

# Effects of age of learning on VOT in voiceless stops produced by near-native L2 speakers<sup>1</sup>

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## Abstract

*This study is concerned with effects of age of onset (AO) of acquisition on the production of Voice Onset Time (VOT) among near-native L2 speakers. 41 L1 Spanish early and late learners of L2 Swedish, who had carefully been screened for their “nativelike” L2-proficiency, participated in the study. 8 native speakers of Swedish served as control group. Spectral analyses of VOT were carried out on the subjects’ production of the Swedish voiceless stops /p t k/. The preliminary results show an overall age effect on VOT in the nativelike L2 speakers’ production of all three stops (answer to Research Question 1). Among the late learners only a small minority exhibits actual nativelike L2 behavior (answer to Research Question 2). Finally, far from all early L2 speakers do pass as native speakers of their L2 regarding the production of voiceless stops (answer to Research Question 3).*

## Introduction

Several studies on infant perception have shown that first language (L1) phonetic categories are already established during the first year of life (e.g. Eimas et al. 1971, Werker et al. 1984). Further evidence that very early exposure is of importance in L1 development comes from children who were deprived from verbal input due to inflammation of the middle ear during their first year of life. Ruben (1997) reports that these children showed significantly less capacity for phonetic discrimination compared to children with normal hearing during infancy when they were tested at the age of nine years. From these findings it has been concluded that there may exist a critical period for phonetic/phonological acquisition and that this critical period may already be over at the age of one year (Ruben 1997).

One classical issue in the field of language acquisition concerns whether this theory of the existence of a critical period can be applied to second language (L2) acquisition. More precisely, the question is if L2 learners typically fail to acquire phonetic detail because of lack

of verbal L2 exposure during a limited time frame for phonetic sensitivity, or if nativelike perception and an accent-free pronunciation is biologically possible for any adult learner, given the right social, psychological, and educational circumstances.

This study is part of an ongoing project on age of onset (AO) and ultimate attainment in L2 acquisition. The project focuses on early and late learners of Swedish with Spanish as their L1, who have been selected on the criterion that they are perceived by native listeners as mother-tongue speakers of Swedish in everyday oral communication. These nativelike candidates’ L2 proficiency has thereafter been tested for various linguistic levels and skills. The present study reports on analyses of Voice Onset Time (VOT) in the production of Swedish voiceless stops.

Swedish and Spanish both distinguish voiced from voiceless stops in terms of VOT but the languages differ as to where on the VOT continuum the two stop categories separate. In languages like Swedish and English short-lag stops are treated as voiced, whereas long-lag stops are classified as voiceless. In contrast, Spanish treats short-lag stops as voiceless, while stops with voicing lead are categorized as voiced (e.g. Zampini & Green 2001). Due to the fact that L2 learners in general show difficulties in correctly perceiving and producing these language specific categories (see, e.g. Flege, 1991), the analysis of VOT production seems to be a good tool for investigating the nativelike subjects’ L2 proficiency.

For the present study the following research questions were formulated:

- (1) Is there a general age effect on VOT production among L2 learners who are perceived by native listeners as native speakers of Swedish?
- (2) Are there late L2 learners who produce voiceless stops with an average VOT within the range of native-speaker VOT?
- (3) Do all (or most) early L2 learners produce voiceless stops with an average VOT within the range of native-speaker VOT?

## Method

### Subjects

A total of 41 native speakers of Spanish (age 21-52 years), who had been selected on the criterion that native listeners perceive them as mother-tongue speakers of Swedish, participated in this study. The nativelike subjects' mean length of residence (LOR) in Sweden was 24 years (range 12-44 years) and their age of onset (AO) of L2 acquisition varied between 1 and 19 years. Furthermore, the subjects' showed an educational level of no less than senior high school and they all had acquired the variety of Swedish spoken in the great Stockholm area.

A control group was added consisting of 8<sup>2</sup> native speakers of Swedish who had been matched with the experimental group regarding present age, educational level and variety of Swedish.

### Material and procedure

Both the nativelike and the native speakers of Swedish were tested individually in a sound treated room. The subject was instructed to read aloud the following three Swedish words with /p t k/ in initial position: *par* ([pɑ:r], 'pair, couple'), *tal* ([ta:l], 'number, speech') and *kal* ([ka:l], 'naked, bald'). Each word was pronounced ten times, with two-second pauses in between. The experiment leader, a male native speaker of Stockholm Swedish, indicated the reading rate to the subject by visually keeping count with his fingers. All readings were recorded through a KOSS R/50B headset microphone at 22,050 Hz with a 16-bit resolution.

Using the Soundswell signal analysis package measurements of VOT were conducted on the basis of broadband spectrograms and the oscillographic display. VOT was measured as the time interval between the release burst of the stop consonant and the onset of voicing in the following vowel.

As has been reported in several studies (e.g. Kessinger & Blumstein 1997, Miller et al. 1986) speaking rate has an effect on both VOT and vowel duration. Findings like these thus suggest that VOT should be treated in relation to syllable or word duration rather than independently. Therefore, also measurements on word length were carried out.

Furthermore, two standard deviations from the average word length were calculated in or-

der to exclude extremely short and long word durations from further analysis: one subject (AO=3) as well as *par* for a subject with AO=9, *tal* for a subject with AO=3, and *kal* for a subject with AO=15.

## Results

Since it is a well-known fact that VOT varies with place of articulation (see, e.g. Lisker & Abramson, 1964) results for the three voiceless stops are presented separately.

Figures 1-3 show the subjects' average VOT-values (in ms) plotted against their age of onset (AO).

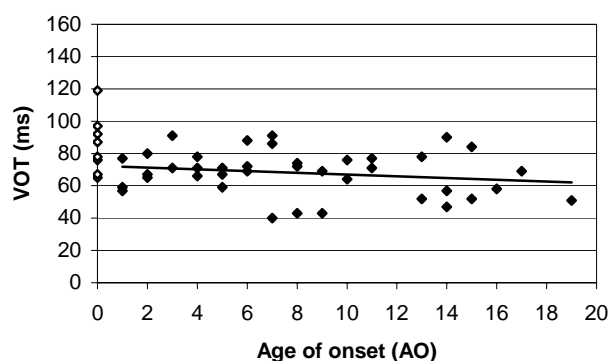


Figure 1. VOT (in ms) for /p/ in relation to age of onset (AO). Unfilled diamonds: native speakers of Swedish, filled diamonds: near-native L2 speakers.

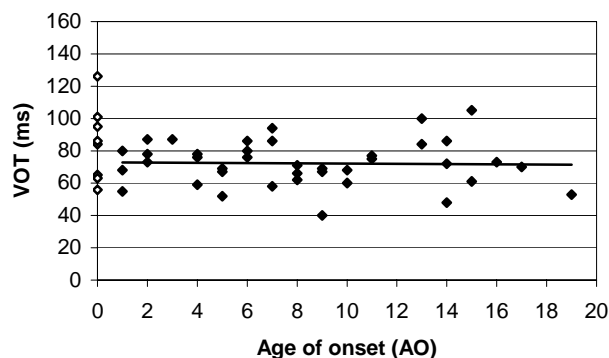


Figure 2. VOT (in ms) for /t/ in relation to age of onset (AO). Symbols as in figure 1.

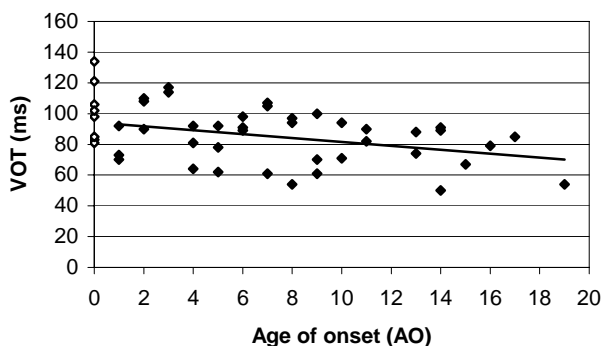


Figure 3. VOT (in ms) for /k/ in relation to age of onset (AO). Symbols as in figure 1.

As can be seen in figures 1-2, no significant age effects on VOT are found for either /p/ ( $r=-0.20$ ,  $df=38$ ) or /t/ ( $r=-0.02$ ,  $df=38$ ). Only for /k/ (see figure 3) a weak but statistically significant correlation between AO and VOT can be observed ( $r=-0.35$ ,  $df=38$ ,  $p<0.05$ ). However, this analysis did not control for possible effects of speaking rate on VOT. In order to achieve a neutralized measure of VOT, milliseconds were transformed into percentages of total word duration.

Figures 4-6 again present VOT in relation to the subjects' AO, but this time with VOT measurements expressed in terms of percentages of word length.

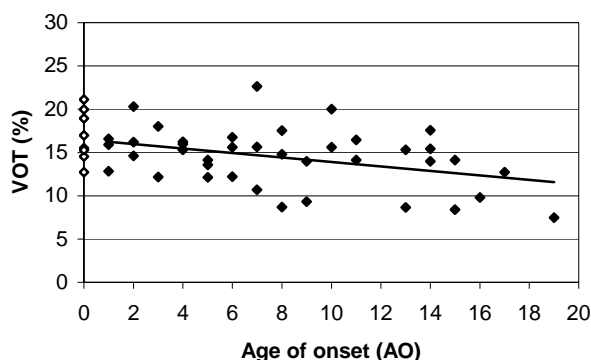


Figure 4. VOT (in %) for /p/ in relation to age of onset (AO). Symbols as in figure 1.

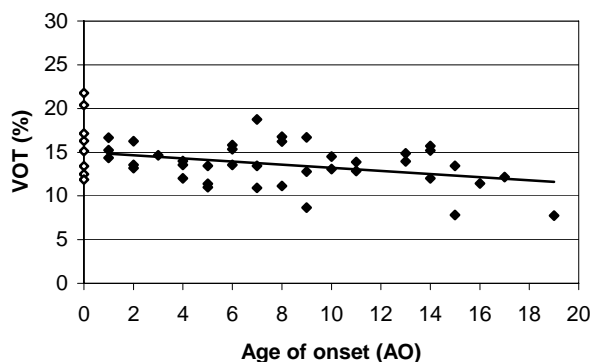


Figure 5. VOT (in %) for /t/ in relation to age of onset (AO). Symbols as in figure 1.

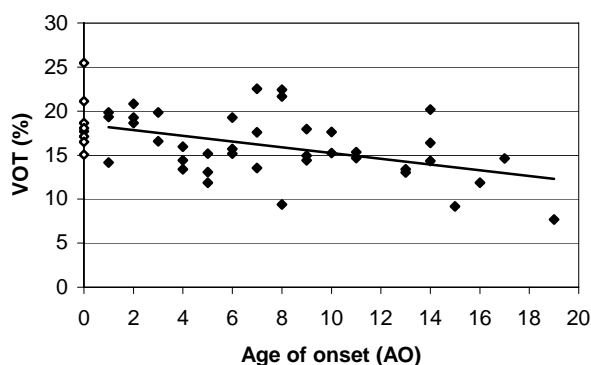


Figure 6. VOT (in %) for /k/ in relation to age of onset (AO). Symbols as in figure 1.

Figures 4-6 reveal that correlations between AO and VOT now have become significant for all three stops: for /p/  $r=-0.38$  ( $df=38$ ,  $p<0.02$ ), for /t/  $r=-0.36$  ( $df=38$ ,  $p<0.02$ ), and for /k/  $r=-0.45$  ( $df=38$ ,  $p<0.01$ ). Furthermore, the figures show that most of the natively-like candidates produce average VOT-values within the range of native speaker VOT. However, this observation is more obvious for /p/ (29 subjects) and /t/ (31 subjects) than for /k/ (22 subjects).

In order to compare early and late learners in a more systematic way, the natively-like candidates were divided into a pre-puberty (AO 1-11 years) and a post-puberty group (AO 12-19 years). By analyzing these two groups separately it becomes clear that a majority (17 out of 30) of the pre-puberty group produce average VOT-values within the range of native speaker VOT for all three stops. Among the 10 late learners this is the case for only two of the subjects (AO 14 years for both).

Within the group of early L2 learners ten subjects show average VOT-values within the range of native speaker VOT for either one or two of the stops. In contrast, three pre-puberty learners (AO=7, 8 and 9 years) can be found who do not produce natively-like VOTs for any of the stops.

In the group of late L2 learners five subjects are found who produce average VOT-values within the range of native speaker VOT for /t/ or for both /p/ and /t/, but never for /k/. Finally, three post-puberty learners (AO=15, 16 and 19 years) can be observed who do not produce average VOTs within the range of native speaker VOT for any of the stops.

## Summary and conclusions

The present study has revealed that among subjects, who have been selected on the criterion that native listeners perceive them as mother-tongue speakers of Swedish, there exists a weak but statistically significant correlation between AO and VOT production. In other words, these findings confirm that there is a general age effect on voiceless stop production even among apparently natively-like L2 speakers (Research Question 1).

The analysis of the post-puberty group has shown that only two (AO=14 years) out of 10 late L2 learners show average VOTs within the range of native speaker VOT for all three stops. Furthermore, eight late learners do not produce VOTs within the range of native speaker VOT regarding all three stops, and three of these sub-

jects (AO=15, 16, and 19 years) do not exhibit nativelike VOTs for any of the Swedish stops. According to these data only a small minority among late, apparently nativelike L2 learners exhibit actual nativelike L2 behavior regarding the production of Swedish voiceless stops (Research Question 2).

An interesting finding is that both early and late L2 learners produce more nativelike VOTs for /p/ and /t/ than for the velar stop /k/. Since Spanish VOTs of voiceless stops are overall shorter (short-lag) than Swedish VOTs (long-lag), and since velars, compared to bilabials and dentals, show the longest VOTs (e.g. Lisker & Abramson 1964), /k/ represents the most extreme, or the most “non-Spanish”, articulation concerning VOT. Therefore, the Swedish velar stop probably generates the most difficulty for both early and late L2 learners.

Regarding the pre-puberty group a majority of the L2 learners do produce average VOT within the range of native speaker VOT for all three stops. However, 13 individuals are found who do not produce nativelike VOT concerning all three stops, and three of these subjects (AO=7, 8 and 9 years) do not exhibit nativelike VOTs for any of the stop consonants. From these results it can be concluded that far from all early learners pass as native speakers of their L2 when analyzed in detail (Research Question 3). Thus, even though early L2 learners generally sound nativelike in everyday oral communication, an early age of onset does not automatically result in an entirely nativelike VOT production.

Finally, when measuring VOT in milliseconds no correlations between AO and VOT could be observed, except for the velar stop /k/. However, after have taken word duration into consideration a significant overall age effect emerged for all three stops. These findings suggest that effects of speaking rate have to be taken into account in the analysis of VOT.

## Acknowledgements

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## Notes

1. A more detailed description and discussion of this study will be given in Abrahamsson, Stölten & Hyltenstam (*in press*).

2. For further analysis the control group will be expanded by another 7 native speakers of Swedish.

## References

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