Pre-schoolers process word onsets and codas similarly: A time-course analysis

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Words can contain minimal phonemic differences in onset (*bin-pin*) or coda positions (*map-mat*). Being able to recognise these words and distinguish them from alternatives is critical for understanding other people. Infants and toddlers process word onsets quickly, recognising the first part (e.g. /beɪ:/) of a word as quickly and accurately as the whole word (e.g. /beɪ:bi/ (*baby*)) [1], and resolving the onset of the word before the coda of the word [2]. Less is known about children's processing of codas. In production, codas are typically acquired later than onsets [3]. In perception, adults confuse newly learned coda minimal pairs more frequently than onset pairs [4]. These findings suggest that children may process codas less efficiently than onsets. However, children (by 1;6), as well as adults, can detect mispronunciations in both onsets and codas with a roughly comparable speed [5]. Although this suggests similar processing for onsets versus codas, the processing time-courses of onsets and codas were not directly compared. The aim of the present study is, thus, to directly compare children's processing of onsets and codas in real words, and to investigate how this relates to adult processing.

Processing was compared between onset and coda minimal pairs (e.g. *bin-pin* vs. *map-mat*). A direct comparison was made by aligning the processing time-courses for onsets and codas at comparable disambiguation points in the acoustic signal (i.e., onset vs. coda burst). If children's later acquisition of codas in production and adults' less accurate learning of coda words are linked to slower processing of codas, we would expect slower processing time for codas than onsets. However, if children and adults process codas as rapidly as onsets, we expect no differences in processing time. Adults are expected to be faster overall than children [2, 5].

Seven Australian English (AuE) speaking adults (M_{age} = 31 years; range 20-41; 4 males) and 28 AuE speaking children (M_{age} = 4.6 years; range 3.2-5.8; 16 males) participated in an eye-tracking study with a Looking-While-Listening paradigm [6]. The stimuli consisted of 30 minimal pairs (18 onset trials, 12 coda trials), with voicing and place of articulation contrasts (Table 1). The session began with a picture naming task to familiarise participants with the stimuli. Then, during the eye-tracking task, participants were shown two pictures for 2000 ms, representing a minimal pair. They heard '*Look at the X'*, after which the pictures remained on screen for a further 4000ms. Onset and Coda trials were blocked with order of presentation counterbalanced across participants. We calculated proportion of looks to the target. Differences between looking curves for Onsets vs. Codas (burst-aligned) were analysed across groups (Adults vs. Children) using cluster-based permutation tests [7]–[9] (Figure 1). Analyses were performed over a -500 to +2000ms window to take into account transitional cues in the preceding vowel.

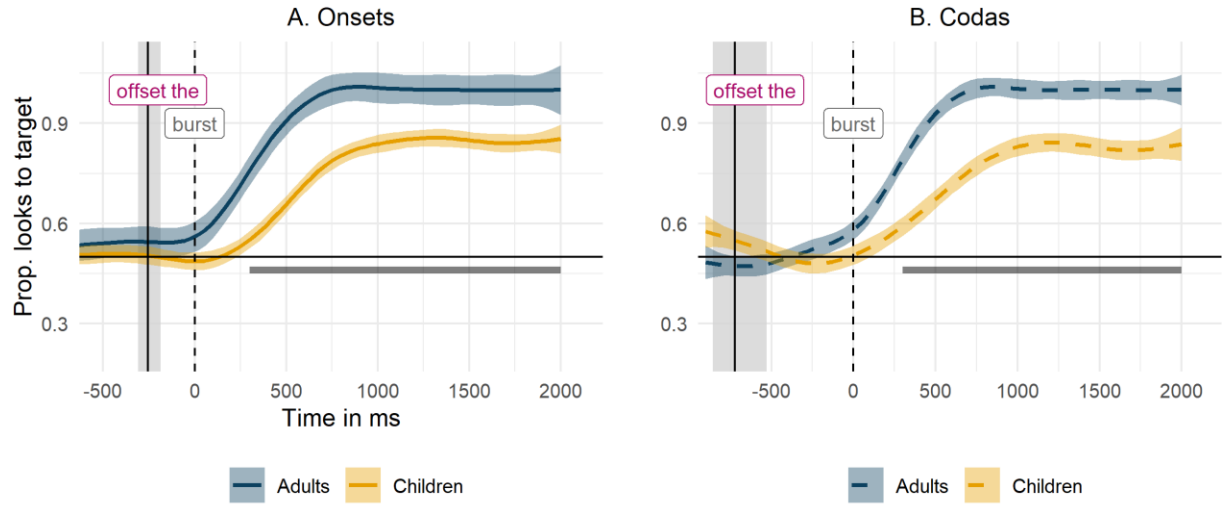
The results did not support the hypothesis that children (or adults) would process onsets faster than codas, as no significant differences were found when comparing Onset vs. Coda curves for either group. However, significant differences were found between Adult vs. Child curves for both Onsets (time-window: 300-2000ms, Monte Carlo $p < 0.001$) and Codas (time-window: 300-2000ms, Monte Carlo $p < 0.001$). This indicates that adults looked significantly more towards the target than children from 300ms until 2000ms after the burst.

In line with [5], these results provide direct evidence that pre-schoolers process codas as fast as onsets, albeit more slowly than adults. This suggests that even though word processing speed increases with age, the mechanisms to process the beginnings and ends of words rapidly are in place early in development. Overall, these findings provide an important baseline to test the word processing speed of children with slow language processing, e.g., those with hearing loss or developmental language disorders.

Table 1. Example phonetic contrasts (number) used for onset and coda minimal pairs. PoA = Place of Articulation

	Onsets	Codas	Examples
PoA (n=20)	b/g(2) p/k(2) b/d(2) p/t(2) d/g(1) t/k(3)	b/g(1) d/g(1) p/k(1) p/t(2) t/k(3)	boat-goat, pea-key, bow-dough | rub-rug, mud-mug, cape-cake pen-ten, date-gate, tape-cape | map-mat, net-neck
Voicing (n=10)	b/p(2) d/t(2) g/k(2)	d/t(2) g/k(2)	bin-pin, deer-tear, goat-coat | seed-seat, log-lock

Figure 1. Time-course of looks to target for Onsets (A) and Codas (B), aligned at the start of the respective stop burst. Curves smoothed using general additive model curve fitting (with 95% confidence intervals). 'Offset the' indicates mean, minimum and maximum offset of '*the'* in carrier sentence *'look at the X'* Grey horizontal bars mark statistically significant time-windows.



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