

**Do children understand adults better or themselves?
Perception and production study of /s, ʂ, ɛ/ contrast in Polish.
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While some research has been conducted on production of sibilants by children (Cristià 2010, Li et al. 2009, Reidy et al. 2017), very little is known about how they perceive sibilants. Previous studies mainly concentrated on child perception of adult speech and were limited to English, Japanese and Chinese (Li 2008, Li et al. 2011). It remains, however, unexplored how children perceive complex sibilant contrasts such as /s, ʂ, ɛ/ and how results may vary if they listen to their own speech as opposed to adults' speech.

The present study fills in this research gap by probing the perception of a complex and typologically rare three-way phonemic contrast /s, ʂ, ɛ/ by Polish children as function of their age. It also investigates how children perceive sibilants depending on whether the stimulus is produced by an adult or the child itself, again depending on its age.

To this end, we ran an acoustic and perceptual experiment with 79 participants: 63 pre-school-aged (35–70 months) and 16 school-aged (71–95 months) children, all monolingual native speakers of Polish living in Szczecin, Poland (40 males). The experiment consisted of three parts. In the first part, the children named pictures displayed on a screen while in the second part they listened to the stimuli previously produced by an adult and chose the correct picture out of three by pressing a button. In the third part, they listened to their own productions recorded in the first part and selected the right picture. During the perception parts besides participants' answers (right/wrong) their reaction times (RT) were recorded. For the purpose of this experiment we constructed a Ubuntu Mate based tool Linguistino (see Fig.1 left).

In the picture naming task children produced bisyllabic stimulus words with sibilants /s, ʂ, ɛ/ in (i) the word-initial and (ii) word-medial position, always stressed on the first syllable. In the perception parts, the same three pictures were shown, accompanied by one acoustic stimulus. The pictures portrayed words which created minimal triplets contrasting the sibilants: [kasa] “cash point/register”, [kaʂa] “goats”, and [kaea] “Cathe, prop.name” (see Fig.1 right). The same triplets, but in a randomized order, were repeated three times. In total, together with distractors, we obtained 48 answers by each child.

The main finding of our study is that the perception of sibilants in Polish is both age- and speaker(stimulus)-dependent. As expected, the discrimination improves with increasing age ($t=2.39$; see Fig. 2 left). It is also significantly better for adult productions than when children listen to themselves ($t=-4.79$; see Fig. 2 left). Furthermore, reaction times, despite being subject to extensive variation, reveal that /ɛ/ is the easiest sound for children to discriminate (the shortest RT), followed by /s/ ($t=3.77$) and /ʂ/ ($t=2.79$; see Fig. 2 right). The smallest number of errors was also made when /ɛ/ was to be recognized. This is in line with the observation that /ɛ/ is the earliest sound acquired by Polish children (Łobacz 1996). Finally, the analysis shows that /s/ vs. /ʂ/ is the most difficult contrast to discriminate.

Our complementary acoustic analysis of the sibilants and surrounding vowels in terms of formants (F1, F2, F3), spectral moments (COG, std, skewness, kurtosis) and spectral slopes (m1, m2) shows that the fast discrimination of /ɛ/ can be explained by the fact that it separates very early (see Fig. 3 left) and the F2 of this sound is significantly different from that of /ʂ/ and /s/ ($z=6.051$; see Fig. 3 right). In other words, transitions of vowels play a crucial role in the production (and perception) of fricatives because younger children rely more on dynamic vowel transition than static sibilant frequency information in the process of phonemic categorization (Nittrouer & Studdert-Kennedy 1987, Bukmaier & Harrington 2016). This might also explain why the process of separation of /s/ and /ʂ/ takes place later: the transitions are not as salient as in the case of /ɛ/ (i.e. the difference between /s/ and /ʂ/ in F1 and F2 is not significant).



/kaʂa/
"groats"

/kasa/
"cash point"

/kaça/
"Katie"

Figure 1: Linguistino (left) and a stimulus triplet (right)

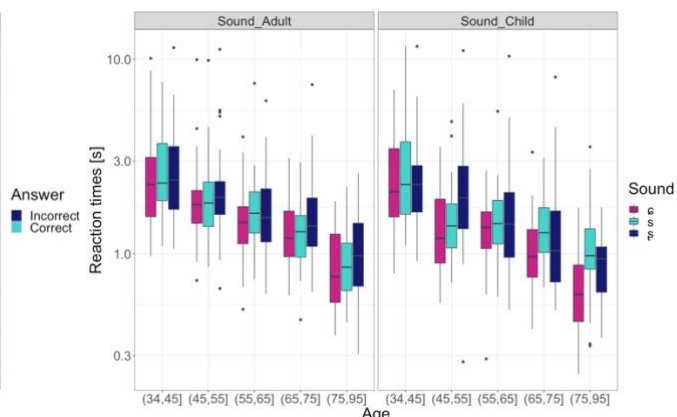
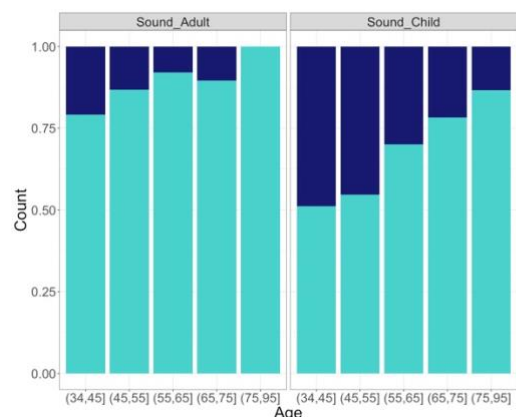


Figure 2: Proportion of (in)correct answers (left) and reaction times to adult and children's stimuli (right)

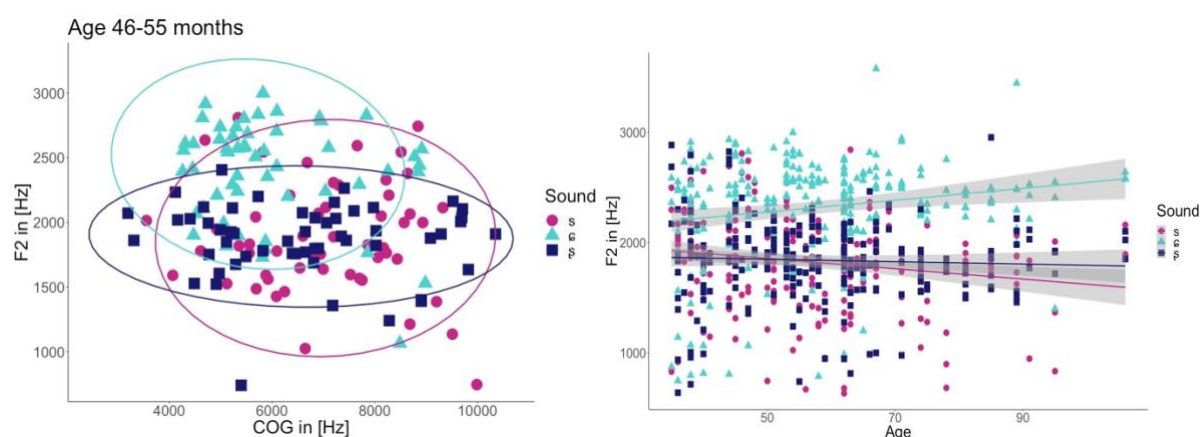


Figure 3: F2 and COG of /s/, /ʂ/ and /ɕ/ as produced by younger (left) and older children (right)

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