

Jessica van Schagen 3986829
Supervisor: Aoju Chen
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Bidirectional Influence on the VOT Production of Dutch Learners of English

BA Thesis

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Abstract

This study investigated the influence of L2 English on L1 Dutch and vice versa. It examined the pronunciation of plosives in the L1 and the L2 and compared the results of more proficient L2 English speakers with less proficient L2 speakers. The participants were students from Utrecht University. Half of the participants were students of English and half of them were not. The focus of this paper was placed on the voice onset time (VOT) of word and phrase initial voiced and voiceless plosives that occur in both languages: /b, p, d, t/. Based on previous research, the general hypotheses were that more proficient speakers were able to differentiate more between the two languages and thus produced the English plosives more like native speakers of English (H1) and the Dutch plosives more like native speakers of Dutch (H2). The proficient speakers pronounced more English voiced plosives with a post-burst VOT (as previous studies indicated was more like native speakers of English), but the duration of their pre-burst VOTs was longer, indicating L1 Dutch influence on L2 English. This contradicted H1. The proficient speakers produced Dutch voiceless plosives with shorter post-burst VOTs, confirming H2 for voiceless plosives. The general results showed that voiceless plosives followed by a high vowel have longer post-burst VOTs and voiceless alveolars have longer post-burst VOTs than voiceless bilabials. This confirmed H3.

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1. Introduction

Many studies have investigated the relationship between a speaker's first language (L1) and second language (L2). According to Pavlenko (2000), many of these studies involve the transfer particular aspects of a first language to a second language. Only a few studies investigated the influence of L2 on L1. Pavlenko divided the different aspects of language that can be looked at when studying L2 influence on L1 in the following way: phonology, morphosyntax, lexicon, semantics, L1-based concepts, pragmatics and rhetoric. The phonological aspect of language and language influence can be studied from several perspectives. Two of these are segmental and suprasegmental. This paper focuses on the phonological aspect and studies this aspect from a segmental perspective by examining the voice onset time (VOT)¹. VOT was chosen because there are several differences between the VOT of Dutch plosives and the VOT of English plosives. Pavlenko compared the results of various studies looking at L2 influence after puberty and found that L2 can influence the phonology of L1 if L2 is learned after puberty. The purpose of this paper is to find out whether L1 Dutch speakers, who have learned to speak English during their puberty, can produce the English plosives in the same way native speakers of English produce them and whether their knowledge of L2 English influences their production of Dutch plosives.

2. Previous Research on Voice Onset Time

2.1. Voice Onset Time in Dutch and English

Voice onset time (VOT) is used to indicate the time between the release of the plosive, or the burst, and the onset of voicing. Three conditions are often classified (Simon, 2010): 1) voicing lead, 2) short voicing lag and 3) long voicing lag. The voicing lead indicates that the voicing

¹ The experiment sessions will be conducted together with the experiment sessions for a study on L2 influence on L1 on lengthening, a suprasegmental feature.

occurs before the burst, also referred to as pre-voiced or pre-burst VOT in this paper. The short voicing lag indicates that the voicing occurs shortly after the burst, creating no aspiration, and the long voicing lag indicates that the voicing occurs much later than the burst, leading to audible aspiration. Both the short and long voicing lag are also referred to as post-voiced or post-burst VOT in this paper. In Dutch, voiceless plosives are produced as voiceless, unaspirated plosives, characterised by a short lag VOT. Dutch voiced plosives are most often produced as unaspirated plosives, characterised by a voicing lead. English initial voiceless plosives are usually produced with audible aspiration in word-initial position, therefore having a long VOT lag, and English voiced plosives are produced without aspiration, having a short VOT lag, sometimes with a slight voicing lead (Van Alphen & McQueen & 2006; Simon, 2009). Van Alphen and Smits (2004) found that there could be individual differences, leading to both pre- and post-voiced voiced plosives in Dutch for seven out of ten speakers (four of which did not produce pre-voiced voiced plosives for approximately half the items). Dutch is sometimes called a “voicing language” due to the presence of pre-voicing and English is sometimes called an “aspirating language” due to the presence of aspiration in pronunciation (Simon, 2009, p. 378).

2.2.Voice Onset Time in L2 Acquisition

When learning an L2, a speaker may need to learn new realisations for a plosive because the VOT realisations of the L1 and L2 can differ. The fact that both English and Dutch have a two-way contrast in their plosives may make it easier for learners to learn the other language. When L1 Dutch speakers learn L2 English, they do not have to learn an extra category as both languages have two categories; both Dutch and English differentiate between two voicing conditions. Dutch distinguishes between voiced plosives with a voicing lead and voiceless plosives with a short voicing lag. English distinguishes between voiced plosives with a short voicing lag and voiceless plosives with a long voicing lag. This is in accordance with the

Contrastive Analysis Theory (Laufer & Girsai, 2008). The Contrastive Analysis theory argues that similarities between two languages make it easier to learn an L2.

However, as the two languages distinguish between voiced and voiceless plosives in different ways, the voiced English plosives may sound similar to voiceless Dutch plosives to Dutch learners of English, especially since Dutch voiceless plosives are unaspirated. A native speaker of Dutch is also required to learn to produce English voiceless plosives with aspiration as the aspiration is a factor that distinguishes between English voiced and voiceless plosives. Flege and Eefting (1987) claim that a sound in L2 will be harder to learn if it is similar to a sound in L1. This is called “Equivalence Classification” (p. 187). According to this theory, the English aspirated voiceless plosives will be easier to acquire for a native speaker of Dutch than the English unaspirated voiced plosives, as the latter are very similar to the Dutch voiceless unaspirated plosives and since the Dutch speakers can get away with using Dutch VOTs.

A third theory tries to explain the production of VOT in L2 according to the Markedness Differential Hypothesis (Robert, 1988; Simon, 2009). This phonological theory groups phenomena of language according to how marked they are. A phenomenon is more marked if the presence of that phenomenon implies the presence of another, less marked, phenomenon but not the other way around. Features that are more marked in L2 are harder to learn and features that are less marked in L1 are transferred to L2 easier. According to Simon (2009), there are different views on which conditions are marked and unmarked in VOT. One theory argues that Germanic languages have the same two-way contrast, that of [voice], and that the difference between voicing and aspirating languages lies in the phonetic realisation. According to this theory, the English voiceless plosives, whether short lag or long lag, are all unmarked, making it easier to learn them for L1 Dutch speakers. However, no distinction is made between the English voiced and voiceless plosives. Another theory states that the

feature [voice] is the contrastive feature in voicing languages (e.g. Dutch), but the feature [spread glottis] is the contrastive feature in aspiration languages (e.g. English). This would mean that the voiceless unaspirated plosives are marked in English, making it easier to learn L2 English voiceless plosives for L1 Dutch speakers. Simon argues that this can be interpreted under the Ease of Articulation analysis, which says that the unmarked, short lag production is easier to produce. In this interpretation of the Markedness Differential Hypothesis a distinction is made between English voiced and voiceless plosives. According to the three theories discussed above, the English voiceless aspirated plosives should be easiest to learn for a native speaker of Dutch, because they are unmarked and least similar to a Dutch pronunciation of plosives, and because both languages have a two-way contrast. What the underlying reasons may be can vary, depending on which theory is adopted.

Much research has been done on the effect of L1 on L2. In this text I will only focus on a study concerning L1 Dutch and L2 English, as these languages are relevant to this study. The results of Simon's study (2009) confirmed the theory that English voiceless aspirated plosives are easier to learn. L1 Dutch speakers were successful in producing long lag aspirated plosives for English voiceless plosives, but not in producing the short lag plosives for English voiced plosives. L1 Dutch speakers produced the English voiced plosives with pre-burst VOTs. Simon proposed this could be caused by the fact that pre-voicing is an important cue for Dutch listeners to determine whether the plosive is voiced or not. Pre-voiced plosives are always perceived as voiced (Van Alphen & McQueen, 2006) and Dutch speakers may be hesitant to lose this aspect of the pronunciation. Simon studied the pronunciation of 16 native speakers of Dutch studying English at university level in a Dutch speaking country. The effect of proficiency was not tested, as all the participants were said to be fluent in English and to have "an advanced pronunciation". Simon compared the speech of the native speakers of Dutch to those of native speakers of English. The data consisted of

spontaneous speech and isolated words from a reading task. The results from this study show that the voiceless unaspirated English plosives were indeed easier to learn for the native speakers of Dutch, conforming to the Equivalence Classification Hypothesis and the Markedness Differential Hypothesis. The influence of L2 on L1 was not examined in Simon's research.

2.3.Voice Onset Time in Studies on L2 Influence on L1

Some studies look at the influence of L2 on L1. Two different studies considered the influence of L2 English on L1 Dutch in the production of plosives. One of these was the study by Flege and Eefting (1987). In this study, Flege and Eefting looked at the perception of /ta/ and /da/ with various VOT values. The study looked at 50 late-bilingual participants who had learned English after the age of 12. They rated their participants' proficiency in English in three ways: they used native speaker evaluations of the participants' pronunciations of certain sentences, they used self-evaluations of the participants by means of a questionnaire and they looked at their pronunciation of /t/ in nonce words. They found that the participants who were found to be more proficient by the first two tests, pronounced /t/ with shorter VOT values in Dutch than the participants who were judged to be less proficient. Flege and Eefting speculated that this meant that the proficient Dutch speakers established a new category for English /t/.

However, a study by Mayr, Price and Mennen (2012) did not support the result of Flege and Eefting. They studied the language production of two twin sisters, who were both born and raised in the Netherlands and spoke Dutch as their L1. One sister (named TZ) had lived in the Netherlands her entire life and the other sister (named MZ) had moved to the United Kingdom at a later age. They found that MZ produced both the Dutch and English voiceless plosives /p,t,k/ with post-voiced VOT values that were longer than the short-lag Dutch norm, but shorter than the long-lag English norm. Mayr, Price and Mennen called this

pattern “cross-linguistic assimilation” (p. 692). MZ appeared to have merged the production of the voiceless plosives for the two languages into one category with VOT values in between the native English and native Dutch ones. This contradicted the findings of Flege and Eefting, where two separate categories were created for the /t/ by more proficient speakers. MZ’s English voiced plosives, however, were even more pre-voiced than her Dutch voiced plosives suggesting L1 transfer. This result conforms to Simon (2009) where L1 Dutch speakers produced English voiced plosives with pre-voicing. However, the twin-study only looked at the production of plosives of two people and many factors could not be controlled in this study, such as outside interference and individual differences, since the authors only looked at two people.

The existence of two separate categories found by Flege and Eefting was also mentioned by Chang (2012). Chang called this a “dissimilatory drift” or “polarisation” of VOT. He mentioned that this is most often seen in speakers who were exposed to the L2 very early. Chang looked at the influence of L2 Korean on L1 American English in the production of plosives by adult speakers and found that from a very early point in the learning process there was noticeable L2 influence. The voiceless Korean plosives changed and became more aspirated, they even became over-aspirated, and the English voiceless plosives “went along for the ride” (p. 259), as Chang put it. This caused the English plosives to become less native-like, according to the American English norms. The basic voicing contrast of the L1 was not altered, however; the English voiceless plosives remained aspirated and stayed different from the English voiced plosives.

These studies show that L2 influence of L1 can take place at a very early stage in the learning of an L2 and that the proficiency of the speakers influences the results.

2.4. Factors Influencing Voice Onset Time

The VOT of plosives is not only influenced by the language of the speaker, but also by certain inherent characteristics of the plosives. These are characteristics that the plosives have in common and which depend on the production of the plosives in the vocal tract. Chang (2012) found that the post-burst VOT was shortest for the voiceless bilabials, longer for the voiceless alveolars and longest for the voiceless velars. This conforms Cho and Ladefoged (1999), in which the physiological and aerodynamic characteristics of the vocal tract were explained. In this paper, the author gives reasons why voiceless bilabials may have the shortest post-burst VOTs and voiceless velars the longest (in most languages) are: 1) the further back the closure of the tract, the longer the post-burst VOT will be (this is due to the differences in cavity sizes before and after the plosive), 2) the bigger the contact area between the articulators, the longer the post-burst VOT will be and 3) the faster the movement of the articulator, the shorter the post-burst VOT will be.

Apart from the inherent characteristics that are present during the production of all plosives, the vowel that follows the plosive can influence the VOT as well. Two studies looked at the effect of the following vowel on the length of the VOT. Klatt (1975) and Nearey & Rochet (1994) found that post-burst VOT values were longer if the voiceless plosives were followed by high vowels than if they were followed by low or non-high vowels. This was true for the English voiceless plosives /p, t, k/ in Klatt's study and for the French voiceless stops /p, t, k/ Nearey & Rochet's study. The vowels studied by Klatt were /i, ε, ay, u/ and the vowels studied by Nearey and Rochet were /u, y, i, a, o/. These studies show that the place of articulation and the height of the following vowel can influence the post-burst VOT of voiceless plosives.

2.5. Effects of VOT on Nativeness and Accent

Both the segmental and suprasegmental level of phonology are features that can predict foreign accent ratings (Pinget, Bosker, Quené & De Jong, 2014). Although VOT is only one feature of language production, several studies indicated that “VOT values are closely correlated with overall judgements on the ‘nativeness’ or ‘accentedness’ of one’s speech” (Pavlenko, p. 180). If it turns out that the proficient speakers of English in this study manage to produce the plosives differently in the two languages, this could mean that they are perceived as more native-sounding in both languages. If, however, the results show that L2 influence on L1 takes place, as in the case of MZ’s voiceless plosives, this can mean that the speakers are perceived as less native. Sounding native-like can influence the lives of speakers because it can make them sound more credible. Lev-Ari and Keysar (2010) found that L2 speakers with a foreign accent (mild or heavy, from various languages) were perceived to be less credible. This perception could be changed when the listeners were made aware of this fact, but the listeners could only change their unconscious opinions for the speakers with a mild accent. This might indicate that learning to sound native-like is not only something that brings prestige to speakers, but also something that may actually help them in life as it makes them sound more credible. If the speakers’ L1 changes under the influence of L2 (for either high or low proficient speakers), their credibility may also be affected.

3. Present Study

The present study focusses on measuring the duration of pre- and post-burst VOT. In this study word-initial plosives were chosen, as word-final plosives tend to be neutralised in Dutch, leading to devoicing, and are unreleased in English. The choice was made to study only alveolar and bilabial plosives, because the voiced velar plosive is not often used in Dutch in initial positions (except in loanwords or in a voiced environment) and no comparison could

be made between the Dutch and English voiced velar plosives. In this study proficient participants (students of English) were compared to less proficient participants (students who did not study English). Before the influence of L1 on L2 and vice versa can be studied, the pronunciation of English words must be studied to see if the more proficient speakers have a more native-like pronunciation in L2 English. If the English pronunciation of the proficient speakers is not different from that of the less proficient speakers, the L2 influence on L1 may be absent. Therefore the first research question was as follows:

RQ1: Does proficiency influence the extent to which L2 English voice onset times in plosives are native target-like for Dutch learners of English?

After this has been examined, the influence of L2 English on L1 Dutch can be studied.

Therefore the second research question is:

RQ2: Does proficiency influence the extent to which L2 English influences L1 Dutch voice onset time in plosives?

As previous studies have found that the vowel height and the place of articulation can influence the post-burst VOT of voiceless plosives in various languages, a third research question, which could influence the results of both RQ1 and RQ2, was:

RQ3: Does the vowel height and place of articulation influence the duration of voice onset times in Dutch and English plosives?

As the students all lived in the Netherlands and had Dutch as their main language of input in their daily lives, it is expected that the influence of L2 on L1 will conform to Flege and Eefting's study (1987). Therefore the first and second hypothesis were:

H1: A higher proficiency obtained during the English Bachelor's programme will lead to a more native-like pronunciation of English voice onset time in plosives.

H2: A higher proficiency obtained during the English Bachelor's programme will lead to a stronger contrast between the L1 and L2 categories, leading to a "more native-like" pronunciation of Dutch voice onset time in plosives.

The height of the vowel following the voiceless plosives has been found to influence the post-burst VOT, making the post-burst VOT of voiceless plosives longer if the plosive was followed by a high vowel. The place of articulation has been found to influence the post-burst VOT, with voiceless bilabials having shorter post-burst VOTs than voiceless alveolars. This led to the third hypothesis:

H3: A high vowel following a voiceless plosive will make the post-burst VOT longer and voiceless alveolars will have longer post-burst VOTs than voiceless bilabials.

4. Method

The experiment consisted of 5 parts and lasted about 50 minutes per participant. The first two parts consisted of pronouncing a number of sentences (to be used for a study on accentual and final lengthening) and a number of words in Dutch. The third part consisted of a proficiency test in the form of a lexical test. The fourth and fifth part consisted of pronouncing a number of sentences (to be used for a study on accentual and final lengthening) and a number of words in English. The sessions ended with a questionnaire on the participant's language background. The participants were paid for their participation.

4.1. Participants

All participants were students at Utrecht University at the time of testing. The students were invited to participate in this study by one of the two experimenters (the author of this paper, Van Schagen, or the author of a lengthening paper, Van den Hoorn). 11 students of English and 10 students who did not study English replied. One of these students of English turned out to be raised bilingually from birth and her data were excluded from the study. The data of

5 participants from each group (English-major vs. non-English major) were analysed for the current purpose due to time constraints. The participants were all female and between the ages of 18 and 24. The participants all followed English lessons at secondary school. The participants were all native speakers of Dutch. The students of English were assumed to have a high proficiency in English and were assigned to the proficient group. The English department at Utrecht University teaches their students how to improve their pronunciation in various obligatory courses increasing the students' proficiency. All the students of English had successfully completed these English proficiency courses. The students that did not study English did not follow these courses and their proficiencies could vary. These students were assigned to the less proficient group. None of the participants reported having speaking or reading difficulties.

4.2. Tasks

The participants were given general instructions by one of the experimenters, explaining there would be 5 parts in the session, followed by a questionnaire. The instructions were in Dutch as all the participants spoke Dutch fluently, but not all of them spoke English proficiently. The participants were randomly placed in one of the two experiment groups: group A or group B. Group A would read the words before they read the sentences and group B would start with the sentences. The two types of general instructions can be found in Appendix A and B. The first and the second part of the session consisted of pronouncing the Dutch words and Dutch sentences. The specific instructions for the first and second part can be found in Appendix C and D. The third part consisted of the proficiency test and the fourth and fifth part consisted of pronouncing the English words and sentences. The specific instructions for part four and five can be found in Appendix E and F. The participants were asked to read the words out loud in a steady voice, pausing between two different words. The participants were

asked to pause between the question and the answer during the pronunciation of the sentences. The pauses made it easier to distinguish between sounds during the analysis.

4.3. Materials

4.3.1. Stimuli

There were two types of stimuli: Dutch and English. In both languages short words were chosen that began with the relevant plosives: /b, p, d, t/. All the Dutch words were monosyllabic and almost all the English words were monosyllabic. Four words were disyllabic to make minimal pairs. The disyllabic words were all stressed on the first syllable, similar to the monosyllabic words. All the plosives were word-initial. The words were chosen to form minimal pairs with the plosive of the same place of articulation leading to b/p minimal pairs and d/t minimal pairs. Examples were:

1. Boek/Poek
2. Diek/Tiek
3. Bork/Pork
4. Door/Toor

Half of the b/p pair consisted of existing words and half of the b/p pairs consisted of at least one non-existing word per pair. This was chosen with the purpose of studying the effect of existing vs. non-existing words in a follow-up study. All the d/t pairs consisted of at least one non-existing word per pair. The nonce words and existing words were balanced.

The vowels were chosen as similar vowels that were used in both languages. The only difference in the usage of the vowel was the length, some were used in a short variant in one language and a long variant in the other. Klatt (1975) and Nearey & Rochet (1994) found that voiceless plosives that were followed by a high vowels had longer post-burst VOT values than voiceless plosives that were followed by a mid or low vowel. This affected the chosen vowels. For the English stimuli there were two high vowels (/u:/ and /i:/) and two non-high

vowels (/ɔ:/ and /ɑ:/). The vowels used for the Dutch stimuli were: /u/, /i/, /ɔ/ and /ɑ/. There were 6 words for every category for the bilabial plosives and 3 words for every category for the alveolar plosives. This led to 48 words with an initial bilabial consonant and 24 words with an initial alveolar consonant, of which half were voiced and half were voiceless. This was true for both languages giving a total of 144 stimuli per participant.

There were 108 filler words per language to prevent the participants from noticing the plosives that were to be studied and interfering with their natural pronunciation of the stimuli. Some of these filler words were monosyllabic and some were bisyllabic to even out the number of mono- and bisyllabic words. These filler words did not start with a bilabial or alveolar plosive. The filler words all started with consonants. The filler words and the stimuli words were randomly mixed.

The stimuli were presented on A4 sheets of paper. There were 20 words per sheet. The participants were also given sentences to pronounce and they were given words to pronounce that contained intervocalic plosives. These stimuli are to be used for the lengthening study and a possible follow-up study on VOT. The stimuli words used in this paper can be found in Appendix G and H².

4.3.2. Proficiency test

The students' proficiencies were tested by means of the LexTale test. This was done to see whether students of English truly had a high proficiency and non-English students a low proficiency. The LexTale test was designed to measure English vocabulary knowledge and it is also a good indicator of general English proficiency (Lemhöfer & Broersma, 2012). The test was administered online. Detailed English instructions were given before the online test began. The participants saw a string of letters on the screen and they had to indicate whether the string of letters was an existing English word or not. The results were sent to the two

² The sentences are discussed in the lengthening paper by Van den Hoorn and the intervocalic items were created by putting “de” or “the” before the stimuli used for this paper.

experimenters via e-mail and the participants were given the option to have the results sent to their e-mailaddresses too. The results were given in percentages of correct answers. The test was administered halfway through the experiment sessions to give the participants a break from the pronunciation parts.

4.3.3. Questionnaire

After producing the stimuli and completing the LexTale test, the participants were asked to fill out a questionnaire on their language background. The questionnaire was in Dutch to make sure both proficiency groups could understand every question. The questionnaire can be found in Appendix I. The information from the questionnaire can be used in a follow-up study.

4.4.Procedure

The experiment took place in a soundproof lab. Throughout the experiment the participant had a cup of water within reach as her throat may become dry from speaking for so long. The participants also had some sweets to eat between the parts to boost their energy and moral. After reading the general instructions the participants had time to ask the instructor questions they might have had. Once the participant indicated she was ready, the recording started and the participants started with the first of five parts. After these 5 parts the participant was asked to fill out a questionnaire on her language background. Once the participant had filled out the questionnaire, she signed a payment form and was paid. Each sessions took about 50 minutes.

The sessions were recorded with a portable recording device (Zoom Handy Recorder H1) and the files were copied to Praat to be analysed for the VOT and lengthening study. For this study each stimulus word was selected from the large sound files. Borders were set to calculate the VOT. Post-voiced borders were indicated with a 1 and a 2, where 1 indicated the start of the burst and 2 indicated the start of the voicing indicated by a change in the black bar in the spectrogram and a more regular waveform. Pre-voiced borders were set with a 3 and a

4, where 3 indicated the start of the voicing and 4 indicated the onset of the burst. These times were extracted from Praat to an Excel file. Figure 1 shows the borders of a pre-voiced word “doeg” and figure 2 shows the borders of a post-voiced word “tons”.

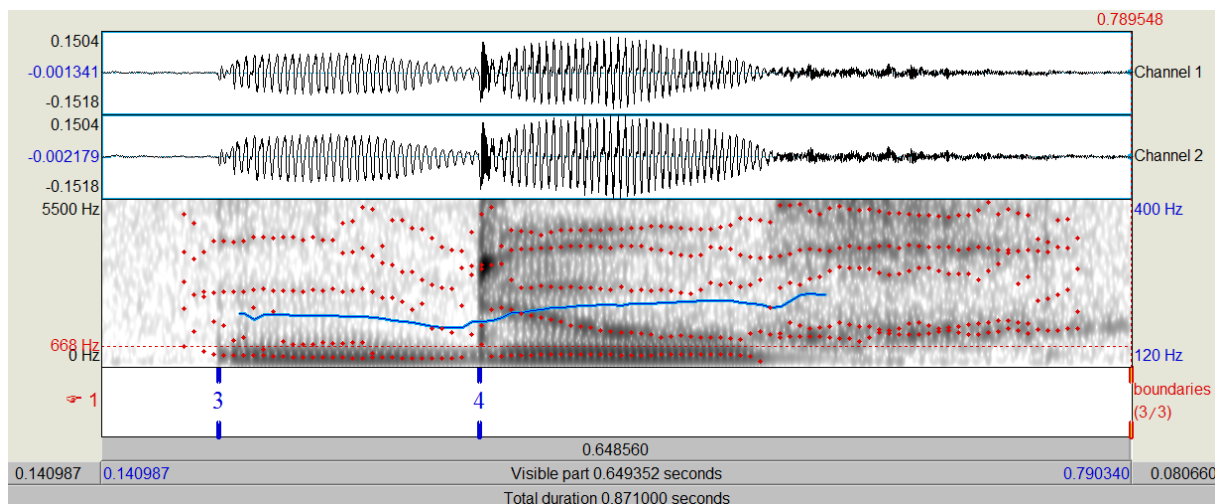


Figure 1. Spectrogram and waveform of the Dutch word *doeg* (/du:x/). The boundary 3 indicates the beginning of voicing of the initial plosive /d/ and the boundary 4 indicates the onset of the burst of the initial plosive /d/.

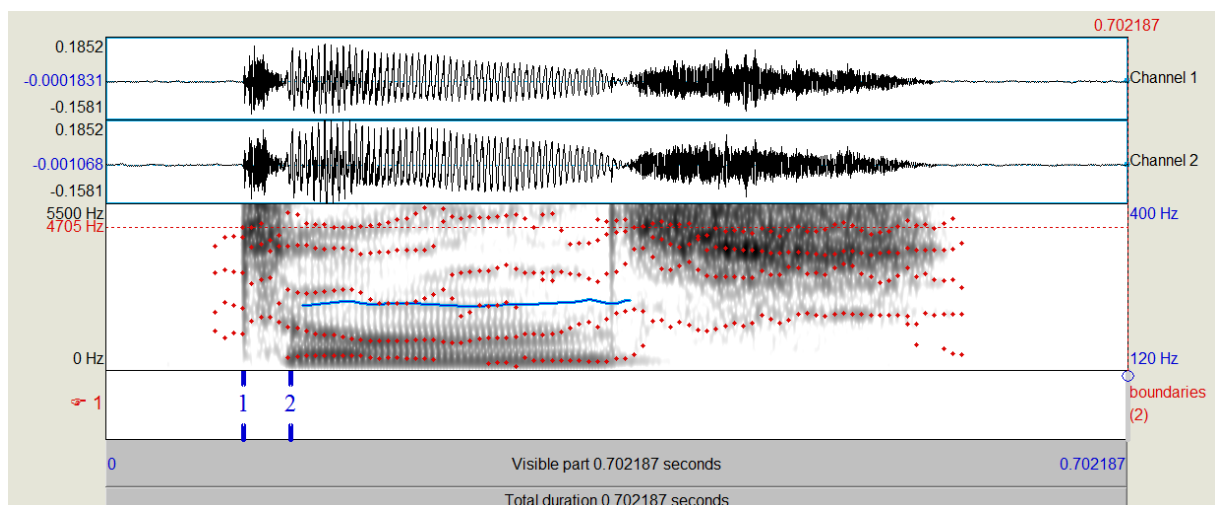


Figure 2. Spectrogram and waveform of the Dutch word *tons* (/tɔns/). The boundary 1 indicates onset of the burst for the initial plosive /t/ and the boundary 2 indicates the beginning of voicing of the initial plosive /t/.

5. Analysis

The data were analysed using IBM SPSS version 22. An independent t-test was performed on the LexTale score to check whether the division of proficiency in two groups according to their degree programme was correct. The proficient group of English major is referred to as g1 and the less proficient group of non-English majors is referred to as g2. This made the

analysis less cluttered. The data were first split in two groups according to language to analyse the results per language. Chi-squares were calculated for the Dutch voiced plosives (/b/ and /d/) and for the English voiced plosives to see whether they were produced with a pre- or post-burst VOT in both proficiency groups. No chi-squares were calculated for the target voiceless plosives (/p/ and /t/) as all the voiceless plosives in both languages were produced with a post-burst VOT. A linear mixed model was used to analyse the duration of VOT in seconds of the voiced plosives produced with pre-voicing, the voiced plosives produced with post-voicing and the voiceless plosives produced with post-voicing English and the voiced plosives produced with pre-voicing, the voiced plosives produced with post-voicing and the voiceless plosives produced with post-voicing in Dutch. The voiceless pre-voiced group was not analysed in either language as no voiceless plosive was pronounced with pre-voicing. The pre- and post-burst VOTs were analysed separately as they are different types of VOT. Random effects were participant and word ID. Fixed effects were proficiency, vowel height, place of articulation and the main effects and two-way and three-way interactions between them were analysed. The dependent variable was duration of VOT.

5.1.T-test for Lextale score

The results of the t-test for LexTale score can be found in Appendix J. The t-value = 2.9 and $p < 0.05$. The t-test confirmed the division of proficiency in the two groups according to major. This was expected as Lemhöfer & Broersma (2012) found that the LexTale test was a good indicator of overall proficiency.

5.2.Distribution of pre-voicing in voiced plosives

5.2.1. English

The Pearson Chi square for the English voiced data was as follows: $\chi^2 (1, N = 360) = 26.918$, $p < .001$. This indicates a significant interaction between proficiency and voiced plosives for

the English stimuli. The low proficient group (non-English major) produced most of the English voiced plosives with pre-voicing while the high proficient group (English major) produced the most of their English voiced plosives with post-voicing (Fig. 3).

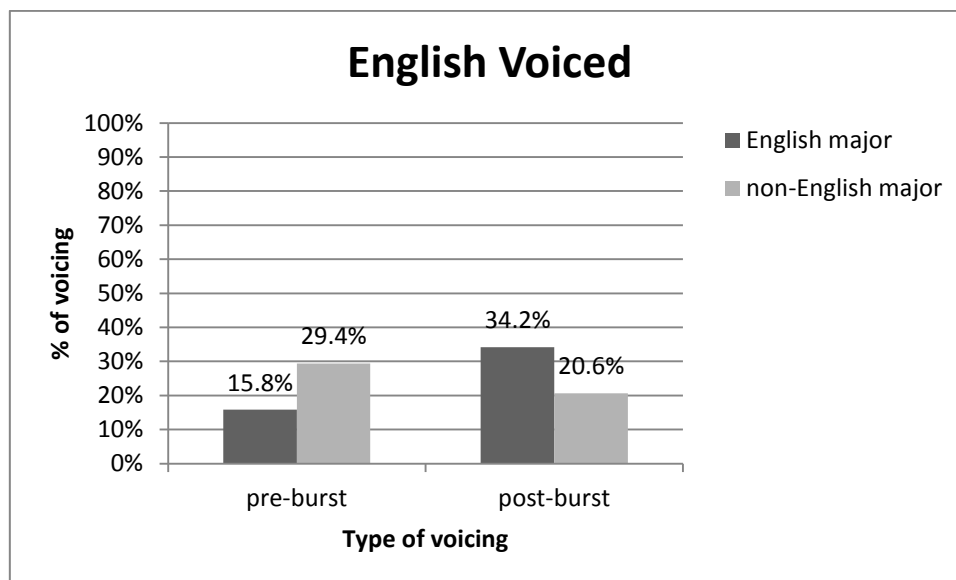


Figure 3. Distribution of pre-voicing and post-voicing in English voiced plosives. Pre-burst indicates the percentage of voiced items produced with pre-voicing and post-burst indicates the percentage of items produced with post-voicing. N= 360 (180 English major and 180 non-English major). The percentages are percentages of the total number of English stimuli. The English major group was the proficient group and the non-English major group was the less proficient group.

5.2.2. Dutch

The Pearson Chi square for the Dutch voiced plosives was as follows: $X^2(1, N = 360) = 9.967, p = .002$. This indicates a significant interaction between proficiency and voiced plosives for the Dutch stimuli. The less-proficient students (non-English major) pre-voiced most of their Dutch voiced plosives; more than the proficient students (English major). For both groups most of the voiced plosives were produced with pre-voicing (Fig. 4).

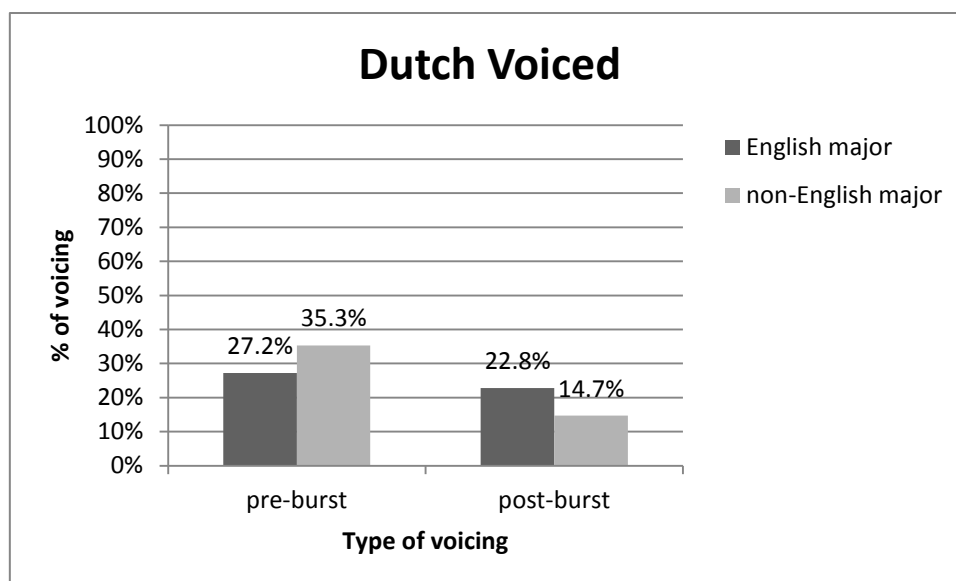


Figure 4. Distribution of pre-voicing and post-voicing in Dutch voiced plosives. Pre-burst indicates the percentage of voiced items produced with pre-voicing and post-burst indicates the percentage of items produced with post-voicing. N= 360 (180 English major and 180 non-English major). The percentages are percentages of the total number of Dutch stimuli. The English major group was the proficient group and the non-English major group was the less proficient group.

5.3.Duration of VOT

5.3.1. English Voiced Pre-voiced

The complete results from the linear mixed model analysis for English voiced pre-voiced plosives can be found in Appendix K and the results for the significant effects can be found in tables 1 and 2. There was a significant effect of vowel height on duration of voicing lead in English voiced plosives ($F(1, 150.331) = 10.527, p = 0.001$) (Table 1). The estimate for the difference between the plosives followed by high vowel and the plosives followed by a non-high vowel was not significantly different from zero (estimate = 0.011, SE = 0.006, $t(147.746) = 1.718, p = 0.088$) (Table 2). This meant that the VOTs of pre-voiced voiced plosives were longer if they were followed by a high vowel.

There was a significant effect of place of articulation on duration of voicing lead in English voiced plosives ($F(1, 150.423) = 4.451, p = 0.037$) (Table 1). The estimate for the difference between alveolar and bilabial was not significantly different from zero (estimate = 0.003, SE = 0.008, $t(147.837) = 0.410, p = 0.682$) even though there was a significant effect

between the estimate and the intercept (Table 2). This meant that VOTs of pre-voiced voiced plosives were longer if they were alveolars.

There was a significant effect of the interaction between vowel height, place of articulation and duration of voicing lead in English voiced plosives ($F(1, 148.504) = 8.078, p = 0.005$) (Table 1). The estimate for the difference between vowel height = high and place of articulation = alveolar and the other interactions between vowel height and place of articulation was not significantly different from zero (estimate = 0.006, $SE = 0.011, t(147.516) = 0.521, p = 0.603$) (Table 2). This meant that pre-voiced voiced plosives had even longer VOTs if they were followed by a high vowel and if they were alveolars.

There was a significant effect of the interaction between proficiency, vowel height and place of articulation on duration of voicing lead in English voiced plosives ($F(1, 148.504) = 5.310, p = 0.023$) (Table 1). The estimate for the difference between proficiency = g1 * vowel height = high * place of articulation = alveolar and the other interactions between proficiency * vowel height * place of articulation was significantly different from zero (estimate = 0.051, $SE = 0.022, t(148.504) = 2.304, p = 0.023$) (Table 2). This meant that the interaction of proficient students and an alveolar plosives followed by a high vowel lead to longer VOTs.

Table 1. Type III Tests of Fixed Effects^a for English voiced plosives produced with pre-voicing, only displaying the significant results.

| Source | Numerator df | Denominator df | F | Sig. |
|---|--------------|----------------|--------|------|
| Intercept | 1 | 8,377 | 86,731 | ,000 |
| vowel_height | 1 | 150,331 | 10,527 | ,001 |
| place_of_articulation | 1 | 150,423 | 4,451 | ,037 |
| vowel_height * place_of_articulation | 1 | 148,504 | 8,078 | ,005 |
| proficiency * vowel_height * place_of_articulation | 1 | 148,504 | 5,310 | ,023 |

a. Dependent Variable: VOT.

Table 2. Estimates of Fixed Effects^a for English voiced plosives produced with pre-voicing, only displaying the significant results.

| Parameter | Estimate | Std. | df | t | Sig. |
|-----------|----------|------|----|---|------|
|-----------|----------|------|----|---|------|

| | | Error | | | |
|--|----------------|---------|---------|-------|------|
| Intercept | ,082346 | ,011476 | 8,811 | 7,176 | ,000 |
| [vowel_height=high] | ,010751 | ,006258 | 147,746 | 1,718 | ,088 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | ,003407 | ,008311 | 147,837 | ,410 | ,682 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [vowel_height=high] * [place_of_articulation=alveolar] | ,005923 | ,011360 | 147,516 | ,521 | ,603 |
| [vowel_height=high] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [vowel_height=non-high] * [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . |
| [vowel_height=non-high] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [proficiency=g1] * [vowel_height=high] * | ,050740 | ,022020 | 148,504 | 2,304 | ,023 |
| [place_of_articulation=alveolar] | | | | | |
| [proficiency=g1] * [vowel_height=high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=bilabial] | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=bilabial] | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=bilabial] | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . |
| [place_of_articulation=bilabial] | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

5.3.2. English Voiced Post-voiced

The complete results for the linear mixed model analysis for English voiced post-voiced plosives can be found in Appendix L and the results for the significant effects can be found in tables 3 and 4. There was a significant effect of proficiency on duration of voicing lag in English voiced plosives ($F(1, 7.260) = 38.126, p < 0.001$) (Table 3). The estimate for the difference between the proficient group (g1) and the less proficient group (g2) was significantly different from zero (estimate = -0.007, SE = 0.002, $t(25.137) = -4.405, p < 0.001$) (Table 4).

There was a significant effect of vowel height on duration of voicing lag in English voiced plosives ($F(1, 30.278) = 4.188, p = 0.049$) (Table 3). The estimate for the difference between plosives followed by a high vowel and plosives followed by a non-high vowel was not significantly different from zero (estimate = 0.002, SE = 0.002, $t(89.514) = 1.179, p = 0.242$) (Table 4).

There was a significant effect of place of articulation on duration of voicing lag in English voiced plosives ($F(1, 30.252) = 14.144, p = 0.001$) (Table 3). The estimate for the difference between alveolar and bilabial plosives was not significantly different from zero (estimate < 0.000, SE = 0.002, $t(72.113) = 0.179, p = 0.858$) (Table 4).

There was a significant effect of proficiency * vowel height on duration of voicing lag in English voiced plosives ($F(1, 160.229) = 8.511, p = 0.004$) (Table 3). The estimate for the difference between proficiency = p1 * vowel height = high and other interactions between proficiency and vowel height was not significantly different from zero (estimate = -0.004, SE = 0.002, $t(160.275) = -1.824, p = 0.70$) (Table 4).

These results indicate that that the proficient group produced post-voiced English voiced plosives with shorter VOTs, showing an influence of L1 on L2, and an effect of place of articulation and vowel height indicating alveolar plosives followed by a high vowel are produced with longer VOTs.

Table 3. Type III Tests of Fixed Effects^a for English voiced plosives produced with post-voicing, only displaying the significant results.

| Source | Numerator df | Denominator df | F | Sig. |
|----------------------------|--------------|----------------|--------|-------|
| Intercept | 1 | ,000 | 3,904 | 1,000 |
| proficiency | 1 | 7,260 | 38,126 | ,000 |
| vowel_height | 1 | 30,278 | 4,188 | ,049 |
| place_of_articulation | 1 | 30,252 | 14,144 | ,001 |
| proficiency * vowel_height | 1 | 160,229 | 8,511 | ,004 |

a. Dependent Variable: VOT.

Table 4. Estimates of Fixed Effects^a for English voiced plosives produced with post-voicing, only displaying the significant results.

| Parameter | Estimate | Std. Error | df | t | Sig. |
|--|----------------|------------|---------|--------|-------|
| Intercept | ,019554 | ,009435 | ,000 | 2,073 | 1,000 |
| [proficiency=g1] | -,006838 | ,001552 | 25,137 | -4,405 | ,000 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . |
| [vowel_height=high] | ,002147 | ,001822 | 89,514 | 1,179 | ,242 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | ,000370 | ,002064 | 72,113 | ,179 | ,858 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [proficiency=g1] * [vowel_height=high] | -,003556 | ,001950 | 160,275 | -1,824 | ,070 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

5.3.3. English Voiceless Post-voiced

The complete results for the linear mixed model analysis for English voiceless post-voiced plosives can be found in Appendix M and the results for the significant effects can be found in tables 5 and 6. There was a significant effect of place of articulation on duration of voicing lag in English voiceless plosives ($F(1, 32) = 40.418, p < 0.001$) (Table 5). The estimate for the difference between alveolar and bilabial was significantly different from zero (estimate = 0.019, $SE = 0.006, t(58.050) = 3.128, p = 0.003$) (Table 6).

There was a significant effect of interaction between proficiency and vowel height on duration of voicing lag in English voiceless plosives ($F(1, 312.000) = 4.740, p = 0.030$) (Table 5). The estimate for the difference between proficiency = g1 * vowel height = high and other proficiency * vowel height interactions was not significantly different from zero (estimate = -0.003, $SE = 0.005, t(312.000) = -0.622, p = 0.534$) (Table 6).

These results indicate that that the proficient group produced post-voiced English voiceless plosives with shorter VOTs, showing an influence of L1 on L2, and an effect of vowel height indicating plosives followed by a high vowel are produced with longer VOTs.

Table 5. Type III Tests of Fixed Effects^a for English voiceless plosives produced with post-voicing, only displaying the significant results.

| Source | Numerator df | Denominator df | F | Sig. |
|----------------------------|--------------|----------------|---------|------|
| Intercept | 1 | 9,074 | 106,311 | ,000 |
| place_of_articulation | 1 | 32 | 40,418 | ,000 |
| proficiency * vowel_height | 1 | 312,000 | 4,740 | ,030 |

a. Dependent Variable: VOT.

Table 6. Estimates of Fixed Effects^a for English voiceless plosives produced with post-voicing, only displaying the significant results.

| Parameter | Estimate | Std. Error | df | t | Sig. |
|--|----------------|------------|---------|-------|------|
| Intercept | ,042407 | ,008895 | 10,436 | 4,768 | ,001 |
| [place_of_articulation=alveolar] | ,018851 | ,006027 | 58,050 | 3,128 | ,003 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [proficiency=g1] * [vowel_height=high] | -,003136 | ,005041 | 312,000 | -,622 | ,534 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

5.3.4. Dutch Voiced Pre-voiced

The complete results for the linear mixed model analysis for Dutch voiced pre-voiced plosives can be found in Appendix N. No significant effects were found on duration of voicing lead in Dutch voiced plosives.

5.3.5. Dutch Voiced Post-voiced

The complete results for the linear mixed model analysis for Dutch voiced post-voiced plosives can be found in Appendix O and the results for the significant effects can be found in tables 7 and 8. There was a significant effect of vowel height on duration of voicing lag in Dutch voiced plosives ($F(1, 34.368) = 4.247, p = 0.047$) (Table 7). The estimate for the

difference between the plosives followed by a high vowel and the plosives followed by a non-high vowel was not significantly different from zero (estimate = 0.002, SE = 0.003, $t(93.220) = 0.748$, $p = 0.456$) (Table 8). This indicates that plosives followed by a high vowel are pronounced with longer VOTs.

Table 7. Type III Tests of Fixed Effects^a for Dutch voiced plosives produced with post-voicing, only displaying the significant results.

| Source | Numerator df | Denominator df | F | Sig. |
|--------------|--------------|----------------|--------|------|
| Intercept | 1 | 24,481 | 15,225 | ,001 |
| vowel_height | 1 | 34,368 | 4,247 | ,047 |

a. Dependent Variable: VOT.

Table 8. Estimates of Fixed Effects^a for Dutch voiced plosives produced with post-voicing, only displaying the significant results.

| Parameter | Estimate | Std. Error | df | t | Sig. |
|-------------------------|----------------|------------|--------|-------|------|
| Intercept | ,025335 | ,007193 | 17,230 | 3,522 | ,003 |
| [vowel_height=high] | ,002238 | ,002993 | 93,220 | ,748 | ,456 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

5.3.6. Dutch Voiceless Post-voiced

The complete results for the linear mixed model analysis for Dutch voiceless post-voiced plosives can be found in Appendix P and the results for the significant effects can be found in tables 9 and 10. There was a significant effect of proficiency on duration of voicing lag in Dutch voiceless plosives ($F(1, 8.139) = 345.433$, $p = 0.006$) (Table 9). The estimate for the difference between the proficient group (g1) and the less proficient group (g2) was not significantly different from zero (estimate = -0.006, SE = 0.003, $t(10.326) = -1.777$, $p = 0.105$) (Table 10).

There was a significant effect of vowel height on duration of voicing lag in Dutch voiceless plosives ($F(1, 32.001) = 19.943$, $p < 0.001$) (Table 9). The estimate for the

difference between high and low vowels was significantly different from zero (estimate = 0.005, SE = 0.002, $t(46.580) = 2.345$, $p = 0.023$) (Table 10).

There was a significant effect of place of articulation on duration of voicing lag in Dutch voiceless plosives ($F(1, 32.001) = 86.484$, $p < 0.001$) (Table 9). The estimate for the difference between alveolar and bilabial plosives was significantly different from zero (estimate = 0.016, SE = 0.003, $t(46.580) = 5.677$, $p < 0.001$) (Table 10).

There was a significant effect of interaction between proficiency and vowel height on duration of voicing lag in Dutch voiceless plosives ($F(1, 311.051) = 7.766$, $p = 0.006$) (Table 9). The estimate for the difference between proficiency = g1 * vowel height = high and other proficiency * vowel height interaction was not significantly different from zero (estimate = -0.002, SE = 0.002, $t(311.095) = -1.329$, $p = 0.185$) (Table 10).

There was a significant effect of interaction between proficiency and place of articulation on duration of voicing lag in Dutch voiceless plosives ($F(1, 311.051) = 25.048$, $p < 0.001$) (Table 9). The estimate for the difference between proficiency = g1 * place of articulation = alveolar and proficiency * place of articulation interactions was significantly different from zero (estimate = -0.006, SE = 0.002, $t(311.028) = -2.657$, $p = 0.008$) (Table 10).

There was a significant effect of interaction between vowel height and place of articulation ($F(1, 32.001) = 4.805$, $p = 0.036$) (Table 9). The estimate for the difference between vowel height = high * place of articulation = alveolar and other vowel height * place of articulation interactions was significantly different from zero (estimate = 0.010, SE = 0.004, $t(46.580) = 2.514$, $p = 0.015$) (Table 10).

These results show that the VOTs of Dutch voiceless plosives pronounced with post-voicing are shorter for the proficient group, indicating a stronger Dutch pronunciation. The

place of articulation and the vowel height were significant too, showing that alveolar plosives and plosives followed by a vowel had longer post-burst VOTs.

Table 9. Type III Tests of Fixed Effects^a for Dutch voiceless plosives produced with post-voicing, only displaying the significant results.

| Source | Numerator df | Denominator df | F | Sig. |
|----------------------------|--------------|----------------|---------|------|
| Intercept | 1 | 13,039 | 345,433 | ,000 |
| proficiency | 1 | 8,139 | 13,628 | ,006 |
| vowel_height | 1 | 32,001 | 19,943 | ,000 |
| place_of_articulation | 1 | 32,001 | 86,484 | ,000 |
| proficiency * vowel_height | 1 | 311,051 | 7,766 | ,006 |
| proficiency * | | | | |
| place_of_articulation | 1 | 311,051 | 25,048 | ,000 |
| vowel_height * | | | | |
| place_of_articulation | 1 | 32,001 | 4,805 | ,036 |

a. Dependent Variable: VOT.

Table 10. Estimates of Fixed Effects^a for Dutch voiceless plosives produced with post-voicing, only displaying the significant results.

| Parameter | Estimate | Std. Error | df | t | Sig. |
|--|----------------|------------|---------|--------|------|
| Intercept | ,023849 | ,002590 | 17,492 | 9,208 | ,000 |
| [proficiency=g1] | -,005624 | ,003165 | 10,326 | -1,777 | ,105 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . |
| [vowel_height=high] | ,005350 | ,002281 | 46,580 | 2,345 | ,023 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [place_of_articulation=alveolar] | ,015859 | ,002794 | 46,580 | 5,677 | ,000 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [proficiency=g1] * [vowel_height=high] | -,002529 | ,001903 | 311,095 | -1,329 | ,185 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . |
| [proficiency=g1] * [place_of_articulation=alveolar] | -,006180 | ,002326 | 311,028 | -2,657 | ,008 |
| [proficiency=g1] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . |
| [proficiency=g2] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [vowel_height=high] * [place_of_articulation=alveolar] | ,009933 | ,003951 | 46,580 | 2,514 | ,015 |
| [vowel_height=high] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |
| [vowel_height=non-high] * [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . |
| [vowel_height=non-high] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

6. Discussion and Conclusion

6.1. Discussion

6.1.1. General results

The t-test for the LexTale score supports the division of proficiency into the two groups based on the participants' major.

The general results confirmed H3. Voiceless plosives followed by a high vowel did have a longer post-burst VOT than those followed by a non-high vowel, and voiceless alveolar plosives did have a longer post-burst VOT than voiceless bilabial plosives. The effect of vowel height and place of articulation was often significant, but the estimate for the difference between the groups was often not significant though the difference between estimate and intercept was.

6.1.2. L1 influence on L2

H1 was not confirmed. The results of the English stimuli indicated an influence of L1 Dutch on L2 English. Though the proficient group produced most of their English voiced plosives with post-voicing, as is in accordance with the native English pronunciation, their pre-voiced plosives were more pre-voiced than those of the less proficient group in the three-way interaction, which is more like the native Dutch pronunciation. The voiced plosives produced with post-voicing of the proficient group were also less post-voiced than those of the less proficient group, which also conforms to the native Dutch pronunciation. These results indicate a bigger influence of L1 on L2 in the proficient speakers for the duration of VOT.

The interaction between proficiency and vowel height was significant for English voiceless plosives, showing a longer post-burst VOT for proficient speakers, but the estimate for the difference between the groups was not significant.

6.1.3. L2 influence on L1

Both groups produced most of their Dutch voiced plosives with pre-voicing, but the less proficient speakers produced more Dutch voiced plosives with pre-voicing than the proficient speakers. This showed that proficient speakers produced the Dutch voiced plosives more like English natives. However, a large proportion (29.4%) of the less proficient speakers also produced Dutch voiced plosives with post-voicing and this can mean the difference can be caused by individual variation, as was found by Alphen and Smits (2004). No significant results were found for Dutch voiced plosives for proficiency. The Dutch voiceless plosives were pronounced with a shorter post-VOT by the proficient speakers. This indicates pronunciation that was more in the direction of the Dutch native way. This confirms H2 for voiceless plosives.

6.2. Conclusion

H2 and H3 were confirmed. The proficient Dutch speakers did produce their Dutch voiceless plosives with less post-voicing, indicating a pronunciation that was more Dutch than English, the voiceless alveolars had a longer post-burst VOT than the voiceless bilabials and the voiceless plosives followed by a high vowel did have longer post-burst VOTs. H1 was not confirmed as the proficient group produced their English voiced plosives with more pre-voicing and their English voiceless plosives with less post-voicing. This can be caused by L1 influence on L2. The proficient speakers did produce more English voiced plosives with post-voicing though, which is more native like for English speakers. Perhaps the proficient speakers are more aware of the distinction between pre- and post-voicing in their L2, but less aware of the change in the duration of the voicing.

6.3. Limitations and Future Research

In this study no native speakers have been studied. In the current study, English nativeness was based on a comparison between the two proficiency groups and previous studies. In

future research the pronunciation of native speakers of English could be looked at to find out how native the pronunciation of the proficient group in L2 English is. The data of this study also took into account existing vs. non-existing words and this difference may be analysed in a follow-up study.

The results of this study are only concerned with word initial and phrase initial plosives. Future research can look at the data of the word initial but phrase intervocalic plosives. Plosives used in an intervocalic environment (whether word initial or word medial), are more often used in continuous speech than word and phrase initial plosives. The data of the intervocalic plosives may thus be more realistic. The intervocalic position may also be a more interesting place to study the duration of VOT as there is much less space for pre-voicing and there can be influences from the previous sound. This can lead to a result in which the pronunciations of the two languages are more similar. Whether there can still be a difference between the two languages may be interesting for future research.

This study found that the Dutch plosives were produced with both pre- and post-voicing by both proficiency groups and that the proficient group pre-voiced fewer of their Dutch voiced plosives. Whether this has an effect on perception of accent has not been studied in this paper. As Lev-Ari and Kaysar (2010) found, even a slight accent may change credibility of the speaker. Whether a different kind of VOT (pre- vs. post-voicing) for plosives can cause this effect may be studied in future research.

Finally, Chang (2012) looked at the influence of L2 Korean on L1 English for beginning students and found that L2 influence on L1 takes place very quickly. Future research can look at how much exposure is needed for L2 influence on L1 to take place. Perhaps the students studied by Chang were overwhelmed by the exotic Korean language, causing them to focus more on the Korean pronunciation and less on the English one. Whether this may also be present when the L2 is much more similar to the L1 (e.g. when

comparing two Germanic languages like English and Dutch), can be the subject of future research.

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8. Appendices

Appendix A: Instructions Group A

Instructies – Groep A

Dit experiment bestaat uit vijf delen:

- Lees een aantal woorden in het Nederlands.
- Lees een aantal zinnen in het Nederlands.
- Een korte online-test waarin gevraagd wordt of een aantal woorden die je ziet bestaande woorden zijn in het Engels of niet. Dit deel dient ook als een korte pauze en er mag wat gedronken worden.
- Lees een aantal woorden in het Engels.
- Lees een aantal zinnen in het Engels.

Je krijgt specifieke instructies voor elk deel van het experiment.

Na het experiment word gevraagd of je een vragenlijst wil invullen van 11 vragen over je taalachtergrond.

De sessie duurt ongeveer 45 minuten.

Hartelijk bedankt voor je deelname aan het experiment.

Appendix B: Instructions Group B

Instructies – Groep B

Dit experiment bestaat uit vijf delen:

- Lees een aantal zinnen in het Nederlands.
- Lees een aantal woorden in het Nederlands.
- Een korte online-test waarin gevraagd wordt of een aantal woorden die je ziet bestaande woorden zijn in het Engels of niet. Dit deel dient ook als een korte pauze en er mag wat gedronken worden.
- Lees een aantal zinnen in het Engels.
- Lees een aantal woorden in het Engels.

Je krijgt specifieke instructies voor elk deel van het experiment.

Na het experiment word gevraagd of je een vragenlijst wil invullen van 11 vragen over je taalachtergrond.

De sessie duurt ongeveer 45 minuten.

Hartelijk bedankt voor je deelname aan het experiment.

Appendix C: Instructions Dutch Words

Lees WOORDEN voor in het Nederlands

In dit deel van het experiment, ga je een aantal Nederlandse woorden voorlezen. Lees op een rustig tempo; probeer alle woorden in het zelfde tempo uit te spreken. Spreek duidelijk en helder in de microfoon.

Als je niet tevreden bent over de uitspraak van een woord, mag je het hele woord met het lidwoord (als er een lidwoord gedrukt staat) opnieuw uitspreken.

Sommige woorden zijn bestaande woorden en sommige zijn niet-bestaande woorden. Voor alle woorden is het lidwoord “de” gebruikt in deze leeslijst. Soms klopt dit bij het zelfstandig naamwoord en soms niet, dat maakt niet uit. Je hoeft hier niet op te letten. De klemtoon ligt altijd op het tweede woord (het zelfstandig naamwoord). Probeer geen pauze te maken tussen het lidwoord en het zelfstandig naamwoord in.

We vragen je of je niet tijdens de uitspraak van het laatste woord op een pagina de pagina om te slaan, maar dit te doen nadat je het woord hebt gelezen.

Je begint eerst met vier oefenwoorden:

- Kachel
- Haardvuur
- De Kachel
- De Haardvuur

Appendix D: Instructions Dutch Sentences

Lees ZINNEN voor in het Nederlands

In dit deel van het experiment, ga je een aantal korte vraag-antwoord dialogen voorlezen in het Nederlands. Lees op een rustig tempo; probeer alle zinnen in het zelfde tempo uit te spreken. Spreek duidelijk en helder in de microfoon.

Als je niet tevreden bent over de uitspraak van een zin, mag je de hele zin opnieuw uitspreken.

We vragen je of je niet tijdens de uitspraak van de laatste dialoog de pagina om te slaan maar dit te doen nadat je die dialoog hebt gelezen.

Je begint eerst met twee oefen dialogen:

Dialoog 1

- (a) Wie gaf het aan Tim?
- (b) Riek gaf het aan Tim.

Dialoog 2

- (a) Aan wie gaf Miek het?
- (b) Miek gaf het aan Hans.

Appendix E: Instructions English Words

Lees WOORDEN voor in het Engels

In dit deel van het experiment, ga je een aantal Engelse woorden voorlezen. Lees op een rustig tempo; probeer alle woorden in het zelfde tempo uit te spreken. Spreek duidelijk en helder in de microfoon.

Als je niet tevreden bent over de uitspraak van een woord, mag je het hele woord met het lidwoord (als er een lidwoord gedrukt staat) opnieuw uitspreken.

Sommige woorden zijn bestaande woorden en sommige zijn niet-bestaande woorden. Voor alle woorden is het lidwoord “the” gebruikt in deze leeslijst. De klemtoon ligt altijd op het tweede woord (het zelfstandig naamwoord). Probeer geen pauze te maken tussen het lidwoord en het zelfstandig naamwoord in.

We vragen je of je niet tijdens de uitspraak van het laatste woord op een pagina de pagina om te slaan, maar dit te doen nadat je het woord hebt gelezen.

Je begint eerst met vier oefenwoorden:

- Face
- Lighter
- The Face
- The Lighter

Appendix F: Instructions English Sentences

Lees ZINNEN voor in het Engels

In dit deel van het experiment, ga je een aantal korte vraag-antwoord dialogen voorlezen in het Engels. Lees op een rustig tempo; probeer alle zinnen in het zelfde tempo uit te spreken. Spreek duidelijk en helder in de microfoon.

Als je niet tevreden bent over de uitspraak van een zin, mag je de hele zin opnieuw uitspreken.

We vragen je of je niet tijdens de uitspraak van de laatste dialoog de pagina om te slaan maar dit te doen nadat je die dialoog hebt gelezen.

Je begint eerst met twee oefen dialogen:

Dialoog 1

- (c) Who gave it to Tim?
- (d) Roy gave it to Tim.

Dialoog 2

- (c) Whom did Mary give it to?
- (d) Mary gave it to Pete.

Appendix G: Dutch Stimuli

Table G. Dutch stimuli used in this study, organised per place of articulation and height of the vowel following the plosive. Underneath every word the pronunciation of the word is given by means of the IPA notation. N = 72.

| | | | Plosive | | | |
|---------|----------|-----|----------|-----------|----------|-----------|
| | | | Bilabial | | Alveolar | |
| | | | Voiced | Voiceless | Voiced | Voiceless |
| | | | /b/ | /p/ | /d/ | /t/ |
| Vowel | High | /u/ | Boek | Poek | Doek | Toek |
| | | | /buk/ | /puk/ | /duk/ | /tuk/ |
| | | | Boet | Poet | Doeg | Toeg |
| | | | /but/ | /put/ | /dux/ | /tux/ |
| | | | Boem | Poem | Doef | Toef |
| | | | /bum/ | /pum/ | /duf/ | /tuf/ |
| | | | Boel | Poel | | |
| | | | /bul/ | /pul/ | | |
| | | | Boef | Poef | | |
| | | | /buf/ | /puf/ | | |
| | | | Boer | Poer | | |
| | | | /bur/ | /pur/ | | |
| | | /i/ | Biek | Piek | Diek | Tiek |
| | | | /bik/ | /pik/ | /dik/ | /tik/ |
| | | | Bieg | Pieg | Dief | Tief |
| | | | /bix/ | /pix/ | /dif/ | /tif/ |
| | | | Biem | Piem | Diel | Tiel |
| | | | /bim/ | /pim/ | /dil/ | /til/ |
| | | | Bieb | Piep | | |
| | | | /bip/ | /pip/ | | |
| | | | Bier | Pier | | |
| | | | /bir/ | /pir/ | | |
| | | | Biet | Piet | | |
| | | | /bit/ | /pit/ | | |
| | Non-high | /ɔ/ | Borg | Porg | Dons | Tons |
| /b ɔrx/ | | | /p ɔrx/ | /d ɔns/ | /t ɔns/ | |
| Bon | | | Pon | Dos | Tos | |
| /b ɔn/ | | | /p ɔn/ | /d ɔs/ | /t ɔs/ | |
| Bong | | | Pong | Don | Ton | |
| /b ɔŋ/ | | | /p ɔŋ/ | /d ɔn/ | /t ɔn/ | |
| Bond | | | Pond | | | |
| /b ɔnt/ | | | /p ɔnt/ | | | |
| Bop | | | Pop | | | |
| /b ɔp/ | | | /p ɔp/ | | | |
| Bol | | | Pol | | | |
| /b ɔl/ | | | /p ɔl/ | | | |
| | | /ɑ/ | Balk | Palk | Damp | Tamp |
| | | | /b alk/ | /p alk/ | /d amp/ | /t amp/ |
| | | | Bark | Park | Dap | Tap |
| | | | /b ark/ | /p ark/ | /d ap/ | /t ap/ |
| | | | Bask | Pask | Dag | Tag |

| | | | | | | |
|--|--|--|-----------------|-----------------|------------|------------|
| | | | /b ɑsk/ Band | /p ɑsk/ Pand | /d ɑx/ | /t ɑx/ |
| | | | /b ɑnt/ Ban | /p ɑnt/ Pan | | |
| | | | /b ɑn/ Bak | /p ɑn/ Pak | | |
| | | | /b ɑk/ | /p ɑk/ | | |

Appendix H: English Stimuli

Table H. English stimuli used in this study organised per place of articulation and height of the vowel following the plosive. Underneath every word the pronunciation of the word is given by means of the IPA notation. N = 72.

| | | | Plosive | | | |
|----------|----------|------------|------------|------------|------------|-----------|
| | | | Bilabial | | Alveolar | |
| | | | Voiced | Voiceless | Voiced | Voiceless |
| | | | /b/ | /p/ | /d/ | /t/ |
| Vowel | High | /u:/ | Boot | Poot | Duvet | Tuvet |
| | | | /bu:t/ | /pu:t/ | /'du:veɪ/ | /'tu:veɪ/ |
| | | | Book | Pook | Dool | Tool |
| | | | /bʊk/ | /pʊk/ | /du:l/ | /tu:l/ |
| | | | Bool | Pool | Dooth | Tooth |
| | | | /bu:l/ | /pu:l/ | /du:ð/ | /tu:ð/ |
| | Non-high | /i:/ | Bean | Pean | Deep | Teep |
| | | | /bi:n/ | /pi:n/ | /di:p/ | /ti:p/ |
| | | | Beef | Peef | Deed | Teed |
| | | | /bi:f/ | /pi:f/ | /di:d/ | /ti:d/ |
| | | | Beet | Peet | Deak | Teak |
| | | | /bi:t/ | /pi:t/ | /di:k/ | /ti:k/ |
| Non-high | /ɔ:/ | Bee | Pea | | | |
| | | /bi:/ | /pi:/ | | | |
| | | Beach | Peach | | | |
| | | /bi:tʃ/ | /pi:tʃ/ | | | |
| | | Beak | Peak | | | |
| | | /bi:k/ | /pi:k/ | | | |
| Non-high | /ɑ:/ | Boss | Poss | Door | Toor | |
| | | /b ɔ:s/ | /p ɔ:s/ | /d ɔ:(r)/ | /t ɔ:(r)/ | |
| | | Bork | Pork | Dalk | Talk | |
| | | /b ɔ:(r)k/ | /p ɔ:(r)k/ | /d ɔ:k/ | /t ɔ:k/ | |
| | | Bort | Port | Dork | Tork | |
| | | /b ɔ:(r)t/ | /p ɔ:(r)t/ | /d ɔ:(r)k/ | /t ɔ:(r)k/ | |
| Non-high | /ɑ:/ | Board | Poured | | | |
| | | /b ɔ:(r)d/ | /p ɔ:(r)d/ | | | |
| | | Ball | Paul | | | |
| | | /b ɔ:l/ | /p ɔ:l/ | | | |
| | | Boar | Poor | | | |
| | | /b ɔ:(r)/ | /p ɔ:(r)/ | | | |
| Non-high | /ɑ:/ | Barb | Parb | Dark | Tark | |
| | | /b ɑ:(r)b/ | /p ɑ:(r)b/ | /d ɑ:(r)k/ | /t ɑ:(r)k/ | |
| | | Bast | Past | Dask | Task | |
| | | /b ɑ:st/ | /p ɑ:st/ | /d ɑ:sk/ | /t ɑ:sk/ | |
| Non-high | /ɑ:/ | Barn | Parn | Darn | Tarn | |
| | | | | | | |

| | | | | | | |
|--|--|--|--|--|------------|------------|
| | | | /b ɑ:(r)n/ Balm /b ɑ:m/ Bark /b ɑ:(r)k/ Bar /b ɑ:(r)/ | /p ɑ:(r)n/ Palm /p ɑ:m/ Park /p ɑ:(r)k/ Par /p ɑ:(r)/ | /d ɑ:(r)n/ | /t ɑ:(r)n/ |
|--|--|--|--|--|------------|------------|

8. Hoeveel uur schat je dat je per week besteedt aan het kijken van Engelse televisieprogramma's of radioprogramma's: ()
9. Hoeveel uur schat je dat je per week besteedt aan het luisteren naar Engelse muziek: ()
10. Hoeveel uur schat je dat je Engels spreekt per week: ()
11. Heeft iemand je ooit aangezien voor een moedertaalspreker van het Engels?
Ja () / Nee ()

Appendix J: Results T-test for LexTale Score

Table J. Independent Samples Test for LexTale score. The 2-tailed result was divided by 2 as the direction of the influence was known. The proficient students achieved significantly higher scores on the LexTale tests, $p < 0.05$.

| Independent Samples Test | | | | | | | | | |
|--------------------------------|---|------|------------------------------|-------|-----------------|-----------------|-----------------------|---|----------|
| | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | Lower | Upper |
| lextaleEqual variances assumed | ,931 | ,363 | 2,922 | 8 | ,019 | 17,25000 | 5,90286 | 3,63798 | 30,86202 |
| Equal variances not assumed | | | 2,922 | 6,069 | ,026 | 17,25000 | 5,90286 | 2,84577 | 31,65423 |

Appendix K: English Voiced Pre-voiced Results

Table K1. Type III Tests of Fixed Effects^a for English voiced plosives produced with pre-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|--------|------|
| Intercept | 1 | 8,377 | 86,731 | ,000 |
| proficiency | 1 | 8,377 | 3,849 | ,084 |
| vowel_height | 1 | 150,331 | 10,527 | ,001 |
| place_of_articulation | 1 | 150,423 | 4,451 | ,037 |
| proficiency * vowel_height | 1 | 150,331 | ,658 | ,418 |
| proficiency * | 1 | 150,423 | ,965 | ,328 |
| place_of_articulation | 1 | 150,423 | ,965 | ,328 |
| vowel_height * | 1 | 148,504 | 8,078 | ,005 |
| place_of_articulation | 1 | 148,504 | 8,078 | ,005 |
| proficiency * vowel_height * | 1 | 148,504 | 5,310 | ,023 |
| place_of_articulation | 1 | 148,504 | 5,310 | ,023 |

a. Dependent Variable: VOT.

Table K2. Estimates of Fixed Effects^a for English voiced plosives produced with pre-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|----------------------------------|----------------|------------|---------|--------|------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| Intercept | ,082346 | ,011476 | 8,811 | 7,176 | ,000 | ,056300 | ,108391 |
| [proficiency=g1] | -,029072 | ,016765 | 9,964 | -1,734 | ,114 | -,066446 | ,008302 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | ,010751 | ,006258 | 147,746 | 1,718 | ,088 | -,001615 | ,023118 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | ,003407 | ,008311 | 147,837 | ,410 | ,682 | -,013016 | ,019831 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | -,016225 | ,010367 | 151,267 | -1,565 | ,120 | -,036709 | ,004258 |
| [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | -,014273 | ,014899 | 150,467 | -,958 | ,340 | -,043712 | ,015166 |
| [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . | . | . |

| | | | | | | | |
|----------------------------------|----------------|---------|---------|-------|------|----------|---------|
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=high] * | ,005923 | ,011360 | 147,516 | ,521 | ,603 | -,016527 | ,028372 |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * | | | | | | | |
| [vowel_height=high] * | ,050740 | ,022020 | 148,504 | 2,304 | ,023 | ,007227 | ,094252 |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

Appendix L: English Voiced Post-voiced Results

Table L1. Type III Tests of Fixed Effects^a for English voiced plosives produced with post-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|--------|-------|
| Intercept | 1 | ,000 | 3,904 | 1,000 |
| proficiency | 1 | 7,260 | 38,126 | ,000 |
| vowel_height | 1 | 30,278 | 4,188 | ,049 |
| place_of_articulation | 1 | 30,252 | 14,144 | ,001 |
| proficiency * vowel_height | 1 | 160,229 | 8,511 | ,004 |
| proficiency * | 1 | 159,325 | 3,549 | ,061 |
| place_of_articulation | 1 | 30,159 | 2,991 | ,094 |
| vowel_height * | 1 | 30,159 | 2,991 | ,094 |
| place_of_articulation | 1 | 30,159 | 2,991 | ,094 |
| proficiency * vowel_height * | 1 | 157,988 | ,422 | ,517 |
| place_of_articulation | 1 | 157,988 | ,422 | ,517 |

a. Dependent Variable: VOT.

Table L1. Estimates of Fixed Effects³ for English voiced plosives produced with post-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|----------------------------------|----------------|------------|---------|--------|-------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| Intercept | ,019554 | ,009435 | ,000 | 2,073 | 1,000 | -,021273 | ,060381 |
| [proficiency=g1] | - | ,001552 | 25,137 | -4,405 | ,000 | -,010034 | -,003642 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | ,002147 | ,001822 | 89,514 | 1,179 | ,242 | -,001472 | ,005767 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | ,000370 | ,002064 | 72,113 | ,179 | ,858 | -,003744 | ,004484 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | - | ,001950 | 160,275 | -1,824 | ,070 | -,007407 | ,000295 |
| [vowel_height=high] | ,003556 | ,001950 | 160,275 | -1,824 | ,070 | -,007407 | ,000295 |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | ,003962 | ,002162 | 158,859 | 1,833 | ,069 | -,000308 | ,008232 |
| [place_of_articulation=alveolar] | ,003962 | ,002162 | 158,859 | 1,833 | ,069 | -,000308 | ,008232 |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |

| | | | | | | | |
|----------------------------------|----------------|---------|---------|-------|------|----------|---------|
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=high] * | ,005011 | ,003014 | 77,341 | 1,663 | ,100 | -,000989 | ,011011 |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * | - | | | | | | |
| [vowel_height=high] * | ,002029 | ,003124 | 157,988 | -,649 | ,517 | -,008199 | ,004142 |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] * | | | | | | | |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] * | | | | | | | |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] * | | | | | | | |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] * | | | | | | | |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] * | | | | | | | |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] * | | | | | | | |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=non-high] * | | | | | | | |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

Appendix M: English Voiceless Post-voiced Results

Table M1. Type III Tests of Fixed Effects^a for English voiceless plosives produced with post-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|---------|------|
| Intercept | 1 | 9,074 | 106,311 | ,000 |
| proficiency | 1 | 8,061 | 1,541 | ,249 |
| vowel_height | 1 | 32 | ,343 | ,562 |
| place_of_articulation | 1 | 32 | 40,418 | ,000 |
| proficiency * vowel_height | 1 | 312,000 | 4,740 | ,030 |
| proficiency * | 1 | 312,000 | 1,649 | ,200 |
| place_of_articulation | 1 | 312,000 | 1,649 | ,200 |
| vowel_height * | 1 | 32 | 1,217 | ,278 |
| place_of_articulation | 1 | 32 | 1,217 | ,278 |
| proficiency * vowel_height * | 1 | 312,000 | 2,129 | ,146 |
| place_of_articulation | 1 | 312,000 | 2,129 | ,146 |

a. Dependent Variable: VOT.

Table M2. Estimates of Fixed Effects^a for English voiceless plosives produced with post-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|---|----------------|------------|---------|-------|------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| Intercept | ,042407 | ,008895 | 10,436 | 4,768 | ,001 | ,022700 | ,062114 |
| [proficiency=g1] | ,018995 | ,012113 | 9,009 | 1,568 | ,151 | -,008401 | ,046392 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | - | ,004921 | 58,050 | -,066 | ,947 | -,010177 | ,009523 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | ,018851 | ,006027 | 58,050 | 3,128 | ,003 | ,006787 | ,030914 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * [vowel_height=high] | - | ,005041 | 312,000 | -,622 | ,534 | -,013053 | ,006782 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | ,000762 | ,006173 | 312,000 | ,123 | ,902 | -,011384 | ,012909 |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | | | | | | | |
| [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |

| | | | | | | | |
|--|----------------|---------|---------|-------|------|----------|---------|
| [vowel_height=high] * | ,014445 | ,008523 | 58,050 | 1,695 | ,095 | -,002616 | ,031505 |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=high] * | - | ,008730 | 312,000 | - | ,146 | -,029915 | ,004441 |
| [place_of_articulation=alveolar] | ,012737 | | | 1,459 | | | |
| [proficiency=g1] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

Appendix N: Dutch Voiced Pre-voiced Results

Table N1. Type III Tests of Fixed Effects^a for Dutch voiced plosives produced with pre-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|--------|------|
| Intercept | 1 | 8,326 | 61,246 | ,000 |
| proficiency | 1 | 8,062 | 1,254 | ,295 |
| vowel_height | 1 | 30,149 | ,385 | ,540 |
| place_of_articulation | 1 | 30,357 | ,241 | ,627 |
| proficiency * vowel_height | 1 | 191,312 | ,082 | ,775 |
| proficiency * | 1 | 191,020 | ,018 | ,894 |
| place_of_articulation | 1 | 191,020 | ,018 | ,894 |
| vowel_height * | 1 | 30,084 | ,278 | ,602 |
| place_of_articulation | 1 | 30,084 | ,278 | ,602 |
| proficiency * vowel_height * | 1 | 190,855 | ,424 | ,516 |
| place_of_articulation | 1 | 190,855 | ,424 | ,516 |

a. Dependent Variable: VOT.

Table N2. Estimates of Fixed Effects^a for Dutch voiced plosives produced with pre-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|---|----------------|------------|---------|-------|------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| Intercept | ,086168 | ,013745 | 8,837 | 6,269 | ,000 | ,054987 | ,117349 |
| [proficiency=g1] | - | ,019411 | 8,771 | - | ,343 | -,063553 | ,024617 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | - | ,006070 | 60,641 | -,611 | ,543 | -,015849 | ,008429 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | ,002719 | ,007459 | 60,438 | ,364 | ,717 | -,012199 | ,017637 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * [vowel_height=high] | - | ,008123 | 185,497 | -,328 | ,743 | -,018691 | ,013359 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | - | ,010116 | 197,916 | -,568 | ,571 | -,025694 | ,014202 |
| [place_of_articulation=alveolar] | ,005746 | ,010116 | 197,916 | -,568 | ,571 | -,025694 | ,014202 |
| [proficiency=g1] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |

| | | | | | | | |
|--|----------------|---------|---------|-------|------|----------|---------|
| [vowel_height=high] * | - | | | | | | |
| [place_of_articulation=alveolar] | ,000142 | ,010705 | 64,415 | -,013 | ,989 | -,021525 | ,021242 |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=high] * | ,009533 | ,014637 | 190,855 | ,651 | ,516 | -,019337 | ,038403 |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

Appendix O: Dutch Voiced Post-voiced Results

Table O1. Type III Tests of Fixed Effects^a for Dutch voiced plosives produced with post-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|--------|------|
| Intercept | 1 | 24,481 | 15,225 | ,001 |
| proficiency | 1 | 6,063 | 2,804 | ,145 |
| vowel_height | 1 | 34,368 | 4,247 | ,047 |
| place_of_articulation | 1 | 35,852 | 3,006 | ,092 |
| proficiency * vowel_height | 1 | 114,404 | 3,485 | ,064 |
| proficiency * | 1 | 114,254 | ,087 | ,768 |
| place_of_articulation | 1 | 114,254 | ,087 | ,768 |
| vowel_height * | 1 | 32,237 | 1,101 | ,302 |
| place_of_articulation | 1 | 32,237 | 1,101 | ,302 |
| proficiency * vowel_height * | 1 | 113,454 | 2,185 | ,142 |
| place_of_articulation | 1 | 113,454 | 2,185 | ,142 |

a. Dependent Variable: VOT.

Table O2. Estimates of Fixed Effects^a for Dutch voiced plosives produced with post-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|--|----------------|------------|---------|-------|------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| | | | | | | Intercept | ,025335 |
| [proficiency=g1] | - | ,008195 | 7,409 | - | ,186 | -,031121 | ,007206 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | ,002238 | ,002993 | 93,220 | ,748 | ,456 | -,003705 | ,008181 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | - | ,003673 | 92,372 | -,180 | ,857 | -,007957 | ,006632 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * [vowel_height=high] | - | ,003747 | 112,847 | -,335 | ,738 | -,008681 | ,006167 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | ,003560 | ,004580 | 117,759 | ,777 | ,439 | -,005510 | ,012631 |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

| | | | | | | | |
|--|----------------|---------|---------|-------|------|----------|---------|
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=high] * | ,007725 | ,004769 | 86,045 | 1,620 | ,109 | -,001755 | ,017204 |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=high] * | - | ,006051 | 113,454 | - | ,142 | -,020934 | ,003043 |
| [place_of_articulation=alveolar] | ,008946 | | | 1,478 | | | |
| [proficiency=g1] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.

Appendix P: Dutch Voiceless Post-voiced Results

Table P1. Type III Tests of Fixed Effects^a for Dutch voiceless plosives produced with post-voicing.

| Source | Numerator df | Denominator df | F | Sig. |
|------------------------------|--------------|----------------|---------|------|
| Intercept | 1 | 13,039 | 345,433 | ,000 |
| proficiency | 1 | 8,139 | 13,628 | ,006 |
| vowel_height | 1 | 32,001 | 19,943 | ,000 |
| place_of_articulation | 1 | 32,001 | 86,484 | ,000 |
| proficiency * vowel_height | 1 | 311,051 | 7,766 | ,006 |
| proficiency * | 1 | 311,051 | 25,048 | ,000 |
| place_of_articulation | 1 | 311,051 | 25,048 | ,000 |
| vowel_height * | 1 | 32,001 | 4,805 | ,036 |
| place_of_articulation | 1 | 32,001 | 4,805 | ,036 |
| proficiency * vowel_height * | 1 | 311,051 | 1,562 | ,212 |
| place_of_articulation | 1 | 311,051 | 1,562 | ,212 |

a. Dependent Variable: VOT.

Table P2. Estimates of Fixed Effects^a for Dutch voiceless plosives produced with post-voicing.

| Parameter | Estimate | Std. Error | df | t | Sig. | 95% Confidence Interval | |
|---|----------------|------------|---------|-------|------|-------------------------|-------------|
| | | | | | | Lower Bound | Upper Bound |
| | | | | | | Intercept | ,023849 |
| [proficiency=g1] | - | ,003165 | 10,326 | - | ,105 | -,012646 | ,001398 |
| [proficiency=g2] | 0 ^b | 0 | . | . | . | . | . |
| [vowel_height=high] | ,005350 | ,002281 | 46,580 | 2,345 | ,023 | ,000759 | ,009940 |
| [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | ,015859 | ,002794 | 46,580 | 5,677 | ,000 | ,010237 | ,021481 |
| [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * [vowel_height=high] | - | ,001903 | 311,095 | - | ,185 | -,006275 | ,001216 |
| [proficiency=g1] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [vowel_height=non-high] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g1] * | - | ,002326 | 311,028 | - | ,008 | -,010757 | -,001604 |
| [place_of_articulation=alveolar] | ,006180 | ,002326 | 311,028 | 2,657 | ,008 | -,010757 | -,001604 |
| [proficiency=g1] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | 0 ^b | 0 | . | . | . | . | . |
| [proficiency=g2] * [place_of_articulation=bilabial] | 0 ^b | 0 | . | . | . | . | . |

| | | | | | | | |
|--|----------------|---------|---------|-------|------|----------|---------|
| [vowel_height=high] * | ,009933 | ,003951 | 46,580 | 2,514 | ,015 | ,001983 | ,017883 |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=high] * | - | ,003292 | 311,051 | - | ,212 | -,010591 | ,002363 |
| [place_of_articulation=alveolar] | ,004114 | | | 1,250 | | | |
| [proficiency=g1] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g1] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=alveolar] | | | | | | | |
| [proficiency=g2] * [vowel_height=non-high] * | 0 ^b | 0 | . | . | . | . | . |
| [place_of_articulation=bilabial] | | | | | | | |

a. Dependent Variable: VOT.

b. This parameter is set to zero because it is redundant.