Does the perception of fricatives correspond to their production? The case of Italian vs. Dutch

MA dissertation

By María Verónica Rivas

Supervisor: Prof. Dr. Paul Boersma.
Second reader: Dr. Paola Escudero.

General Linguistics
Faculty of Humanities
University of Amsterdam
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Introduction

The primary objective of the present study is to provide a comprehensive description, explanation, and prediction of how the phonemic and underlying contrast of /s/ and /z/ occurs in intervocalic position. Although most observations and explanations of the fricative contrast have been based on perception data, approaches based on production differences have also been considered. This study aims to provide quantitative evidence for duration and voicing factors involved in the production of /s/ and /z/ in intervocalic position and how they correlate to the perception process.

The main purpose of the present study is to investigate the production of the /s/ and /z/ fricative contrast in Dutch and Italian, as well as the way in which the perception of this contrast may take place. For example, when this contrast happens in production, are listeners able to discriminate it in perception? If so, do they weight the acoustic information in the same way listeners of a different L1 would? If not, could we establish the difference between two cases of different cue reliance? The studies that have compared Dutch/Italian production of the fricative contrast (Van Oostendorp 1999, Slis and Heugten 1989; Stevens et. al 1992, Bertinetto 2000) have arrived at different conclusions regarding the occurrence of the /s/ and /z/ alternation. Furthermore, they have been limited to production, namely that they do not consider perception or possible differences in cue reliance. Other studies considering perception of fricative contrasts in

other languages, (Flege and Hillenbrand 1986 and Cole and Cooper 1975) did not report either on cue differences. Consequently, I carried out a study that aimed to find answers to the production and perception questions put forward in this paragraph as well as to provide more evidence that could unite the findings of previous studies. This new study tested the production and perception of the Italian and Dutch /s/-/z/ contrast by L1 speakers and listeners in terms of duration of the frication period and percent of voicing (Brunner and Fuchs 2005).

The rest of this paper is organized as follows. In the first chapter we review the relevant theoretical framework, research questions and hypotheses. In the second chapter we include a description of the experiments, subjects, methods, procedures, results. We then go on to discussing the results for each experiment, how they correlate with each other and how they answer our research questions. The paper closes explaining the conclusion drawn from the experiments and their results; gives an overview of the limitations and ends with some suggestions for follow-up research.

Chapter one – Theoretical framework

In Chapter one, we will present the theory related to speech perception and production along with the fricatives cases for Dutch and Italian and all the relevant theory for the development of this paper. We will start by defining some of the most basic concepts and move on to the speech models on which the paper will be based.

1.1- Speech perception and production

Speech is a process in which a speaker attempts to attain a sequence of targets corresponding to the speech sounds he/she is attempting to produce. In general, speech is thought to be a sequence of elements. It consists of a series of sounds that can be interpreted as higher-level units such as words. Language formulation processes are described as sets of independent levels of processing (Hayward 2000).

Speech perception is the ability to comprehend speech through listening. Speech perception is not dependent on the extraction of simple invariant acoustic patterns in the speech waveform. The sound's acoustic pattern is complex and greatly varies. It is dependent upon the preceding and following sounds (Moore 1997). According to Fant (1973), speech perception is a process consisting of both successive and concurrent identification on a series of progressively more abstract levels of linguistic structure.

1.2- Speech perception models

In this section we will explain what the models suggest in terms of the perception of native contrasts. This section will introduce the relevant theories related to perception such as *Motor Theory* (Liberman 1996) and *The Perceptual Magnet Effect* (Kuhl 1991).

1.2.1. Motor Theory

One theory of how speech is perceived is the Motor Theory of speech perception (Liberman, Cooper, Shankweiler, & Studdert-Kennedy 1967). The Motor Theory postulates that speech is perceived by reference to how it is produced; that is, when perceiving speech, listeners access their own knowledge of how phonemes are articulated. Articulatory gestures such as rounding or pressing the lips together are units of perception that directly provide the listener with phonetic information.

In the motor theory the objects of speech perception are the intended phonetic gestures of the speaker. According to Liberman (1996), “they are represented in the brain as motor commands that call for movements of the articulators through certain linguistically significant configurations.” The listener perceives the articulatory gesture the speaker is intending to make when producing the word or utterance. In the motor theory, speech perception and speech production are closely linked and innately specified. This model accounts for many speech perception characteristics. However, the model does not specify how the

translation from the signal to the perceived gesture is accomplished, thus making the model incomplete (Liberman 1996). The motor theory is in two ways motor. First, it is considered motor because it takes the proper object of phonetic perception to be a motor event. Secondly, it assumes that adaptations of the motor system for controlling the organs of the vocal tract took precedence in the evolution of speech (Liberman and Mattingly 1985).

1.2.2. The Perceptual Magnet Effect

The Perceptual Magnet Effect posits that when one listens to a phonetic category prototype, sounds that were close to the prototype could not be distinguished from the prototype, even though they were physically different. The sounds are perceptually pulled toward the prototype, which is the most representative instance of a category (Kuhl 1991).

Kuhl mentions that individuals are able to identify the best or prototype examples of a vowel compared to poorer or non-prototype examples of the same vowel from a series of acceptable presentations of the vowel. Cross-language studies have found that by 6 months of age, exposure to the infant's ambient language alters their perception of the phonetic units of language, i.e., their prototypes are becoming more language specific (Iverson and Kuhl 1995). The authors mention "This effect reduces differences of good representations of a sound, thus helping individuals ignore irrelevant differences between members of a category."

From the models described above we can summarise that the Motor Theory predicts the connection between perception and articulation. That speech is perceived by reference to how it is produced, namely that the listener perceives the articulatory gesture the speaker is intending to make when producing the word or utterance and bases the perception on this motor event. The second model, the Perceptual Magnet Effect, posits that the sounds are perceptually pulled towards a prototype, which represents the most representative instance of a certain category.

However, these models do not include suggestions for the way in which the acoustic or phonemic information might be weighted by listeners of different L1. This study will show how listeners' perception can be analysed in terms of these models and will also account for the way acoustic information might be weighted.

1.3- Fricative cases

According to Ladefoged and Maddieson (1996) a fricative is produced when a turbulent airstream passes through the vocal tract, forcing air through a narrow channel made by placing two articulators close together. In many fricatives, particularly sibilants, an exactly defined shape of the vocal tract has to be held for a noticeable period of time. Sibilants are a particular subset of fricatives. Ladefoged and Maddieson (1996) mention "When forming a sibilant, one is forcing air through a narrow channel, but in addition the tongue is curled

lengthwise to direct the air over the edge of the teeth. English /s/, /z/, /ʃ/, and /ʒ/ are examples of this."

In the following section, we will talk about the voiced and voiceless /s/ cases and when they occur in each of the languages related to this study.

1.3.1. Fricative voicing in Dutch

Dutch is a West Germanic Language. In some dialects of Dutch, the voiced fricatives have almost completely merged with the voiceless ones, namely that /v/ is usually realized as /f/ and /z/ is usually realized as /s/ (Kooij 1983). In Dutch, the most likely position where voicing is produced for phonologically voiced fricatives is in intervocalic position.

"The s/z alternation occurs only after Tense vowels and diphthongs: after Lax vowels we only find the voiceless fricative" (Kooij 1983). Van Oostendorp (1999) mentions that the fricative contrast in Dutch is seen in intervocalic position, voiced fricatives after long vowels and voiceless after short ones.

1.3.2. Fricative voicing in Italian

Treves (2002) describes Italian as a mixed language with components from Latin, Medieval Florentine and French. It is from the latter that Italian takes after with the /z/ as the **s** is pronounced as voiced in French. Nowadays, many Italian dialects from the Northern area, such as Lombardian for instance, display

intervocalic voicing of the fricative **s**. In some very restricted environments, such as Tuscan[1], intervocalic *s*-voicing does not apply (Krämer, 2001).

Treves (2002) mentions that in Italian, such an s is voiceless in, what he identifies as 'native popular words' (*chiuso, desiderare, difesa*) and voiced in Gallicisms (*Luisa, fiso, rasente*). He mentions some of the cases when we can see the intervocalic **s** as voiced:

- "In some words, like *battesimo* (popular, from an older *battesmo*), the **s** is voiced because it was originally followed by a voiced consonant.
- Learned compound words in which the second part begins with an **s** have a voiceless **s** if they are felt as compound by modern Italians (*unisono, verisimile*), a voiced **s** if they are not (*desinenza, filosofo*).
- The Latin prefix *ex*- in Latinisms, when followed by a vowel, became *ess*- in the Italian of Dante (*essilio, essercito*), but *es*- with a voiced **s** in modern Italian (*esilio, esercito*)."

1.4- Studies on Fricatives

We will now present a summarised view of some of the studies carried out to test the presence of the fricative contrast in Dutch and Italian. We will also discuss some other studies conducted on the presence of the s/z alternation in other languages. We will explain their main objectives and discuss their findings.

[1] Though intervocalic voicing does not apply in the Tuscan region, Florence, however, is an exception to this generalisation.

1.4.1. Studies on Dutch

Van Oostendorp (1999) reported that “the 'voicing' opposition in West Germanic often behaves as a length distinction. There is phonological and phonetic evidence that this is the case also in Dutch.” He mentions some phonological evidence “First, in intervocalic position, we can find voiceless fricatives after 'short' vowels, and voiced fricatives after 'long' vowels. This can be understood if we assume that voiceless fricatives are 'long' and voiced fricatives are 'short' and every word-internal syllable contains at most two positions.”

There is also phonetic evidence that length is more important in fricatives than voicing. Slis and Van Heugten (1989) wrote, based on their own measurements, that there are two cues indicating the voiced-voiceless distinction, viz. presence or absence of voice activity and duration. Remarkably, voicing is often lacking in [+voice] fricatives. The voiced-voiceless distinction in these cases is cued by duration.

1.4.2. Studies on Italian

A study by Stevens et. al (1992) reported that listeners based their voicing judgments of intervocalic fricatives on an assessment of the time interval in the fricative during which there is no glottal vibration. This time interval must exceed about 60 ms if the fricative is to be judged as voiceless.

Bertinetto (2000) reported that the primary difference between the two fricatives is level of voicing. He mentions that voicing will be present in an intervocalic environment whether or not the phoneme is voiced, because of the influence of the surrounding vowels. On the other hand, when completely surrounded by voiceless segments, voiced fricatives may become entirely devoiced and when this happens, the listeners rely on length.

1.4.3. Other fricative studies

Studies on fricatives in other languages show some interesting results. In a study done by Flege and Hillenbrand (1986) studying the effect of linguistic experience on perception of the English /s/–/z/ contrast showed that the non-native subjects (French, Swedish, and Finnish) used cues established for the perception of phonetic contrasts in their native language to identify fricatives as /s/ or /z/. They reported that lengthening vowel duration increased /z/ judgments in every group, although the effect was smaller for native speakers of French than for native speakers of other languages. Shortening fricative duration, on the other hand, significantly decreased /z/ judgments by English and French subjects.

Cole and Cooper (1975) conducted a series of experiments to study the effects of consonant and vowel duration on the perception of the voiced–voiceless distinction for /z/ vs. /s/ among other fricatives and affricates. They shortened the frication of each syllable in small steps by removing frication from just prior to the vowel and then closing the gap. Their first series of experiments showed that

shortening the duration of frication for a voiceless affricate or fricative produced a change in the percept from voiceless to voiced (i.e., from /sa/ to /za/).

These studies show the main cues regarding fricative perception for Dutch and Italian speakers. The difference between /s/ and /z/ for Dutch appears to be higher regarding duration. On the other hand, for Italians, the difference appears to be higher concerning voicing.

The studies presented in this section present conclusive evidence for the Italian and Dutch differences in fricative perception but none of them managed to give sufficient evidence in terms of production and the possible differences between one process and the other. Some of the conclusions drawn seem a good start to hypothesize about these processes, but the evidence is not conclusive enough. Consequently, there is a need for more reliable evidence. The research questions and the hypotheses will now be presented. They follow from the questions and theoretical framework that previous studies used and they try to find answers for some of the speaker and listener behaviour that those previous studies did not fully explain.

1.5- Research questions and hypotheses

As stated in the introduction, the purpose of this study is to further investigate, test and explain the findings of research carried out by different authors (Van Oostendorp 1999, Slis and Van Heugten 1989; Stevens et. al 1992 and Bertinetto

2000) regarding the production of the /s/ and /z/ contrast in Italian and Dutch. The analysis will be based upon differences reported on percent of voicing and duration of the frication period in order to verify whether they make the right predictions concerning speakers' alternations. By basing the analysis on percent of voicing and duration of the frication period, it will be possible to confirm whether the difference in the structure of Dutch and Italian syllables results in differences when producing the /s/ and /z/ contrast in intervocalic position, corresponding to the differences in findings by Kooij (1983) and Krämer (2001). In addition, the Motor Theory and The Perceptual Magnet Effect will allow the analysis of the perception of fricatives to verify whether the perception process shows any similarities regarding the production of the contrast.

Although both Dutch and Italian have the presence of the s/z alternation in the same position, the characteristics for each of the languages may vary, but even if the differences in the production of /s/ and /z/ are different for Dutch and Italian, can listeners perceive this difference the same way? This brings us to our first research question: does the perception of fricatives correspond to their production? Thus, following Van Oostendorp's (1999) findings, the first hypothesis is that for Dutch speakers the main difference will be regarding duration, corroborating what he reported, pointing out that "Dutch shows evidence that the opposition of voiced vs. voiceless fricatives is really one of length, with voiceless fricatives being long; at the same time, voicing

assimilation facts seem to argue in favour of an analysis where the two types are distinguished by a feature."

As for Italian speakers, it is expected that the main difference between voiced and voiceless will be that of voicing degree, given that Bertinetto (2000) found that the difference between the two fricatives is level of voicing. He mentions that perception of the contrast is mainly cued by voicing.

The second hypothesis is based on the perception of phonological contrasts and how this perception can be based on the integration of multiple acoustic cues. That is, there is a many-to-one relation: more than one phonetic cue signals the same phonemic contrast (Escudero 2000c). Similarly, the cues manifest a relative effect on the perception of contrasts. In other words, listeners can show a difference in cue weighting regarding the same phonemic information. This brings us then to our second research question: Is there a difference in cue reliance between Dutch and Italian listeners when perceiving the /s/ and /z/ contrast?

Chapter two – Experiments

This chapter presents a cross-sectional and experimental study carried out to test the hypotheses posed in the previous section, namely, (i) Dutch and Italian speakers have a difference producing the fricative contrast, showing that Dutch differentiates in duration of the fricative period and Italian in percent of voicing, and (ii) that Dutch and Italian listeners show a similar difference in cue reliance, therefore matching the production to the perception process. The subjects and experimental design are first presented. Following a detailed explanation of the tasks and the procedure, the findings and the discussion are presented.

2.1- Production experiment

To test the predictions mentioned above, a production test was carried out in which subjects were asked to read sentences in their own language. Filler sentences were also included, to disguise the sentences carrying the fricative contrast. In this section I will present the methodology used for the study, which aimed to gather reliable data that would support the hypotheses.

2.1.1. Subjects

In order to verify the different findings in the production of /s/ and /z/ by Dutch and Italian speakers, a quantitative methodology was applied. The subjects chosen for this experiment were five native Dutch speakers from The Netherlands, most of them PhD students from the *Wageningen Universiteit &*

Researchcentrum; and five native Italian speakers from Italy, who varied between post-graduate students and middle-class workers. The participants were selected for the experiment based on the place of origin and whether they produced the contrast or not. Kooij (1983) and Krämer (2001) reported that only speakers from certain areas of each country produced the contrast, so only participants from these areas would be used. In the case of Italian participants, their place of origin had to be in the area of Northern Italy (including Florence) and in the case of the Dutch speakers, their place of origin had to be from the North East part of the country. A total group of 10 participants were asked to read and record 140 sentences in their native language. Only speakers able to produce the contrast were considered, since the contrast was the main objective of the study; speakers from different parts of Italy and The Netherlands were considered not relevant for this experiment.

All the speakers reported to speak at least one second language. They all reported to have English as a second language, and some reported also having some knowledge of German, French, Latin or Spanish. None of them reported to speak a second language at home, especially, none of them reported to have any knowledge of the other language used in the study. In general, the subjects accepted to participate in the study voluntarily. Their ages at the time of the study vary between 25-31 years.

2.1.2. Materials

The participants' production was analysed from their reading of 140 topically-unrelated sentences, taken from monolingual dictionaries of each of the languages to be tested. Some of the words were taken from Nespor and Vogel (1986) and Treves (2002). This technique was chosen to guarantee that all relevant phonological contexts were included in the corpus. This corpus included 30 sentences containing one occurrence of each of the sibilant fricatives, each placed in intervocalic word-internal position. This gave a total of 60 target sentences, to which were added 80 fillers containing one of the phonological contexts /p, t, k, b, d, m, n, l/, meaning each participant read 140 sentences in total.

The sentences were organised in random order to prevent any possible ordering effect or making the intention of the study known so that the speakers would exaggerate the pronunciation of the fricatives when reading. Finally, all the sentences were checked by native speakers of each language, and though there were words not considered of common use, they were still considered very simple and clear so that the participants had no trouble reading sentences carrying such words.

Fig. 1 – Four screens showing Dutch sentences (top) and Italian sentences (bottom).

2.1.3. Procedure

Participants were given a questionnaire containing biographical questions for participating in the study (see Appendices A and B) most importantly to learn about their place of origin. Then, in order to make sure that they would read all the sentences without pausing between words, they were given oral instructions. Participants were told that the aim of the study was to investigate differences in pronunciation, thus they were allowed to reread the sentences up to three times in order to read them without hesitating, a procedure that guaranteed the fluent reading of the majority of sentences. Participants were also told beforehand that many words could be unfamiliar to them, another reason for repeating the sentences that they hesitated to read, since only the production without pauses would be considered. They were also asked to read in a regular pace but making sure that all the sounds were pronounced correctly and in a clear manner.

The sentences were recorded in the language lab of the Institute of Phonetic Sciences and the Public Library of Wageningen, both using a digital voice recorder and a microphone model Trust Basic MC200 Premium. The time spent for each recording varied from 10 to 15 minutes, depending on the number of times each participant needed to reread the sentences. They were also asked to read the sentences for a second time in order to make sure that we could obtain the best production for the analysis.

The procedure to analyse the data focused on the two aspects mentioned in the introduction: (1) the duration of the frication period and (2) the percent of voicing (Brunner and Fuchs 2005). Concerning duration, a comparison was carried out between /s/ and /z/ in order to find out the difference in length for both fricatives. Finally, an analysis related to the percent of voicing was conducted in order to show the two main distinctive cues for each of the languages as reported by Van Oostendorp (1999) and Bertinetto (2000), respectively.

2.1.4. Production results

In this section we will show the results drawn from the first part of the experiment. As mentioned above, the main objective was to find the difference between Dutch and Italian in the production of the sibilant fricatives. The results show duration of the frication period and percent of voicing as cues.

2.1.4.1. Duration of the frication period

Duration is an amount of time or a particular time interval. Durations, and their beginnings and endings, may be described as long, short, or taking a specific amount of time. As such, the *duration range* is the difference in length between the shortest and longest (DeLone et. al. 1975).

Looking at the results, and comparing the production of both fricatives, we can observe that the duration of the frication period varies. The durations for Dutch and Italian speakers are reported as follows:

Language-Fricative	Lowest Duration	Maximum Duration	Average Duration	Standard Deviation
Italian /s/	90ms	153ms	118ms	26ms
Italian /z/	73ms	92ms	80ms	13ms
Dutch /s/	104ms	127ms	115ms	9ms
Dutch /z/	62ms	77ms	72ms	6ms

Table 1 – Values for duration of frication period for Italian and Dutch

Table 1 shows the standard deviation for the duration of the frication period. The standard deviation for the Dutch experimental values indicates that speakers produce the fricative contrast closer to the mean value. The Italian production of /s/ and /z/ seems to differ to a larger extent than that of the Dutch.

2.1.4.2. Percent of voicing

A voiced sound is produced when air expelled from the lungs causes the vocal cords to vibrate. The resulting sound is modified by movements in the vocal tract, by the volume of the airflow and by the degree of constriction of the vocal

cords (Hayward 2000). With purely unvoiced sounds, there is no fundamental frequency in the excitation signal and therefore no harmonic structure either. Unvoiced sounds are also usually more silent and less steady than voiced ones (Kleijn et al. 1998).

The percent of voicing was calculated thanks to a Praat script based on the values of harmonicity and voicing frames of each of the fricative sounds (See Appendix E). The following table shows a summary of the values.

Language-Fricative	Lowest Voicing	Maximum Voicing	Average Voicing	Standard Deviation
Italian /s/	19%	47%	37%	11%
Italian /z/	48%	87%	71%	15%
Dutch /s/	42%	55%	48%	6%
Dutch /z/	58%	91%	71%	12%

Table 2 – Values for percent of voicing for Italian and Dutch

Table 2 shows the standard deviation for the percent of voicing. In contrast with the table for the duration the values seemed to be more scattered considering their mean. The high percent values for the standard deviation show more differences among speakers.

The following Figure illustrates the results we just explained and shows a boundary that best separates the production of /s/ and /z/ for each of the language groups tested. This boundary was drawn by a logistic regression which calculated values based on duration and voicing (see Appendices I and J).

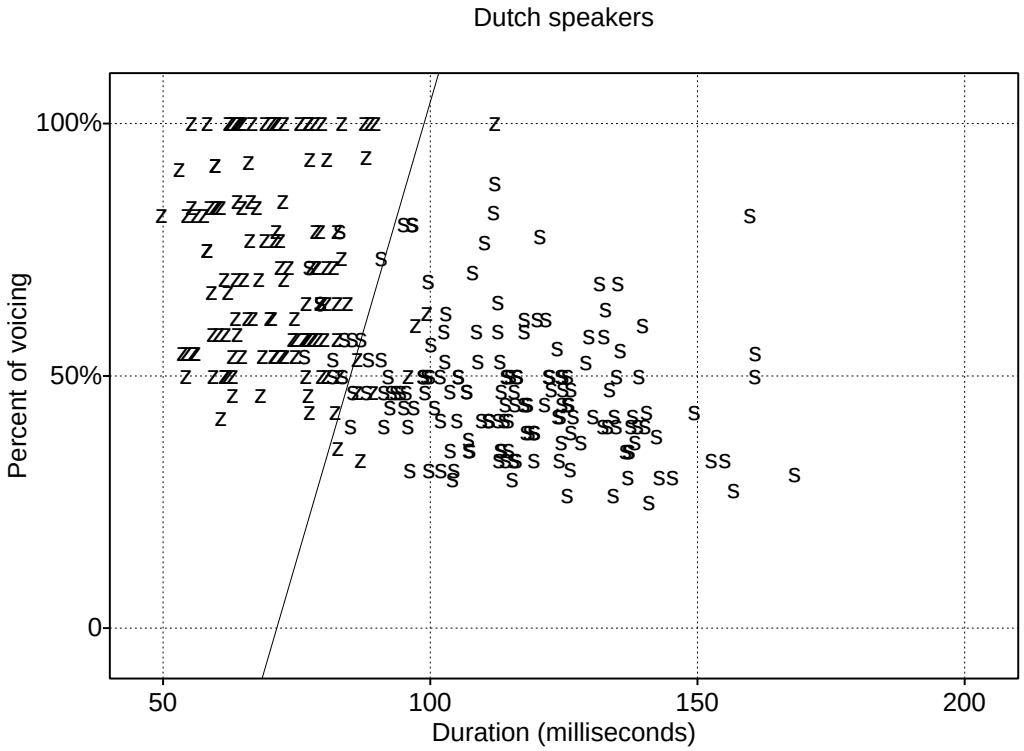

Fig. 2 – Dutch production of fricative contrast /s/ and /z/[2]

As we can see from Figure 2, Dutch speakers show a difference between /s/ and /z/ based on duration of the frication period. These results corroborate that reported by Van Oostendorp (1999) that the difference for Dutch is that of length. Looking at the figure we can see that the boundary that best separates the fricatives is drawn from the duration axis, confirming that the main difference in production is indeed duration of the fricative period.

[2] Thanks to Prof. Dr. Paul Boersma who wrote the script for Figures 2, 3, 5, 6, 7 and 8 (see Appendix I for Figures 2 and 3 and Appendix J for Figures 5, 6, 7 and 8).

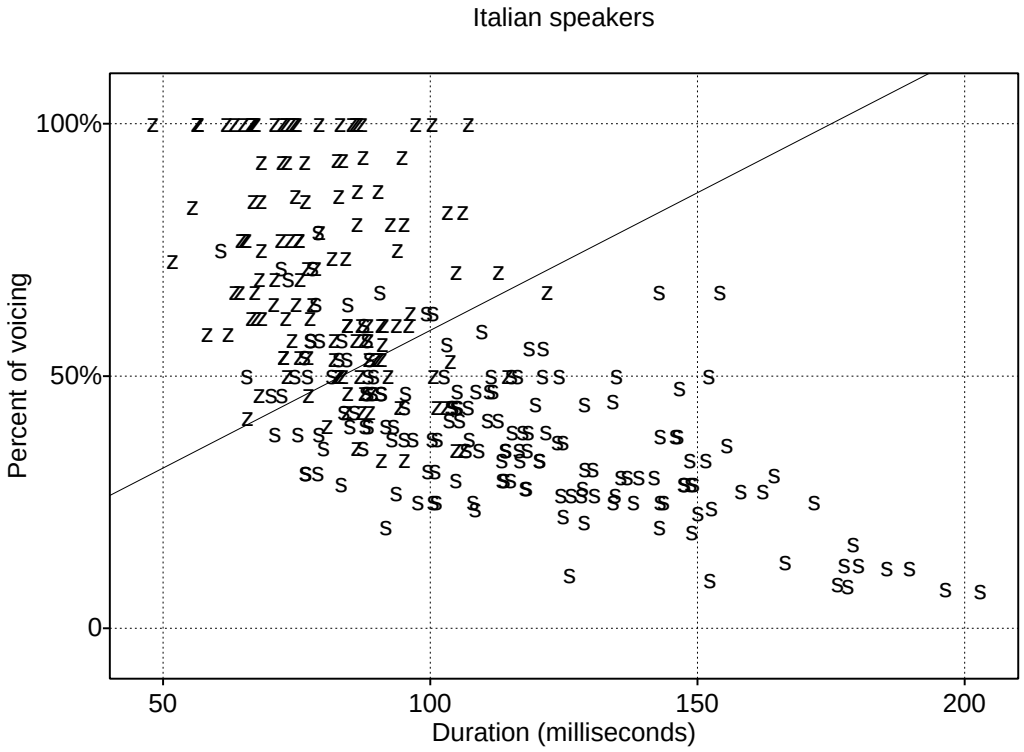

Fig. 3 – Italian production of fricative contrast /s/ and /z/

In the case of the Italian speakers, they also show a difference in duration and voicing; we can even see how the difference in duration for some of the utterances is very big. However, Italian speakers show a bigger difference regarding the percent of voicing, corroborating again that reported by Bertinetto (2000) that the difference for Italians is in level of voicing. Again, if we look at Figure 3 we can see that the boundary that best separates the fricatives is drawn from the voicing axis, confirming that the main difference in production is the percent of voicing.

When analysing the production of /z/ by Italian speakers, the level of voicing seemed higher and clearer than that of Dutch. When listening to the Italian

utterances the difference between voiced and voiceless appeared to be clearly distinguishable. However, in the case of Dutch utterances the difference was rather close. This led me to believe that the Italian /z/ would come out as much more voiced than the Dutch one. Nevertheless, looking at the Figures presented in this paper and the average of voicing calculated from the values, the difference between voicing of Italian and Dutch /z/ was small, namely that the average for both language groups was calculated at 71% (see page 20).

2.2- Perception experiment

The perception experiment was conducted to test the knowledge of the voicing contrast. Now that we have seen that the difference in the production of fricatives was clear, it is time to move on with our experiments to see whether the difference is also clear in perception.

2.2.1. Subjects

After confirming with the production findings the difference in the production of /s/ and /z/ by Dutch and Italian speakers, it was time to look for an answer to our second research question posted in previous sections. The subjects chosen for this experiment were eight native Dutch listeners from The Netherlands, this time all of them PhD students from the *Wageningen Universiteit & Researchcentrum*; and six native Italian listeners from Italy, that, again, varied between post-graduate students and middle-class workers living in The Netherlands. Unlike the production experiment, the participants selected for this

experiment did not have to come from a certain region or place of origin since we wanted to have a general perception of the contrast. A total group of 14 participants were asked to listen to 600 stimuli, 300 VCV Dutch sounds and 300 VCV Italian sounds.

As well as for the production experiment, listeners reported to speak at least one second language. They all reported to have English as a second language, and some also had knowledge of German, French, Latin and Spanish. None of them reported speaking any language at home other than their native language.

2.2.2. Materials

The participants were asked to listen to 600 natural stimuli[3], played as VCV sounds, 300 in Dutch and 300 in Italian. These sounds were extracted from the 60 sentences carrying the fricative contrast, read for the production experiment. All ten speakers (5 for Dutch and 5 for Italian) read 30 sentences with /s/ and 30 sentences with /z/ which summarised 60 sentences per speaker; 600 VCV sounds counting 60 stimuli by 10 speakers.

In order to avoid any confusion with the different accents it was necessary for the sounds to have the same characteristics. First, using the program Praat, the recordings were modified in order to equalize the intensity. Second, the VCV sounds were extracted from the production adding 50ms to each vowel sound. Third, the stimuli were extracted as bell shape sounds using a raised cosine

[3] It was necessary to use natural stimuli in order to test our first hypothesis.

formula (see Appendix F) in order to make the sounds smoother and clearer. Finally, the stimuli were included in an experiment file that would be in charge of running the experiment in Praat.

The participants listened to the VCV sounds and selected from the two options shown on the screen. Figure 4 illustrates how the perception experiment was conducted.

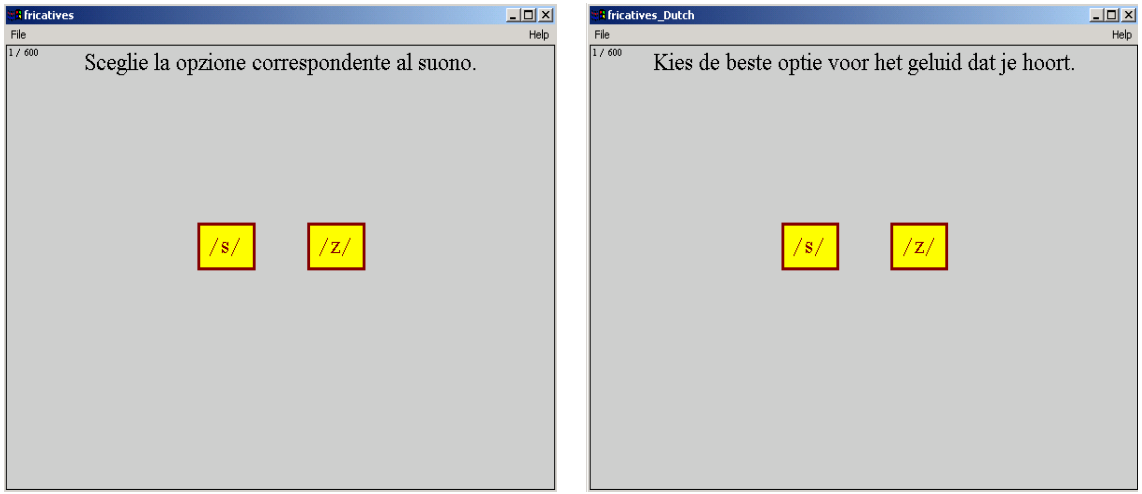

Fig. 4 – Experiment screens, on the left instructions in Italian and on the right in Dutch

2.2.3. Procedure

The participants were given oral instructions on how to do the test and were trained with the first ten sounds in order to make sure that they would understand how the experiment should be. Participants were explained in detail that the aim of the study was to investigate the difference in the pronunciation of /s/ and /z/, therefore they were aware that the choices presented on the screen did not correspond to orthographic symbols but phonetic symbols. Participants were also

told beforehand that many of the sounds presented might be too short, but even then they still had to select an option in order to continue. It was explained to them that there were no correct or incorrect responses.

Each participant listened to 600 natural stimuli played randomly in different order for each listener to prevent any possible ordering effect. The participants had breaks every 60 stimuli and they could decide whether they wanted to continue or rest for a couple of seconds. The time spent for each test varied from 35 to 50 minutes, depending on the number of breaks each participant decided to take.

As well as for the production part, the procedure to analyse the data focused on two aspects: (1) the duration of the fricative period and (2) the percent of voicing. For the perception experiment, duration and voicing were selected as cues to identify the fricatives, as reported by (Van Oostendorp 1999 and Bertinetto 2000).

2.2.4. Perception results

The analysis of the results was done using a logistic regression on Praat that helped us draw the boundaries for the perception and determine which cue was then the main cue to identify the options selected by the listeners of each language. We explain the results and show Figures 5 and 6 where we can observe the boundaries for each language.

2.2.4.1. Cue reliance

It has been shown that all contrasts are signaled by more than one phonetic cue, in most cases by two most important ones (Escudero 2000c). Furthermore, one of the cues may be primary or most important. Therefore, it might be the case that the Dutch and Italian listeners have a different cue weighting where Dutch will rely on the duration of the frication period and Italians on percent of voicing.

As mentioned in the introduction section, the study aims to provide quantitative evidence for duration and voicing factors involved in the production and perception of /s/ and /z/ in intervocalic position. We saw that Dutch and Italian speakers showed a difference in the production of the fricative contrast, primarily differences in duration of the frication period and degree of voicing, respectively. Once again, the analysis of the perception results was based on duration and voicing factors in order to determine whether Italian and Dutch listeners showed a difference in cue reliance. Our predictions stated that the perception for Dutch and Italian listeners would correspond to their production, but our results, however, show a different picture.

Both groups of listeners show that in order to discriminate sibilant fricatives they relied on percent of voicing.

Figures 5, 6, 7 and 8 illustrate the results of the perception experiment where Dutch and Italian participants listened to 600 natural stimuli. The figures show responses **s**, **z** and **?**. The **s** and **z** correspond to responses given by the total number of speakers; whenever the total number of speakers would select the same category the response will show either an **s** or a **z**. The **?** corresponds to categories selected by a lower number than the total of listeners, indicating that the sound was not a unanimous category.

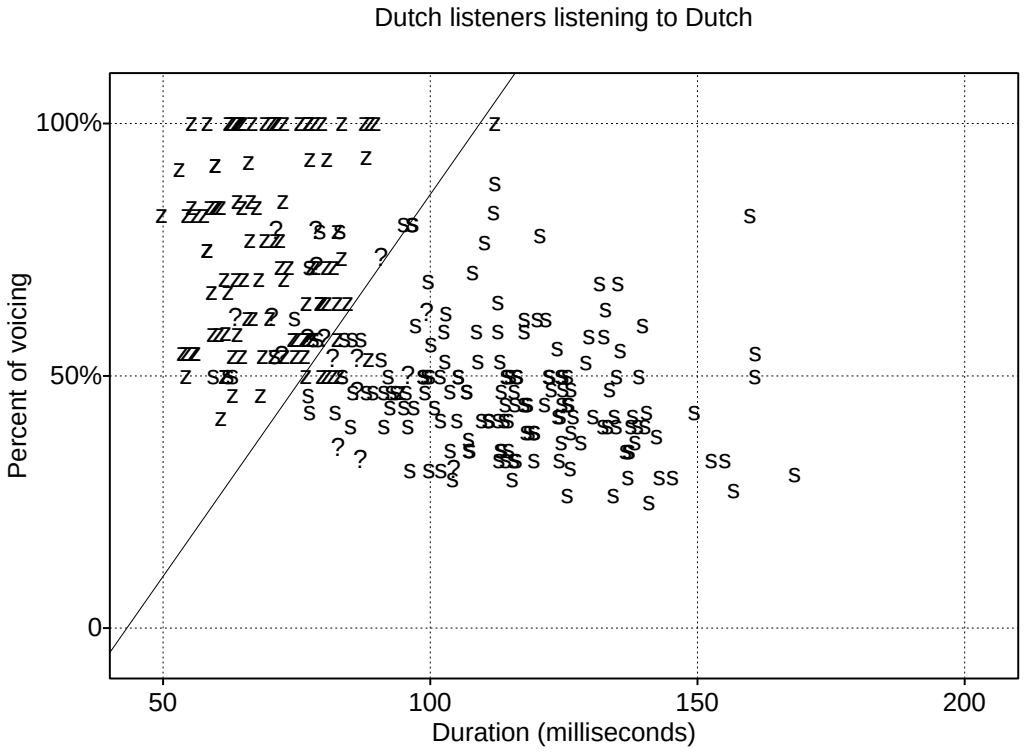

Fig. 5 – Dutch perception of Dutch

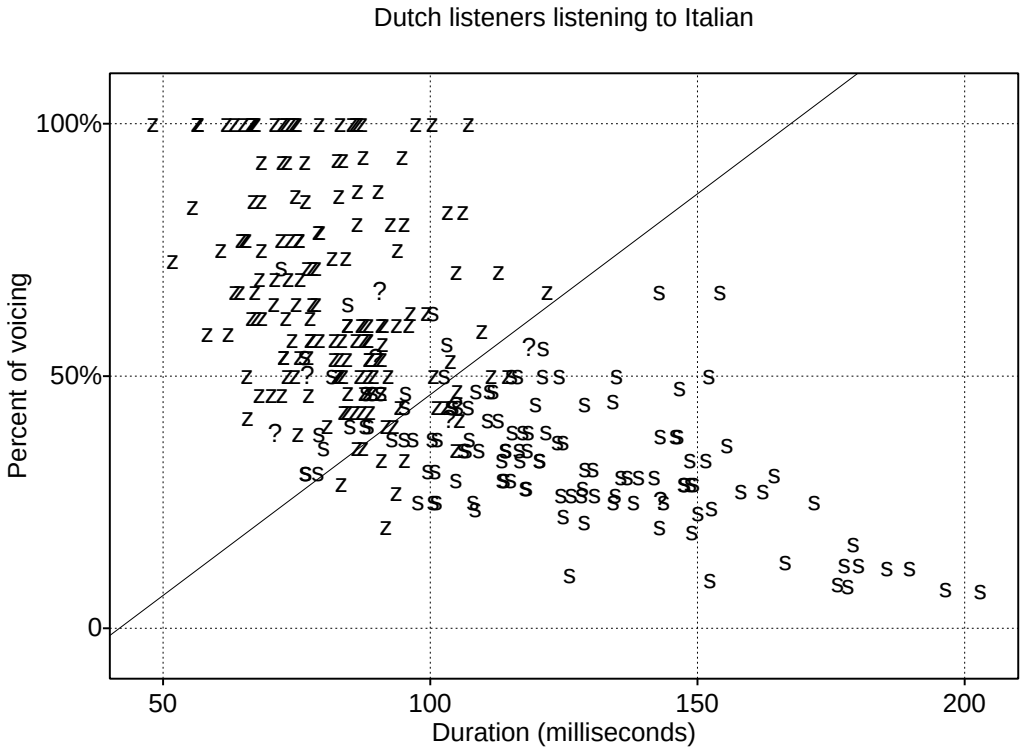

Fig. 6 – Dutch perception of Italian

Looking at the perception results for the Dutch listeners we see that unlike the prediction the Dutch listeners relied on percent of voicing to discriminate the sounds of /s/ and /z/ for both languages. We can even see that the patterns for the Dutch appear to be closer to the categories intended by the speakers in both cases, Dutch and Italian.

The Dutch results can be expressed in terms of the Motor Theory, namely that the selection of the fricatives was based on their own articulation. Participants reported that after listening to the sounds they would think of a word and produce it in order to confirm whether they would produce it as an /s/ or a /z/.

The classification of the /s/ and /z/ for the Dutch was made based on the articulation relating the perception of a category on motor elements of speech.

Let us look at Figures 7 and 8 where we would then see the perception of the Italian listeners.

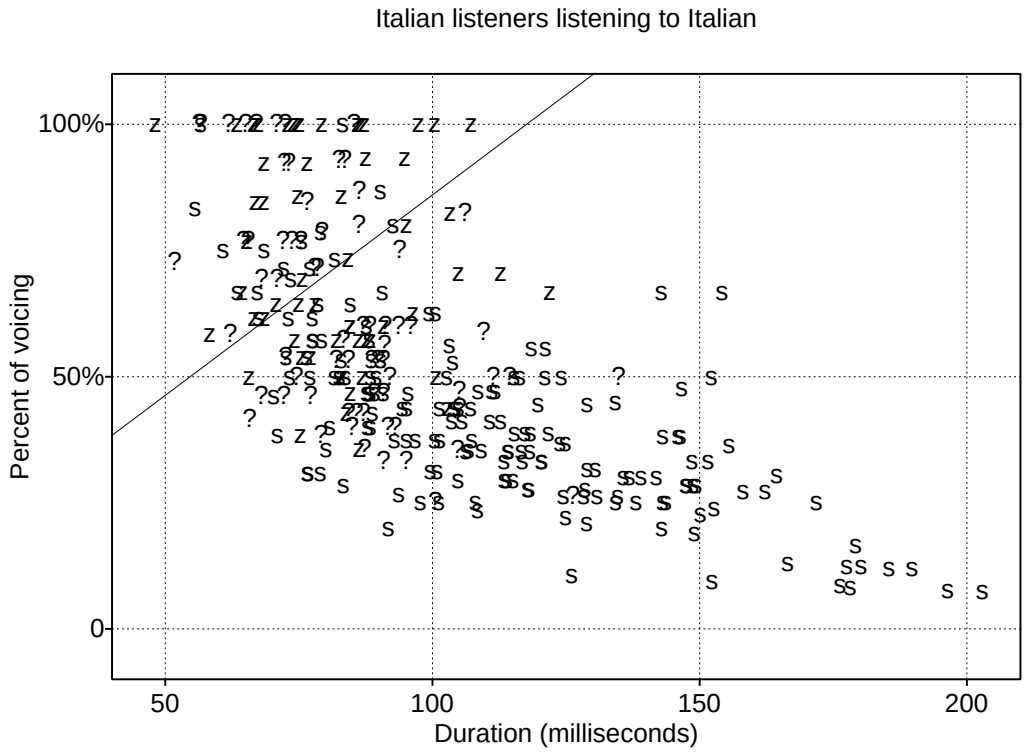

Fig. 7 – Italian perception of Italian

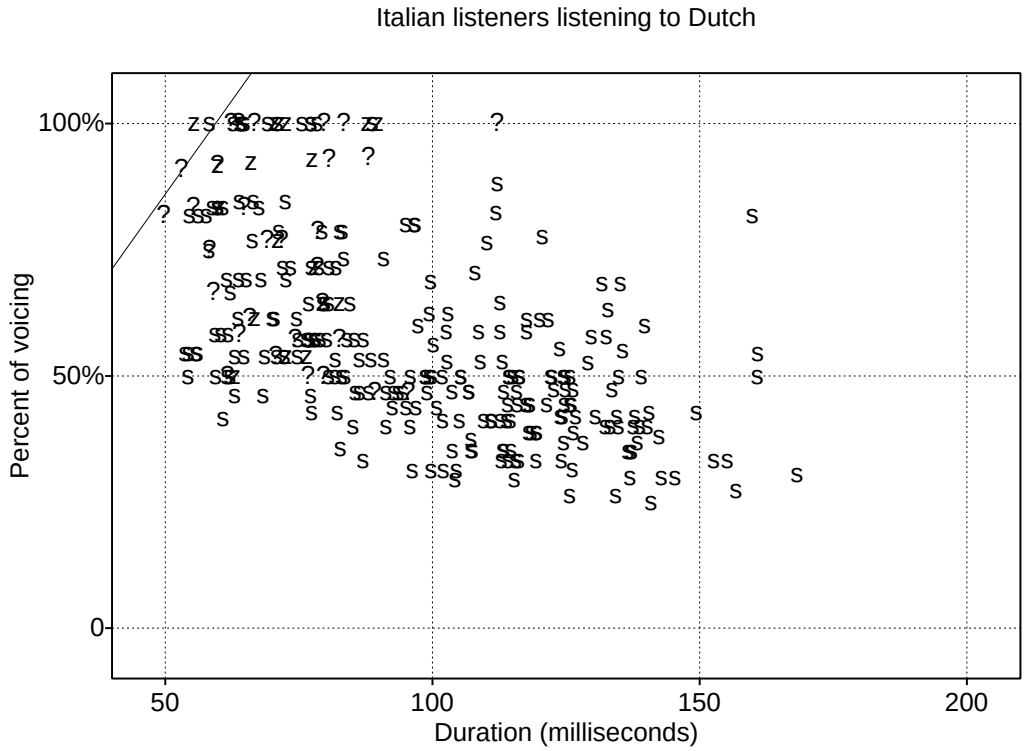

Fig. 8 – Italian perception of Dutch

Looking at the perception results for the Italian listeners we see that according to the predictions the Italian listeners relied on percent of voicing to discriminate the sounds of /s/ and /z/ for both languages. What is interesting in the results for the Italians is that they show a big bias towards /s/ even when perceiving Italian. Looking at the Italian perception of Dutch we can see that the percent of voicing in Dutch is considered as not significant by Italian listeners.

The Italian results can be expressed in terms of the Perceptual Magnet Effect, namely that the perception of /s/ appears to be closer to what can be considered a prototype, i.e., the most representative instance of the /s/ category. Looking at Figure 7 we can see the same effect, but to a lesser extent, in their perception of

Italian. The prototype of the /s/ category functioned like a perceptual magnet for other category members, viz. /z/; it assimilated neighboring stimuli, effectively pulling them towards the prototype (Kuhl 1991).

In general terms we can say that the figures suggest the existence of a third cue that might also be involved in the perception process, in accordance with Escudero (2000c) when she reports that all contrasts are signaled by more than one phonetic cue. The figures drawn from this experiment suggest that in the case of the /s/ and /z/ contrast there even might be three important cues.

In the following section we will discuss all the results drawn from both production and perception experiments. We will once more summarise the results and give what are believed to be some of the possible explanations for the results.

2.3- Discussion

This section will be divided in three sub-sections: Production of /s/ and /z/ and Perception of /s/ and /z/. This will facilitate the analysis of the discussion by the reader and relate the discussion to each one of the topics mentioned.

2.3.1- Production of /s/ and /z/

The findings of the production test showed small differences between speakers in duration regarding the standard deviation. However, the differences in voicing indicated larger differences among speakers.

A possible explanation of this phenomenon can be linked to non-measurable variables, such as less air passing through the vocal cords. A lower airflow can reduce the vibration of the vocal cords which translates into less periodicity, lowering the F0 and therefore reducing the level of voicing. As explained by Kleijn et al. (1998) “With purely unvoiced sounds, there is no fundamental frequency in excitation signal and therefore no harmonic structure either and the excitation can be considered as white noise.” In other words, the airflow influences the amount of vibration produced by the vocal cords which characterise a voiced sound, therefore, if the vibration reduces, so can the level of voicing.

2.3.2- Perception of /s/ and /z/

In the case of the Dutch listeners, the perception results show that they seem to be closer to the productions of each of the languages making them ‘better’ perceivers (even in Italian) than the Italians who showed a rather different pattern. Unlike the Dutch, the Italian listeners seem to be very ‘poor’ perceivers, showing a very big bias towards the /s/ which could have been caused by an orthographic effect.

Another possible reason for this event could be that Italian participants had more cultural differences among them. Since the listeners were not selected according to their place of origin, their perception could have been influenced by a bigger difference in dialects than that seen in the results for the Dutch. This hypothesis can be translated in a better perception of Italian for the Dutch as seen in the results.

According to Van Oostendorp (1999) and Bertineto's (2000) findings Dutch and Italian have a difference in cue reliance, viz. Dutch listeners would rely on duration and Italian listeners on voicing. The results drawn from the perception experiment conducted for this paper, show that both language groups relied on the same cue, i.e. percent of voicing. These results lead me to believe that there might be a third cue involved that would then be weighted as a main or decisive cue in the discrimination of /s/ and /z/. It would be necessary to do some further research in order to determine what the third cue could be.

Chapter three – Conclusions and future research

The present study intended to find answers for two research questions, namely, (i) does the perception of fricatives correspond to their production? and (ii) is there a difference in cue reliance between Dutch and Italian listeners when perceiving this contrast? This chapter presents the concluding answers proposed after the analysis and discussion of the findings. Despite the existence of evidence that supports the conclusions here, there is a clear need for further experimental studies that could provide stronger and more reliable evidence for the conclusions here. We will explain the limitations of this study and how they influenced the results. Consequently, suggestions for possible follow-up research are made in the third and final section.

3.1- Conclusions

The aim of this study was to investigate the production of the /s/ and /z/ fricative contrast in Dutch and Italian, as well as the way in which such perception may take place. The findings of the experiments conducted are shown below:

- In line with the findings reported by Van Oostendorp (1999) and Bertinetto (2000), Italian and Dutch showed a difference in the production of /s/ and /z/ drawing a boundary for duration of the

frication period in the case of Dutch and percent of voicing in the case of Italians.

- The results indicated that fricative perception does not correspond to its production. Our prediction mentioned that the cue reliance would differ between Dutch and Italian listeners. The latter relying more on voicing and the first relying on duration. Contrary to the predictions, both language groups relied on the same cue, viz. percent of voicing. Furthermore, the results even suggest the existence of a third cue that was not identified.

- Even though in the production of the fricative contrast the Italian /z/ sounded much more voiced to me than the Dutch one, the average percent of voicing indicates that they are equally voiced.

- The difference reported within the voicing values might be affected by non-measurable variables, whereas duration is not. This can be evidenced with the values of the standard deviations (see pages 19 and 20; Tables 1 and 2).

- Dutch listeners seemed to be ‘better’ perceivers of the fricative contrast than Italians. The Dutch perception appears to be closer

to the production of both languages. On the other hand, Italians showed a large bias towards /s/.

This study gave significant scientific evidence and posed new questions that can be used as a starting point for future investigation and opens a window for further research in the area. The next section summarises some of the new questions that arose from this study.

3.2- Future research

This section shows some of the topics that can be considered for further research and mentions some suggestions to be taken into account in the future.

3.2.1- Research topics

In addition to the discussion topics presented in the previous section, there are still some open questions that could be considered for further research as continuity of the experiments conducted for this paper.

- Investigate difference in voicing among speakers.
- Investigate whether there is a third cue involved and explain how this cue can be weighted in perception.
- Can this experiment be conducted in an L2 setting? It would be interesting to see whether L2 speakers and listeners would draw the same results.

- Modelling fricative perception with Optimality Theory (Prince and Smolensky 1993).

3.2.2- Recommendations

- One limitation of this study has to do with the number of participants in relation to the primary number established for the experiment. At first the number established for the experiment was established of minimum 15 participants for the perception part in order to provide sufficient evidence from a significant number of listeners. Due to time reasons it was not possible to test the number of participants wanted. There is the possibility that even with a larger number of participants the results would have been the same, but they would certainly have been more reliable.

- As mentioned in Chapter two, the speakers were recorded between the Institute of Phonetic Sciences and the Public Library of Wageningen which caused the recordings to be different and to have different sets of background noise. The main reason was to make it easier for the subjects to participate in the study, since there was no possibility to have more planning time in order to make the recordings in one place. Many of the subjects were found in the area of Wageningen, therefore it was easier for them to be tested in that area. There is no evidence that this even had any influence on the results, however, it is advisable for further research to have a common setting for all speakers.

In general terms we can say that the time limitations did not allow the experiments to be completed in a more optimal way. It would be interesting to see whether the experiment results would show any difference taking into account all the recommendations just mentioned.

Bibliography

Bertinetto, P. M. 2000. *Boundary strength and linguistic ecology (Mostly exemplified on intervocalic /s/- voicing in Italian)*. Folia Linguistica XXXIII, pp. 267-286.

Boersma, P. **1998.** *Functional Phonology. Formalizing the interactions between articulatory and perceptual drives*. (Doctoral dissertation, University of Amsterdam).

Brunner, J. & Fuchs, S. 2005. *Conflicting requirements for voiced alveolar fricatives*. Conference on Turbulences (abstract). http://www.zas.gwz-berlin.de/turbulences/abstract/Fuchs_ab.pdf

Cole, R & Cooper, W. 1975. *Perception of voicing in English affricates and fricatives*. The Journal of the Acoustical Society of America. Volume 58, pp. 1280-1287.

Escudero, P. 2000c. *The perception of English vowel contrasts: Acoustic cue reliance in the development of L2 perception*. Paper presented at the Fourth International Symposium on the Acquisition of Second Language Speech, New Sounds 2000. University of Amsterdam, The Netherlands.

Fant, G. 1973. *Speech Sounds and Features*. Cambridge, MA: The MIT Press.

Flege, J. & Hillenbrand, J. 1986. *Differential use of temporal cues to the /s/–/z/ contrast by native and non-native speakers of English*. The Journal of the Acoustical Society of America. Volume 79, pp. 508-517.

Hayward, K. 2000. *Experimental Phonetics. Longman*. New York.

Iverson, P. & Kuhl, P. 1995. *Mapping the perceptual magnet effect for speech using signal detection theory and multidimensional scaling*. The Journal of the Acoustical Society of America. Volume 97, pp. 553-562

Kooij, J. 1983. *Morphological alternations and phonological rules: the case of Dutch intervocalic fricatives*, in Hans Bennis and Ans van Kemenade (eds.) Linguistics in the Netherlands 133-138.

Krämer, Martin. 2001. *On Obstruent Voicing in Breton, German, and Italian*, in Holmer, Arthur, Jan Olof Svantesson & Åke Viberg (eds), Proceedings of the 18th Scandinavian Conference of 26 Linguistics, Travaux de l'institut de linguistique de Lund 39, Vol 1, Lund University Press, Lund, pp. 39-55.

Kuhl, P. 1991. *Human adults and human infants show a `perceptual magnet effect' for the prototypes of speech categories, monkeys do not*. Perception & Psychophysics, Volume 50, pp. 93-107.

Ladefoged, P. & Maddieson, I. 1996. *The Sounds of the World's Languages*. Cambridge, MA, and Oxford: Blackwell Publishing.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. 1967. *Perception of the speech code*. Psychological Review, Volume 74, pp. 431-361.

Liberman, A.M. and Mattingly, I.G. 1985. *The Motor Theory of Speech Perception Revised*. Cognition, Volume 21, pp. 1-36.

Liberman, A.M. 1996. *Speech*. Cambridge, MA: The MIT Press.

Loporcaro, Michele. 1999. *Teoria fonologica e ricerca empirica sull'italiano ed i suoi dialetti*, in Paola Benincà, Alberto Mioni & Laura Vanelli (eds.), Fonologia e morfologia dell'italiano e dei dialetti d'Italia. Atti del 31° Congresso della Società di Linguistica Italiana, Bulzoni, Roma, pp. 117-151.

Moore, B.C.J. 1997. *An Introduction to the Psychology of Hearing*. (4th ed.) San Diego, CA: Academic Press.

Nittrouer, S., Manning, C., & Meyer, G. 1993. *The perceptual weighting of acoustic cues changes with linguistic experience*. Journal of the Acoustical Society of America, Volume 94, (abstract).

Nespor, M. & Vogel, I. 1986. *Prosodic Phonology*. Foris, Dordrecht.

Prince, A. & Smolensky, P. 1993. *Optimality Theory: Constraint interaction in generative grammar*. Rutgers University Center for Cognitive Science Technical Report.

Slis, I. & M. van Heugten. 1989. *Voiced-voiceless distinction in Dutch fricatives*, in Hans Bennis and Ans van Kemenade (eds.) Linguistics in the Netherlands, 123-132.

Stevens, K. 1986. *Models of Phonetic Recognition II: A feature based model of speech recognition*. Montreal Satellite Symposium on Speech Recognition. Edited by P. Mermelstein.

Stevens, K., Blumstein, S., Glicksmann, L., Kurowski, K. 1992. *Acoustic and perceptual characteristics of voicing in fricatives and fricative clusters*. The Journal of the Acoustical Society of America. Volume 91, pp. 2979-3000.

Studdert-Kennedy, M. and Shankweiler, D. 1970. *Hemispheric Specialization for Speech Perception*. Journal of Acoustical Society of America, Volume 48, pp. 579-592.

Treves, M. 2002. *Remarks on Italian Phonetics*. Italica, Volume 24, pp. 62-68.

Van Dale. 2003. *Groot woordenboek Nederlands*. Utrech/Antwerpen, Van Dale Lexicografie.

Van Oostendorp, Marc. 1999. *Italian s-voicing and the structure of the phonological word*, in S. J. Hannahs & M. Davenport (eds.), Issues in Phonological Structure, Benjamins, Amsterdam, New York, pp. 197-212.

Zingarelli, N. 2006. *Il nuovo Zingarelli*. Bologna: Zanichelli.

Appendices

A- Italian Questionnaire

B- Dutch Questionnaire

C- List of Italian Sentences

D- List of Dutch Sentences

E- Fricative Analysis Script

F- Create Stimuli Script

G- Tabulate Results Script

H- Add Stimulus Properties to Response Table Script

I- Draw Production Script

J- Draw Responses Script

APPENDIX A – ITALIAN QUESTIONNAIRE

Questionario per scegliere partecipanti per uno studio di lingue

Data: _____ Nome: _____
Età: _____ Data e luogo di nascita: _____
Madrelingua: _____ Mestiere: _____

1) Nomina le città e i paesi che avete visitato o dove avete vissuto più di due settimane da quando siete nato.
Città e paese: _____, Durata: _____
Città e paese: _____, Durata: _____
Città e paese: _____, Durata: _____
Città e paese: _____, Durata: _____
2) Dove sono nati i vostri parenti? Nominate la città e il paese.
a) Madre: _____ b) Padre: _____
3) Studiate qualche altra(e) lingua(e) adesso? _____
Specificate lingua(e), livello (essempio: principiante, intermedio, avanzato) e ore alla settimana:
Lingua:_____, Livello: _____, Ore a la settimana: _____
Lingua:_____, Livello: _____, Ore a la settimana: _____
4) Avete studiato qualche altra(e) lingua(e) prima? _____
Specificate quale lingue, età e per quanto tempo:
Lingua: _____, Età: _____, Settimane/Mesi/Anni: _____
Lingua: _____, Età: _____, Settimane/Mesi/Anni: _____
Lingua: _____, Età: _____, Settimane/Mesi/Anni: _____
5) Segnalate il numero correspondente per indicare il vostro livello di **comprensione** nella(e) lingua(e) che studiate o che avevi studiato. (0 significa che non capite niente; 7 significa che capite tutto.)
Lingua: _____, 0 1 2 3 4 5 6 7
Lingua: _____, 0 1 2 3 4 5 6 7
Lingua: _____, 0 1 2 3 4 5 6 7
6) Segnalate il numero correspondente per indicare quanto potete **parlare** nella(e) lingua(e) che studiate o che avevi studiato. (0 significa che non parlate niente; 7 significa che parlate come un parlante nativo)
Lingua: _____, 0 1 2 3 4 5 6 7
Lingua: _____, 0 1 2 3 4 5 6 7
Lingua: _____, 0 1 2 3 4 5 6 7
7) Guardate TV o ascoltate radio in altre lingue? _____
Specificate le lingue: _____
8) Parlate con qualcuno qualche lingua(e) diversa(e) fuori le lezioni? _____
Specificate il rapporto che avete con questa persona (essempio: amico, zia, fratello, sorella, ecc.):
Lingua: _____, Persona: _____, Ore/minuti a la settimana: _____
Lingua: _____, Persona: _____, Ore/minuti a la settimana: _____

APPENDIX B – DUTCH QUESTIONNAIRE

Enquete voor het selecteren van deelnemers voor een taal onderzoek

Datum:_____ Naam: _____
Leeftijd: _____ Geboortedatum en geboorteplaats: _____
Moedertaal: _____ Beroep: _____

1) Noem steden en landen waar u langer dan twee weken bent geweest sinds u geboren bent.
Stad en land: _____, Duur van het verblijf: _____
Stad en land: _____, Duur van het verblijf: _____
Stad en land: _____, Duur van het verblijf: _____
Stad en land: _____, Duur van het verblijf: _____
2) Waar zijn uw ouders geboren? Noem de stad en het land.
a) Moeder: _____ b) Vader: _____
3) Leert u op dit moment een andere taal of andere talen? _____
Noem de taal of talen, het niveau (bijvoorbeeld: beginner, gevorderde) en uur per week:
Taal: _____, Niveau: _____, Uur per week: _____
Taal: _____, Niveau: _____, Uur per week: _____
4) Hebt u eerder een andere taal of andere talen geleerd? _____
Noem welke taal of talen, leeftijd en hoe lang:
Taal: _____, Leeftijd: _____, Weken/Maanden/Jaren: _____
Taal: _____, Leeftijd: _____, Weken/Maanden/Jaren: _____
Taal: _____, Leeftijd: _____, Weken/Maanden/Jaren: _____
5) Omcirkel het nummer dat overeenkomt met de mate waarin u de taal/talen die u hebt geleerd **begrijpt**. (0 betekent dat u niets begrijpt; 7 betekent dat u absoluut alles begrijpt)
Taal: _____,0 1 2 3 4 5 6 7
Taal: _____,0 1 2 3 4 5 6 7
Taal: _____,0 1 2 3 4 5 6 7
6) Omcirkel het nummer dat overeenkomt met de mate waarin u de taal/talen die u hebt geleerd **spreekt**. (0 betekent dat u geen word spreekt; 7 betekent dat u de taal/talen perfect spreekt, bijna al seen moedertaalspreker):
Taal: _____,0 1 2 3 4 5 6 7
Taal: _____,0 1 2 3 4 5 6 7
Taal: _____,0 1 2 3 4 5 6 7
7) Keek u televisie of luisterde naar de radio in de andere taal/talen? _____
Welke taal/talen? _____
8) Sprak u de taal/talen met andere mensen dan die van uw klas? _____
Welke relatie had u tot deze persoon (bijvoorbeeld: vriend, tante, broer, zus, enz.)
Taal: _____, Persoon: _____, Uur/minuut per week: _____
Taal: _____, Persoon: _____, Uur/minuut per week: _____

APPENDIX C – LIST OF ITALIAN SENTENCES

Un mio confidente
Sento fatica
Cerco la sigla
Il mare aperto
Grande podere
Bel roseto
Stai sempre accanto
Zona asismica
Prende l'alimento
Dare risalto
L'uomo adatto
Vedo la signora
Donna ribelle
Voglio riposare
Civiltà latina
Vedo l'aletta
Era solo
Fare l'analisi
Posso resistere
Bomba atomica
Molta sabbia
Devo capire
Andare in galera
Deve rasarsi
Sono d'accordo
Bella sagra
Bibita amara
Sono presente
L'uomo adonide
Stile asettico
Vedo la cabina
Uomo pesista
Fare un bilancio
Primo secolo
Mettere l'anello

Trasporto pesante
Tela batista
Studio le secche
Sotto coperta
Timbro nasale
Compro un gelato
Sento una beccata
Un po' di sale
Devo cibarmi
Libro ameno
Prende la misura
Grande badile
Donatore di sangue
Il mio debutto
Estrema miseria
Animale in calore
Essere sodo
Libro banale
Lui dipinge
Caccia al tesoro
Giardino botanico
Prendo la sacca
Legge l'epilogo
Mi sono pesata
Legge daccapo
Zona sacra
Una casa enorme
Una bella camicia
Non abusare
Parto podalico
Abbiamo bisogno
L'orso ibernato
Comportamento lesivo
Il fiore celeste
Parole simili

Un gesto benigno
Parole isofone
Camicia di cotone
Vede la sua
Legge l'ipotesi
Sono gasato
Andare in macchina
Scrivere saggi
Lavoro con il cemento
Il vino è finito
Vedo il basalto
Futuro predetto
Mi piace filare
Essere sobrio
Non ho mobili
Specie esotica
Tutti i colori
E così di seguito
Dare un bonifico
Estremo disagio
Scrittore dotato
Rispondi subito
Sa di meccanica
Uomo apatico
Sono disabile
La pubblica accusa
Prende la sabbia
Sposarsi in comune
Zona desertica
Il Signore sia lodato
Non posso citare
Sano e salvo
Vedo l'abisso
Calcola il coseno
Sembra un diluvio

Fare le sintesi
Ti invito a cenare
Bella casetta
Vedo la catena
Molte sedie
Vedo la cipolla
Nobile casato
Strada bloccata
Vedo la sala
Ho un dominio
Pollo brasato
Vedo l'accademia
Devo desistere
Vedo il limone
Uomo obeso
Grosso blasone
Fare una denuncia
Cerca l'elenco
Salire di sopra
Grande potere
Rimane basito
Donna cinese
Leggo i salmi
Sono a babordo
Sono coperto
Vena basilica
Bel blocchetto
Sapere a memoria
Ero secco
Primo capitolo
Donna ladina
Grande asilo
Salsa piccante
Lei ti libera
Aspetta un momento

APPENDIX D – LIST OF DUTCH SENTENCES

Ik zie de kadootjes
Ik wil ze dateren
Ik wil ze traceren
de status aparte
De laatste editie
Tien farizeeërs
Ik zie de acacia
Ik ga in cassatie
Ik ben amechtig
We willen die zakken
Het verse kadetje
De wijn is mousserend
Ik zie de cabine
We zagen die zieken
Ik zie de katheter
We willen rouleren
Ik zie de essentie
Ze is wat anemisch
Dat is bijzonder
Ik zie de boetieken
Ik wil ze masseren
Ik zie het kapittel
Het is te elastisch
Ik zie de bazinnen
Ik zie de boeketten
We zagen die sokken
Ik zie de emissie
Ik zie de gazonnen
Ik heb een addictie
Ik zie de cassette
We zagen die boeven
Dat is het bizarre
Ik hoor de ballade
Ze worden passiever
Ik zie het enigma

We willen poseren
Ik zie de ethiek
Ik zie de docenten
Ik zie de japonnen
Op de Azoren
Ik zie de ballonnen
We willen die kanten
Ik teken die cirkel
Ik zie het kobalt
Ik zie de kamelen
Daar komt de visite
Ik zie de cadenzen
Ik zie palissades
Ik zie de labielen
Ik zie de vizieren
Ik voel me balorig
Ik zie carrousellen
Ik zie de kanarie
Ik zie de kapellen
Ik zie oppositie
De eerste etage
We willen die saaie
Ik zie de rapporten
Ik zie de vazallen
Ik zie de collocatie
Ik zie de passage
Ik zie de kaneel
Ik hoor de lamenten
Ik woon in Mazoeren
Ik zie de cadetten
Niet van dat dociele
Ik zie de libellen
Ik zie de fazanten
Ik zie de collectie
We eten die samen

Ik zie de bananen
Dat is niet diezelfde
De tuin is botanisch
Ik zie de cassave
Ik zie de apostel
Ik zie de bazooka
De saus is pikanter
Ken uw klassieken
Ik zie een omissie
Ik zie de chinezen
Ik ben in Brazilië
Het pak is driedelig
Ik zie het dilemma
Ik zie de Pacific
Ik zie het mobielen
Ik zie de chrysanten
Ik voel me jaloerser
Ik zie de bassist
Ik zie de anode
Ik zie de kozakken
Ik zie imitatie
Ik zie de blesseren
Ik zie de kroketten
Hij is niet capabel
Ik zie het basilicum
Ik zie de lokalen
Het werd een deceptie
Ik zie de limieten
Ik zie de kazerne
Ik zie de gradatie
Ik zie de notatie
Ik wil ze klasseren
Dat laat me siberisch
Ik zie een gazelle
De boor is elektrisch

Ik zie de dissectie
Ik zie de fanaten
Ik zie de rozetten
Ik zie de kritieken
Ik zie de fossielen
Ik wil het draperen
Je moet beter fraseren
Ik zie de loketten
Ik wil een assertie
Ik zie diplomaten
Ik zie de blazoenen
Ik zie de idyllen
Het Hof van Assisen
De epidemieën
Het mag wel stabieler
Ik zie limousines
Ik zie de finale
Ik zie embolisme
Ik kan incasseren
Het mag fanatieker
Ze willen die zaden
Ik zie de fonemen
Ik zie de placenta
Ik wil het proberen
De emancipatie
Ik zie de bazaar
Ik zie de pakketten
Het was wel dramatisch
Ik zie de receptie
Ik zie monopolie
Ik zie het kadaver
Dat moet je hierop baseren
Ik zie de briketten
Ik zie de lobelia
Ik zie de familie

APPENDIX E – FRICATIVE ANALYSIS SCRIPT

```
#! Praat script analyseFricatives.praat
# Paul Boersma, June 26, 2006

# This script analyses durations and voicednesses of /s/ and /z/
# in a selected Sound + TextGrid.

form Analyse fricatives
	choice Gender 2
		button Male
		button Female
endform
timeStep = 0.01
pitchFloor = if gender$ = "Male" then 75 else 100 fi
pitchCeiling = if gender$ = "Male" then 300 else 500 fi
sound = selected ("Sound")
textgrid = selected ("TextGrid")
if numberOfSelected ("Pitch") = 0
	select sound
	To Pitch (cc)... timeStep pitchFloor 15 no 0.03 0.45 0.01 0.0 0.0
pitchCeiling
	pitch = selected ("Pitch")
	plus sound
	To PointProcess (cc)
	pulses = selected ("PointProcess")
	select sound
	To Harmonicity (cc)... timeStep pitchFloor 0.1 1.0
	harmonicity = selected ("Harmonicity")
else
	pitch = selected ("Pitch")
	pulses = selected ("PointProcess")
	harmonicity = selected ("Harmonicity")
endif

select textgrid
numberOfIntervals = Get number of intervals... 1
echo phoneme'tab$'duration'tab$'voiFrames'tab$'hnr
for interval to numberOfIntervals
	text$ = Get label of interval... 1 interval
	if text$ = "s" or text$ = "z"
		tmin = Get starting point... 1 interval
		tmax = Get end point... 1 interval
		duration = tmax - tmin
		select sound
		plus pitch
```

```
                plus pulses
                voiceReport$ = Voice report... tmin-0.03 tmax+0.03 pitchFloor
pitchCeiling 1.3 1.6 0.03 0.45
                unvFrames = extractNumber (voiceReport$, "Fraction of locally
unvoiced frames:")
                voiFrames = 1 - unvFrames
                hnr = extractNumber (voiceReport$, "Mean harmonics-to-noise
ratio:")
                select harmonicity
                ;hnr = Get mean... tmin tmax
                select textgrid
                printline 'text$"tab$"duration:6"tab$"voiFrames:6"tab$"hnr:3'
        endif
endfor
```

APPENDIX F – CREATE STIMULI SCRIPT

```
speaker1$ = "FITP1IM31_R1"
speaker2$ = "MITP1FC33_R1"
speaker3$ = "MITP2MP23_R1"
speaker4$ = "MITP3FS23_R1"
speaker5$ = "MITP4JC31_R1"
speaker6$ = "FNLP1IB27_R1"
speaker7$ = "FNLP2RG28_R1"
speaker8$ = "FNLP3JK28_R1"
speaker9$ = "FNLP4AS25_R1"
speaker10$ = "FNLP5ML27_R1"

dir$ = "Sound files"
echo Stimuli:
for speaker to 10
	speaker$ = speaker'speaker'$
	Read from file... 'dir$'/'speaker$'.wav
	Read from file... 'dir$'/'speaker$'.TextGrid
	nint1 = Get number of intervals... 1
	assert nint1 = 121
	nint2 = Get number of intervals... 2
	assert nint2 = 121
	ntier = Get number of tiers
	if ntier = 3
		Remove tier... 3
	endif
	Insert interval tier... 3 stimuli
	n = 0
	for interval to 121
		text$ = Get label of interval... 1 interval
		if text$ = "s" or text$ = "z"
			n += 1
			tmin = Get starting point... 1 interval
			tmax = Get end point... 1 interval
			Insert boundary... 3 tmin-0.08
			Insert boundary... 3 tmax+0.08
			vcv$ = Get label of interval... 2 interval
			vcv$ = replace$ (vcv$, "\ef", "e", 0)
			vcv$ = replace$ (vcv$, "\ct", "o", 0)
			vcv$ = replace$ (vcv$, "\as", "a", 0)
			assert length (vcv$) = 3 ; 'tmin:3' <'vcv$'>
			stimulus$ = speaker$ + "_'n'_" + vcv$
			Set interval text... 3 interval 'stimulus$'
			select Sound 'speaker$'
			Extract part... tmin-0.08 tmax+0.08 Rectangular 1 no
```

```
                    Formula... self * if x< 0.02 then 0.5 * (1-cos(pi*x/0.02))
                    ... else if x> xmax-0.02 then
                    ... 0.5*(1-cos(pi*(x-xmax)/0.02)) else 1 fi fi
                    Write to WAV file... Stimuli/'stimulus$'.wav
                    Remove
                    printline "'stimulus$'"
                    select TextGrid 'speaker$'
                endif
        endfor
        assert n = 60
        select Sound 'speaker$'
        plus TextGrid 'speaker$'
        Remove
Endfor
```

APPENDIX G – TABULATE RESULTS SCRIPT

```
Read from file... Results/Perception/IT_Subject 1
Read from file... Results\Perception\IT_Subject 2
Read from file... Results\Perception\IT_Subject 3
Read from file... Results\Perception\IT_Subject 4
Read from file... Results\Perception\IT_Subject 5
Read from file... Results\Perception\IT_Subject 6
Read from file... Results\Perception\NL_Subject 1
Read from file... Results\Perception\NL_Subject 2
Read from file... Results\Perception\NL_Subject 3
Read from file... Results\Perception\NL_Subject 4
Read from file... Results\Perception\NL_Subject 5
Read from file... Results\Perception\NL_Subject 6
Read from file... Results\Perception\NL_Subject 7
Read from file... Results\Perception\NL_Subject 8
select ResultsMFC IT_Subject_1
plus ResultsMFC IT_Subject_2
plus ResultsMFC IT_Subject_3
plus ResultsMFC IT_Subject_4
plus ResultsMFC IT_Subject_5
plus ResultsMFC IT_Subject_6
plus ResultsMFC NL_Subject_1
plus ResultsMFC NL_Subject_2
plus ResultsMFC NL_Subject_3
plus ResultsMFC NL_Subject_4
plus ResultsMFC NL_Subject_5
plus ResultsMFC NL_Subject_6
plus ResultsMFC NL_Subject_7
plus ResultsMFC NL_Subject_8
Collect to Table
Insert column... 2 lislang
Formula... lislang if index (self$[row,"subject"], "IT") then "IT" else "NL" fi
Insert column... 4 spelang
Formula... spelang if index (self$[row,"stimulus"], "IT") then "IT" else "NL" fi
Insert column... 5 speint
Formula... speint left$(right$(self$[row,"stimulus"],2),1)
Write to table file... allResponses.table
```

APPENDIX H – ADD STIMULUS PROPERTIES TO RESPONSE TABLE SCRIPT

```
Read from file... allResponses.table
Read from file... stimulusProperties.table
select Table allResponses
Append column... duration
Append column... voiFrames
numberOfRows = Get number of rows
for row to numberOfRows
	stimulus$ = Get value... row stimulus
	select Table stimulusProperties
	stimulusRow = Search column... stimulus 'stimulus$'
	duration$ = Get value... stimulusRow duration
	voiFrames$ = Get value... stimulusRow voiFrames
	select Table allResponses
	Set string value... row duration 'duration$'
	Set string value... row voiFrames 'voiFrames$'
endfor
```

APPENDIX I – DRAW PRODUCTION SCRIPT

```
# Praat script Rivas/drawProductions.praat
# Paul Boersma, August 8, 2006
# This script draws an "s" or a "z" at all the duration-voicedness positions
# of the speakers of Dutch and/or Italian.

form Draw responses
	choice Speaker_language 1
		option Dutch
		option Italian
endform
#
# Select only the requested speaker language.
#
Read from file... allResponses.table
if speaker_language$ = "Dutch"
	Extract rows where column (text)... spelang "is equal to" NL
	numberOfSpeakers = 5
elsif speaker_language$ = "Italian"
	Extract rows where column (text)... spelang "is equal to" IT
	numberOfSpeakers = 5
else
	Copy... source
	numberOfSpeakers = 10
endif
Rename... source
#
# Sort by stimulus.
#
Sort rows... stimulus subject
numberOfRows = Get number of rows
numberOfStimuli = 60 * numberOfSpeakers
numberOfListeners = numberOfRows / numberOfStimuli
Erase all
Axes... 0.04 0.21 -0.1 1.1
Text bottom... yes Duration (milliseconds)
One mark bottom... 0.05 no yes yes 50
One mark bottom... 0.10 no yes yes 100
One mark bottom... 0.15 no yes yes 150
One mark bottom... 0.20 no yes yes 200
Text left... yes Percent of voicing
One mark left... 0 no yes yes 0
One mark left... 0.5 no yes yes 50\%
One mark left... 1 no yes yes 100\%
Draw inner box
```

```
for stimulus to numberOfStimuli
	rowOffset = (stimulus - 1) * numberOfListeners
	duration = Table_source [rowOffset + 1, "duration"]
	voiFrames = Table_source [rowOffset + 1, "voiFrames"]
	numberOfEsses = 0
	for listener to numberOfListeners
		numberOfEsses += Table_source$ [rowOffset + listener, "speint"]
= "s"
	endfor
	assert numberOfEsses = 0 or numberOfEsses = numberOfListeners
	mark$ = if numberOfEsses > numberOfListeners / 2 then "s"
	... else if numberOfEsses < numberOfListeners / 2 then "z" else "?" fi fi
	Text... duration Centre voiFrames Half 'mark$'
endfor
Text top... yes 'speaker_language$' speakers
#
Append column... s
Formula... s self$[row,"speint"]="s"
Append column... z
Formula... z self$[row,"speint"]="z"
Remove column... subject
Remove column... lislang
Remove column... stimulus
Remove column... spelang
Remove column... speint
Remove column... response
To logistic regression
info$ = Info
intercept = extractNumber (info$, "Intercept: ")
durCoeff = extractNumber (info$, "duration: ")
voiCoeff = extractNumber (info$, "voiFrames: ")
bottom = (intercept + voiCoeff * -0.1) / -durCoeff
if bottom >= 0.040
	x = bottom
	y = -0.1
else
	x = 0.040
	y = (intercept + durCoeff * 0.040) / -voiCoeff
endif
top = (intercept + voiCoeff * 1.1) / -durCoeff
Draw line... x y top 1.1
echo <<<'info$'>>>
```

APPENDIX J – DRAW RESPONSES SCRIPT

```
# Praat script Rivas/drawResponses.praat
# Paul Boersma, August 7, 2006
# This script draws an "s" or a "z" at all the duration-voicedness positions
# of the speakers of Dutch and/or Italian, depending on the responses
# of the listeners.

form Draw responses
	choice Speaker_language 3
		option Dutch
		option Italian
		option Dutch and Italian
	choice Listener_language 1
		option Dutch
		option Italian
		option all
endform
#
# Select only the requested speaker language.
#
Read from file... allResponses.table
if speaker_language$ = "Dutch"
	Extract rows where column (text)... spelang "is equal to" NL
	numberOfSpeakers = 5
elsif speaker_language$ = "Italian"
	Extract rows where column (text)... spelang "is equal to" IT
	numberOfSpeakers = 5
else
	Copy... dummy
	numberOfSpeakers = 10
endif
Rename... dummy
#
# Select only the requested listener language.
#
if listener_language$ = "Dutch"
	Extract rows where column (text)... lislang "is equal to" NL
elsif listener_language$ = "Italian"
	Extract rows where column (text)... lislang "is equal to" IT
else
	Copy... source
endif
Rename... source
```

```
#
# Sort by stimulus.
#
Sort rows... stimulus subject
numberOfRows = Get number of rows
numberOfStimuli = 60 * numberOfSpeakers
numberOfListeners = numberOfRows / numberOfStimuli
Erase all
Axes... 0.04 0.21 -0.1 1.1
Text bottom... yes Duration (milliseconds)
One mark bottom... 0.05 no yes yes 50
One mark bottom... 0.10 no yes yes 100
One mark bottom... 0.15 no yes yes 150
One mark bottom... 0.20 no yes yes 200
Text left... yes Percent of voicing
One mark left... 0 no yes yes 0
One mark left... 0.5 no yes yes 50\%
One mark left... 1 no yes yes 100\%
Draw inner box
for stimulus to numberOfStimuli
	rowOffset = (stimulus - 1) * numberOfListeners
	duration = Table_source [rowOffset + 1, "duration"]
	voiFrames = Table_source [rowOffset + 1, "voiFrames"]
	numberOfEsses = 0
	for listener to numberOfListeners
	numberOfEsses += Table_source$ [rowOffset + listener, "response"] =
"s"
	endfor
	mark$ = if numberOfEsses > numberOfListeners / 2 then "s"
	... else if numberOfEsses < numberOfListeners / 2 then "z" else "?" fi fi
	Text... duration Centre voiFrames Half 'mark$'
endfor
Text top... yes 'listener_language$' listeners listening to 'speaker_language$'
#
Append column... s
Formula... s self$[row,"response"]="s"
Append column... z
Formula... z self$[row,"response"]="z"
Remove column... subject
Remove column... lislang
Remove column... stimulus
Remove column... spelang
Remove column... speint
Remove column... response
To logistic regression
info$ = Info
```

```
intercept = extractNumber (info$, "Intercept: ")
durCoeff = extractNumber (info$, "duration: ")
voiCoeff = extractNumber (info$, "voiFrames: ")
bottom = (intercept + voiCoeff * -0.1) / -durCoeff
if bottom >= 0.040
	x = bottom
	y = -0.1
else
	x = 0.040
	y = (intercept + durCoeff * 0.040) / -voiCoeff
endif
top = (intercept + voiCoeff * 1.1) / -durCoeff
Draw line... x y top 1.1
echo <<<'info$'>>>
```