of acquiring contrastive consonant length, leading to overproduction of long consonants. This seemed to be the pattern regardless of the frequency of French and English words that the children heard and produced, which prompted a closer look at the realisation of medial consonants in French in both adult and children. Longitudinal data from 10 Lebanese-speaking children were collected between the beginning and end of the one-word stage (roughly between ages 1;3 and 2;2). The children were recorded at home while engaged in 30-min spontaneous interactions with their mothers. Data for this paper are drawn from around 5000 target utterances across children and stages. These were disyllables with medial singleton/geminate consonants in from the Arabic and French utterances produced by the mothers and the children. The utterances were labelled and transcribed using narrow IPA transcription. Then, duration measurements for the medial consonants, their surrounding vowels and the whole word were made in PRAAT in order to calculate absolute and proportional durations. Results show that the adults are variable in their production of medial consonants in French, and those who lengthen them do so to a ratio of 1:1.5, as opposed to 1:2 found for singleton-geminate consonants in Arabic. The children, on the other hand, treat the French words the same as Arabic words with a medial geminate, turning a 3-way duration contrast in the adult production into a 2-way contrast and using French words to aid their acquisition of the geminate contrast. The interaction between variable input, phonetic ability and phonological learning will be explored.
References


The Acquisition of Phonetic Vowel Reduction

Ellinor Payne & Ladan Baghai Ravary
University of Oxford (UK)

Studies on the acquisition of vowel reduction have mainly focused on phonological vowel reduction (PLVR) [1, 2] rather than ‘online’ phonetic vowel reduction (PTVR). PTVR may include spectral changes (e.g. centralisation), and/or other changes e.g. shortening, devoicing [3, 4], though quantitative data is scarce [4]. As reduction is tied to prominence relations it is claimed to be an important factor in the rhythm percept [5, 6], with greater variability in vocalic duration correlated with the percept of uneven (‘stress-timed’) rhythm, e.g. English. There are claims that spectral reduction can contribute too [7]. With respect to acquisition, [8] show that young infants (2 years) exhibit more even timing than adults, suggesting durational correlates of vowel reduction are less evident in early speech. A related question is the extent to which children signal prominence relations through spectral change.

To explore this, we investigated spectral PTVR for different stages of acquisition (2, 4 and 6 year-olds) in English, Catalan and Spanish, and compared these with adult targets. The material consisted of semi-spontaneous child/mother dialogues between 9 English-speaking female adults and their 2-, 4- and 6-year old children. Vowels were segmented and labelled for relative ‘prominence’ in Praat (lexical stress, presence of pitch accent), then extracted for formant analysis. Identifying and measuring formants in high-pitched speech is problematic, since spacing between pitch harmonics (up to 400 Hz) can be wider than the formants themselves (B1 and B2 c. 100 Hz). Instead of using a formant tracker, which is prone to serious error, average F1 and F2 values over the whole of each phoneme were extracted.

In adult speech, we found evidence of centralisation in the mid vowels /ɒ ɛ/ in positions of low prominence when compared with positions of high prominence: e.g. in /ɒ/ a lower F1 and higher F2 when unstressed (p<0.001, F(1,73) (see Figure 1a). No such pattern was found in the high vowels /i:/ or /ɪ/. In child speech, we found no evidence of vowel centralisation for mid or high vowels in positions of low prominence, for any age tested (see Figure 1b).

The results show that, as with durational differences, children have yet to acquire the spectral means to cue prominence alternations in English by age 6. As infants typically sound like they are stressing each word, the question arises as to whether they have a flatter prosodic structure at this point, or have simply not yet mastered the phonetic cues of prominence alternations. Their perceptual sensitivity to prosody would support the latter. The connection with temporal reduction is also considered; i.e. can vowel undershoot be explained as a mechanical consequence of shorter duration? The pattern in adult speech would suggest the two are independent of each other, since centralisation is restricted to certain parts of the vowel space, while shortening is not.
Figure: F1 mean F1 and F2 in Hz for high and low prominence contexts for /d/. 1a (left) shows adult values; 1b (right) shows child values

References


Undifferentiated tongue shapes for /r/: Ultrasound, perceptual, and acoustic correlates

Harriet Klein, Tara McAllister Byun, Lisa Davidson, & Maria Grigos
New York University (USA)

Treatment for speech sound disorder (SSD) often features verbal cues encouraging the child to adopt a more accurate placement of the articulators. When the target articulatory posture for a sound is not externally visible, though, perceptual analysis alone may not allow the clinician to determine precisely how the child’s tongue is configured during misarticulation. This study used ultrasound imaging to explore tongue shapes associated with children’s correct and incorrect productions of English /r/. Our study expands on previous work in two ways. First, imaging data were compared against perceptual ratings and acoustic measurements for a multidimensional perspective on children’s /r/. Second, we were able to collect longitudinal data from two children with /r/ misarticulation as they acquired perceptually correct /r/ over 6-8 months of intervention. For comparison, data were also obtained from three typically developing children.

In our study, ultrasound images of children’s tongue shapes for /r/ were coded as retroflex, bunched, or undifferentiated (Figure 1). Undifferentiated tongue shapes reflect a lack of discrete control of functionally independent regions of the tongue, such as tip/blade versus root (Gibbon, 1999). Coding agreement between two blinded raters exceeded 90%. In the data from children with /r/ misarticulation, generalized linear models revealed agreement between tongue shape codings and perceptual and acoustic measurements: Undifferentiated tongue shapes were rated significantly less accurate than differentiated (retroflex/bunched) tongue shapes, and they exhibited significantly less adult-like acoustics (larger F3-F2 distance). However, a number of tongue shapes from typical children were also coded as undifferentiated, even though these tokens were perceptually and acoustically accurate. We thus undertook to refine our categorization using quantitative measures representing the degree of tongue curvature and location of the curvature peak (Ménard et al., 2012). Linear discriminant analysis revealed two subgroups within the undifferentiated category. Tongue shapes in the “anterior constriction” subgroup were acoustically and perceptually more accurate and more likely to have been produced by typical speakers. The “posterior peak” category, featuring a highly curved, posteriorly located tongue shape, was least accurate and was generally produced by speakers with SSD. This finding agrees with recent work by Boyce et al. (2011), who reported that children with the most severe /r/ misarticulation exhibit a “humped” tongue shape crucially characterized by the absence of a pharyngeal constriction formed with the tongue root. We also found that the occurrence of posterior peak shapes declined over the course of successful intervention, during which participants with SSD were encouraged to adopt a retracted tongue posture. We thus support Boyce’s contention that intervention for /r/ misarticulation should include cues that explicitly encourage formation of a pharyngeal constriction. Lastly, we examined differences between consonantal/onset and vocalic/syllabic /r/. We found that these variants were associated with different perceptual, acoustic, and articulatory properties, with distinct trajectories of change over the course of treatment. Unlike McGowan et al. (2004), we did not find that perceptually correct vocalic /r/ can be produced with a simpler tongue shape than consonantal /r/. This finding also has implications for the nature of cues provided during /r/ intervention.
Figure 1. Ultrasound images illustrating children’s tongue shapes for /r/.  

a) An example of a retroflex /r/, produced by a typically developing child.

b) An example of a bunched /r/, produced by a typically developing child.

c) An example of an undifferentiated /r/ (“posterior peak” subcategory), produced by a child with SSD.

References


Isolated words in input to infants: A critical wedge?

Tamar Keren-Portnoy & Marilyn Vihman
University of York (UK)

The importance for early lexical development of hearing words in isolation as compared with having to segment them from running speech is hotly debated (e.g., Aslin et al., 1996, Brent & Suskind, 2001, Fernald & Hurtado, 2006; Lew-Williams et al., 2011; Junge et al., 2012). Although several studies have shown that by 12 months infants are able to segment the speech stream with the help of distributional cues, this need not be the primary way that infants learn words. Aslin et al. (1996) found that when asked to teach their 12-month-olds words such as lip, wrist, lobe, both American and Turkish mothers tended to place the words sentence-finally, but they also used them in isolation. Brent and Siskind (2001) demonstrated that isolated-word frequency in input speech better predicts later word use than word frequency overall, while Junge et al. (2012) found more reliable 10-month-old learning based on isolated words than words heard in passages.

Here, we directly tested the comparative effects of input word use in isolation and in sentence-final position on 12-month-olds’ word learning. We designed a picture book to illustrate words unlikely to be familiar to infants (e.g., condor, dassie, pudu), placing them either in isolation or sentence-finally. Parents read the books to the infants repeatedly over a period of 3 weeks. Each infant was then tested on (i) trained words heard in isolation, (ii) trained words heard sentence-finally, and (iii) phonotactically-matched untrained words (Experiment 1) or on trained words heard either (i) in isolation or (ii) sentence-finally vs. (iii) untrained words (Experiment 2). Stimuli were presented in word lists using the Head-turn Preference procedure. Experiment 1 showed a tendency (F = 2.936, df = 1.4, p = .09) for group differences in mean looking times (Figure 1). However, using preference ratios (proportion of attention to, e.g., isolated words out of total attention to isolated and unfamiliar words) to compare performance on each of two word types, we found greater attention to words heard in isolation than to those heard in sentences (p = .02), a tendency towards greater attention to words heard in isolation over untrained words (p = .07) and no significant difference between attention to words heard in sentences vs. untrained. We are in the process of running Experiment 2, which will allow more clearly interpretable pairwise comparisons.

Although reported proportion of isolated-word use in IDS ranges from 9% (Aslin et al., 1995; Brent & Siskind, 2001) to 39% (van de Weijer, 1998), there is reason to believe that these words play a disproportionate role in word learning, in that they may initiate the process of segmentation. Bortfeld et al. (2005) showed that placement of a target word after an infant’s name enhances target-word learning at 6 months, while Lew-Williams et al. (2011) show that distributional learning is more successful when combined with isolated-word learning. Our study provides further evidence that isolated words may afford a ‘critical wedge’ into the speech stream.
References


Elija: A computational model that learns to pronounce through caregiver interactions


Imitation is almost always assumed to be the mechanism by which infants learn to pronounce speech sounds and hence to learn the pronunciation of L1 words. Specifically, it is believed that auditory matching enables a child to reproduce speech sounds by copying those that he hears. Here we test an alternative account involving a non-imitative mechanism originally proposed by Gattegno (1962), using Elija, a computational model of an infant.

Elija begins to learn to pronounce by teaching himself to babble. To model this initial process with developmentally plausible influences, Elija finds potential vocal motor schemes (VMSs) by searching for vocal tract configurations that lead to distinct motor patterns and sensory consequences.

At this point, Elija can interact with a human subject. We ran six separate experiments with native speakers of English, French and German playing the role of caregiver. The first interactions with each caregiver allowed them to reformulate his putative speech sounds if such a response felt natural to the subject. It is accepted that young children recognise the dynamics of imitative games of various kinds, so from these interactions we allowed Elija to infer correspondences between his utterances and those of the adults. Note that the content of the correspondences was based on a judgment of sound similarity or equivalence made by the caregiver rather than by Elija.

These correspondences were the information Elija needed during a second, word imitation phase of interaction. He could now parse simple words in terms of those sounds he had heard before and respond using his associated motor actions. Consequently each caregiver was able to teach their instance of Elija to say some simple words by serial imitation of their component speech sounds.

This presentation will first summarise the principles, operation and current limitations of the Elija model, including the active learning of initial sound productions, his reinforcement and association mechanisms, and the use of the associations between Elija’s VMSs and caregiver reformulations in acoustic imitation of words spoken by the caregiver.

Then we will describe the data analysis, based on phonemic transcriptions of the caregivers’ responses, and show that each caregiver interpreted Elija’s output using their individual biases, which were influenced by their native language. Finally, we will present the results of an analysis of the interactions and caregiver utterances that take place during the word imitation phase.
Overall, our results demonstrate the viability of the mechanisms employed in our computational model and provide support for an alternative to a purely auditory matching hypothesis for learning to pronounce.
Proportions of partial reduplication and /i/-ending words in input predict later lexical development

Mitsuhiko Ota & Barbora Skarabela
University of Edinburgh (UK)

One noticeable feature of infant/child-directed speech is the use of register-specific lexical items such as tummy and choo-choo, commonly known as ‘baby-talk words’. Baby-talk words are present across culturally and linguistically diverse speech communities, and they share several structural characteristics. One recurrent pattern is reduplication, the repetition of syllables either fully (e.g., boo-boo, night-night) or partially with no more than one segmental difference (e.g., daddy, tick-tock, teeny). Another common feature is the use of diminutives (e.g., -/i/ in English, -tje in Dutch, -ita/ito in Spanish).

Currently there is no comprehensive model that explains why baby-talk words have shared structural properties cross-linguistically. One possible account, based on recent findings from speech perception research, is that the observed common characteristics reflect some subtle facilitative effects they have on word segmentation and, consequently, on word learning. Reduplicated words may be easier to detect because infants are perceptually biased toward adjacent repetition in stimuli (Gervain et al., 2008; Gervain, Berent, & Werker, 2012;). Diminutives may also facilitate word segmentation because they reduce variance in word endings (Kempe, Brooks, & Gillis, 2005; Kempe et al., 2007) and increase the frequency of words with the dominant stress pattern (Jusczyk, 1997; Echols, Crowhurst, & Childers, 1997).

If baby-talk words have emerged cumulatively through perceptual biases that favor more detectable phonological forms, we expect to find an ontogenetic effect of those biases in language development as well. Specifically, infants who hear more words with reduplication and phonological endings corresponding to diminutives – whether or not they are baby-talk words – should have an advantage in word segmentation and therefore break into lexical learning earlier.

We tested this prediction by comparing the phonological properties of input words with the lexical development of 16 English-learning children in the Brent corpus (Brent & Siskind, 2001). Input measures were the proportions of words (by type count) in the mother’s speech containing full reduplication, partial reduplication and/or /i/-ending after a stressed syllable (9 and 12 months). Measures of lexical development were the sizes of the child’s productive and receptive lexicons based on CDI data (12, 15 and 18 months). Regression analyses were carried out using these measures as well as the quantity of maternal speech (indexed to the mean token of words per session) and lexical diversity of maternal input (indexed to the type/token ratio) as potential confounds.

Proportions of partial reduplication and /i/-ending words emerged as significant predictors of the lexicon size in subsequent months, although collinearity made it difficult to separate the effects. Other measures of maternal speech did not reveal any reliable relationship with measures of lexical development. The results support the prediction that ending invariance facilitates word segmentation and learning, and also suggest a conspiratorial relationship between ending invariance and partial reduplication in the shape of words in child-directed speech.
References


General Session, June 12th
Contribution of articulatory-movement-related visual information to phonological awareness learning

Grozdana Erjavec[1,2] & Denis Legros[1,2,3]
[1]University Paris VIII (France); [2] Laboratory CHART (France); [3] University Paris-Est Créteil (France)

Phonological awareness is commonly defined as a capacity to detect oral language structure and to manipulate its sound components such as syllables, onsets and rimes, and phonemes (Goswami, Bryant, 1990). Phonological awareness skills are primarily important for their causal implication in early literacy development (see Kirby, Desrochers, Roth, & Lai, 2008, for a review) which is why early phonological awareness instructions have received much attention in the scientific literature.

As a compound of oral language skills early development of phonological awareness is based upon speech perception which is well known to be multimodal in its nature – based on fusion between visual and auditory information (see Dohen, 2009, for a review). On these grounds one could expect adding visual information to auditory one should be facilitative for phonological awareness learning. The goal of the present study was to answer two questions: i) Can multimodal, audio-visual, speech input enhance phonological training efficiency? ii) If so, how visual input should be presented (mouth vs whole face presentation) for its maximal facilitative effect in this context?

A standard pretest, training, posttest design was used with 105 French speaking kindergartners (mean age = 5 years and 9 months) participating in the study. Participants were divided into 3 training conditions differing in training items presentation, one being unimodal (audio-only (AO) group), and two being multimodal (audio-video “mouth” (AVM), and audio-video “face” (AVF) groups). The three groups were submitted to a phonological training consisting of 17 exercises which were conceived upon 4 organizational principles: “Detection” of a target phonological unit within an item, “Deletion” of a target phonological unit from an item, “Grouping” items on the grounds of a common phonological unit, and “Fusing” items (“Rebuses”). The exercises were conceived to train for syllable, rime and phoneme awareness and were delivered in whole classroom setting with the means of interactive whiteboard. Pupils’ performance in detecting syllables, rimes and phonemes was measured before and after training. Posttest-pretest differences were calculated for each participant and were submitted to a split-plot ANOVA design analysis with Group as between-subject factor and Phonological Awareness Form as between-subject factor.

Results showed a significant effect of factor “Group” \((F(2,78) = 6.786, p < .011, \eta^2 = .080)\) with AVF training being highly and the most efficient in the study, while AO and AVM trainings had poor and comparable efficiency. Group x Phonological Awareness Form interaction was significant as well \((F(4,239) = 3.249, p < .014, \eta^2 = .077)\). We found that AVF training enhanced best pupils’ phoneme awareness skills while AO and AVM trainings produced particularly poor outcomes at this level.

Such results demonstrate that enhancing speech perception by providing multimodal input is facilitative for phonological awareness learning at the kindergarten level. Visual cues seem particularly helpful for identification of the smallest and highly coarticulated phonological units, phonemes. Surprisingly, facilitative effect of multimodal training was only found with
whole face format which suggests that kindergartners are only able to process holistically presented visual speech information.

References


Table 1. Means and standard deviations for posttest-pretest score differences by experimental conditions resulting from crossing experimental factors modalities and by each experimental factor (Group and Phonological Awareness Form) separately.

<table>
<thead>
<tr>
<th></th>
<th>AO</th>
<th>AVM</th>
<th>AVV</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>SYLLABLES</td>
<td>0.861</td>
<td>1.313</td>
<td>-0.160</td>
<td>2.764</td>
</tr>
<tr>
<td>RIMES</td>
<td>0.028</td>
<td>1.612</td>
<td>0.400</td>
<td>1.658</td>
</tr>
<tr>
<td>PHONEMES</td>
<td>-0.722</td>
<td>1.485</td>
<td>-1.040</td>
<td>1.813</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.167</td>
<td>2.261</td>
<td>-0.800</td>
<td>3.905</td>
</tr>
</tbody>
</table>

Figure 1. Example of speech-related visual input presentation under AVM (2a) and AVF (2b) training conditions.
The phonological specificity of new lexical representations predicts rhyme awareness skill and vocabulary size in Dutch 4-year-olds

Merel van Goch[1,2], Ludo Verhoeven[1], & James McQueen[1,2,3]
[1] Radboud University Nijmegen, Behavioural Science Institute, Nijmegen (The Netherlands); [2] Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Nijmegen (The Netherlands); [3] Max Planck Institute for Psycholinguistics, Nijmegen (The Netherlands)

Phonological knowledge (e.g., knowing how different words sound) is essential in becoming literate, since learning to read involves mapping graphemes onto phonemes. The degree of lexical specificity, i.e., knowledge about how certain words ought to sound, is important for phonological awareness (i.e., the ability to consciously reflect upon and to manipulate speech sounds, an important predictor of emergent literacy). In order for children to become phonologically aware and hence to be able to manipulate sounds in words, their lexical representations have to be specified to a certain extent. Lexical specificity is defined as the richness and specificity of phonological representations in the emerging mental lexicon. It evolves over time: whereas initial lexical representations are holistic, they become more segmental through infancy and early childhood. According to the lexical restructuring account, this increasing segmentation of phonological representations is driven by vocabulary growth (Metsala & Walley, 1998).

To investigate the role of lexical specificity in 4-year-olds showing typical language development, the current study was set up. A lexical specificity task was used to measure the phonological specificity of lexical representations. In the task, which was presented to the children as a word learning game, children were taught new spoken words. Children were forced, over the course of the task, to attend to increasingly subtle acoustic-phonetic differences between the new words, and they could only succeed in the last phase if they had learnt the specific one-feature difference between two words.

A cohort of 101 monolingual, native Dutch children (54 male, Mage = 50.43 months, all in the first year of kindergarten) participated in the study. Structural equation modelling revealed that lexical specificity predicted passive vocabulary size and rhyme awareness, and that phonological short-term memory predicted all three previously mentioned precursors (see Figure 1). Increasingly segmental representations, leading to explicit access to the phoneme, give rise to the ability to consciously reflect upon and manipulate phonemes (Metsala & Walley, 1998) and having more specific lexical representations make rhyming easier (Treiman & Zukowski, 1996). Additionally, lexical specificity predicted vocabulary size, suggesting that increasingly segmental representations lead to increasing vocabulary size. The current lexical specificity task thus seems to measure two skills: the ability to learn new words and the ability to distinguish between new words. The results thus suggest that phonologically well-specified lexical representations make rhyming easier (the phonological component of the task) and make learning new words easier (the word learning component of the task). These results are in accordance with a study that showed that making lexical representations phonologically more specific (by means of lexical specificity training) increased rhyme awareness in Dutch prereaders (Van Goch, McQueen, & Verhoeven, resubmitted). Furthermore, the results showed that
phonological short-term memory predicted vocabulary size, lexical specificity and rhyme awareness, which is in accordance with previous studies on phonological short-term memory.

In summary, exploring the interrelations of phonological precursors to literacy, the current study showed that lexical specificity (i.e., the phonological richness and specificity of new lexical representations), predicts both rhyme awareness skill and vocabulary size.

Figure 1. Structural equation model of phonological short-term memory, lexical specificity, vocabulary size, and rhyme awareness (n = 101). Note. The numbers indicate standardized Beta Coefficients.

References


Introduction. This presentation explores the behavior of stops in the acquisition of French children. As the main transformations are substitutions and deletions (Kirk: 2008), we compare these processes in a Government Phonology (GP) framework. We argue that Element Theory (ET) (Scheer: 2004, Backley: 2011) reveals the mechanisms at play in [labial], [coronal] and [dorsal] substitutions and deletions and explains their differing patterns hence shedding new light on the mechanisms underlying phonological acquisition.

Experimental conditions. Our study considers results based on a sample of 20 children between 2,1 and 3,8 years. The experimental protocol is composed of 40 items including clusters in initial, medial and final position. It has been tested using a naming and repetition task. We extracted 348 substitutions and 682 deletions.

Results and discussion. We observe how children deal with consonants: do position and nature of segments play a role in substitutions and deletions? And if so, how?

1. Deletions

Diagram (1) illustrates the total number of deletions for each segmental class.

(1) Data in Acquisition: Deletions process

[coronal] and [dorsal] are the most deleted. We observe particularly that [s] and [θ] are the most deleted segments in 45.85% and 36.80% respectively. Most of the time these segments are in coda position: #sC or vCCv or CC# (see Goad: to appear and Hilaire-Debove & Kehoe: 2004). In the literature, there is a debate about the complexity of coda position (Demuth & McCullough: 2009). We assume that there is a link between syllabic position and operation of deletion. But there is no certainty that the problem lies on the syllabic position as it may be due to segmental reasons. In order to deal with this question, our position is that both deletions and substitutions should be considered.

2. Substitutions

Table (2) shows examples of substitutions.

(2) Substitutions place in acquisition:
Looking at the number of substitutions in each place of the total of substitutions, we see that the [dorsal] class is the mostly substituted (in 56,03%). Apparently, we can prove that [dorsal] is more complex than others because it is more problematic for children.

(3) Data in Acquisition: Substitutions place

<table>
<thead>
<tr>
<th></th>
<th>Labial /P/</th>
<th>Dorsal /K/</th>
<th>Coronal /T/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal</td>
<td>20 (5,75%)</td>
<td>151 (43,39%)</td>
<td>33 (9,48%)</td>
</tr>
<tr>
<td>Labial</td>
<td>20 (6,03%)</td>
<td>11 (3,16%)</td>
<td>12 (3,45%)</td>
</tr>
<tr>
<td>Dorsal</td>
<td>4 (1,15%)</td>
<td>33 (9,48%)</td>
<td>63 (18,10%)</td>
</tr>
<tr>
<td>Sum</td>
<td>45 (12,93%)</td>
<td>195 (56,03%)</td>
<td>108 (31,03%)</td>
</tr>
</tbody>
</table>

The [dorsal] class is mostly substituted by [coronal] (43,39%). Labials are substituted in 5,75% of the cases by [coronal] and 6,03% by [labial]. [coronal] are substituted in 18,10% by [dorsal]. It appears that coronals are the most common substitute whatever the nature of the consonant (although the labial prefer to stay labial), what tends to support the view that coronals have a special status (Paradis & Prunet: 1991, Kirk: 2008). But the fact that [coronal] turns most often [dorsal] show a surprising behavior. [coronal] become [dorsal] in very few cases (18,10%). Indeed, we expected that [coronal] most often become [coronal] but this is not the case.

Studies on the acquisition of French as Yamaguchi (2012), Rose & Wauquier-Gravelines (2007) show that the [coronal] is less complex because acquired earlier. Our protocol was also performed on 20 patients with aphasia and our data in aphasia show the same result as (Wauquier, Yamaguchi and Rose), [dorsal] become mostly [coronal] and coronal become mostly [coronal]. But here it is not exactly the case. We have a little but important percentage where [coronal] become [dorsal]. We will try to provide a reason for this phenomenon: a possible explanation is that almost all cases of [coronal] that become [dorsal] are cases of assimilation (Stemberger & Stoel-Gammon: 1991).

We think that acquisition informs us about the correct "complexity" scale of stops. In the line of BrandAo de Carvalho & Klein (1996), we propose that this complexity results from the nature of the operations used to define segments. Dorsals and coronals are the result of an operation while labials contain only one \{U\} element (hence their relative stability in acquisition). \{U\} element for labiality and \{I\} for palatality.

\[
\begin{align*}
\text{CORONAL} /\text{T/} & \quad \text{LABIAL} /\text{P/} & \quad \text{DORSAL} /\text{K/} \\
\text{\{I\}} \cap \text{\{U\}} & \equiv \text{\{Ø\}} & \text{\{U\}} & \text{\{I\}} \cup \text{\{U\}} & \equiv \text{\{IU\}}
\end{align*}
\]
References


Cross-situational word learning of monosyllables with different degrees of phonological overlap

Paola Escuerdo[1], Karen Mulak[1], & Haley Vlach[2]
[1] University of Western Sydney (Australia); [2] University of Wisconsin (USA)

Word learning studies have typically focused on participants’ ability to learn novel word-referent pairings presented unambiguously in a single trial. However, in the real world words are encountered amidst myriad possible referents. Recently, a cross-situational learning paradigm has been used to better model the ambiguity in real-world situations. In a typical experiment, participants are presented with multiple visual referents on a screen as the corresponding spoken words are presented in random order. To learn word-object pairings, learners need to track co-occurrence probabilities of words and referents across trials.

Previous studies on cross-situational learning have involved words that are phonologically very distinct (e.g., regli, colat). Consequently, it is unknown whether learners are able to simultaneously learn cross-situational statistics while distinguishing phonologically minimal pairs. This is particularly interesting because previous research on early word learning has demonstrated that both toddlers and adults have difficulty distinguishing and learning words that form minimal pairs when the task is to associate words and referents presented in a single trial. In this study, we used a cross-situational word learning paradigm to examine whether 22 17-month-olds could learn monosyllabic words with different degrees of phonological overlap. Specifically, we tested learning of word-referent pairings that form minimal pairs differing in either a consonant (bon-don) or vowel (deet-doot), near-minimal pairs (don-deet), and non-minimal pairs (bon-deet).

Stimuli consisted of eight monosyllabic nonsense words together with their randomly assigned object referents (see Figure 1). Four of the words differed minimally by their first consonant (Figure 1, left), while the other four differed in their vowel (Figure 1, right). The novel words followed English phonotactic probabilities and were chosen from those included in previous infant studies. Infants were presented with a typical cross-situational learning paradigm (see Figure 2): In each learning trial, two of the eight pictures of novel items appeared on the screen while two novel words for the images were spoken, such that images were either named left to right, or right to left. During testing, participants again saw pairs of visual referents but heard the spoken word for only one of the images (a preferential looking paradigm). Looking time to the named image was recorded using a Tobii X120 eye-tracker.

We found a main effect of pair type, $F(3, 63) = 2.968, p = .039, \eta^2_p = .124$. One-sample t-tests revealed participants’ looking to the named image was above chance only for vowel minimal pairs, $t(21) = 2.197, p = .039$.

This finding is contrary to the results of a recent study we conducted with adults using the same stimuli and task, where the adults successfully learned all word pairs and mean accuracy was lowest for vowel minimal pairs. Our finding for infants is also at odds with the many studies that have demonstrated that consonant information is more important than vowel information in
lexical processing and acquisition. Implications of our findings for the role of vowels and consonants in early word learning, as well as why we observe differences in performance across development, will be discussed.

Figure 1. The eight novel words and their novel object referents.

<table>
<thead>
<tr>
<th>/bon/</th>
<th>/dit/</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>/pon/</td>
<td>/duit/</td>
</tr>
<tr>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>/ton/</td>
<td>/dit/</td>
</tr>
<tr>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>/don/</td>
<td>/duit/</td>
</tr>
<tr>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
</tr>
</tbody>
</table>

Figure 2. Examples of the cross-situational word learning trials.

Trial 1: /dit/, /dit/ /bon/, /bon/

Trial 2: /don/, /don/ /dit/, /dit/

Trial 3: /bon/, /bon/ /pon/, /pon/
Early word recognition in sentence context: two-year-olds’ sensitivity to sentence medial mispronunciations and assimilations

Katrin Skoruppa[1], Nivedita Mani[2], Kim Plunkett[3], & Sharon Peperkamp[4]


During their second year of life, infants encode words with phonetic detail, as evidenced by their sensitivity to mispronunciations of familiar words (e.g., Swingley & Aslin, 2000; Swingley, 2009; Mani et al., 2012). To date, all mispronunciation studies have tested the recognition of words in isolation or in sentence-final position. Here, we focus on sentence medial words, which might be particularly difficult to recognize because, firstly, they are acoustically less salient, and, secondly, they can undergo phonological variation due to across-word phonological processes. For instance, French has voice assimilation in obstruent clusters. Thus, the final voiceless /s/ of bus ‘bus’ becomes voiced in bus direct (‘direct bus’), where it is followed by the voiced obstruent /d/, but not in bus marron (‘brown bus’), where it is followed by the sonorant /m/. As a consequence, the form bu[z] is a legal, assimilated variant of the word bus in bu[z] direct but a mispronunciation in bu[z] marron.

Using an Intermodal Preferential Looking paradigm (Figure 1), we examined 24-month-olds’ recognition of sentence-medial words by assessing their processing of standard pronunciations, mispronunciations and assimilations. In Experiment 1, we tested French toddlers. Each trial started with the presentation of a familiar object accompanied by its label (e.g. un bus ‘a bus’). Next, an unfamiliar object was shown and accompanied by a novel label that differed only in the voicing of the final consonant (e.g. un *buz). Finally, the two objects appeared side-by-side and a probe sentence was presented in one of three conditions (Standard, Mispronunciation, Assimilation; Table 1). Toddlers looked more towards the familiar object in the post-naming phase compared to the pre-naming phase following standard pronunciations ($t(31)=2.21, p<.04$) and assimilations ($t(31)=4.02, p<.001$), but not following mispronunciations ($t(31)<1$). Thus, French 24-month-olds are sensitive to voicing mispronunciations in sentence-medial contexts and compensate for voice assimilation during word recognition.

In Experiment 2 we examined whether compensation for assimilation is language specific by testing English toddlers, whose language does not have voice assimilation. Thus, we implemented voicing changes in English stimuli, and probed the infants with sentences in a Standard, a Mispronunciation, and a Pseudo-Assimilation condition (Table 2); the difference between the latter two is that in the Pseudo-Assimilation but not in the Mispronunciation condition the voicing change respects the French voice assimilation rule. Toddlers looked more towards the familiar object in the post-naming phase compared to the pre-naming phase following standard pronunciations ($t(30)=4.41, p<.001$), but not following mispronunciations ($t(30)=1.71, p=.098$) or pseudo-assimilations ($t(30)=1.33, p>.1$). Thus, like French toddlers, English 24-month-olds are sensitive to voicing mispronunciations in sentence-medial contexts; however, they do not compensate for French voice assimilation during word recognition.

A global ANOVA with the factors Language, Phase and Condition yielded significant effects of
Phase \((F(1,64)=24.37, p<.001)\) and Condition \((F(2,128)=3.67, p=.045)\), as well as a triple interaction \((F(2,128)=5.17, p=.007)\), confirming that French and English toddlers reacted differently in the different conditions. Taken together, the experiments show that 24-month-old toddlers take phonetic detail into account during sentence-medial word recognition, and that their compensation for phonological variation is language-specific.

Figure 1: Schematic illustration of a sample trial.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example</th>
<th>English translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td><em>Regarde le bus maintenant.</em></td>
<td>‘Look at the bus now.’</td>
</tr>
<tr>
<td>Mispresentation</td>
<td><em>Regarde le buz maintenant.</em></td>
<td>‘Look at the [byz] now’.</td>
</tr>
<tr>
<td>Assimilation</td>
<td><em>Regarde le buz devant toi.</em></td>
<td>‘Look at the bus in front of you’.</td>
</tr>
</tbody>
</table>

Table 1: Examples of stimuli used in Experiment 1.

Figure 2: Mean proportions of looking to the familiar object by condition in the pre- and postnaming phase for French (left) and English (right) toddlers.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td><em>Can you find the sheep now?</em></td>
</tr>
<tr>
<td>Mispresentation</td>
<td><em>Can you find the sheep now?</em></td>
</tr>
<tr>
<td>Pseudo-assimilation</td>
<td><em>Can you find the sheeb there?</em></td>
</tr>
</tbody>
</table>

Table 2: Examples of stimuli used in Experiment 2.
References


Lexical neighbors are words that differ in a single phoneme (e.g., ‘pear’-‘bear’). Lexical neighbors hinder adult word recognition, as adults find it more difficult to recognize a word when a lexical neighbor is present (‘speaker’ when there is also a beaker; e.g., Allopenna, Magnuson & Tanenhaus, 1998).

Lexical neighbors hinder infants during word learning. Infants have difficulties learning novel minimal pairs (i.e., novel ‘bin’ and novel ‘din’; Werker & Stager, 1996; Nazzi, 2005) and learning a novel word that is the lexical neighbor of a familiar word (i.e., novel ‘tog’ in addition to familiar ‘dog’; Swingley & Aslin, 2007). On the other hand, infants detect one-phoneme mispronunciations of familiar words in word recognition (i.e., ‘vaby’ instead of ‘baby’; Swingley & Aslin, 2000, 2002). This combination of results begs the question whether already-acquired lexical neighbors in the infant lexicon are sufficiently specified to be kept apart during word recognition.

Dutch infants prove an interesting test case, since most 12-month-olds already know two minimal-pair triplets: ‘hand’-‘hond’-‘mond’ (hand-dog-mouth) and ‘bed’-‘bad’-‘bal’ (bed-bath-ball; Junge, Cutler & Hagoort; 2012). By testing how infants recognize words from these triplets, we could answer three questions:

1) Can 18-month-olds recognize words in the presence of lexical neighbors (i.e., recognize ‘hond’ when they see a ‘hond’ and a ‘hand’)?

2) Is the effect of lexical competition influenced by the position within the word at which the lexical neighbors differ (onset, nucleus, or coda)?

3) Do infants consider the vowel-changing lexical neighbor or the consonant-changing lexical neighbor as more similar to the non-present target (i.e., recognize vowel-changing ‘hand’ or consonant-changing ‘mond’ for ‘hond’)?

Children were tested in a preferential-looking task. On each trial they saw two pictures and were asked to look at one of them. A positive naming effect occurred if infants looked longer at the target picture after hearing the word than before it. Preliminary results with 17 children showed that:

1) Infants recognized words in the presence of a lexical neighbor (t[16]=2.79, p=.013; see Figure 1).

2) Within the neighbor trials, infants had the weakest recognition for onset neighbors (‘hond’ and ‘mond’), intermediate recognition for nucleus neighbors (‘hond’ and ‘hand’), and strong recognition for coda neighbors (‘bal’ and ‘bad’; F[1,44]=7.15, p=0.011; See Figure 2). Surprisingly, infants appear to rely most on the coda to discriminate between lexical neighbors. Possibly, infants switch back to the
(incorrect) neighbor when the unfolding word resembles that neighbor, and such further unfolding does not occur when the coda disambiguates.

3) When infants had to choose between two incorrect lexical neighbors, they preferred the lexical neighbor that had the same vowel as the non-present target (t[16]=2.14, p=.049; see Figure 1). This vowel-preference probably stems from the large acoustic overlap between words that share a vowel.

Together, the present results provide strong evidence that infants with small lexicons can recognize words in the presence of a lexical neighbor. Their recognition is hampered by the presence of a lexical neighbor, especially if the difference between the two words is found earlier in the words.

Figures

Figure 1: Infants saw three trial types of interest. On the left: In the control and neighbour trials there were significant naming effects: infants looked longer at the target after naming. The dotted line indicates no increase, but performance at chance. Below this line the upper word is the auditory target, and the lower words the visual objects corresponding to the words. On the right: results from the preference trials, where the auditory target did not have a visual counterpart present on the screen, but two phonological competitors instead.

Figure 2: Naming effect was largest for minimal pairs that ambiguated on the coda, but smallest for pairs that ambiguated on the onset.
References


Early acquisition of word stress: a cross-linguistic infant study

Brigitta Keij & René Kager
UiL-OTS, Utrecht University (The Netherlands)

According to the Metrical Segmentation Hypothesis (Cutler & Norris 1988), metrical structure is used by infants to segment words from the speech stream. However, the evidence for this hypothesis comes mainly from initial stress languages (Höhle et al. 2009). Consequently, it is unknown how language-specific this hypothesis is and a cross-linguistic approach should be adopted to tackle this issue (Nazzi et al. 2006). Infants learning metrically opposed languages, namely infants learning Dutch (initial/ pre-final stress) and infants learning Turkish (final stress), are tested. In order to use metrical cues for word segmentation, infants first have to build a representation of the metrical structure of their native language. Therefore, we test the emergence of rhythmic preference in Dutch- and Turkish-learning infants during the first year of life.

Instead of using the traditional head turn preference procedure, an innovative preferential listening paradigm using eye tracking is employed to test the emergence of rhythmic preferences. The research question is: do Dutch- and Turkish-learning infants show a language-specific rhythmic preference and at what age does this preference appear? In total, 90 Dutch-learning and 90 Turkish-learning infants aged 4, 6 and 8 months have been tested. The first results of the Dutch-learning infants showed that they do not present a rhythmic preference at 4 months of age, but that they do show a language-specific rhythmic preference at 6 months of age.

However, since there was no interaction between the factors stress pattern and age, we cannot yet speak of a development between 4 and 6 months. Therefore we tested an additional group of Dutch-learning 8-month-olds and also included this older age group in the Turkish study. These ‘fresh off the shelf’-results will be presented in this paper and will give us more insight into the development during the first year of life, as well as allow us to interpret the results in a cross-linguistic perspective.

References


Coronals have a special status in many phonological systems, and it is often assumed they have an unmarked or underspecified place of articulation (Paradis & Prunet, 1991). This special phonological status has typically been associated with lexical underspecification. This is reflected in perceptual asymmetries, such as the detection of a labial that is mispronounced as a coronal, but not a coronal that is mispronounced as a labial, by both children (Fikkert, 2010) and adults (Lahiri & Reetz, 2010). Interestingly, a comparable perceptual asymmetry has recently been reported in six-month-old infants for the contrast /paan/-/taan/ (Dijkstra & Fikkert, 2011). As infants at this age are generally considered 'universal listeners' (e.g., Eimas, Siqueland, Jusczyk, & Vigorito, 1971), this suggests a prelexical basis, at least for the labial-coronal perceptual asymmetry.

As prelexical does not necessarily equal pre-experience, a crucial open question remains if the observed asymmetry is language-specific, or rather general across languages. The current project therefore compares the perception of the contrast in the word-medial consonant cluster /ompa/-/onta/ in Dutch and Japanese.

At present, 16 four-month-old and 16 six-month-old Dutch infants, as well as 13 four-month-old and 16 six-month-old Japanese infants were assessed on their discrimination of the contrast in the word-medial consonant clusters of the non-words /ompa/-/onta/. Eight tokens of each /ompa/ and /onta/, recorded by a native speaker of Dutch, were chosen as stimuli. In a slightly modified version of the Central Fixation paradigm (Werker et al., 1998), half of the infants were habituated to tokens of /ompa/, whereas the other half were habituated to /onta/, while they fixated on a central screen. Both groups were then presented with new /ompa/ and /onta/ tokens, while the visual stimuli remained unchanged. The test /onta/ constituted a 'switch' for the /ompa/-habituated infants, whereas it mapped onto the 'same' category for the /onta/ infants, and vice versa. A mixed ANOVA revealed that infants looked longer to 'switch’ trials \( F(1,53) = 6.27, p = 0.015 \), but that this effect interacted with the type of habituation stimulus \( F(1,53)= 8.93, p = 0.004 \). Infants increased their looks during switch trials when habituated to /ompa/ (\( p < 0.001 \)), but not when habituated to /onta/ (\( p = .649 \)). Neither the between-subject factors language and age nor any interactions between them reached significance, suggesting that infants across languages and age groups find it harder to hear a switch from coronal to labial than vice versa (Figure 1).
This work provides support for a prelexical and language-independent basis of the labial-coronal asymmetry, contributing an important piece to the puzzle of the etiology of the special status of coronals in the phonologies of the world.
Figures

Figure 1. Infants’ looking times (s) to same and switch trials by stimulus presentation order and language. Upper (orange) row represents Dutch infants, lower (blue) row represents Japanese infants.

References


Two-to-three-month olds’ mismatch responses reveal fast distributional learning and perceptual bias

Karin Wanrooij[1], Paul Boersma[1], & Titia van Zuijen[2]
[1] Amsterdam Center for Language and Communication, University of Amsterdam (The Netherlands); [2] Department of Child Development and Education, University of Amsterdam (The Netherlands)

An important mechanism for learning speech sounds in the first year of life is ‘distributional learning’, i.e., learning by simply listening to the frequency distributions of the speech sounds in the environment. In the lab, where exposure to speech sound distributions typically lasts only a few minutes, distributional learning has been reported for infants of four months and older.1,2,3,4,5 The present study examined whether such fast distributional learning can also be demonstrated before this age.

Two-to-three-month-old Dutch infants were presented with either a unimodal or a bimodal vowel distribution based on the English /ɛ/-/æ/ contrast, for only twelve minutes. Subsequently, mismatch responses (MMRs) were measured in an oddball paradigm, where one half of the infants in each group heard a representative [ɛ] as the standard and a representative [æ] as the deviant, and the other half heard the opposite pattern.

The results disclosed a larger MMR for bimodally trained infants than for unimodally trained infants, thus extending an effect of distributional learning found in previous behavioral research to a younger age group and a new method (MMRs as measured from event-related potentials in the electroencephalogram). Moreover, the results revealed a robust interaction between the distribution (unimodal vs. bimodal) and the identity of the standard stimulus ([ɛ] vs. [æ]), which provides direct evidence for an interplay between an asymmetry in vowel perception6 and distributional learning. These results were obtained when infants were awake, drowsy or in active sleep during the test; when infants were in quiet sleep there was no effect of distributional learning or perceptual bias.
References


Towards an integrated model of early language acquisition: A longitudinal approach

Alejandrina Cristi[1], Amanda Seidl[2], & Brian French[3]
[1] LSCP, CNRS (France); [2] Purdue University (USA); [3] Washington State University (USA)

Recent evidence suggests that individual variation in behavioral and neurophysiological measures of infant speech processing predicts language outcomes. Such a longitudinal approach could both inform early detection and intervention for communicative impairments, and illuminate theoretical models of language development. For instance, two broad classes of theories explain the emergence of language in the first year of life, which could be termed "phonology first" or "lexicon first". Both models assume infants have some knowledge at both the level of speech sounds and words, but they differ crucially in the hypothesized interaction between the two levels. The best way to adjudicate between the two models would be to assess sound level knowledge and word level knowledge at multiple points in development for the same infants, and determine which variables best predict the others. Such a solution can only be possible if meaningful individual differences at each of these levels can be measured reliably.

Therefore, it is important to evaluate this emergent longitudinal literature. To this end, we meta-analyzed 18 published studies that investigated the relationship between a measure of speech perception gathered before 12 months, and concurrent or subsequent vocabulary size. The median effect size was significantly different from zero for all linguistic levels that have been investigated (speech sounds $r = .35$ [confidence interval .22;.47], words $r = .28$ [.14;.4], and prosody $r = .42$ [.18;.61]). We compared these linguistic predictors with well-established non-linguistic predictors of language, arising from habituation ($r = .45$ [.26;.65]), dishabituation ($r = .42$ [.29;.54]), and rapid auditory processing ($r = .54$ [.25;.74]). The fact that the median effect sizes overlap between these two groups of measures is both encouraging and troublesome. On the one hand, it suggests that infant speech perception tasks developed to assess group effects are picking up individual variation that is stable enough to result in significant correlations with vocabulary outcomes. On the other, one would have predicted higher correlations for speech-specific measures than general cognitive measures. As this does not obtain, the possibility remains that both speech and non-linguistic measures are tapping a similar construct, possibly something akin to 'general task performance'.

To assess this possibility, we gathered multiple measures from a single group of 45 infants tested at 5 to 6.5 months on a linguistic (preference for trochees over iambic) and a cognitive task (Visual Recognition Memory), and at 6.5 to 8 months on another linguistic (vowel discrimination) and another cognitive task (A-not-B). If all tasks are tapping a single general performance construct, correlations across all measures should be comparable. This prediction was not met (Table 1), since only the two linguistic tasks showed a significant association.

In sum, a meta-analytic approach reveals moderate bivariate correlations between infant speech perception and vocabulary acquisition. While promising, the predictive power of such measures cannot at present be attributed to specific factors, rather than general performance. With new data, we show how a multivariate approach may inform our understanding of how infants build
language in the first year of life and beyond.

Table 1. Pearson correlation in infant performance across pairs of tasks. Bold indicates that the correlation pertains to two measures thought to assess the same construct (linguistic compared to cognitive). * indicates $p < 0.05$

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preference for trochees</th>
<th>Vowel discrimination</th>
<th>Visual Recognition Memory</th>
<th>A-not-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowels</td>
<td><strong>0.30</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VRM</td>
<td>0.05</td>
<td>-.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABScore</td>
<td>0.10</td>
<td>-0.20</td>
<td><strong>0.09</strong></td>
<td></td>
</tr>
</tbody>
</table>