TEMPORAL MEASURES OF REDUCED /sC/-CLUSTERS IN TODDLER SPEECH: EVIDENCE FOR A DETAILED LEXICAL SPECIFICATION

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ABSTRACT

Cluster reduction is a common phenomenon in toddlers' productions. The question in this paper is how toddlers store target complex onsets in their mental lexicon: are cluster reductions the result of an incomplete lexical specification? We focus on cluster reductions in /sC/-onsets, like in [liːp] for 'sleep'. By means of a detailed acoustic analysis we compare toddlers' productions of target /sC/-onsets that have been phonetically transcribed as reduced to a single consonant, to their productions of similar target words with a singleton consonant. The main finding in this study is that in the acoustic signal of reduced productions of target /sC/-onsets there is a temporal trace of the 'deleted' segment, providing evidence for a covert contrast between words with complex- and simple onsets. Toddlers' lexical representations of /sC/-onsets thus appear to be complete.

Keywords: cluster reduction, toddler speech, /sC/-onsets, singleton consonant

1. INTRODUCTION

Studying the acoustic waveforms of toddlers' productions is an interesting way to find out more about the lexical representations of early words. Up until now, young children's lexical representations have mostly been studied using perception experiments. However, a detailed analysis of their productions gives a different perspective on the issue, and directly confronts the apparent asymmetry that exists between detailed representations and reduced productions. Acoustic analyses have led to the discovery of a number of "covert contrasts" in toddlers' productions. For a broad overview on different papers treating the covert contrast topic, Scobbie's overview article is of great interest [10].

Another two studies of importance for the present paper are [11] and [2] given that there, just like in this paper, a duration measure was used. Firstly, Song and Demuth [11] found significant differences between reduced target coda clusters and similar correctly produced target singleton forms: compensatory vowel lengthening was found in case the coda cluster was reduced. Secondly, in [2] truncations were analyzed. Children had to repeat sentences like 'He kissed Lucinda' and 'He kissed Cindy'. Here too a significant durational difference was found between reduced "kissed Cinda" and correct "kissed Cindy" productions.

A study of the development of the voicing contrast in English showed that toddlers produce voiceless targets with significantly longer VOTs than voiced stops, although this difference is not perceivable [6]. In another study [7], it was found that the VOT of [k] originating from a target /sk/ onset cluster was significantly shorter than the VOT of a correctly produced onset [k].

Formant differences were found in Dutch child language productions, comparing reduced target /Cr/-clusters to similar singleton /C/ targets. Omission of /r/, like in *trein* (train), resulting in [tɛin], was accompanied by a relatively high F2 in the vowel onset when contrasted to a word like *tijd* [tɛit] (time) [3].

All of the above-mentioned studies thus reveal knowledge that language learners have, but that is not made explicit enough for the listener to perceive.

In this paper we focus on temporal aspects of words with reduced target /s/-clusters, elicited from Dutch toddlers. Our research question is whether a temporal trace is left when either the C1 or the C2 of target words with a /sC/-onset is – perceptually speaking – omitted from the production. On the basis of our findings we will discuss the lexical representation of target /sC/-onset words: does it reflect the perceived reduced production, or does it contain more information than a toddler is able to reveal to the listener?

2. METHOD

2.1. Participants

The participants who took part in the study were twelve toddlers (range = 1;8-2;8 years, mean = 2;2, 5 boys, 7 girls). Data from 11 participants were analyzed due to all-correct productions from 1 participant. The participants were recruited from two day-care centers in Amsterdam (the Netherlands). All participants were monolingual speakers of Dutch and had no reported speech or hearing problems.

2.2. Procedure and materials

The participants were tested individually in a quite room at the day-care center. The participants were tested with two sets of words: 9 sC-onset words like *staart* (tail), and 18 control words with a simple onset, like *taart* (cake). For each test word, there were two corresponding control words, one sharing the onset consonant /s/ plus following vowel, and one sharing the second consonant of the cluster plus following vowel (see Table 1). The test words contained 5 /s/-plosive, 2 /sx-/, 1 /sl-/ and 1 /sn-/ onsets.

Table 1: Example test word and corresponding control words.

test word	translation	control words	translation
staart [staːɹt]	tail	taart [saːɹt]	cake
		saap [saːp]	nonword

The test and control words were elicited from the participants by means of a repetition task with supporting pictures. The test words were supported with pictures of known items, the control words were supported by pictures of either known items or nonce animals. First a participant was presented a picture of, for instance, a dog tail and was told this was a tail, then the participant was shown a picture of two dog tails and was asked to repeat "two tails" *twee staarten*. This was done in order to assess the duration between a reduced cluster, or singleton consonant, and a preceding vowel. The test and control words were randomly distributed during the repetition task.

The participants' utterances were recorded using a M-Audio Microtrack II digital Wave recorder and an external Microtrack II mini-microphone at 44.1kHz (16 bits precision, stereo sound).

The toddlers' elicited productions were transcribed by a trained transcriber and categorized as first consonant (C1) or second consonant (C2) deletions. C1 deletions occurred most often. This could be due to the higher number of /s/-plosive test words[1], which tend to be reduced to plosives [5, 8].

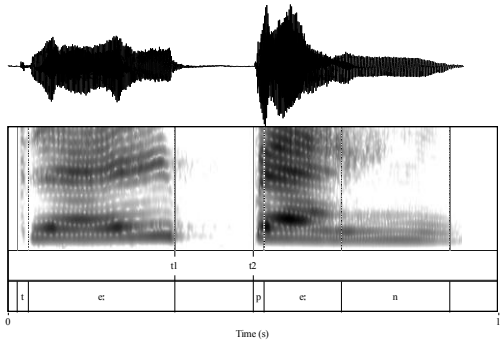
All measures were carried out in PRAAT [1] by a single properly trained assistant. A second assistant checked 50% of the C1 deletion measure and 100% of the C2 deletion measure (see 2.3 and 2.4). For the first measures the correlation between the two assistants was r=0.52 and was statistically significant (p<0.05). For the second measure the correlation was r=0.48 and was again statistically significant (p <0.05).

2.3. Duration measure C1 deletion

In our data set, the 11 participants produced 60 reductions of the test words in total. Out of these, 43 were C1 deletions, coming from target /sn/-words (2), /sx/-words (8) and /s/-plosive words (33). These reductions resulted in forms like [taːɹt] when *staart* (tail) was intended.

To measure cases where C1 was omitted, utterances consisting of *twee* (two) followed by the test or control item were taken into account. The time between the end of the /e/ in *twee* and the beginning of the consonant of the reduced word was measured (a between-word duration measure). Stated more concretely, we mean the time between the offset of the voicing of the vowel and the start of the plosive closure. An illustration of this measure is in Figure 1, where t1 (time1) and t2 (time 2) indicate the beginning and the end of the duration measure in *twee spenen* "two pacifiers", produced as [teː peːn]. The same procedure was applied to control word constructions like *twee peken* "two *peken* (nonword)".

Figure 1: An oscillogram and a spectrogram of the production [teː peːn]; t1 and t2 indicate the between-word duration measure.

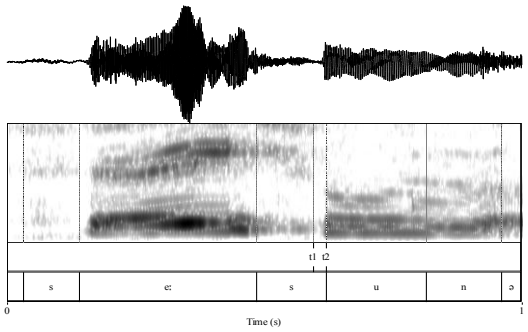


2.4. Duration measure C2 deletion

The participants only produced 17 C2 deletions, coming from target /sn/-words (5), /sx/-words (6) and /sl/-words (6). These reductions resulted in forms like [sup] when *snoep* (candy) was intended.

Here we carried out a word-internal measure. In the test- and control words, the time between the onset fricative and the following vowel was measured. Final weakening is one of the acoustic characteristics of fricatives. Some scholars consider this to be part of the fricative noise [9], but others distinguish fricative noise from a fricative-vowel (FV) transition, just before the vowel onset [4]. Here we adopt the notion of FV transition by which we mean the period of voicelessness between the offset of friction to the onset of voicing of the vowel. This is illustrated in Figure 2 for *schoen* "shoe", reduced to [sun]. The time between the end of the constant fricative noise of /s/ (t1) and the onset of /u/ (t2) is measured. The same procedure was applied to control words starting with /s/ like *soep* (soup).

Figure 2: An oscillogram and a spectrogram of the construction *twee schoenen*, where t1 (time1) and t2 (time2) indicate the duration of the FV transition.

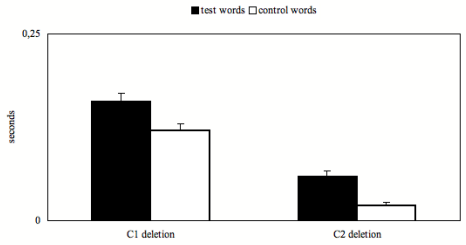


3. RESULTS AND DISCUSSION

3.1. Temporal trace in C1 deletion

Our first research question was whether toddlers leave a temporal trace when they delete C1 in target /sC/ onset words. For this purpose we compared the duration values for the test- and the control words, conducting a paired-samples t-test. The average score of the test words is 40ms higher than that of the control words, with a 95% confidence interval of 13~77ms. This difference is reliably different from zero ($t(43)=2.89$, two-tailed $p=0.006$), see Figure 3, left columns. Toddlers thus tend to show a longer pause after *twee* "two" when a reduced cluster word follows than when a correct single onset word follows. We therefore conclude that Dutch toddlers indeed leave a temporal trace of the deleted C1 in /sC/-onset words.

Figure 3: Mean values and standard error bars indicating the duration differences in seconds between test words and control words for the C1- (left) and the C2 deletion measure (right).



3.2. Temporal trace in C2 deletion

In order to answer our second research question we compared the durations of the FV transition in reduced test words to those in control words, conducting a paired-samples t-test. The average score of the test words is 40ms higher than that of the control words, with a 95% confidence interval of 10~56ms. This difference is reliably different from zero ($t(17)=3.54$, two-tailed $p=0.003$), see Figure 3, right columns. The FV transition thus takes longer when the vowel follows a reduced cluster than when it follows a correct singleton onset: in the case of *schoenen* "shoes", reduced to [sunə], for example, one participant took around 60 milliseconds to realize the transition of /s/ to the vowel /u/, while it took around 20 milliseconds to produce the /u/ after the fricative in non-reduced *soep* "soup". Because the number of data is small for the C2 set, we tentatively conclude that Dutch toddlers also leave a trace when C2 in a /s/-cluster word is deleted.

For both C1 and C2 deletions, we are thus able to (tentatively) conclude that toddlers indeed leave a temporal trace of the deleted segment when producing a reduced form of a /sC/-onset word.

4. DISCUSSION AND CONCLUSION

We can now discuss whether toddlers store words according to their own productions, i.e. in a simplified fashion, or according to the adult target, i.e. as a form that is more detailed than their own productions. Given that we found evidence for temporal traces of the deleted segments in reduced /s/-clusters, and given that other studies have found acoustic or temporal traces in other simplified productions [2, 3, 11], we can conclude that children provide more acoustic detail in their

production than can be perceived by the adult ear. The evidence from production data, pointing to the toddler's awareness of phonetic detail, leads us to conclude that the forms they have stored in their mental lexicon are more complex than their actual productions. This corroborates findings in infant perception studies. However, studies investigating the perception of consonant clusters have not been carried out to date, and are needed to further confirm our conclusion.

Future research should try to give a developmental perspective on covert contrasts in toddlers' speech. Are all currently known covert contrasts present from the start, or do they emerge at some point? Longitudinal studies, or studies testing different age groups, like [6], are needed to answer this question.

5. REFERENCES

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[1] The /s/-plosive words in Dutch are highly frequent s-cluster words, as far as the productive vocabulary of two-year-olds is concerned [12].