The acquisition of second language contrasts: a problem of phonological representation or phonetic implementation?

A case study of the final obstruent voicing contrast with Dutch speakers learning English.

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1 Introduction

This research paper deals with the acquisition of second language (henceforth L2) contrasts, more specifically with the acquisition of the English final obstruent voicing contrast. This contrast is absent in the Dutch language while present in English. Because of this difference between the two languages, the final obstruent voicing contrast is a known obstacle in the acquisition of English pronunciation. Dutch speakers learning English tend to devoice the voiced final obstruents in English words, as they are used to in their native language. For example, many Dutch speakers learning English pronounce the English word ‘bed’ as [bet]. However, research shows that Dutch speakers learning English can perceive the final obstruent voicing contrast as well as native speakers in an auditory perception experiment (cf. Broersma, 2005).

I have previously investigated the phenomenon of final devoicing, or final laryngeal neutralisation, with Dutch children who had not yet received formal instruction in English (cf. Vael, 2010). Final devoicing entails the absence of the [+voice] characteristic in obstruents in final position. Whereas the contrast in voicing is maintained in this position in English, final obstruents are always devoiced in Dutch. In initial and medial position, a distinction in voice is made in both languages, which may lead to the belief that native speakers of Dutch will also be able to identify the difference in voicing in final position. The results indicated that there was an asymmetry between perception and production. The participants devoiced about 80% of the English words ending in a voiced obstruent while they could identify the final obstruent of about 70% of the English words correctly in an auditory perception experiment.

The present study aims to examine whether the high scores on the perception experiment were the result of a mere deciphering of phonetic characteristics or whether they were the result of a correct phonological representation of the English words. In this paper, I will investigate what caused the large number of production errors of Dutch speakers learning English with respect to the final obstruent voicing contrast. Two hypotheses can be formulated: First, the errors could be due to phonological misrepresentation, i.e. the learner is not aware of the contrast on meta-level. If this is the case, words like ‘bed’ and ‘bet’ are treated as homophones. Secondly, the errors could be
the result of erroneous phonetic realisation, i.e. a general difficulty to produce the right phoneme, despite a correct phonological representation. Further, the influence of the orthography on the phonological representation of the final obstruent will be included in the investigation. An orthography which is inconsistent with the pronunciation could distract the attention from the phonology, resulting in a wrong categorisation of the phoneme. For example, the word ‘eyes’ is written as <eyes>, with an <s> as final grapheme, while it is pronounced as [aɪz], the final phoneme being /z/. Inconsistence between orthography and phonology does not occur much in English with respect to consonants, but there are cases where it does, as is shown in the example.

By means of a literature study, this paper will first explore the insights derived from existing research on phonological representation. In the first chapter, the difference between two important terms is investigated, namely ‘phonology’ and ‘phonetics’. The properties of both terms are reviewed and a comparison is made. The second chapter deals with the influence of orthography on the phonological representation. In this chapter, the influence of reading acquisition on phonological awareness, the influence of orthography on production and perception respectively, and the influence of orthography in the acquisition of a foreign language are examined. In the third chapter, speech perception and the cognitive processing of speech are discussed. This chapter investigates the phenomenon of lexical access and the mechanisms of phonological representation in the mind of the speaker/listener. The final chapter discusses difficult contrasts for Dutch speakers acquiring English, with a focus on the final voicing contrast. The differences between the Dutch and English phonological systems, the different mental representation of the contrast in the two languages, and the technical difficulties in acquiring the contrast are discussed.

Next, by means of a series of experiments, I will determine whether Dutch speakers learning English have a correct phonological representation of the voice of English final obstruents or not. The role of orthography will also be examined by looking at the categorisation of the phonemes. I had, a priori, conducted a control experiment with native speakers of English, with the purpose of controlling the linguistic behaviour of the native speakers of English with respect to the final voicing contrast. Two experiments were conducted with two different groups of Dutch learners of English. The first experiment was a combination of a rhyme task and a phoneme classification task. The phonemes investigated
were the final obstruents of a number of common English words. By comparing rhyming and phoneme classification, the difference between subconscious knowledge and meta-knowledge should become clear, although mutual interference between the two tasks should be taken into account. A small similar task with Dutch words accompanied this task, in order to compare the representations in the two languages and establish possible transfer relations. In this first experiment, the orthography was visible and may have interacted with the decisions of the participants. Therefore, a second experiment was conducted with a different group. This experiment entailed the same tasks as the first one, except that the written words had been replaced by pictures. The reason for the replacement by pictures was an attempt to eliminate the influence of the spelling as much as possible. A comparison with the first experiment would then determine whether there was a significant difference between the results of the two experiments. This comparison should show whether the explicit presence of spelling influenced the phonological decision-making.
2 Phonology and phonetics

To determine the nature of the errors Dutch speakers make with respect to final obstruent voicing, the distinction between phonetics and phonology should be clarified. This distinction is important to our research question because of our two hypotheses. The first hypothesis, dealing with phonological representation, is linked with phonological features, while the second hypothesis, dealing with erroneous pronunciation, is linked with phonetic features (cf. section 1, ‘Introduction’).

2.1 Properties of phonetic features

According to Collins and Mees (2003: 8), the branch of ‘phonetics’ studies sound in human language. It is a branch studying the technical properties of human language. Phonetic properties are part of the human biological system, and not bound to a specific language. Keating (1984: 297) distinguishes three phonetic categories concerning obstruents, namely prevoiced, voiceless unaspirated and voiceless aspirated ones. These categories are based on the specific acoustic phonetic properties they possess, such as voice and aspiration. A concrete human sound which is pronounced differently by all speakers, but is comprehended by others because they make abstraction of the individual differences in the speech signal is called an ‘allophone’. The abstract signal that is realised as an allophone is called a ‘phoneme’. Each language has its own phoneme system, so this type of signal is language-specific and does not deal with technical or biological features (cf. section 2.2).

Our second hypothesis, namely that the errors in the production of the final obstruents of Dutch speakers learning English are due to erroneous pronunciation, is linked to the phonetic properties of the human articulatory system. This would mean that it is difficult for Dutch speakers to pronounce a voiced speech signal before a pause. The ease, or difficulty in this case, of pronunciation is linked to the principle of markedness. One of the criteria to determine the level of markedness is ease of acquisition. A feature which is hard to acquire is called a marked feature, and a feature which is easy to acquire is called an unmarked or less marked feature (cf. Archangeli, 1999). If we consider the difficulties learners have in acquiring the pronunciation of final voiced obstruents, we can assume that this is a marked feature, at least with respect to pronunciation. Usually the less marked
features are also more present in the languages of the world, while the more marked ones are less present in the languages of the world (cf. Archangeli, 1999).

Another factor inhibiting the acquisition of the English final obstruent voicing contrast is transfer from the native language. Ellis (1994) defines transfer as “the incorporation of features of the L1 into the knowledge systems of the L2 which the learner is trying to build” (Ellis, 1994: 28). A large number of studies have shown that transfer has a considerable influence on the acquisition of L2 phonology (cf. Ellis, 1994, Odlin, 1989, Simon, 2010a, Vael, 2010). It is widely known that the pronunciation accuracy of L2 learners provides many difficulties. Since Dutch speakers are used to devoicing all final obstruents, they will continue to do so when speaking an L2, especially in the initial stages of acquisition. The learner’s pronunciation would approximate the target language more as the learner gains a higher level of proficiency.

The transfer of the final devoicing process from the mother tongue into the target language is reinforced by the drive towards unmarked features. Because of the cooperation of these two factors, Dutch learners of English tend to maintain voiceless codas where English speakers use voiced codas. Ellis (1994) also acknowledges the joined influence of transfer and markedness in his hypothesis that “learners will transfer unmarked forms when the corresponding TL form is marked, and learners will resist transferring marked forms, especially when the corresponding TL form is unmarked” (Ellis, 1994: 320). This hypothesis is related to the ease with which Dutch speakers transfer the final devoicing process from Dutch into English.

2.2 Properties of phonological features
Phonology is “the study of the selection and patterns of sounds in a single language” (Collins and Mees, 2003: 8). Phonology uses ‘phonemes’, abstract segments of speech, which are linked to a particular language. Each language has its own phoneme system, which can show correspondences to other languages but is overall unique to each language. The study of the differences and similarities between phoneme systems of different languages is called ‘contrastive analysis’. The phoneme systems of English and Dutch are largely similar, but some differences are observed. With respect to the obstruents, they have some similar phonemes, namely /t, d, p, b, s, z, f, v, k, j, ʒ/. The English system further contains the
phonemes /ɒ, θ, ɡ/, which do not appear in Dutch, except in loanwords. In Dutch, the phonemes /ɣ, χ/ appear, which, in their turn, are not part of the English phoneme system.

Phonemes are “contrastive units of sound which can be used to change meaning” (Collins and Mees, 2003: 11). For example, in English, the final voice contrast between phonemes /t/ and /d/ can cause a change of meaning (e.g. ‘bad’ /bæd/ vs. ‘bat’ /bæt/). In Dutch, a contrast in voice can never occur in final position, which sometimes results in the formation of homophones (e.g. <hard> ‘hard’ vs. <hart> ‘heart’, both pronounced as [hørt]). However, these same phonemes /t/ and /d/ are contrasted in initial and middle position (e.g. /Bɛn/ ‘Ben’ vs. /pɛn/ ‘pen’ and /baːdɑn/ ‘bathe’ vs. /baːtɔn/ ‘avail’).

Phonemes are abstract units which only exist in the mind of the speaker. Only an allophone can be pronounced; it is the realisation of a particular phoneme. Phonemes are the units which are used when one refers to phonological representation. The first hypothesis, namely that errors in the pronunciation of final voiced obstruents are due to phonological misrepresentation, is linked with the phonological properties of the segment. If this is the case, the lexical representation of the word is incorrect because the phonological representation of the final consonant is [-voice] rather than [+voice].

This hypothesis is linked with the branch of psycholinguistic studies. This field of study investigates how a speech message is formulated in the brain of the speaker and how it is interpreted in the brain of the listener. Psycholinguistic studies investigate the nature of phonological representation, and various definitions have been formulated. Taft & Hambly (1985) stated that a phonological representation has for a long time been seen as “a silent version of the pronunciation of the word” (Taft & Hambly, 1985: 321). In this definition, no distinction is made between phonetics and phonology. Later, generative phonologists started making a distinction between phonetics and phonology. They assumed that “morphologically related words share the same abstract underlying phonemic representation from which their surface phonemic representations are generated by rule application” (Taft & Hambly, 1985: 321). The mental representation of a word was not necessarily equal to its phonetic realisation anymore. For example, the word ‘thief’, [θi:f] can
be assumed to have the underlying phonological representation /θi:v/, containing a voiced obstruent, since it is morphologically related to the plural ‘thieves’, [θi:vz], /θi:vz/.

The difference between the decoding of a word at the phonetic level or at the phonological level depends on the lexical proficiency of the speaker. Foss and Blank (1980, in Taft & Hambly, 1985: 320) have presented the ‘Dual Code hypothesis’, which states that decoding happens at the phonetic level before lexical access has taken place and at the phonological level after lexical access has been achieved. If a learner of English hears a word of which he does not yet know the lexical meaning, he will process it based on phonetic (acoustic) properties. If the learner, on the other hand, knows what the word means, he will decode the acoustic signal as it is stored in his mind. In the latter case, the speaker already possesses a representation of the phonemes that the word contains and expects to hear these particular phonemes as the word unfolds.

2.3 The link between phonology and phonetics

Keating (1984: 287) differentiates between phonetics and phonology in terms of the number of features used to describe the different segments. The phonetic categories entail more detail because they have to describe any possible differences between sounds. Therefore, there are many more phonetic categories than there are phonological ones. The phonological categories describe the underlying, abstract forms of sounds. With respect to voice, variation in obstruents is phonologically described across languages by means of two phonemic classes: voiced and voiceless ones. Keating (1984: 289) argues that using the same set of features contributes to the confusion between phonetics and phonology.

The difficulty with the comparison between phonologically voiced and voiceless obstruents in Dutch and English, is that these obstruents belong to different phonetic categories in the different languages. Dutch distinguishes between fully voiced unaspirated obstruents and voiceless unaspirated obstruents, while English distinguishes between voiced unaspirated obstruents and voiceless aspirated obstruents. The final ‘voiced’ obstruents in English are usually partially devoiced, although they are still different from the final obstruents which are completely voiceless and aspirated. Because of this partial devoicing in final position, vowel duration is an important cue for English speakers with respect to voice. In English, the vowel duration is “proportional to the phonetic ‘voicedness’ of the following
stop” (Keating, 1984: 293). Dutch speakers do not use vowel duration as a cue in their native tongue because the voice characteristic can be determined based solely on the acoustic features of the speech signal (voiced unaspirated or voiceless unaspirated). Therefore, it is difficult for Dutch learners of English to start using vowel length as a cue. In her experiment, Broersma (2005) found that, although the Dutch learners of English could categorise the final obstruents equally well as the native English speakers, they disregarded vowel length as a cue for voice and based their categorisations on the realisation of the obstruent itself.

The problem for Dutch learners of English with respect to final obstruents is mainly that there are three phonetic categories of voice in English. The phonological feature [+voice] is always voiced unaspirated, but the feature [-voice] can be voiceless aspirated or voiceless unaspirated. In Dutch, on the other hand, [+voice] is always voiced unaspirated and [-voice] is always voiceless unaspirated. In final position, English speakers realise the voiced obstruent as an allophone between the phonetic categories of voiced unaspirated and voiceless unaspirated. Since aspiration is not used as a significant marker for voice in Dutch, Dutch speakers tend to disregard the value of aspiration in English. Because Dutch speakers are not familiar with vowel length as a cue, nor with aspiration as a cue, they have difficulties with discerning the exact nature of the final obstruent. They can either categorise the obstruent as voiced because the speech signal is not completely devoiced, or they can categorise it as voiceless because it is less voiced than a fully voiced obstruent.
3 Orthography and phonology

Controversies exist about the connection between the phonological and the orthographic representation of a word. The relative influence of orthography on the phonological representation has been studied extensively in psycholinguistics (cf. Goswami et al, 2005, Alario et al, 2007, Lindell et al, 2008). Over the years, many different roles have been attributed to the orthography. In this chapter, a number of views on the effect of the orthography on the phonological representation will be discussed, in order to establish a framework which will be used as a basis for the analysis of the experiments.

3.1 The influence of reading acquisition on phonological awareness

Goswami et al. (2005) investigated the way in which reading acquisition affects the phonological representation in children. They compared how reading acquisition affected the phonological representations of English and German children. Since English and German have a different orthographic system and a similar phonological system, it may be expected that reading acquisition of these different orthographies will affect the phonological representations of the two groups differently. The German orthographic system is more transparent, i.e. the graphemes correspond to the phonemes more consistently than the graphemes of the English system do. For example, the English phoneme /f/ can be represented as <ph>, as in the word ‘telephone’, or as <f>, as in the word ‘face’. The same phoneme /f/ in German is only represented by one grapheme <f>, as in the word ‘Telefon’ (‘telephone’).

First, Goswami et al. (2005) note that phoneme awareness only plays a role with learners whose written language has an alphabet that represents these phonemes. Both English and German learners qualify for this criterion. They add, however, that “cross-language variation in the reciprocal relation between the acquisition of written language and the further development of phonological awareness” (Goswami et al., 2005: 346) exists even between languages that share the same alphabet. The ‘psycholinguistic grain size theory’ (Ziegler & Goswami, 2005, in Goswami et al., 2005) describes the difference in phonological awareness between prereaders and beginning readers whose alphabet represents phonemes. The general evolution of phonological representations before and after access to spelling is a transition from large units, such as whole words or syllables, to a smaller unit,
the phoneme. This transition is a direct result of the teaching of sound-to-spelling correspondences.

The differences between English and German spelling are roughly similar to the differences between English and Dutch spelling. In English, the spelling-to-sound correspondences of the consonant/obstruent remain intact in a word ending in a voiced obstruent. In German and Dutch, however, the final voiced obstruent becomes voiceless while remaining voiced in the spelling. The children acquiring reading skills have to learn this inconsistency in order to develop a correct phonological awareness of their mother tongue. As we can see in figure 1 below, English and Dutch use the same word to refer to a ‘bed’. This word is spelled the same way and has the same underlying representation in the two languages, but it differs with respect to realisation. Because of the final devoicing rule in Dutch, the realisation of the final obstruent is voiceless and hence deviant from the orthographic and underlying phonological representation. In English, the final obstruent retains the [+voice] aspect in the phonetic realisation.

<table>
<thead>
<tr>
<th></th>
<th>English</th>
<th>Dutch</th>
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<tbody>
<tr>
<td>Orthography</td>
<td>&lt;bed&gt;</td>
<td>&lt;bed&gt;</td>
</tr>
<tr>
<td>Phonological rep.</td>
<td>/bed/</td>
<td>/bed/</td>
</tr>
<tr>
<td>Phonetic rep.</td>
<td>[bed]</td>
<td>[bet]</td>
</tr>
</tbody>
</table>

*Figure 1: example of difference in final voicing between English and Dutch*

Another differentiating factor between English and German/Dutch is the difference in consistency of the spelling-to-sound correspondences. In German or Dutch, spelling-to-sound relations are relatively consistent, so these children “acquire reading by recoding words at smaller grain sizes” (Goswami et al., 2005: 347). In English, however, letters have multiple pronunciations and one phoneme can have different spellings. Therefore, English children learning how to read “look for higher levels of orthographic consistency to supplement phonological recoding at smaller grain sizes” (Goswami et al., 2005: 347). Based on this observation, Goswami et al.’s (2005) hypothesis is that “differences in spelling-to-sound consistency result in the use of different orthographic grain sizes by beginning readers in different languages” (Goswami et al., 2005: 347).

Goswami et al.’s (2005) first experiment consisted of a rhyme task with German and English readers and prereaders. The children had to pick the odd one out, which did not share the rhyme, in a sequence of three words. The spelling of the words was consistent in
half the words (e.g. ‘house’ - ‘mouse’) – the rhyming part of the words was spelled the same way – and inconsistent in the other half (e.g. ‘state’ - ‘great’). The words were auditory presented to the participants. The results of this experiment showed a consistency effect in child readers but not in child prereaders. The prereaders did not experience a hindering effect by the inconsistent spelling of rhyming words while the beginning readers did. This effect is seen as a direct result of the reading acquisition. These results suggests that the children who were able to read activated the spellings of the words they heard, whereas the prereaders focused solely on what they heard. From the moment they had learned how to read, the children based their phonological decisions at least partially on the orthographic representation. On the basis of Goswami et al.’s (2005) results, one may assume that literate adults will most likely behave in the same way. They will probably activate the spelling, even if it is not explicitly present (cf. section 8).

Goswami et al. (2005) also conducted a second experiment, rearranging the triplets used in the first experiment (e.g. ‘state’ - ‘great’ - ‘fleet’). In this second experiment, the participants had to make an oddity judgment about the vowel, i.e. they had to indicate the word with the different vowel. The German participants outscored the English participants in this experiment. This result can be attributed to the greater transparency of the German language. Goswami et al. (2005) concluded that the German readers had developed a better phoneme awareness, while the English readers used a larger grain size, the rime, to make phonological judgments. The results of their experiments indicate that there is indeed interaction between the orthographic consistency of a language and the manner in which phonological representation is established.

In an earlier paper, Goswami (1999) explored the importance of rhyme in early reading acquisition. In the ‘causal connections theory’ (Goswami and Bryant, 1990, in Goswami, 1999), “a connection between pre-school awareness of rhyme and alliteration and later progress in reading and spelling, a connection between tuition at the level of the phoneme and the development of phonemic awareness, [...] and a connection between progress in spelling and progress in reading”(Goswami, 1999: 218) is assumed. The basis for this theory is that reading happens at different levels. Beginning readers take into account the spelling, rhyme and phonemes, as presented in figure 2 below. Rhyme is an important element in the acquisition of the English spelling system, since this system is inconsistent
with the phonological system. Whereas consonants are reasonably consistent in English, the inconsistency is most obvious in the vowels. In an analysis of monosyllabic \(=C_1VC_2\) words, the pronunciation of vowels only has a consistency rate of 51\% (cf. Treiman et al., 1995, in Goswami, 1999). The analysis by Treiman et al. (1995, in Goswami, 1999) showed that the spelling system of English is most consistent for initial consonants \(=C_1\), final consonants \(=C_2\), and rimes \(=VC_2\). She further found that the final consonant contributes to the pronunciation of the vowel (e.g. ‘cat’ vs. ‘ball’). Since the rime is considered as a unit in English, one must use the rime as a means to investigate the final consonant. In the experiments in the present paper, the rime will be used as a unit to investigate the participants’ knowledge of the final obstruent voicing contrast.

![Diagram](image)

**Figure 2: factors influencing beginning readers (adapted; in Goswami, 1999: 219)**

### 3.2 The influence of orthography on production

Although the link between orthography and production is not a direct one, these two aspects of language acquisition are linked through the lexical representation of words. Language speakers have different interacting systems dealing with language production. The orthographic system is used during written language production and the phonological system is used during spoken language production. Both these systems draw on mental representations before any production can take place. A language speaker has a specific representation (either orthographic or phonological) in his mind and uses this representation as a basis for the production of speech or writing.

One scholar who investigating the effect of orthography on speech production was Roelofs (2006). He conducted three experiments in Dutch, with 18 adult participants that were native speakers of Dutch. In one experiment, the spelling was relevant (oral reading)
and in the other two the spelling was irrelevant (object naming, spoken word generation). He wanted to investigate whether spelling influences word production only when relevant for the production task at hand, or whether it influences every form of word production. Roelofs (2006) first reviewed the insights brought by Meyer (1990, 1991, in Roelofs, 2006), who argued in favor of a limited influence of orthography, i.e. only when the spelling was relevant for the task. Meyer (1990, 1991, in Roelofs, 2006) claimed that his results were a consequence of the ‘preparation effect’, which meant that orthographically homogeneous sets of words induced a faster spoken response than heterogeneous sets. An alternative view was proposed by Damian and Bowers (2003, in Roelofs, 2006). They argued in favor of the view that orthography influences spoken word production, regardless of its relevance.

Roelofs’ (2006) experiments (word reading, object naming and word generation) produced the following results: In the reading experiment, “participants could benefit from foreknowledge of the initial phoneme of a word, but only when the spelling of the phoneme was also shared” (Roelofs, 2006: 35). This result already suggests that there is definitely some influence of the orthography on spoken production. In the object naming and the word generation experiment, “participants could benefit from foreknowledge of the initial phoneme, regardless of whether the spelling of the phoneme was shared” (Roelofs, 2006: 36). From the results of these experiments, Roelofs (2006) concluded that the effect of the spelling only operates when spelling is relevant for the production task at hand. However, Damian and Bowers’ (2003, in Roelofs, 2006) experiment dealt with English participants while Roelofs’ (2006) experiment was conducted with Dutch participants. There could be cross-linguistic differences in the degree to which orthography and phonology interact in speech production. These differences would be related to the orthographic consistency of both languages.

Another view was given by Alario et al. (2007), who argued that the speech production process was not affected by the orthography. They noted that the relationship between orthography and production differs from the relationship between orthography and perception/processing of speech. The latter are linked to one another more directly than the former. Language processing, a direct consequence of perception, happens through “the joint activation of orthography, phonology and semantics” (Alario et al. 2007: 465). Alario et al. (2007) pointed out that the study of orthographic effects on spoken language
had been limited to perception studies, and that little attention had been paid to the orthographic influence on production. Further, the few studies that had dealt with production had produced contrastive results.

Controversies remain in this area, especially because it is difficult to design adequate experiments to test the influence of orthography on production without accessing other factors of speech processing, such as the memory. Some scholars (cf. Damian and Bowers, 2003, in Roelofs, 2006) favour the view that the orthography influences all forms of word production, and others (cf. Alario et al., 2007) deny any influence that spelling may have on word production. It will yet take much more research to determine the exact degree of influence that orthography exercises on word production.

3.3 The influence of orthography on speech perception and processing

Already in 1985, Taft & Hambly established a connection between orthography and phonological processing. They conducted a vowel categorisation experiment in which the words were only presented orally and the participants had to classify the vowel they heard. Despite the fact that they did not see the words, their responses were influenced by the orthography of the words. Taft & Hambly concluded from this result that the orthographic information is inherent to the lexical representation of a word. The suggestion made here is that “once a language user learns to spell, his knowledge of orthography fundamentally alters his phonological representations” (Taft & Hambly, 1985: 325).

Taft & Hambly (1985) propose two hypotheses about the influence of orthography on the lexical representation of words. According to the first hypothesis, the lexical representation of a word is equal to an orthographic representation, with sound-to-spelling conversion and lexical information linked to the spelling, not to the phonology. The second hypothesis is that the lexical representation remains at an abstract phonological level, with some orthographic influence. Taft & Hambly (1985) favour the second view. They see the lexical representation of a word as an instrument which entails codes for both the pronunciation and the spelling of the word. Instead of seeing orthography and phonology as separate entities, Taft & Hambly (1985) see them as ‘combined forces’ which are used to access information about a word.
Bitan et al. (2007) also dealt with the interaction between orthographic and phonological information. They established four relations between orthography and phonology. Either word pairs have a different orthography and phonology (e.g. the rimes in ‘staff’ - ‘gain’), or the same orthography and phonology (e.g. the rimes in ‘lime’ - ‘dime’). These two relations are called ‘non-conflicting conditions’. The word pairs can also appear in ‘conflicting conditions’. In that case, the word pairs have a similar phonology and different orthography (e.g. the rimes in ‘jazz’ - ‘has’), or a similar orthography and different phonology (e.g. the rimes in ‘pint’ - ‘mint’). Bitan et al. conducted an experiment containing two tasks. In both tasks, they presented the participants with orthographic representations of the stimuli. The first task was an orthographic task in which the native English participants had to make a judgment about the spelling (i.e. indicate whether it was correct or not). The second one was a phonological task in which the participants had to make a rhyming judgment. Bitan et al. (2007) wanted to see which processes were activated during the tasks. They found that in the conflicting pairs, the participants were mapping orthography to phonology, using conflicting information irrelevant to the task at hand. For example, when making rhyming judgments about written words, orthographic processes interfered with the phonological processes in the conflicting conditions (e.g. ‘pint’ - ‘mint’ elicited many errors). In non-conflicting pairs this interference was less apparent.

Orthographic and phonological representations are not only examined in the field of psycholinguistics but also in the field of neurolinguistics. Lindell et al. (2008) investigated whether the incapability of the right hemisphere to produce language is linked to its inability to convert orthography to phonology. They found neurological evidence that phonological processing tends to be restricted to the left hemisphere with males, but available in both hemispheres with females. They also found that, in conscious comparison of stimuli, such as rhyme judgments, orthographic similarity of the stimuli has a great influence on the accuracy and elicits faster responses.

3.4 The role of orthography in the acquisition of a foreign language
Learners of a foreign language often learn this language after they have learnt to read their native language. Hence an influence of orthography may be expected in the acquisition of the phonology of a new language. Unlike the acquisition of the first language, which is learned mainly through spoken input, a second language is often learnt through visual input
such as spelling in textbooks. In this section I will discuss the acquisition of English as a foreign language and how orthography may influence the learning process.

Simon et al. (2010) investigated whether exposure to new grapheme-to-phoneme correspondences can help language learners in the acquisition of a new phonological contrast. They wanted to know whether learning to distinguish two similar-sounding categories is helped by a different spelling of the two categories. Simon et al.’s (2010) hypothesis was that “two different orthographic representations will help learners create two different phonological representations” (Simon et al., 2010: 382). Their experiment tested American English-speaking learners’ knowledge of the French contrast between /u/ and /y/. The outcome of the experiment, however, did not support their hypothesis that the presence of spelling would aid the learners to build separate phonological classes of the new contrast. They provided two possible explanations for the lack of effect of orthography. The first explanation was that the participants already had two distinct lexical classes in particular contexts. A second experiment showed that two-category assimilation was indeed preferred when the vowel was followed by a bilabial consonant. The second explanation was that there was too much variation in the stimuli, because they were produced by different native speakers of French.

In order to eliminate these factors, Simon et al. (2010) conducted a third experiment, where the tokens were all produced by the same person and where the consonantal context was held constant at alveolar. Nevertheless, even after this experiment, the results were not conclusive. The results were explained by referring to the specific nature of the English language. In English, there is no one-to-one grapheme-to-phoneme correspondence for most vowels. Therefore, English speakers “may be less likely to rely on spelling to create distinct phonological categories than speakers of a language with a more transparent orthographic system” (Simon et al. 2010: 391-392).

This conclusion can be extended to Dutch speakers learning English. Overall, the Dutch orthographic system is more transparent than the English one. However, with respect to final obstruents, Dutch speakers have learned not to rely on spelling. Therefore, it is possible that Dutch speakers would have erroneous phonological representations of final voiced obstruents in English if they were not taught explicitly about the difference between Dutch and English regarding the final obstruent voicing contrast. Although the spelling
supports the distinct phonological categories of final obstruents, the Dutch learners may not see the different graphemes as representing distinct phonological classes.

3.5 Orthographic effects on the lexical representation of L2 words

Van Heuven, Dijkstra and Grainger (1998) examined the effect of orthographic neighbours on word recognition with Dutch-English bilinguals. An orthographic neighbour is defined as “any word differing by a single letter from the target word, respecting length and letter position” (Van Heuven et al., 1998: 460). For example, the words ‘man’ and ‘mad’ are orthographic neighbours, since they differ from each other by only one letter. Two hypotheses have been formulated by Van Heuven et al. The first hypothesis is that the recognition of a target word is only affected by neighbourhood effects in the target language. This hypothesis predicts that no effects from the non-target language will be experienced. For example, when a bilingual English-Dutch speaker is presented with the English word ‘dog’, he would experience a neighbouring effect from the English word ‘log’, but not from the Dutch word ‘dom’ (‘dumb’). Their second hypothesis is that neighbourhood effects of both languages will be experienced during word recognition. This second hypothesis thus predicts that word recognition in one language will be influenced by orthographic factors from both the target language and the non-target language. In this case, a neighbouring effect would be experienced from both the English word ‘log’ and the Dutch word ‘dom’ (‘dumb’), when the bilingual English-Dutch speaker is presented with the English word ‘dog’.

Van Heuven et al. conducted four experiments to test their hypotheses. The first two experiments involved word identification. The participants were Dutch students which were divided in two groups, respectively with high and low proficiency in English. They were given a series of words; each word appeared gradually on the screen of a computer. They were asked to identify the word as soon as they recognised it. The first experiment included blocks of English or Dutch words respectively, while the second experiment involved mixed blocks of English and Dutch words. The results of these two experiments confirmed the second hypothesis, namely that word recognition was influenced significantly by the number of orthographic neighbours in the non-target language. The third experiment involved a generalised lexical decision. The participants were presented with a string that was either a Dutch or an English word and they were asked to identify this string. Also in this experiment,
significant inhibition from neighbours from the non-target language was observed. Since the dominant language of the bilinguals was Dutch, this language influenced the performance towards non-word input most. Rejection times were longer when a certain input had many Dutch orthographic neighbours, as opposed to an input with many English orthographic neighbours. In the fourth experiment, the performance of Dutch-English bilinguals and English monolinguals was compared. The participants had to make a lexical decision about English words and English-like non-words. The results of this experiment showed that the number of Dutch orthographic neighbours did not influence the responses of English monolinguals, while this factor did significantly influence the responses of Dutch-English bilinguals.

The general conclusion of Van Heuven, Dijkstra and Grainger’s (1998) investigation was that the input words and non-words “automatically activate orthographically similar words in both the target language and the other language of the bilingual participant” (Van Heuven et al., 1998: 473). Since the bilinguals were described as having an L1 (Dutch) and an L2 (English), their performance on the experiments can be compared to proficient Dutch learners of English. Van Heuven et al. (1998) noted that the cross-language neighbourhood effects were stronger in L2 target words than in L1 target words. This observation reflects the limited exposure of the bilinguals to L2 input as opposed to L1 input. Exposure to L2 input is a factor which can be extended to Dutch learners of English, whose exposure to English is limited (usually in the classroom and from popular culture) as opposed to exposure to their mother tongue, Dutch.

Ota, Hartsuiker and Haywood (2009) discussed the effect of near-homophony in word recognition with learners of an L2. They examined the effect of phonological neighbours in the L2 containing a contrast which is absent in the learner’s L1. Ota et al. (2009) studied the contrast /l/ vs. /r/ with Japanese-English and Arabic-English bilinguals. Their hypothesis was that the phonological representations of /l/ and /r/ were not completely separated in the minds of the participants, making word pairs containing this contrast homophones. Or as they put it, “lack of L2 contrasts in the L1 can lead to indeterminacy in phonological representations of L2 words in the mental lexicon” (Ota et al., 2009: 264).
They first established that viewing a visual word (e.g. the word ‘bare’) activates its homophone (e.g. the word ‘bear’) and causes semantic interference. The participants in their experiment were two groups of non-native English speakers, the first group with L1 Arabic, and the second with L1 Japanese. They also assembled a control group of native English speakers. The prediction of their experiment was that near-homophones would cause homophone-like effects in non-native speakers whose L1 did not contain the contrast, while it would not cause such effects in the group of native English speakers. They found that such homophone-like effects were observed only with minimal pairs that contained the contrast absent in the L1. The observed cross-lexical activation could not be attributed to auditory misperception, since the input was all visual. The results of their study showed that the recognition of non-native words and their representations is affected by L1 phonology, and that the effects are even visible in written word recognition, where the contrast is indicated by the orthography.
4 Mechanisms of cognitive processing of speech

4.1 Introduction
Phonological representations are formed in the speaker’s mind. They are not equal to the phonetic realisations of the words, but they are abstract entities that are stored in the mind of the language user. This storing of abstract entities is part of the cognitive processing of speech. Simply put, language users have since their birth stored a large number of concepts and have linked those concepts to a speech signal, to a word. When they hear a word or speak themselves, they access this ‘database’ of words and pick the language entities that are most appropriate for the message they want to convey. In this section, a number of views on the specific functioning of the cognitive processing of speech will be discussed.

Gaskell, Hare and Marslen-Wilson (1995) interpret the cognitive processing of speech in terms of a connectionist model. They claim that the mechanisms of lexical access of listeners accept certain deviation from the ‘ideal’ form with respect to the lexical representations. The lexical representation is seen as an abstract entity. The perceptual system, in the processing of speech, allows systematic variation of a form (e.g. a dialect word) while it rejects random variation (a non-word). The abstract phonological representations in the mental lexicon of the language user enable him to distinguish between those phonetic features that cannot deviate and those features that are susceptible to variation.

“Phonological variation is generally described in terms of a mapping from underlying to surface forms in the production of speech” (Gaskell et al., 1995: 408). When applied to actual phonetic variation, the above quote assumes an abstract phonological representation, which can be mapped to various surface forms, from which the speaker chooses one which he realises phonetically. This concrete form is understood by the listener, who maps it back to the abstract phonological representation. The phonetic realisation of the word is compared to the information stored in the mental lexicon, i.e. the abstract lexical representation of the received speech. This representation functions as a key to the meaning of the word. The cognitive system treats natural variation and random variation differently. Gaskell et al. (1995) found that whereas random variation significantly disrupted the process
of lexical access, systematic changes were accepted by the cognitive system as legitimate deviations.

Gaskell et al. (1995) discuss a theory concerning lexical abstraction as part of the cognitive processing of speech. The ‘theory of radical underspecification’ (Archangeli, 1988, in Gaskell et al., 1995) states that only some aspects of a word form are represented in the mind of the speaker, namely only the ones that are ‘unpredictable’. Which aspects are underspecified and which ones are specified is language-bound. Only the fixed characteristics, which are not prone to change, are represented in the mental lexicon, while all features which are open to variation are not specified. According to this theory, Dutch final obstruents would thus be underspecified for the voice characteristic while English final obstruents would be specified for this characteristic. Therefore, a word with a final voice feature which is deviant from the abstract phonological representation of that form is not tolerated by the cognitive system of English speakers. Dutch speakers’ cognitive systems would accept both forms, voiced and voiceless, since the voice characteristic is not relevant in final position. Normally, all Dutch final obstruents are voiceless but the cognitive system of a Dutch speaker will probably not be disturbed by a voiced obstruent in final position, because no voice contrast is present in that position. In Dutch, the voice feature is underspecified in final position. According to the theory of radical underspecification, tolerated phonological variation only occurs with unspecified features. This is the only kind of variation which is accepted by the cognitive system of language users. If variation were to occur with a specified feature, the cognitive speech processing system would object because the input would not match the representation present in the mind of the speaker.

A second aspect related to the cognitive processing of speech, according to Gaskell et al. (1995), is ‘phonological inference’. This is “a process that analyzes segments with reference to their phonological context in order to elucidate their underlying identity” (Gaskell et al., 1995: 413). Phonological inference is the ‘mapping back’ of concrete phonetic information to an abstract representation in the mind of the listener. By decoding the phonetic information, the listener can deduct the lexical information contained in the speech signal. Although random variation (non-words e.g. ‘zok’ instead of the Dutch word ‘kok’, English ‘cook’) is rejected by the cognitive system, regular variation (e.g. dialect forms)
is cancelled out in the mapping to the abstract lexical class, in the process of phonological inference.

In Gaskell et al. (1995), variation is understood as the assimilated form of a word in connected speech. It is assumed that the isolated form of a word equals the underlying form and that this form is used as reference in the processing of assimilated forms. This model of the formation of phonological representations has implications for the role of perception in the cognitive processing of speech. It assumes that phonological representations do not exist prior to perception, but that they are shaped during perception. The brain then distinguishes between underlying forms and forms which are adapted by connected speech. These underlying forms are retained and start being used as abstract representations, and concrete realisations are measured against these representations. Gaskell et al. (1995) conducted an experiment which showed that the viability of a concrete realisation is measured by the similarity between that realisation and the ideal (the representation). They found that the mapping from the surface form to its underlying representation is a necessary part of speech perception. They also extrapolated their findings to the production of speech. The mapping can be reversed in order to derive ‘rules’ of inference from their perceptual experience, rules which are used in the producing of speech.

4.2 The process of lexical access

Cutler, Weber and Otake (2006) see the processing of speech as the mapping from phonetic to lexical representations. They investigated this mapping with respect to the English /r/-/l/ contrast by means of an ‘eyetracking paradigm’ with Japanese learners of English. Because of the technique of ‘eyetracking’, it is possible to follow the listener’s processing before it is certain which word form is being heard, when alternative possibilities are still competing. This way, they can determine whether the participants make a distinction at all between the two categories, and if they do, which is the dominant category with the Japanese listeners.

Their results suggested that L2 listeners may maintain a distinction between two phonetic categories of the L2 in their lexical representations. This would be possible even though they are incapable of perceptually discriminating the contrast. At the phonetic processing level, however, one of the L2 categories is dominant. This dominance could be determined by acoustic-phonetic closeness or by orthographic influence. According to Cutler et al. (2006), the results show a dominance determined by the acoustic-phonetic proximity
to the nearest L1 category. The Japanese category of the flap /r/ is closest to the English /l/.

The experiment showed that both words with an /r/ and an /l/ were perceived as containing an /l/ before the participants made a final decision. Cutler et al. (2006) assume that the Japanese listeners have learned that for example ‘write’ and ‘light’ are supposed to sound different, and that they have thus stored this distinction in some way in the phonological representations of the words containing these sounds, even though they do not perceive the difference.

The influence of native-language phonology on lexical access is studied by Pallier et al. (2001). They investigated the many errors L2 learners make when two L2 phonemes are assimilated to the same L1 phoneme (cf. Cutler et al., 2006, on the Japanese’s difficulties with the /l/-/r/ contrast). The participants in their study were Catalan-Spanish bilinguals, some with Spanish as the dominant language and others with Catalan as the dominant language. The participants were presented with auditory stimuli containing three Catalan-specific contrasts and were asked to make a lexical decision about the words they heard. Pallier et al. (2001) found that most Spanish-dominant bilinguals could not well perceive a Catalan contrast that did not exist in Spanish. Minimal pairs containing this contrast were processed as homophones. Pallier et al. (2001) conclude from this result that speakers will often represent L2 word pairs as homophones if they have difficulties perceiving the contrast. They claim that the native phonological representations, once acquired, are hard to modify. This view is opposed to Cutler et al.’s (2006) view, who claims that, although the contrast is not perceived, the L2 learners have an abstract notion of the contrast in their mental lexicon.

Van Heuven, Dijkstra and Grainger (1998) discuss how the way of storing and processing words from different languages is influenced by cross-language interference effects. They discuss two hypotheses about the nature of the mental storage room of a foreign lexicon in Dutch-English bilinguals. Either the learners have one integrated lexicon for both languages, or they have two separate lexica, one for each language. They pose the question “whether words of both languages are activated (or considered as candidates) during word recognition, or only words belonging to the targeted language”(Van Heuven et al., 1998: 458-459). Figure 3 schematically presents the hypotheses.
Figures 3A and 3B are representations of a hypothesis that assumes language-selective access, i.e. only words of the targeted language are activated during word recognition. Figure 3A assumes two separate lexica while figure 3B assumes one integrated lexicon, containing both languages. If one assumes this type of access, the process goes as follows. The learner, at first, only accesses representations in one of the languages. If the representation is not found in the accessed lexicon, the learner contacts the other lexicon. According to figures 3C and 3D, words from both lexica that are partially compatible with the input are activated simultaneously. Hypothesis 3C assumes that words of one lexicon are checked before those of the other, i.e. that one language is dominant in the mental representational system of the learner. In hypothesis 3D, words from both lexica are accessed in order of their relative frequency. Whereas hypotheses 3C and 3D assume intrinsic inhibitions caused by differences between the two languages, hypotheses 3A and 3B limit these inhibitory influences to within the language.

These hypotheses can be applied to proficient Dutch learners of English who are presented with an English word ending in a voiced obstruent. If one assumes hypothesis 3A or 3B, the process of activation goes as follows: If the phonological representation is not
(yet) present in English, the L2 learner uses the Dutch phonological representation (e.g. ‘bed’ represented as [bet]). In hypothesis 3C, Dutch words would be checked before English words, since Dutch is the main language in the lexicon of a proficient speaker of English with Dutch as mother tongue (e.g. ‘bed’ represented first as [bet] and then as [bed]). Lastly, in hypothesis 3D the proficiency has reached a stage where the lexica of mother tongue and second language are nearly equal, to the point where the lexica are mixed in the mind of the learner (e.g. ‘bed’ represented simultaneously as [bet] and [bed]).

4.3 The representation of phonological form

As we have discussed in the introduction to this chapter, phonological forms are represented in speakers’ minds as abstract entities. Not only the entire word form is represented as a lexical entity, but also the phonological features of the word forms are represented. Jongman (1992) discussed the phonological representation of the voice characteristic. He compared Dutch representations of the voice contrast with English representations and claimed that the underlying form was similar in both languages. Both English and Dutch have an underlying contrast in obstruent voicing and in vowel length. The difference lies in the surface forms. In Dutch, the voicing contrast is neutralised when it occurs in final position in the surface form, while in English the contrast is maintained in all positions. Jongman (1992) suggests that listeners’ perception is guided by the underlying phonological representations.

The suggestion in Jongman’s (1992) paper is that the phonetic information provided to a listener is largely interpreted in terms of the phonological representations present in the listener’s mind. Jongman (1992) illustrates this with the different realisations of the word form ‘hand’ (Lahiri and Marslen-Wilson, 1991, in Jongman, 1992). In the sequence ‘hand you’, the final /d/ may become a [d3]. In the sequence ‘hand me’, the /d/ may be realised as [m] as a result of the deletion of [d] and the assimilation of preceding [n]. In the sequence ‘hand care’, the consonant cluster may result in [n], again because of deletion of [d] and assimilation of [n]. Although the underlying phonological representation of this form is /hænd/, the word form may phonetically be realised as [hænd] (in isolated pronunciation), [hænd3], [hæm] or [hæn]. Nevertheless, in all the above contexts, the listener is aware that the lexical entity meant by the speaker is the abstract phonological form /hænd/. This example is a first step towards illustrating that listeners interpret speech signals in terms of
Jongman (1992) attempted to determine the nature of phonological representations and investigated to what extent listeners use phonological representations in the processing of speech. His experiment focused specifically on the representation of voicing in word-final obstruents, comparing the Dutch and English language. He noted that this contrast is still visible through the spelling or morphology in Dutch, where the final voice contrast is cancelled out in the surface form. It can be present in the singular word, mostly with stops (e.g. <pat> = [pat], ‘toad’) or it can become apparent in the morphological process of plural formation, mostly with fricatives (e.g. <dief>, <dieven>, ‘thief’, ‘thieves’). In the latter case, which is usually the case with fricatives, the spelling has been adapted to the realisation in the singular form, but the plural form still contains (phonetically and orthographically) the underlying voiced character of the final obstruent. In Dutch, minimal pairs differing only in the underlying voice of the final obstruent do not show any phonetic differences. For example, the words <hart> and <hard> are both pronounced as [hart]. In other words, Dutch speakers use complete phonetic neutralisation of the voice contrast in final obstruents.

In order to determine whether the underlying phonological representation influences the perception of word forms, Jongman (1992) conducted a vowel categorisation task. The purpose of this task was to examine whether the participants categorised a vowel with ambiguous duration differently when the voicing of the final obstruent differed in the underlying form but not in the surface form. If the participants were aware that vowels preceding voiced medial obstruents are longer than the ones preceding voiceless medial obstruents, the question was whether this vowel length cue could influence their categorisation judgment when hearing stimuli with ambiguous vowel duration followed by final obstruents whose voice aspect had been phonetically neutralised.

The stimuli used in Jongman’s (1992) experiment were the existing Dutch words ‘zat’ (/zat/, [zat], ‘drunk’), ‘zaad’ (/za:d/, [zaːt], ‘seed’), and ‘stad’ (/stɑd/, [stɑt], ‘city’), ‘staat’ (/stɑːt/, [stɑːt], ‘state’). These word pairs were chosen because they contrast with respect to the combination of vowel length and underlying voice of the final obstruent. The Dutch participants heard stimuli with a vowel duration somewhere in a continuum from short to long, in a random order. Jongman (1992) found that the categorisation of vowel duration
was affected significantly by the underlying voicing of the final obstruent. In the ambiguous vowel duration region, the participants perceived the same vowel duration as short when followed by an underlying voiceless obstruent, and as long when followed by an underlying voiced obstruent. For the ‘stad’ – ‘staat’ pair, the participants assumed that a slightly longer [a] was the result of vowel lengthening before a voiced obstruent and categorised the vowel as short. It should be noted that, in normal circumstances, there is no difference between the vowel length before a final underlying voiced or voiceless obstruent. When the vowel length is ambiguous, however, all knowledge is used to make a judgment, so the knowledge that a vowel before a medial voiced obstruent is longer is extrapolated to final obstruents. For the ‘zat’ – ‘zaad’ pair, on the other hand, the participants concluded that the slightly longer [a] was not caused by vowel lengthening before a voiced obstruent, but rather categorised the vowel as long. Jongman (1992) concluded from these results that listeners indeed use the underlying phonological representation in the perception of word forms. When the acoustic information is unambiguous, the listener knows from this information alone which word is meant, but if some ambiguity arises, the listener uses all his knowledge to decide which lexical representation is meant.

Jongman’s (1992) ideas are supported by evidence from other fields of research. Eulitz and Lahiri (2004) provided neurobiological evidence for the assumption of abstract phonological representations in the mental lexicon. They, like Gaskell et al. (1995), assumed abstract underspecified representations in which not all features were stored, only the contrastive or specified ones. They stated that all predictable and non-distinctive information could be excluded from the representations in the mental lexicon. They claimed this because not all phonetic signs are necessary for the recognition of a lexical form. They used ‘mismatch negativity’ (MMN), an “automatic change detection response” (Eulitz and Lahiri, 2004: 577) in the brain, to test their hypothesis. This technique is based on whether the features from the surface form and the phonological representation are identical or similar. If they are similar, there is no conflict. On the other hand, if the features are fundamentally different, a conflict in the brain is perceived. Their results can be interpreted as proof that “the human brain uses phonologically underspecified mental representations” (Eulitz and Lahiri, 2004: 581).
4.4 The representation of variation

In the introduction to this chapter, we discussed Gaskell et al. (1995), who explained the theory of ‘radical underspecification’ (Archangeli, 1988, in Gaskell et al., 1995). This theory deals with the processing of phonetic variation in speech perception. According to Gaskell et al. (1995), the perceived phonetic realisation of the word form is compared to the abstract lexical representation in the mind of the speaker. This representation functions as a key to the meaning of the word. They distinguish between systematic variation (e.g. assimilation) and random variation (invalid pronunciations, non-words). The cognitive system treats natural variation and random variation differently. Random variation would significantly disrupt the process of lexical access, and systematic changes would be accepted by the cognitive system as legitimate deviations.

Ranbom and Connine (2007) also dealt with the representation of variation in word recognition. They connect the lexical representation with the frequency of occurrence in the experienced language environment. Their first hypothesis about the processing of speech was that the mental lexicon only contains the most frequent phonological form for each word, and less frequent forms would be processed at the sub-lexical level. In order to explain the recognition of forms affected by variation, they also suggested a second hypothesis i.e. that listeners have multiple lexical representations. These multiple representations would be graded based on the frequency with which they were perceived. High frequency words would be more strongly represented than low frequency words. Consequently, since they connect perception with the formation of lexical representations, they suggest that “the lexical representation of a word is influenced by exposure to productions of that word” (Ranbom and Connine, 2007: 274).

On the basis of this idea, we can formulate a new hypothesis related to non-native input, namely that Dutch learners of English who almost exclusively hear input from their fellow-students may develop the wrong representation concerning the voice of the final obstruent. Since it is well-known that Dutch learners of English tend to devoice final voiced obstruents in English (because of their native tendency towards final devoicing), their phonological representations may also be influenced by this constant perception of devoiced final obstruents in the L2 English of their fellow-students. The experiments discussed in sections 7 and 8 will provide more clarity with respect to the validity of this hypothesis.
Two previous models of lexical processing are discussed by Ranbom and Connine (2007). According to the ‘Direct Access Model’ by Marslen-Wilson and Warren (1994, in Ranbom & Connine, 2007), the speech signal is mapped directly to a lexical representation. The ‘Distributed Cohort Model’ by Gaskell and Marslen-Wilson (2002, in Ranbom & Connine, 2007) states that “all possible candidates are activated resulting in multiple activation of, and competition among, phonological and semantic associates with continuous updating from the speech signal” (Ranbom and Connine, 2007: 274). In order to test the ‘Distributed Cohort Model’, they used an eyetracking paradigm. They also discuss the ‘classical’ views of the underspecification theory and the phonological inference mechanisms (cf. section 4.1). Lastly, in a ‘tolerance-based’ approach, as opposed to the underspecification view, all features are explicitly represented in the mental lexicon. This last view states that an intact input will be more effective at activating the target representation than an input that differs from the representation by a single feature.

Ranbom and Connine (2007) examined their hypotheses with respect to the variant production of the nasal flap and the [nt] in English. They first established that the nasal flap was the most frequent production in conversational speech by means of a corpus analysis. Then they conducted five experiments to test the hypotheses. With respect to recognition, they found that, overall, [nt] productions were recognised more quickly and were considered a better production than the nasal flap. However, nasal flap productions were recognized more quickly in words that are frequently produced with the nasal flap (e.g. the word ‘twenty’) than in words that are more frequently produced with the [nt] (e.g. the word ‘enter’).

These results suggest that recognition of the nasal flap and the [nt] is influenced by the frequency of each variant in a specific context. They concluded that the findings of their experiments suggested that both productions are lexically represented, and that exposure to a certain phonetic form influences its lexical representation, with stronger representations for the more frequent input and weaker ones for the less frequent input. They also suggested that spelling may influence phonological representations. They explained the explicit representation of the [nt] partially by its correspondence with the spelling. The joint influence of phonetic input and orthographic input is explained by the development of the listeners. The [nt] representation is quickly accessible since it is derived from the
orthography, and the nasal flap representation becomes stronger as this production is encountered more often in the input.
The final voicing contrast: a difficult contrast for Dutch speakers

It is generally known that Dutch speakers have difficulties pronouncing final voiced obstruents (cf. Jongman, 1992, Simon, 2010a&b, Vael, 2010 etc.). Broersma (2005) investigated the perception of the final voicing contrast, which exists in English but not in Dutch, with Dutch-speaking participants who were proficient learners of English. Although their production was still far from perfect, they were able to distinguish the contrast as well as the native English control group in an auditory perception experiment. They did not, however, use vowel duration as a cue for the voice of the final obstruent, as opposed to the native English speakers, who were misguided when contrasting information was presented in the vowel length and the final obstruent. The Dutch participants focused more on the characteristics of the speech signal itself and even disregarded vowel length when it did not match the speech signal they were asked to identify. For instance, when the [v] in the word ‘save’ was preceded by a short vowel, the Dutch speakers focused on the speech signal [v] while the English speakers were misled by the short vowel and assumed the word ‘safe’ rather than ‘save’.

In my bachelor paper (Vael, 2010), I found that even Dutch speakers who are non-proficient in English, and have not even had formal instruction in English, could identify the final obstruent of about 70% of English words correctly in an auditory perception experiment. With respect to production, the participants devoiced about 80% of the English words ending in a voiced obstruent. Dutch speakers, regardless of their proficiency in English, make few mistakes when asked explicitly to focus solely on the voice of the final obstruent. When they have to use this distinction in speaking, however, they tend to fall back on their native knowledge and produce the voiced final obstruents as voiceless ones. The question raised here is what the cause of this difference in proficiency between perception and production is. One hypothesis is that the learners focus solely on phonetics when they are asked to and do not really know the phonological differences between Dutch and English. A second hypothesis is that learners do have the correct phonological representations and hence perform well on a perception task, but still fail to produce the correct realisation.
In this chapter, the differences between the English and Dutch phonological systems will be discussed, to determine the grade of similarity between both languages. The focus will then shift to the phonological representation of voice, with some attention paid to the different categories of voicing in the respective languages. Lastly, the process of final devoicing, or final laryngeal neutralisation, will be discussed from the point of view of Optimality theory, with attention for the influencing factors of markedness and transfer from the mother tongue.

5.1 Differences between the Dutch and the English phonological system

In *Modern English Pronunciation*, Collins and Vandenbergen (2000) sum up the most common phonological mistakes that speakers of Dutch make when pronouncing English. In general, the phonologies of these two languages are relatively similar. They both have a phonological system consisting of vowels, stops, fricatives, approximants and nasals. Most phonemes occur in both languages, with some exceptions, such as the [θ] and [ð] which are two obstruents that are exclusive to the English system.

Another well-known difference is the opposition [ɛ] – [æ] in Dutch as opposed to [e] – [æ] in English. Best (2001) describes this difference in terms of perception. The Perceptual Assimilation Model (henceforth PAM, in Best, 2001) formulates a theory that assumes a strong influence from the phonological system of the mother tongue. The PAM distinguishes different types of discrimination of non-native contrasts, based on the grade of similarity between those contrasts and native contrasts. Best (2001) claims that listeners assimilate non-native speech signals to the native phonological system whenever possible. This assimilation may occur in three ways: either the new phoneme is perceived as a Categorized exemplar of some native phoneme (e.g. English /t/ corresponds to Dutch /t/), as an Uncategorized speech signal that is similar to two or more native phonemes (e.g. English /æ/ is similar to Dutch /a/ and /e/), or as a Nonassimilable nonspeech sound that does not correspond to any native phoneme (e.g. ‘clicks’ in Zulu).

With respect to the perception of non-native contrasts, Best (2001) distinguishes two types of processes of assimilation to the native language. Two Category assimilation occurs when a contrast in the target language is similar to a native contrast (e.g. the contrast /t/-/d/ is similar in Dutch and English). This type of assimilation aids the perception. Single Category
assimilation occurs when two foreign phonemes correspond to a single native phoneme or vice versa (e.g. Dutch phonemes /a/ and /e/ are both similar to English /æ/). This type of assimilation obstructs the perception. The contrasts investigated here are categorised by Best (2001) as part of the Two Category assimilation. The contrasts /t/-/d/, /p/-/b/, /f/-/v/ and /s/-/z/ exist in Dutch and in English and are similar in both languages.

Departing from the PAM, the expectation is that no problems should arise in the perception of these contrasts in English words by Dutch-speaking participants. This turned out to be the case in the perception experiment I conducted for my Bachelor paper (Vael, 2010). It remains to be investigated then what exactly causes the productive difficulties with these contrasts in final position. Since Dutch speakers also use these contrasts in initial and medial position, the difficulties are assumed to depend solely on the position of the voiced obstruents. According to the Markedness theory, it is most common to have only voiceless obstruents before a pause. The underlying form could be a voiced one, but on the surface the voice feature is neutralised. English is one of the few languages that has not implemented this neutralisation.

Although, strictly phonologically speaking, the English and the Dutch systems are similar with respect to the phonemes in the above mentioned contrasts /t/-/d/, /p/-/b/, /f/-/v/ and /s/-/z/, the position in which these phonemes occur influences their behaviour differently in both languages. In initial and medial position, the phonemes in the contrasts retain their (voice) features in both English and Dutch. In final position, the phonemes are processed differently in English and in Dutch. Whereas the features of all phonemes in the contrasts are maintained in English, the voice contrast is neutralised in Dutch, concretely meaning that the voiced variant loses the feature of voice, thus becoming equal to the voiceless variant.

5.2 The phonological representation of voice

As discussed in section 4, mental representations do not only entail lexical items, but also phonological characteristics like, for instance, voice. Jongman et al. (1992) examined this characteristic in the Dutch language. Their point of view was that, in Dutch, the voice characteristic remained in the underlying form while being neutralised in the surface form. In this view, Dutch speakers have a mental representation that contains the voice contrast also in final position. They argued that the underlying phonological representation of stops is
reflected in the spelling. For example, the Dutch word <hand> (/h\(\ddot{a}\)nd/, [h\(\ddot{a}\)nt], English ‘hand’) suggests an underlying voiced representation of the obstruent, even though, on the surface (phonetic realisation), the voice contrast disappears. In words like <kat> (/k\(\ddot{a}\)t/, [k\(\ddot{a}\)t], English ‘cat’), on the other hand, the underlying representation equals the surface form; they both contain a voiceless final obstruent.

Jongman et al. (1992) found that the participants in their experiment, containing words that ended in a stop consonant, indeed used the underlying representation of voice in the perception and identification of spoken words. Nevertheless, the question could be raised whether this observation was the effect of the use of the underlying representation or whether it was the effect of the influence of the orthography. Since they claim that the underlying representation is presented in the orthographic representation, it is difficult to distinguish the actual ‘pure’ representation from a representation influenced by spelling. All participants were literate adults, so it would be possible that the speakers’ innate knowledge of the spelling influenced their decisions, instead of the phonology. This is plausible because in the phonetic realisation there is no indication of voice whatsoever. Another possible explanation to account for their results is that the participants’ representations were influenced by their knowledge of the spelling of these words. It would be interesting to contrast the results found in Jongman et al.’s (1992) experiment with the same experiment conducted with prereaders or illiterate participants.

To determine whether the phonological representation of voice is language-specific, it might be useful to look at the phonetic categories in different languages. Keating (1984) stated that the two phonological categories of voice, namely voiced and voiceless, are realised differently by the various languages of the world. The phonetic realisation of these phonological classes can differ drastically in different languages. Since this paper investigates the differences between English and Dutch, we will use these languages as a starting point. In several languages, including English, vowel duration before obstruents is used to determine the voice of that obstruent. It is generally agreed that vowel duration is longer before a voiced obstruent than before a voiceless one. Phonetically speaking, three classes are distinguished. Most languages make a distinction between fully voiced, voiceless unaspirated, and voiceless aspirated obstruents. With respect to the VOT (Voice Onset
there is a distinction between prevoiced and unprevoiced on the one hand, and voiceless aspirated and voiceless unaspirated on the other hand.

The difficulty with transferring the phonological categories from Dutch into English as a learner is that the contrasts in both languages are between different phonetic categories. Dutch contrasts prevoiced obstruents with voiceless unaspirated ones. English, on the other hand, contrasts fully voiced, but not prevoiced obstruents with voiceless aspirated ones. Another obstacle for Dutch speakers acquiring English is that, in final position, voiced obstruents are often partly devoiced but still present a contrast with completely voiceless unaspirated final stops. Whereas in Dutch the contrast is relatively straightforward between two phonetic categories, in English different phonetic categories are contrasted in different positions. Because of this phonetic complexity, one can wonder whether Dutch speakers acquiring English know which phonetic category corresponds to which phonological representation in English. Since they have learned not to rely on spelling for the phonetic realisation of the final obstruent, they may not use the orthography as an aid for the phonological representation either. This paper intends, therefore, to gain insight in Dutch learners’ mental representation of voice with respect to English words ending in either a voiced or a voiceless final obstruent.

5.3 Neutralisation of the voicing contrast in Dutch

Simon (2010b) noted that, in the view formulated by the traditional generative approach, the term ‘final devoicing’ implies underlying voiced obstruents that are deprived of the voice characteristic when they are realised in final position. A more recent view is that final obstruents in Dutch are laryngeally neutral, meaning that the voice characteristic is delinked from the segment. Simon (2010b) included a statement by Ernestus (2003, in Simon, 2010b), who claimed that the obstruent is neutral in that its pronunciation depends on what form is pronounced with least articulatory effort. In final position, before a pause, the voiceless form is produced with least effort, hence the voiceless realisation of an underlying voiced obstruent.

In English, as opposed to Dutch, obstruents are not laryngeally neutral. If they were, they would also be realised as voiceless segments because that is articulatory the easiest option. English final obstruents, although they remain phonologically voiced, are often partially devoiced in final position. However, because the cue of the vowel length remains,
English speakers have no problem recognising the voice of the obstruent. Since it is more difficult to produce voiced fricatives than it is to produce voiced stops, Simon (2010b) made a distinction in testing these segments. She found that fricatives, indeed, were devoiced more frequently than stops. In Dutch, this difference is also noticeable in the spelling. Whereas words ending in a stop present the underlying voiced character in the singular and the plural form (e.g. <hand, handen>, English ‘hand’, ‘hands’), words ending in a fricative only present the underlying voice in the plural form (e.g. <kaas, kazen>, English ‘cheese’, ‘cheeses’).

Archangeli (1999) discusses the influence of markedness on the acquisition of a foreign language in the framework of Optimality Theory (henceforth OT). OT presents a number of universal constraints, based on cross-linguistic similarities. Some of these constraints are violable in different languages. The degree of violation permitted for each constraint is unique to each language. The constraints relevant for our purposes are called Markedness constraints. These constraints prefer unmarked configurations, such as voiceless codas. The constraint of voiceless codas is violated in English but not in Dutch, hence final devoicing in Dutch. One of the criteria to define Markedness constraints is that they are satisfied in most languages of the world. Voiceless codas are permitted in almost all languages in the world, while voiced codas are only tolerated in a much smaller group of languages, including English. Another criterion that determines the markedness of a feature is the ease of pronunciation of that feature. As discussed in Simon (2010b), the theory of laryngeal neutralisation assumes that a neutralised segment is always produced with the least articulatory effort possible in the surrounding context. Applied to our case, a voiceless coda obstruent is produced with more ease than a voiced one.

When Dutch speakers, being used to a neutralised coda obstruent, acquire English, they have to adapt their conception of the violation of constraints with respect to the final voicing contrast in obstruents. It is generally agreed that this phonological contrast is one of the most difficult to acquire, so this is a difficult task for Dutch speakers. Previous studies (cf. Simon, 2010a, Vael, 2010, Broersma, 2005 etc.) have shown that, in the Dutch-English interlanguage, Dutch learners tend to devoice many to all of the final voiced obstruents, according to their level of proficiency. Simon (2010a) examined to what extent Dutch speakers learn to suppress the devoicing rules from their L1 when speaking English. She
hypothesises that the extent of the transfer is proportional to the frequency of the rule in the L1, which in the case of final devoicing is categorical, i.e. always applied.

Simon (2010a) found that Dutch speakers transfer the devoicing rules for coda fricatives much more frequently than for coda stops. She also found that the participants had learnt to control the tendency towards final devoicing to some extent in controlled conditions (e.g. word reading task), but not in conversational speech. She derived from these results that “the learners have learnt the contrast but fail to phonetically implement it when they are paying minimal attention to pronunciation, i.e. the high percentage of devoicings in the conversations is the result of lack of mastery and not lack of knowledge” (Simon, 2010a: 72). These results suggest that the cause of the difficulties in the acquisition of this L2 contrast is not a problem of phonological representation but of phonetic implementation. The participants seemed to be aware of the voice contrast on a meta-level but had difficulties to pronounce the correct allophone.
6 Experiment with control group of native speakers

6.1 Method
The aim of this experiment was to control if native speakers of English did not devoice final obstruents, and to provide a standard for comparison with the Dutch participants in the actual experiments (cf. sections 7 and 8). The experiment was designed to investigate the participants’ conscious awareness as well as their subconscious knowledge with respect to the voicing of final obstruents.

6.1.1 Participant description
The participants in the control study were ten native speakers of English between the ages of 30 and 69. They were all inhabitants of the town of Abingdon, about 10 miles South of Oxford. This location was chosen because it lays within the London-Oxford-Cambridge triangle. The English is probably more standard in that area than in the North of Great Britain. Among the participants, no dialect speakers were reported. The group of participants consisted of six females and four males. The experiment was conducted in Abingdon, so that I could explain clearly what the instructions were and so that the participants could ask questions. The informants participated on a voluntary basis and were recruited by a member of Abingdon’s twinning society.

6.1.2 Stimuli
The stimuli for this experiment consisted of eighty pairs of existing monosyllable English words. The contrasts investigated were final /p-b/, /t-d/, /f-v/ and /s-z/. The pairs were divided into four categories (where possible). These categories were ‘same phonology, same orthography’ (e.g. ‘bat’ - ‘cat’), ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’), ‘same phonology, different orthography with same letter for final obstruent’ (e.g. ‘weight’ - ‘gate’) and ‘same phonology, different orthography with different letter for final obstruent’ (e.g. ‘dressed’ - ‘nest’). The last two categories were only possible for the contrasts /t-d/ and /s-z/ because with the contrasts /p-b/ and /f-v/ the spelling and pronunciation are never incongruent. The stimuli were completed with twenty fillers (e.g. ‘nut’ - ‘nun’), to distract the attention away from the purpose of the experiment. In total, the experiment consisted of one hundred pairs of stimuli. After analysis of the experiments, one pair (‘cheese’ - ‘hippies’)
was eliminated. This pair contained a disyllabic word with the stress on the first syllable and was therefore not fitting for the purposes of the experiment.

6.1.3 Procedure
The experiment comprised two parts. The first part consisted of a rhyming task where the participants were asked to indicate for each pair whether the two words were rhyming or not. With this task, I intended to investigate the participants’ subconscious knowledge of the voicing of final obstruents. At this stage, the participants did not have to think about phonemes yet. They just had to revise their pronunciation to discover whether, when they pronounced them, the words rhymed or not.

The second task was designed to test the conscious awareness of the participants. They were asked to write down the last phoneme of each word. The instructions were made as transparent as possible to avoid confusion. Because the linguistic meta-language might have been unclear to them, the instructions were formulated as follows “Write down the last consonant sound you pronounce”. Then, an example was given to clarify the task further. If they still didn’t understand the instructions, I gave some more examples and eventually all participants knew what to do. It took about twenty minutes to complete the experiment.

6.2 Results and discussion
On the first part of the experiment, namely the rhyming task, the participants got a nearly perfect score. The answers were correct in 98,6% of the cases. The participants’ subconscious knowledge with respect to the voicing of final obstruents was excellent. These results corroborate the hypothesis that native English speakers do not devoice final obstruents. They do not have any problems with indicating whether two words are rhyming or not, with the main criterion being the voice aspect of the last phoneme.

However, when asked to identify the last phoneme, the orthography distracted many participants when it was incongruent with the pronunciation. For the contrasts /p-b/ and /f-v/, a perfect score was achieved by each of the participants. These results can be explained by the fact that, with these contrasts, there never occurs an incongruence between spelling and pronunciation. The participants all gave 100% correct answers, with respect to indicating the rhyme and to identifying the phoneme.
With respect to the contrast /t-d/, one case of incongruence between spelling and pronunciation caused problems. This was the case of pairs containing past participles ending in <ssed> and pronounced /st/ (e.g. ‘blessed’ - ‘nest’). Orthographically a <d> occurred while phonetically the word ended in a /t/. Some participants wrote down the wrong phoneme for the words spelled with a <d>, while being correct about the rhyme. Four participants wrote down the right phoneme in all instances, while five others always wrote down a “d” for <ssed> and a “t” for <st>, while still being correct about the rhyme. So, these last five subconsciously knew the last phoneme but when asked to identify it, they were distracted by the spelling. One participant wrote down “s” for <ssed> and for <st>. This was probably the influence of this participant’s particular dialect.

For the contrast /s-z/, the influence of orthography was most obvious. In the cases where both orthography and phonology were different, no problems occurred. In all other cases, the spelling influenced eight out of ten participants. When phonology and orthography were the same, eight participants wrote down an “s” where the spelling was <s> but the pronunciation was /z/ (e.g. ‘seas’ - ‘peas’). In the cases where the phonology was the same but the orthography was different in the final obstruent, the influence of orthography was most obvious in the identification of the last phoneme. For example, in the pair ‘eyes’ - ‘size’, seven out of ten participants indicated that these words rhymed, but wrote down that the last phoneme was “s” for ‘eyes’ and “z” for ‘size’.

In conclusion, the control group of native English speakers who participated in the experiment all had subconscious knowledge of the voicing rules with respect to final obstruents in the English language. Nevertheless, when asked to identify the last phoneme, the majority of the participants was distracted by the orthography of this phoneme when it was different from the phonology.
After having established the behaviour of the native English speakers for the purposes of control, I will now proceed to the actual experiments with the Dutch speakers. I have conducted two experiments, with two separate groups of Dutch speakers of approximately the same age and the same level of proficiency. The first experiment was a written experiment which consisted of two tasks: rhyming judgment and phoneme classification. The stimuli in the first experiment were written words, as in the experiment with the control group. This experiment was accompanied by a similar experiment containing Dutch words. This smaller experiment was conducted in order to check what the participants did in their native language and to compare the results with the experiment containing English words. The second experiment was composed in such a way that it excluded the factor of spelling as much as possible. The words and structure of this experiment were exactly the same as in the first experiment. The difference between the first and the second experiment was that, in the latter, the words were presented through pictures instead of through written words.
7 Experiment 1: Rhyming and phoneme judgment – written words

7.1 Aim
This experiment was conducted to gain some insights with respect to the devoicing or neutralisation of final obstruents in English words by native speakers of Dutch. Whereas Dutch speakers tend to devoice the final voiced obstruents in English words, their perception of these obstruents is almost as good as the perception of native English speakers (cf. Broersma, 2005). In my Bachelor paper, I have investigated the production and perception of the final voicing contrast with Dutch children, aged 11, who had not yet received formal instruction in English. The result was that, even at this early stage, the perception clearly exceeded the production of final voiced obstruents (cf. Vael, 2010).

The aim of the present study is to investigate what causes this discrepancy between production and perception of the final voicing contrast by speakers of Dutch. In this respect, I have formulated two hypotheses. The first hypothesis states that the production errors with respect to the final voicing contrast are due to phonological misrepresentation. If this is the case, the learner is not aware of the contrast on a meta-level and hence does not produce the right phoneme. The second hypothesis is that the production errors are the result of mere erroneous phonetic realisations. In this case, learners have the correct phonological representations of final obstruents in English, but fail to phonetically implement these in production.

Secondarily, I wanted to investigate whether exposure to orthography influenced the phonological representation of the final obstruent. I did this by providing an orthographic representation for one group (experiment 1) while no such representation was present for the second group (see section 8: experiment 2). Hypothetically, an orthography which is inconsistent with the phonology would distract the attention from the phonology, resulting in a wrong categorisation of the phoneme. An orthography which is consistent with the phonology, on the other hand, should help the classification of the phoneme. I will examine whether there is any influence from the orthography by comparing the results of the two experiments.
7.2 Method

7.2.1 Participant description

In total, 17 informants participated in this experiment. The participants were students attending the sixth grade of secondary school. All participants were native speakers of Dutch.¹ The participants received general secondary education and had three hours of English tuition a week. They were hence assumed to be proficient speakers of English. The group of participants consisted of fourteen female and three male participants, all of whom were 17 or 18 years old. The number of female participants exceeded that of male participants because I conducted the experiments in a school which was originally a girls’ school and still accommodates more female than male students.

7.2.2 Stimuli

The stimuli for this experiment consisted of 58 target pairs of existing English words and of 12 pairs of fillers (e.g. ‘nut’ - ‘nun’), adding up to a total of 70 word pairs (cf. appendix). All words were common words in English and were hence supposed to be known by the participants. The fillers were added to distract the attention from the purpose of the experiment. The target pairs were divided into four categories, according to the type of relation between phonology and orthography, as in the control experiment with native English speakers (cf. section 6). Sixty-eight pairs consisted of two monosyllabic words (e.g. ‘shoes’ - ‘lose’) and two pairs consisted of a monosyllabic and a disyllabic word (e.g. ‘skis’ - ‘Chinese’). The disyllabic words were included because very few examples of this particular kind of contrast (/s-z/: ‘same phonology, different orthography with same letter for final obstruent’, see below) could be found that included only monosyllables.

However, for both disyllables (cf. ‘canoes’, ‘Chinese’) the stress was on the last syllable (cf. [ka’nəuːz], [tʃæi’nɪːz]), so that the rhyme was not confusing because of the place of the stress. As mentioned in section 6, the control experiment also included the word ‘hippies’. This word was disqualified because the stress is on the first syllable here and interferes with the rhyme, thus hindering the purpose of the experiment. When stress

¹ Originally, in this group, four native speakers of Turkish participated in the experiment. They had lived in Belgium all their lives, but reported to speak Turkish at home. Although their answers did not seem to differ from those given by the native speakers of Dutch, I had to disqualify their results. Since my investigation focused on native Dutch speakers, the results of the Turkish speakers could not be processed together with the results of the native Dutch participants.
interferes, the rhyme judgment is no longer based solely on the nature of the final obstruent. Therefore, the disyllables that have the stress on the last syllable do not pose a problem, as opposed to disyllables that have the stress on the first syllable.

The contrasts investigated were final /p-b/, /t-d/, /f-v/ and /s-z/. The contrast /k-g/ was not included because the English /g/ does not occur in Dutch, except in loan words. Whereas /p-b/, /t-d/, /f-v/ and /s-z/ are equivalent in Dutch and English, the English velar stop /g/ corresponds to the Dutch velar fricative /ɣ/ (e.g. ‘good’ /gʊd/ vs. ‘goed’ /ɣut/). In final position, Dutch speakers use a /ɣ/ instead of a /ɣ/ (e.g. ‘wij zagen’ /weɪzaːɣən/ vs. ‘hij zag’ /heɪ zəɣ/; ‘we saw’ vs. ‘he saw’). Since /g/ is not a Dutch phoneme, the opposition /k-g/ does not exist in Dutch. Because one cannot compare the English opposition /k-g/ to the same opposition in Dutch, this opposition was excluded from the experiment.

As in the experiment with the control group, the pairs were divided into four categories. These categories were based on the nature of the final obstruent. Either the final obstruents of the words in the pairs had the ‘same phonology, same orthography’ (e.g. ‘bat’ - ‘cat’), ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’), ‘same phonology, different orthography with same letter for final obstruent’ (e.g. ‘weight’ - ‘gate’) or ‘same phonology, different orthography with different letter for final obstruent’ (e.g. ‘dressed’ - ‘nest’). The last two categories were only possible for the contrasts /t-d/ and /s-z/ because the contrasts /p-b/ and /f-v/ never have an incongruence between spelling and pronunciation. The four categories in which I have divided the pairs deal with the relation between phonology and orthography. A comparison between the results in the different categories may help determine if, and where, the spelling has an influence on the classification and hence on the phonological representation.

7.2.3 Procedure
The experiment was conducted in the participants’ classroom in the secondary school “Onze-Lieve-Vrouw Presentatie Humaniora” in Sint-Niklaas, Belgium. I had received permission from the English teacher (and the direction) to use some of her classroom time in order to conduct my experiments. The participants did not know the purpose of the experiment beforehand.
The experiment was composed in the form of a written test. The participants had to fill out a form containing the pairs of stimuli. The task that the participants had to perform was twofold. First, they had to indicate whether the two words of the pair were rhyming or not. Secondly, they had to write down the last phoneme below each word. The instructions were given orally in Dutch, to avoid any confusion as to what the task entailed. An example was also clarified orally, accompanied by a small PowerPoint presentation. Special attention was paid to the fact that the participants had to write down the last phoneme and not the last grapheme. The participants were invited to ask clarifications if they did not understand the instructions.

The instructions to the experiment also appeared on the form itself, followed by the example (cf. figure 4) that had been clarified by means of an oral presentation accompanied by a PowerPoint presentation. The example contained words ending in /k/ or /g/, a contrast excluded from the contrasts investigated, to avoid giving away a clue to the answers to the actual task. On the form, the instructions appeared in Dutch, and were formulated as follows: “a. Duid aan of de twee woorden rijmen of niet. b. Schrijf de laatste MEDEKLINKER die je uitspreekt/hoort onder de woorden.” (translation: “a. Indicate whether the two words are rhyming or not. b. Write down the last CONSONANT you pronounce/hear below the words.”).

<table>
<thead>
<tr>
<th></th>
<th>rhyming</th>
<th>not rhyming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shake – cake</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>..K.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>..K.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ache – plague</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>..K.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>..G.</td>
<td></td>
<td></td>
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</tbody>
</table>

*Figure 4: Representation of the example given in experiment 1*

The participants completed this experiment in approximately twenty minutes. They filled out the experiment individually, without help. The teacher and I personally supervised that no student consulted a classroom mate to help them. During the experiment, the students could still ask questions if they experienced a problem. I did not, however, have to help them in any way with respect to the relevant word pairs. The only question I was asked dealt with a filler (one girl asked me how to indicate the last phoneme of the word ‘cage’),
and was hence not important for the result of the experiment. When all forms had been completed, the participants and the teacher received a little reward (in the form of candy bars) to thank them for their time and cooperation.

7.3 Results

The results of the rhyming task and those of the phoneme classification task are considered separately. These are separated since the rhyming judgment should represent the subconscious knowledge of the final voicing contrast and the phoneme classification should represent the conscious knowledge of this contrast.\(^2\) No distinction is made between males and females since the female participants outnumber the male participants. It would thus not be a valid comparison between the sexes. Since the group is a homogeneous one, the results are not looked at individually. Instead, the averages for each type of contrast and each type of category are taken as a reference for the group’s competence.

7.3.1 Results of the rhyming task

<table>
<thead>
<tr>
<th></th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phon/same orth</td>
<td>100%</td>
<td>98.8%</td>
<td>97.6%</td>
<td>97.6%</td>
<td>98.5%</td>
</tr>
<tr>
<td>e.g. ‘cat’ - ‘bat’</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diff. phon/diff. orth</td>
<td>49.4%</td>
<td>40%</td>
<td>28.2%</td>
<td>29.4%</td>
<td>36.8%</td>
</tr>
<tr>
<td>e.g. ‘cat’ - ‘bad’</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>same phon/diff. orth,</td>
<td>97.1%</td>
<td>/</td>
<td>76.5%</td>
<td>/</td>
<td>86.8%</td>
</tr>
<tr>
<td>same obstr. e.g. ‘weight’ - ‘gate’</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>same phon/diff. orth,</td>
<td>91.8%</td>
<td>/</td>
<td>83.5%</td>
<td>/</td>
<td>87.7%</td>
</tr>
<tr>
<td>diff. obstr. e.g. ‘dressed’ - ‘test’</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average per contrast</td>
<td>83.9%</td>
<td>69.4%</td>
<td>71.2%</td>
<td>63.5%</td>
<td>total: 74.2%</td>
</tr>
</tbody>
</table>

Table 1: scores for rhyming judgments English words

First, we will discuss the scores on the rhyming judgments, which are presented in table 1. The overall score on the rhyming judgment task is 74.2%. The results are divided by type of contrast on the one hand, and by type of category (cf. section 7.2.2) on the other hand. For the contrast /t-d/, the average score on the rhyming judgments was 83.9%, and for the contrast /p-b/, it was 69.4%. This results in an average of 76.7% for the rhyming judgment on the stops. For the contrast /s-z/, the rhyming judgment was correct in 71.2% of the cases, and for the contrast /f-v/, it was correct in 63.5% of the cases. The average score for fricatives on the rhyming judgment was hence 67.4%.

\(^2\) However, since the participants have to do one task after the other, one may assume some mutual interference between the rhyming task and the classification task.
When we divide the results for rhyming judgments by type of category, we encounter the following averages. For contrasts with the ‘same phonology, same orthography’ (e.g. ‘cat’ - ‘bat’), the score is 98.5%. For the contrasts having a ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’) the score is only 36.8%. The following two categories only apply to the contrasts /t-d/ and /s-z/. The category ‘same phonology, different orthography with same letter for final obstruent’ (e.g. ‘weight’ - ‘gate’) yields a score of 86.8%. Finally, the category ‘same phonology, different orthography with different letter for final obstruent’ (e.g. ‘dressed’ - ‘test’) amounts to an average score of 87.7%.

7.3.2 Results of the phoneme classification task

<table>
<thead>
<tr>
<th>Category</th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phon/same orth e.g. ‘cat’ - ‘bat’</td>
<td>94,1%</td>
<td>94,1%</td>
<td>63,5%</td>
<td>85,9%</td>
<td>84,4%</td>
</tr>
<tr>
<td>diff. phon/diff. orth e.g. ‘cat’ - ‘bad’</td>
<td>57,6%</td>
<td>67,1%</td>
<td>48,2%</td>
<td>52,9%</td>
<td>56,5%</td>
</tr>
<tr>
<td>same phon/diff. orth, same obstr. e.g. ‘weight’ - ‘gate’</td>
<td>98,5%</td>
<td>/</td>
<td>20,6%</td>
<td>/</td>
<td>59,6%</td>
</tr>
<tr>
<td>same phon/diff. orth, diff. obstr. e.g. ‘dressed’ - ‘test’</td>
<td>78,8%</td>
<td>/</td>
<td>57,6%</td>
<td>/</td>
<td>68,2%</td>
</tr>
<tr>
<td>average per contrast</td>
<td>81,4%</td>
<td>80,6%</td>
<td>48,9%</td>
<td>69,4%</td>
<td>total: 68,2%</td>
</tr>
</tbody>
</table>

Table 2: scores for phoneme classification English words

The results with respect to the phoneme classification are presented in table 2. The general score on phoneme classification was 68.2%. We will apply the same division, namely by contrast and by category. We start by formulating the scores with respect to the different contrasts under investigation. For the /t-d/ contrast, the average result is 81.4%, and for the /p-b/ contrast, it is 80.6%. The average score for stops with respect to phoneme classification is hence 81%. The score for the /s-z/ contrast is 48.9% while the score for the /f-v/ contrast is 69.4%. This results in an average score of 59.2% on phoneme classification for the fricatives.

When we consider the scores for phoneme classification for the different types of categories, we find the following figures. For the category ‘same phonology, same orthography’ (e.g. ‘cat’ - ‘bat’), the score is 84.4%. For the contrasts with a ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’) the score is only 56.5%. The following two categories again only apply to the contrasts /t-d/ and /s-z/. The contrasts having the ‘same phonology, different orthography with same letter for final obstruent’ (e.g. ‘weight’ -
‘gate’) have a general score of 59.6%. And lastly, the category ‘same phonology, different orthography with different letter for final obstruent’ (e.g. ‘dressed’ - ‘test’) amounts to an average score of 68.2%.

7.4 Discussion

When comparing the overall scores on the rhyming judgment to the ones on the phoneme classification, we notice that for the contrasts /t-d/ and /f-v/, the scores are approximately the same. For the contrasts /p-b/ and /s-z/, however, there is a considerable discrepancy between the scores for rhyming judgment and the scores for phoneme classification (cf. figure 5). With respect to the contrast /p-b/, the scores on phoneme classification (80.6%) are considerably higher than those on rhyming judgment (69.4%). This discrepancy suggests that the participants are, in many cases, aware of the difference in voicing, but fail to implement it in a rhyming task (and probably also in their own English interlanguage). Another explanation is that the high score on phoneme classification is the result of exposure to the spelling, which, in the case of the final contrast /p-b/, is always equal to the phonological representation (e.g. <cat> = /kæt/, <bad> = /bæd/).

![Figure 5: Graphical representation of scores per contrast (Experiment 1)](image)

With respect to the contrast /s-z/, an opposite trend can be observed. Whereas the scores on the rhyming judgment task were relatively high (71.2%), the scores for the phoneme classification task were remarkably low (48.9%). In the case of the /s-z/ contrast, there is a discrepancy of over 20% between rhyming judgment and phoneme classification. Here, the results suggest that the participants, with respect to this particular contrast, have
no – or little – conscious knowledge of the difference in voicing, although they do make the correct rhyming judgments.

When we compare the scores on rhyming judgment and phoneme classification with respect to the categories, we come to the following findings. The contrasts with the ‘*same phonology, same orthography*’ overall have the highest scores (rhyming: 98.5%, phoneme classification: 84.4%). The contrasts that have a ‘*different phonology, different orthography*’ have the lowest score, namely 36.8% on rhyming judgment and 56.5% on phoneme classification (cf. figure 6). The most common mistake made in this case was that the participants indicated that the two words were rhyming. In most of the cases, both the phoneme classification and rhyming judgment were incorrect (e.g. with ‘road’ - ‘goat’), and at times they classified the phonemes correctly but still indicated that the words were rhyming (e.g. with ‘cat’ - ‘sad’). The categories that were inconsistent with respect to phonology and orthography, namely ‘*same phonology, different orthography with same letter for final obstruent*’ and ‘*same phonology, different orthography with different letter for final obstruent*’, both had a high score on the rhyming judgment and a lower score on the phoneme classification. This suggests that, although the participants generally judged the rhyme correctly, they could not classify the phonemes with the same degree of correctness.

![Figure 6: Graphical representation of scores per category (experiment 1)](image)

In the stimuli that were used, the contrast */s-z*/ had most cases of an inconsistency between spelling and phonology. It is therefore the most adequate contrast to check whether an influence of the spelling can be observed in the phoneme classifications and the
rhyming judgments, i.e. on a conscious and subconscious level. When a word was written with an <s> which was pronounced [z], the participants indicated that the phoneme was “s” in the majority of the cases. For example, for the word pair ‘bees’ - ‘cheese’, belonging to the category ‘same phonology, different orthography with same letter for final obstruent’, 13 of the 17 participants wrote down “s” for both words. However, since they classified both phonemes wrongly, the words were still rhyming. They all indicated that the words were rhyming, which was a correct answer. The scores on these kinds of word pairs may not give a correct representation of the participants’ abilities, because they allow false positives. For instance, many participants indicated that ‘rose’ and ‘nose’ were rhyming, which is correct, but they indicated that the phonological representation of both words was ‘s’, which is incorrect. From these examples, I deduct that for words written with final <s> but pronounced with final [z], the phonological representation of the majority of the participants is wrong.

To verify this hypothesis, I will examine another example, this time from the category ‘same phonology, different orthography with different letter for final obstruent’, namely the word pair ‘eyes’ - ‘size’. Orthographically, this word pair contains the final contrast <s-z> but phonologically, both words end in /z/. Five participants answered correctly, three were misled by the spelling and indicated “s” and “z”, and the other nine wrote “s” for both words, ignoring the spelling of the word ‘size’. The participants who did not rely on the spelling did this probably because their phonological representation of the final obstruent in ‘size’ was a voiceless, hence wrong, representation. Note that the participants only ignored the spelling when a voiced obstruent was written. They did not write down that the phoneme was voiced when the spelling represented a voiceless obstruent, except with ‘goose’. Since this mistake (making a voiceless obstruent a voiced one) only occurs with this one word, it is not relevant and probably can be attributed to the specific word.

The contrast /p-b/ is also interesting in this respect. With this contrast, the participants again did not rely on the spelling to make the phonemes fit their rhyming judgment, and hence their phonological representation. For the contrast /p-b/, the phonology and the orthography are always consistent, so the spelling should help the language user to form the right phonological representation. The scores for phoneme classification are higher than those for rhyming judgment with the /p-b/ contrast, suggesting
that the participants’ phonological representations are correct but that they subconsciously still devoice the voiced obstruent when making, for example, a rhyming task. Nevertheless, whereas some participants use the spelling as an aid for the classification of the phonemes, others disregard the spelling of the voiced obstruent. All participants score poorly on the rhyming judgment task with respect to the /p-b/ contrast. Some words which were especially difficult to classify were ‘lab’ and ‘rib’. For the word ‘lab’, nine of the seventeen participants indicated a “p”. For the other words ending in <b> (e.g. ‘globe’, ‘cab’), the last phoneme was usually indicated correctly. An explanation for these results is that the words ‘lab’ and ‘rib’ also exist in Dutch, where they are always devoiced. With respect to the contrast /f-v/, more or less the same effect was observed (e.g. the word ‘dove’ is similar to its Dutch translation ‘duif’ and the final obstruent was hence classified as an “f” more often than in the other stimuli ending in a /v/).

With respect to the contrast /t-d/, the category ‘same phonology, different orthography with different letter for final obstruent’ referred to word pairs like ‘test’ - ‘stressed’. The majority of the participants did not let the deviant orthography distract them. Some did write down a “d” for words like ‘stressed’, but all indicated that the words were rhyming, so subconsciously they did know that, in this case, phonologically there is a voiceless phoneme. This is again an example of the observation that the participants tend to disregard the spelling if the obstruent written is a voiced one. In this case they are correct in disregarding it, but in the case of the /s-z/ contrast, the spelling of the voiced obstruent (e.g. in words like ‘size’) should not be disregarded.

The general observation from this experiment is that the phoneme awareness depends largely on the type of contrast. No general difference between stops and fricatives was observed. The only difficult contrast seemed to be the contrast /s-z/. Whereas the scores for the contrasts /t-d/, /p-b/ and /f-v/ were relatively high, the score for the contrast /s-z/ was extremely low compared to the other contrasts. We can deduct from these results that the final contrast /s-z/ is most difficult to form a correct phonological representation of. This is probably caused by the impairing effect of the orthography in the case of the contrast /s-z/. In the other cases, the phonology and the orthography are relatively consistent, and

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3 It should be noted that, although I specifically asked the participants to write down the last the last sound and not the last letter, some people had difficulties with the task.
thus aid the language user in forming a phonological representation. This is probably the main reason why the other contrasts outscored the /s-z/ contrast in such an obvious manner. In order to test whether the presence of the spelling has an influence, experiment 2 will work with pictures to represent the words. A comparison between experiment 1 and experiment 2 will then provide a decisive answer as to the influence of the spelling.

7.5 Comparison with native language

In addition to the actual experiment containing English words as stimuli, the participants of the first experiment were also asked to fill out a shorter experiment in Dutch. The aim of this extra task was to control what the participants did when asked to give rhyming judgments and phoneme classifications in their native language. This was, first of all, an extra way of controlling whether they had correctly understood the instructions. Secondly, it was a way of controlling whether they were aware of the final devoicing rule in their mother tongue, i.e. in Dutch.

7.5.1 Method

The experiment with the Dutch words was conducted with the same participants as the experiment with the English words. The participants first filled in the experiment with English words. Then the instructions for the extra experiment were given, again with an orally explained example and accompanied by a PowerPoint presentation. These instructions were identical to the instructions of the experiment containing English words. Finally, the participants were asked to fill out the form containing the Dutch words, which was shorter than the other experiment.

The stimuli in the Dutch experiment were thirty pairs of existing Dutch monosyllable words. The pairs were divided into two categories where possible: *same phonetics, same orthography* (e.g. ‘hart’ - ‘zwart’, [hɑrt] – [zwɑrt]; ‘heart’ - ‘black’) and *same phonetics, different orthography* (e.g. ‘lint’ - ‘kind’, [lɪnt] – [kɪnt]; ‘ribbon’ - ‘child’). The second category could only be used for the orthographic contrasts of final <t-d> and final <p-b>, since the orthography is nearly always consistent with the phonetic realisation in the case of final fricatives (e.g. ‘dief’ - ‘lief’, [diːf] – [lɪːf]; ‘thief’ - ‘dear’). Phonetically, all final obstruents were voiceless, so all relevant word pairs were rhyming. Of the total of forty word pairs, thirty

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were relevant and ten were fillers (e.g. ‘mol’ - ‘mot’; ‘mole’ - ‘moth’). None of the fillers were rhyming, so as to provide some differences in the answers.

7.5.2 Results and discussion

The general scores on the Dutch experiment were extremely high, namely 96.7% for the rhyming judgment and 88.4% for the phoneme classification.

<table>
<thead>
<tr>
<th></th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phonetics/same orth</td>
<td>98,8%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>99,7%</td>
</tr>
<tr>
<td>same phonetics/diff. orth</td>
<td>96,5%</td>
<td>84,7%</td>
<td>/</td>
<td>/</td>
<td>90,6%</td>
</tr>
<tr>
<td>average per contrast</td>
<td>97,7%</td>
<td>92,4%</td>
<td>100%</td>
<td>100%</td>
<td>total: 96,7%</td>
</tr>
</tbody>
</table>

Table 3: scores for rhyming judgments Dutch words

With respect to the rhyming judgments (cf. table 3), the scores on the contrasts involving fricatives were 100%. The scores on the stops varied according to the kind of category. The categories used for this experiment are ‘same phonetics, same orthography’ and ‘same phonetics, different orthography’. We use the term phonetics here, because there is an underlying voiced phonological representation of some final obstruents in Dutch (e.g. ‘bed’, /bed/, [bet]; English ‘bed’). For ‘same phonetics, same orthography’, the scores for the contrasts <t-d> and <p-b> were 98.8% and 100% respectively. For the category ‘same phonetics, different orthography’, the scores were 96.5% for <t-d> and 84.7% for <p-b>. It appears that, when the orthography and the phonetic realisation do not match, the participants experience some impediment from this discrepancy. However, the mistakes for the contrast <p-b> are limited to three participants. The other fourteen all have perfect scores, so these results cannot be generalised for the entire group. These results suggest that the native Dutch participants have a nearly perfect subconscious knowledge of the final devoicing rule in their mother tongue, i.e. they know how to produce the final obstruent, despite the discrepancy with the spelling of the final consonant.

<table>
<thead>
<tr>
<th></th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phonetics/same orth</td>
<td>80,0%</td>
<td>83,5%</td>
<td>100%</td>
<td>100%</td>
<td>90,9%</td>
</tr>
<tr>
<td>same phonetics/diff. orth</td>
<td>92,9%</td>
<td>74,1%</td>
<td>/</td>
<td>/</td>
<td>83,5%</td>
</tr>
<tr>
<td>average per contrast</td>
<td>86,5%</td>
<td>78,8%</td>
<td>100%</td>
<td>100%</td>
<td>total: 88,4%</td>
</tr>
</tbody>
</table>

Table 4: scores for phoneme classification Dutch words

With respect to the phoneme classification, the scores were slightly lower than those on the rhyming judgment. For the contrasts involving fricatives, again a perfect score was found for both <s-z> and <f-v>. The stops, the scores of which were 86.5% for the <t-d>
contrast and 78.8% for the <p-b> contrast, apparently pose a larger problem. Nevertheless, eight of the seventeen participants got a perfect score on the phoneme classification task, so these have a perfect phoneme awareness of their mother tongue. The other nine had problems with classifying the contrasts <t-d> and <p-b> correctly. In my opinion, most of these participants were distracted by the spelling of the first few stimuli. The first word pair of which the last phonemes had to be classified was ‘haard’ - ‘baard’ (‘fireplace’ - ‘beard’). Most participants who classified the last phonemes of this word pair as “d” and “d”, corrected themselves when the next instance of words ending in the contrast <t-d> appeared. This next instance was ‘koud’ - ‘hout’ (‘cold’ - ‘wood’) and belonged to the category ‘same phonetics, different orthography’. They then probably realised that they had been misled by the spelling and wrote the correct phonemes for this word pair. It appears that the participants were distracted by the spelling when two voiced obstruents appeared in writing, but when one of the obstruents was voiceless, they classified both correctly.

These results seem to indicate that the native Dutch speakers have an excellent subconscious and conscious knowledge of their mother tongue. The mistakes that they made were either inflicted by distraction through the spelling or were limited to a few participants and hence not representative of the whole group. They appear to be aware of the fact that all final obstruents have to be realised as voiceless in their mother tongue. Regarding the experiment containing English words, we noticed that the participants did not have the same accurate awareness of the final phonemes in English.

The Dutch experiment already suggests that the spelling can be a mayor distracting factor, even in the participants’ mother tongue. In order to eliminate this factor as much as possible, an experiment was composed containing pictures instead of written words. The purpose of this experiment (experiment 2) is to compare it to the first experiment and discover whether there is a difference that indicates a greater influence of the spelling in the first experiment.
Experiment 2: Rhyming and phoneme judgment – pictures

8.1 Aim

This second experiment deals specifically with the influence of the spelling. It aims to investigate whether the orthography has an influence on the phonological representation of the final obstruent. Most interesting would be the comparison between both groups with respect to the treatment of the contrast /s-z/, since this contrast seemed to generate most problems in the first experiment. An orthography which is inconsistent with the phonology would distract the attention from the phonology, resulting in a wrong categorisation of the phoneme, as we have seen for the contrast /s-z/ in the first experiment. An orthography which is consistent with the phonology, on the other hand, should facilitate the classification of the phoneme. In the first experiment, this was for example the case for the contrast /p-b/. However, for the contrast /t-d/, the participants apparently knew when and when not to disregard the spelling. Whereas the participants indicated the correct phonemes for words containing the final contrast /t-d/, regardless of whether the orthography was an aid or not, they did not do this for the contrast /s-z/. This second experiment aims to examine whether these results can be explained by an influence from the orthography or not.

The first experiment already indicated that the two hypotheses formulated in the introduction were valid, depending on the contrast investigated. The first hypothesis, that the production errors with respect to the final voicing contrast are due to phonological misrepresentation, was suggested by the results of one contrast (the contrast /s-z/). The second hypothesis, that the production errors are the result of mere erroneous phonetic realisation, despite a correct phonological representation, was more consistent with the results of the other three contrasts (the contrasts /p-b/, /t-d/ and /f-v/). The results of the first experiment suggested that the spelling had an impairing effect for the contrast /s-z/, which orthography is often inconsistent with the phonology. For the other three contrasts (/p-b/, /t-d/ and /f-v/), the spelling seemed to aid the participants in the categorisation of the phonemes. From this observation, it was not entirely clear whether the low scores on the contrast /s-z/ were the effect of the spelling only or whether they were the result of the participants’ (wrong) phonological representations.
8.2 Method

8.2.1 Participant description
The participants in this experiment were another group of students attending the sixth grade of secondary school. The 20 participants in this group were all native speakers of Dutch. The participants received general secondary education and had two hours of English tuition a week. This was one hour a week less than the participants in experiment one, but the English teacher assured me that the level of proficiency in English was equal for both groups. They were hence also assumed to be proficient speakers of English. The group of participants consisted of sixteen female and four male participants, all aged of 17 or 18 years. The number of female participants exceeded that of male participants, because this experiment was conducted in the same school as experiment 1, which was originally a girls’ school and still accommodates more female than male students.

The reason the second experiment was conducted with another group of participants was that the stimuli of the written experiment and the picture experiment were exactly the same words. The participants would still have the words in their minds when completing the second of the experiments, regardless of which one was completed first. This would result in a false impression as to the influence of the spelling, and the comparison between the two experiments would not be valid.

8.2.2 Stimuli
The stimuli used in this experiment were 70 pairs of pictures, of which 12 pairs were fillers. The words that the pictures represented were the same as the words that were used in the first experiment. The picture experiment was an exact replica of the experiment with written words. Only, this experiment used pictures to represent the words. The two experiments were composed with the same words to make sure that the comparison between both experiments was as valid as possible. The order in which the pairs of pictures were presented in experiment 2 matched the order in which the pairs of written words were presented in experiment 1.

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5 In this group, one native speaker of Turkish was present, of which I had to disqualify the results. The results of the Turkish speaker could not be processed together with the results of the native Dutch participants because my investigation focused specifically on the mental representations of native Dutch speakers.
In this experiment, as in experiment 1, the picture-pairs were divided into four categories where possible. These categories were based on the phonological nature of the final obstruent. I will now provide some examples, to give an idea of the kind of pictures that were used. The categories that were used were ‘same phonology, same orthography’ (e.g. figure 7), ‘different phonology, different orthography’ (e.g. figure 8), ‘same phonology, different orthography with same letter for final obstruent’ (e.g. figure 9) and ‘same phonology, different orthography with different letter for final obstruent’ (e.g. figure 10). These four categories in which I have divided the pairs deal with the relation between phonology and orthography. They may thus be an efficient division to use when looking at the differences between the results of this experiment and those of the first experiment. A comparison between the results in the different categories will help determine if and where the spelling influences the phoneme classification.

![Figure 7: ‘cat’ - ‘bat’](image)

![Figure 8: ‘cat’ - ‘bad’](image)

![Figure 9: ‘weight’ - ‘gate’](image)

![Figure 10: ‘dressed’ - ‘nest’](image)

Words were selected which were easy to present by means of an image. Unfortunately, not all words were depicted with the same ease. In order to have enough stimuli for each contrast and for each category, some words were included that were more abstract than others. I have managed to find a fitting picture for each of the words that was present in the experiment with the written words (experiment 1). The first and second
experiment were composed simultaneously, to make sure that no problems would occur with the finding of a fitting picture. Some words that were present in the experiment with the native speakers of English are not in the actual experiment with the native Dutch speakers. In most of these cases, the reason is that no fitting picture was found for these specific words. Nevertheless, at least four pairs were found for each category. The pictures were made as transparent as possible. All pictures were found through the internet, by means of a search on ‘Google pictures’. The majority of the images were drawings.\(^6\)

8.2.3 Procedure

The experiment was conducted in the participants’ classroom, during classroom time, in the secondary school “Onze-Lieve-Vrouw Presentatie Humaniora” in Sint-Niklaas, Belgium. The participants did not know the purpose of the experiment beforehand. However, since they were interested in knowing what I investigated, I agreed to tell them the subject of my investigation after completion of the experiment.

For the picture experiment, I first explained to the students – in Dutch – what was expected of them. Since with this experiment it was more difficult to understand what they had to do than with the first experiment, I explained the experiment elaborately to the participants. I emphasised that they should focus on the phonemes (the pronunciation), not on the way the words were spelled. When they all understood what was expected of them, I proceeded to go over the most difficult pictures with them. As I have mentioned in section 8.2.2 (about the stimuli), not all words were easily represented by means of a picture. Therefore, I reviewed the most difficult, i.e. most abstract words, together with the participants, showing the pictures on a PowerPoint.

I asked the students to identify the pictures one by one. The first student sitting in the first row started with the first picture, and so the whole class participated successively in the identification of the difficult pictures. I asked them to speak up, so that everyone in the classroom knew what was meant by which picture. When they did not directly identify the

\(^6\) Many of the pictures were found on websites for the development of children in the first year of primary school, i.e. children who are just learning to read and write. Since most of the words in the experiments were simple, monosyllabic words, they were presented as pictures on those websites as an aid for beginning readers and writers.
picture correctly, the classmates could help out if they thought they knew what the picture was supposed to represent. With the very difficult ones, I helped the participants by giving them clues. For example, the picture that represented the word ‘missed’ (figure 11) was difficult to identify for the participants. I helped them out by saying in Dutch, this picture represents “deze pijlen hebben het doel ...” (translation: “these arrows have ... the target”). Then, they knew what was meant without me having to say it for them. It was quite vital that I did not say any of the target words myself, since my pronunciation could reveal the correct pronunciation to participants who did not have a correct phonological representation.

![Figure 11: ‘missed’](image)

When all pictures had been identified, I gave an example of what the participants had to do, to make sure that everyone of them understood the task. I gave one example of a rhyming pair and one of a non-rhyming pair. In the process of explaining these examples, I used a PowerPoint presentation to project the pictures. The examples were the following: First, I asked if the words depicted by pictures of a ‘mouse’ (figure 12) and a ‘house’ (figure 13) were rhyming or not. Then, I asked the participants to identify the last phoneme of each of these words. For the second example, a picture of a ‘mouse’ (figure 12) and a picture of a ‘cake’ (figure 14) were used. With respect to these pictures, the participants were also asked whether the words represented by the pictures were rhyming or not and they were asked to identify the last phoneme of each word.

![Figure 12: ‘mouse’](image)

![Figure 13: ‘house’](image)

![Figure 14: ‘cake’](image)
The instructions to the experiment appeared on the form itself, formulated in Dutch as follows: “a. Duid aan of de twee prentjes rijmen of niet. b. Schrijf de laatste MEDEKLINKER die je *uitsprekt/hoort* onder de prentjes.” (translation: “a. Indicate whether the two pictures are rhyming or not. b. Write down the last CONSONANT you *pronounce/hear* below the pictures.”). Below the instructions, the example that had been clarified in class before was presented (cf. figure 15).

**Example:**

<table>
<thead>
<tr>
<th></th>
<th>Rhyming</th>
<th>Not rhyming</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image of house and mouse]</td>
<td>![Image of mouse and cake]</td>
<td>![Checkmark]</td>
</tr>
</tbody>
</table>

*Figure 15: representation of the example given in experiment 2*

Finally, I handed out the forms on which the participants had to fill out whether the words that the pictures represented were rhyming or not, and which was the last phoneme. If they still did not know what was meant by a specific picture, they could either ask me for help or they could indicate on the form that they did not know the word. They were not allowed, however, to ask their class mates for help. The teacher and I supervised that no student consulted a classroom mate if they did not know the meaning of a picture. The participants completed the experiment in approximately half an hour.

When all forms had been completed, the participants and the teacher received a little reward (in the form of candy bars) to thank them for their time and cooperation. After the experiment had been completed by all, I also explained what I was investigating, since the participants had asked me this at the beginning of the experiment.

### 8.3 Results

For the second experiment, the results of the rhyming task and those of the phoneme classification task are considered separately, to maintain an analogy with the experiment containing written words. Since the rhyming judgment is linked to the subconscious knowledge of the final voicing contrast and the phoneme classification to the conscious
knowledge\textsuperscript{7}, we could use this distinction to note whether any differences occur with respect to these two types of knowledge. The results are not looked at individually because the group of participants consisted of students with more or less the same profile. The averages for each contrast and each category are taken as a reference for the group’s competence.

8.3.1 Results of the rhyming task

First, I will look at the results with respect to the rhyming task (cf. table 5). In general, the participants got a score of 71.2% on the rhyming task.

<table>
<thead>
<tr>
<th></th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phon/same orth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. figure 7 (‘cat’ - ‘bat’)</td>
<td>96,0%</td>
<td>96,8%</td>
<td>84,4%</td>
<td>91,4%</td>
<td>92,2%</td>
</tr>
<tr>
<td>diff. phon/diff. orth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. figure 8 (‘cat’ - ‘bad’)</td>
<td>55,7%</td>
<td>46,5%</td>
<td>22,7%</td>
<td>29,3%</td>
<td>38,6%</td>
</tr>
<tr>
<td>same phon/diff. orth, same obstr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. figure 9 (‘weight’ - ‘gate’)</td>
<td>87,8%</td>
<td>/</td>
<td>79,7%</td>
<td>/</td>
<td>83,8%</td>
</tr>
<tr>
<td>same phon/diff. orth, diff. obstr.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. figure 10 (‘dressed’ - ‘nest’)</td>
<td>92,0%</td>
<td>/</td>
<td>72,2%</td>
<td>/</td>
<td>82,1%</td>
</tr>
<tr>
<td>average per contrast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>82,9%</td>
<td>71,7%</td>
<td>64,8%</td>
<td>60,4%</td>
<td>total: 71,2%</td>
</tr>
</tbody>
</table>

*Table 5: scores for rhyming judgments pictures*

When considering the contrasts separately, we notice that the scores for the stop contrasts /t-d/ and /p-b/, 82.9% and 71.7% respectively, are higher than the scores for the fricative contrasts /s-z/ and /f-v/, which are 64.8% and 60.4% respectively. This finding already constitutes a first difference with the results of the first experiment, where the difference between stops and fricatives was less clear.

Looking at the different categories, we find that the participants got a very low score in the category ‘different phonology, different orthography’, namely only 38.6%. However, this was the only category that got such a low score. All other categories got extremely high scores, compared to this first category. In the category ‘same phonology, same orthography’, the participants did very well on the rhyming task, with a score of 92.2%. The participants got a score of 83.8% on the category ‘same phonology, different orthography with same letter for final obstruent’ and a score of 82.1% on the category ‘same phonology, different orthography with different letter for final obstruent’.

\textsuperscript{7}cf. footnote 2: However, since the participants have to do one task after the other, one may assume some mutual interference between the rhyming task and the classification task.
8.3.2 Results of the phoneme classification task

With respect to the phoneme classification task (cf. table 6), the participants got an average score of 62.1%, almost 10% less than the average score on the rhyming task.

<table>
<thead>
<tr>
<th></th>
<th>T-D</th>
<th>P-B</th>
<th>S-Z</th>
<th>F-V</th>
<th>average per category</th>
</tr>
</thead>
<tbody>
<tr>
<td>same phon/same orth</td>
<td>88,9%</td>
<td>98,9%</td>
<td>50,0%</td>
<td>78,5%</td>
<td>79,1%</td>
</tr>
<tr>
<td>e.g. figure 7 ('cat' - 'bat')</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>diff. phon/diff. orth</td>
<td>66,0%</td>
<td>73,7%</td>
<td>32,0%</td>
<td>51,1%</td>
<td>55,7%</td>
</tr>
<tr>
<td>e.g. figure 8 ('cat' - 'bad')</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>same phon/diff. orth, same obstr.</td>
<td>83,8%</td>
<td>/</td>
<td>7,6%</td>
<td>/</td>
<td>45,7%</td>
</tr>
<tr>
<td>e.g. figure 9 ('weight' - 'gate')</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>same phon/diff. orth, diff. obstr.</td>
<td>76,0%</td>
<td>/</td>
<td>39,2%</td>
<td>/</td>
<td>57,6%</td>
</tr>
<tr>
<td>e.g. figure 10 ('dressed' - 'nest')</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average per contrast</td>
<td>78,7%</td>
<td>86,3%</td>
<td>32,2%</td>
<td>64,8%</td>
<td>total: 62,1%</td>
</tr>
</tbody>
</table>

Table 6: scores for phoneme classifications pictures

Looking at the different contrasts, we notice that there is, again, a difference between stop and fricative contrasts. For phoneme classification, the scores for the stop contrasts /t-d/ and /p-b/ are 78.7% and 86.3% respectively. The scores for the fricative contrasts /s-z/ and /f-v/ are lower than those for stop contrasts, with scores of 32.2% for /s-z/ and 64.8% for /f-v/. The difference between stops and fricatives is hence considerably larger in the phoneme classification task than in the rhyming task. When we look at the general score for stop contrasts and fricative contrasts, we find that for the stops, the participants got a general score of 82.5%, and for the fricatives, they got a general score of 48.5%. This is a discrepancy of more than 30% between the classification accuracy of stops and fricatives. In the Discussion (section 8.4), we will attempt to determine the cause of this large discrepancy.

When we look at the different categories, we find that the category ‘same phonology, same orthography’ stands out with a score of 79.1%. The other categories all got a score of around 50%. These are the categories that contain pairs with different orthographies. Even though this factor should play a lesser role in this experiment, since it consists of pictures instead of written words, there seems to be a certain impact from the orthography on the scores. The categories ‘different phonology, different orthography’ and ‘same phonology, different orthography with different letter for final obstruent’ got scores of 55.7% and 57.6% respectively. The category that got the lowest score was the category ‘same phonology, different orthography with same letter for final obstruent’. In this category, the participants
scored a mere 45.7%. This last result does not correspond with a view concerning influence of the orthography, since the grapheme for the relevant phoneme remained the same.

When we compare the scores for the rhyming judgment and those for the phoneme classification, we find a general difference of almost 10%. With respect to the stop contrasts, the participants got a score of 77.3% on the rhyming judgment task and a score of 82.5% on the phoneme classification task. For the fricative contrasts, they got a score of 62.6% for the rhyming judgment task and scored 48.5% on the phoneme classification task. We see an opposite result for stops and fricatives here. Whereas the participants scored better on the phoneme classification task with respect to stops, they scored better on the rhyming judgment task with respect to fricatives. The discrepancy between rhyming judgment and phoneme classification was largest for the fricatives (14.1%, vs. 5.2% for stops). The discrepancy between stops and fricatives was largest with phoneme classification (34%, vs. 14.7% for rhyming judgment).

8.4 Discussion

8.4.1 Rhyming judgment vs. phoneme classification

When we compare the average scores on the rhyming judgment to those on the phoneme classification, we notice that the scores for the contrasts /t-d/ and /f-v/ are relatively similar with respect to the classification task and the rhyming task. The contrasts /p-b/ and /s-z/, however, show more differences depending on the type of task (cf. figure 16).

*Figure 16: graphical representation of scores per contrast (experiment 2)*
For the contrast /p-b/, the phoneme classification outscores the rhyming judgment. This concretely means that the participants wrote down the correct phoneme in more cases than they actually knew the correct phoneme subconsciously, i.e. the participants could not implement their knowledge with respect to a rhyming task. To illustrate this given, we take for instance the pair represented by figure 17 (‘lab’ - ‘cap’). Whereas only twelve out of twenty participants got the rhyming judgment correct on this word pair, sixteen out of twenty indicated the right final phonemes. In other words, four participants indicated the correct final phonemes (“b” and “p”) but still wrote that the words were rhyming. This could mean one of two things. The first hypothesis would be that even those who did not know the contrast on a subconscious level, did know it at the meta-level. The second, more plausible hypothesis, would be that these participants, despite the lack of a visual representation of the spelling, were still influenced by the orthography because it is so inherent to their knowledge of English. They have, after all, learned the language in secondary school, mainly through textbooks, spelled word lists and other written input.

![Figure 17: ‘lab’ - ‘cap’](image)

We already noticed this effect for the contrast /p-b/ in the first experiment, where the scores for phoneme classification were also higher than those for rhyming judgment with respect to the /p-b/ contrast. I suggested there that the participants’ phonological representations were correct but that they subconsciously still devoiced the voiced obstruent when completing a rhyming task. We can deduct from these findings that, at least in the case of the contrast /p-b/, the orthography influences the identification of the last phoneme, and hence the phonological representation, whether the spelling is explicitly present or not. However, the participants still need to practice much in order to be able to implement this knowledge and realise the final voiced phonemes correctly.

With respect to the seemingly most difficult contrast, the final contrast /s-z/, the result is similar to the result of the first experiment. The average score on the rhyming judgment task (64.8%) is twice as high as the score on the phoneme classification task (32.2%). The discrepancy between rhyming judgment and phoneme classification is over
30%. This is even more than in the first experiment, where we found a discrepancy of over 20% between rhyming judgment and phoneme classification. This larger discrepancy could be caused by the nature of the experiment, since the participants in the first experiment had access to the spelling of the final phoneme and the participants in the second experiment did not. I will shortly come back to the investigation on the influence of the spelling.

When we compare rhyming judgment and phoneme classification with respect to the different categories (cf. figure 18), we find that the highest average score was found in the category ‘same phonology, same orthography’. For the category ‘different phonology, different orthography’, the scores were very low for both rhyming judgment and phoneme classification, although the score on phoneme classification was still about 15% higher than the score on rhyming judgment. So far, there is a general analogy with the first experiment. However, with respect to the categories that have a discrepancy between orthography and phonology, we find a different development. For the categories ‘same phonology, different orthography with same letter for final obstruent’ and ‘same phonology, different orthography with different letter for final obstruent’, the scores on the rhyming judgment were very high, while the scores on the phoneme classification were remarkably low. This is the same development as in the first experiment, where the scores for rhyming judgment were also higher than those for phoneme classification, but in this case, the discrepancy is much greater.
8.4.2 The influence of orthography

In our investigation of the influence of the spelling, we will start with the most interesting contrast, namely the contrast /s-z/. The last phoneme of a word which last segment was written as an <s> but pronounced as a [z], was, also in the picture experiment, generally classified as an “s”. For instance, for the pair represented by figure 19 (‘bees’ - ‘cheese’), belonging to the category ‘same phonology, different orthography with same letter for final obstruent’, the final phonemes were classified correctly by only one participant. All the other participants wrote down “s” for both words. Nevertheless, seventeen out of twenty participants got the rhyme judgment correct. For this particular case, the rhyme judgment does not give a correct view of the abilities of the group. Since the participants had classified both phonemes wrongly, the words were still rhyming, despite the wrong representations of the final phonemes. This example shows clearly that for words written with final <s> but pronounced with final [z], the phonological representation of the majority of the participants is wrong. This finding matches what we found in the first experiment, where the spelling was visually present. Even though the spelling is not explicitly present in this experiment, it seems that the participants think in terms of spelling when they are asked to classify a phoneme. It could also be that, spelling left aside, the participants simply have a (wrong) phonological representation with a final /s/. Their responses would then be the result of this wrong representation.

To test the hypothesis that the “s” responses for the word pair represented by figure 19 are the result of an influence of the spelling, we will discuss an example from a different category. For instance, the pair represented in figures 20 and 21 (‘eyes’ - ‘size’), belonging to the category ‘same phonology, different orthography with different letter for final obstruent’, orthographically contains the contrast <s-z> but phonologically, both words end in /z/. Thirteen out of 20 participants had the rhyming judgment correct, i.e. indicated that the words were rhyming. With respect to phoneme classification, the situation is a little more complicated. Ten participants indicated that the last phoneme of figure 20 (‘eyes’) was “s” and that the last phoneme of figure 21 (‘size’) was “z”. Although the spelling was not present in this experiment, it seems to have had a considerable influence, since half of the
participants indicated phonemes according to the spelling. Nine participants wrote down “s” for both words, and one participant indicated correctly that the last phoneme of both words was “z”. From this example, we can deduct that half of the participants were influenced by the spelling, even though this was not explicitly present, and that the other half thought that both phonemes were voiceless, regardless of the voiced consonant at the end of the word represented by figure 21 (‘size’). The fact that the majority of the participants indicated that the words were rhyming and wrote down the wrong categorisations of the phonemes (either they indicated “s” and “z” or “s” and “s”), suggests that they have a wrong representation and a wrong implementation (influenced by final devoicing) of the final phonemes, in the case of the final contrast /s-z/.

With respect to the contrast /t-d/ belonging the category ‘same phonology, different orthography with different letter for final obstruent’ (e.g. figure 22: ‘test’ - ‘stressed’), the majority of the participants did not pay attention to the orthography. This is the same development we find in the first experiment. Some wrote down a “d”, but only for the word represented by figure 11 (‘missed’). Almost all participants indicated that the picture pairs belonging to this category and contrast were rhyming, so subconsciously they did know that, in this case, a voiceless phoneme should be realised. This suggests again that the participants tend to disregard the orthography if the final grapheme is a voiced obstruent. In this case they are correct in disregarding it, but in the case of the /s-z/ contrast, the last grapheme which represents a voiced obstruent does matter.
8.4.3 Comparison between experiment 1 (written words) and experiment 2 (pictures)

The main difference between the first and the second experiment was that, in general, more participants gave a correct phoneme classification in the first experiment. This could mean that the explicit presence of the spelling does help a little in cases of doubt. However, there were no significant differences between both experiments that could indicate a mayor influence from explicit presence of the orthography. Note that, similarly to the first experiment, the participants in the second experiment only ignored the spelling (or did not pay attention to it, since it was not explicitly present) when the written form contained a letter representing /b/, /d/, /v/ or /z/. This observation suggests that the final devoicing rule is so inherent to the participants’ language system, that they cannot ‘turn it off’ with respect to a foreign language.

![Figure 23: comparison between experiment 1 and 2 with respect to contrasts](image)

A comparison between the first and the second experiment revealed that the explicit representation of the orthography did have an effect, although not a striking one (cf. figure 23). In general, the results were similar for the experiment with explicit orthographic detail (experiment 1) and the one without (experiment 2). Nevertheless, one striking difference was that, whereas the discrepancy between rhyming judgment and phoneme classification for the /s-z/ contrast was around 20% in the first experiment, it amounted to around 30% in the second experiment. Concretely, this means that the participants classified even fewer phonemes correctly with respect to the /s-z/ contrast when the spelling was not explicitly present. We are dealing here mainly with words written with a <z> (e.g. ‘breeze’, <breeze>,...
/briːz/) which last phonemes were classified correctly in the first experiment and wrongly in the second by most participants. For the words which orthography and phonology did not match for the last segment (e.g. ‘eyes’, <eyes>, /aɪz/), there was no or little difference between the phoneme classifications in the first and second experiments.

Another measure that was taken to investigate whether the orthography influences the phonological representation is dividing the stimuli in four groups or categories according to the correspondence between orthography and phonology (cf. figure 24). For the categories ‘same phonology, same orthography’ (e.g. ‘cat’ - ‘bat’) and ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’), the orthography of the final consonant is equal to the phonology of the final obstruent. The former of these categories generally got a very high score and the latter generally got a very low score. These results suggest that the participants tended to assimilate most final obstruents in the rhyming task, regardless of the voice. The phoneme awareness seemed to be influenced by the spelling in both experiments, since the scores on phoneme classification are higher than the scores for rhyming judgment in both experiments, with respect to the category ‘different phonology, different orthography’ (e.g. ‘cat’ - ‘bad’). We can deduct from this finding that the spelling exercises an influence even if it is not explicitly present.

The category ‘same phonology, different orthography with same letter for final obstruent’ (e.g. ‘weight’ - ‘gate’) should not have been a problematic category. Although the
spelling of the words is different here, the spelling of the final obstruent matches its phonology. As expected, this category got slightly lower scores as opposed to the category ‘same phonology, same orthography’ (cf. figure 24). This result can be explained by the participants being distracted by the different spelling, even though this different spelling was not manifested in the final obstruent. The scores for phoneme classification were about 15% lower in the second experiment than in the first one, so we can assume a certain impediment from the absence of the spelling here.

The category ‘same phonology, different orthography with different letter for final obstruent’ (e.g. ‘dressed’ - ‘nest’), however, did not have a matching phonology and orthography for the final obstruent. The scores between the first and second experiment were similar with respect to this category, although slightly lower in the second one (cf. figure 24). This can be explained by the fact that the spelling is an impediment for this category. The participants may have disregarded the spelling in this case, even when it was explicitly present, since it was not consistent with the phonology (e.g. most participants wrote “t” and “t” for ‘dressed’ and ‘nest’). Therefore, little difference between the group which had access to explicit spelling and the group which did not have access to explicit spelling was observed.

8.4.4 A third hypothesis

An additional hypothesis that I posed in the literature section was that these students may have wrong phonological representations because of an environmental factor, namely that they only hear (wrong) input from their peers with respect to the voice of final obstruents. As we saw in both experiments, with respect to the final contrasts /s-z/ and /p-b/, the participants tended to ignore the spelling or did not pay attention to it almost exclusively for final graphemes which were voiced obstruents (e.g. in ‘size’, ‘lab’). This could be the result of a wrong phonological representation, driven by the final devoicing rule in their native language, Dutch. Since the only interactive input these students hear is input from their friends and classmates at school, they may have developed a representation based on this input. Even if they hear native English, they may store a final [b] as a /p/ because the Dutch phonotactic system does not allow final voiced obstruents. Nevertheless, the participants did learn the differences between Dutch and English final obstruents at school (according to the English teacher). It is my opinion that more attention should be paid to this vital
difference, since the students are likely to subconsciously develop an erroneous representation based on input from their peers, when they are not fully aware of these differences.

The general observation from this second experiment is similar to the conclusion from the first experiment, namely that the phoneme awareness seems to depend largely on the type of contrast involved. In the second experiment, we observed a clearer contrast between stops and fricatives (cf. section 8.3). Again, the most difficult contrast seemed to be the contrast /s-z/. These results confirm the hypothesis from the first experiment, namely that it is most difficult to form a correct phonological representation of the final contrast /s-z/. This difficulty with respect to the final /s-z/ contrast seems to be caused mainly by the impairing effect of the orthography. With respect to the other contrasts investigated, the phonology and the orthography are relatively consistent, and thus aid the language user in forming a phonological representation. However, at times, the participants tended to disregard this aid and indicated a voiceless obstruent for words ending in a voiced obstruent, even if the spelling disagreed with this representation.
9 Conclusion

The general aim of this research paper was to investigate what causes the production errors with respect to the final voicing contrast by native speakers of Dutch learning English. Two hypotheses were formulated as to the cause of this problem. The first hypothesis was that the production errors with respect to the final voicing contrast are due to phonological misrepresentation. If this would be the case, the learner would not be aware of the contrast on a meta-level and would hence not produce the right phoneme. An extra hypothesis in this respect was that, if the errors would be caused by phonological misrepresentation, this wrong representation could be the result of the input that the participants received. Assuming that most of the interactive input\(^8\) the participants received was from classmates, i.e. peers, it would be possible that this input would cloud the representation of the participants. The general production of Dutch learners of English contains constant instances of final voiceless obstruents where final voiced obstruents should be used. The second hypothesis was that these production errors are the result of mere erroneous phonetic realisation. In this case, there would be a failure to implement their knowledge, i.e. a failure to produce the right phoneme, despite a correct phonological representation.

These two main hypotheses were tested by means of two experiments, each with a group of participants who were proficient in English. The first experiment consisted of a rhyming judgment task and a phoneme classification task, based on orthographically represented words. The second experiment consisted of the same tasks, but based on pictures, i.e. visual representations of the words but without orthographic markers. The rhyming judgment task meant to represent the participants’ subconscious knowledge of the final voicing contrasts and the phoneme classification task mean to test their meta-knowledge of these contrasts. The outcome of these experiments was dual. It did not confirm one of the two hypotheses but suggested a mixed influence. The results suggested that the participants generally had the correct phonological representation for the final contrasts /t-d/, /p-b/ and /f-v/. In these cases we can assume that the second hypothesis is valid, i.e. participants had the correct phonological representation but failed to implement their knowledge. Nevertheless, the final contrast /s-z/ caused more problems. In the case of

\(^8\) In the classroom, the students are actively engaged in the language learning process. Other input, like English series and films on television, involves a more passive engagement.
In this contrast, the participants did not always seem to be aware of the correct phonological representation. In this case we can then assume that the first hypothesis is a valid one: with respect to the final contrast /s-z/, the participants did not always have the correct phonological representation.

In conclusion, the two hypotheses seem to be valid depending on which final contrast is investigated. We cannot exclusively elect one of the two hypotheses as the correct one. There seems to be a difference depending on which aspect of the final voicing contrast is investigated. The spelling seemed to influence the participants’ judgment, even when it was not explicitly present. For the contrasts in which the participants were aided by the spelling, a more or less correct phonological representation was observed. For the instances where the spelling was an impediment (the final contrast /s-z/), the phonological representation was more often than not incorrect. Whereas in the other three cases (the final contrasts /t-d/, /p-b/ and /f-v/) the orthography is in the great majority of instances consistent with the orthography, in the case of the contrast /s-z/ it is usually not. Words ending in the grapheme <s> are often plural forms which have to be pronounced ending in a [z] (e.g. the words ‘eyes’, ‘knees’, and ‘bees’). As became apparent from analysis of the rhyming judgment task, the participants subconsciously devoiced the voiced instances of final obstruents in many of the cases, sometimes even when they had correctly classified the final obstruents (in the cases of the final contrasts /t-d/, /p-b/ and /f-v/). This observation corroborates the hypothesis that the participants have the correct phonological representation, but when they are asked to implement it, they make mistakes.

Nevertheless, it should be noted that only a relatively small number of participants engaged in the experiment, and that the participants were all of the same age group. The results found in the present study are therefore not representative of all Dutch proficient speakers of English. In order to generalise the results, another study would have to be conducted with a larger and more heterogeneous group of participants. Also note that the results of the present experiments were not analysed by means of statistical analysis. To test the significance of the differences found in the experiments, statistical analysis would be needed.

On a final pedagogical note, it would be interesting to teach more explicit phonology with respect to the final voicing contrast in English classes in secondary schools. The final
voicing contrast is an important contrast in English because a lack of contrast in final obstruents could lead to homophones, which could lead to misunderstandings (e.g. pronouncing ‘crab’ as [kræp] instead of [kræb], thus changing the meaning). The teacher of the participants in the present experiments mentioned that the students are taught the difference between final obstruent voicing in English and in Dutch, but only very briefly and not as elaborate as it should be. Perhaps tasks like the ones in the present experiments would be helpful to make students consciously realise the differences with respect to the final obstruent voicing contrast in Dutch and in English.
Bibliography


Cutler, Anne, Andrea Weber & Takashi Otake. 2006. Asymmetric mapping from phonetic to lexical representations in second-language listening. *Journal of Phonetics* 34. 269-284.


Appendices

Appendix A: stimuli experiment native speakers

\textit{T – D (same phonology / same orthography)}

bat – cat
bad – sad
red – bed
boat – goat
road – toad

\textit{T – D (different phonology / different orthography)}

sad – hat
cloud – shout
rat – bad
cat – bad
bat – sad
road – goat
net – bed
mad – cat

\textit{T – D (same phonology / different orthography, same letter for obstruent)}

street – Pete
code – road
spade – maid
weight – gate
road – ode

\textit{T – D (same phonology / different orthography, different letter for obstruent)}

lost – crossed
dressed – nest
list - missed
mist – kissed
stressed - test
P – B (same phonology / same orthography)
shrub – blub
ape – grape
map – cap
rope – pope
ship – lip

P – B (different phonology / different orthography)
job – shop
cup – club
rope – globe
blub – pup
lab – cap
ship – rib
map – cab

S – Z (same phonology / same orthography)
seas – peas
(he) feeds – seeds
seats – (he) eats
toes – (he) goes
ice – mice
bus – plus
bees – knees
breeze – freeze
nose – rose

S – Z (different phonology / different orthography)
plus – buzz
freeze – grease
moose – booze
size – rice
jazz – ass
mice – size
grease – breeze
booze - goose
size – ice
ice – prize

S – Z (same phonology / different orthography, same letter for obstruent)
bees – cheese
skis – Chinese
shoes – lose
cruise – canoes
cheese – hippies (disqualified!)

S – Z (same phonology / different orthography, different letter for obstruent)
eyes – size
cheese – breeze
shoes – booze
grease – peace
moose – juice

F – V (same phonology / same orthography)
dove – glove
thief – chief
cave – wave
leaf – thief
leave - sleeve

F – V (different phonology / different orthography)
roof – move
leave – leaf
tough – dove
stuff – glove
leave – chief
sleeve – thief
safe – cave
safe – slave
leaf – sleeve
wave – safe

*Fillers (not rhyming)*

feel – feet
now – not
sheet – sheep
mean – meat
clown – brown
mix – mill
rose – rope
bag – back
ape – lake
king – kill
sheep – shield
pig – pin
gum – gun
nut – nun
web – wet
man – map
cage – cave
box – bomb

*Fillers (rhyming)*
sun – nun
book – hook
moon – spoon
flower – shower
rows – bows
Appendix B: stimuli experiment English words

*T – D (same phonology / same orthography)*
bat – cat
bad – sad
red – bed
boat – goat
road – toad

*T – D (different phonology / different orthography)*
cat – bad
bat – sad
road – goat
net – bed
mad – cat

*T – D (same phonology / different orthography, same letter for obstruent)*
code – road
spade – maid
weight – gate
road – ode

*T – D (same phonology / different orthography, different letter for obstruent)*
lost – crossed
dressed – nest
list – missed
mist – kissed
stressed – test

*P – B (same phonology / same orthography)*
shrub – blub
ape – grape
map – cap
rope – pope
ship – lip
**P – B (different phonology / different orthography)**

rope – globe
blub – pup
lab - cap
ship – rib
map – cab

**S – Z (same phonology / same orthography)**

ice – mice
bus – plus
bees – knees
breeze – freeze
nose – rose

**S – Z (different phonology / different orthography)**

mice – size
grease – breeze
booze - goose
size – ice
ice – prize

**S – Z (same phonology / different orthography, same letter for obstruent)**

bees – cheese
skis – Chinese
shoes – lose
cruise – canoes

**S – Z (same phonology / different orthography, different letter for obstruent)**

eyes – size
cheese – breeze
shoes – booze
grease – peace
goose – juice

**F – V (same phonology / same orthography)**
dove – glove
thief – chief
cave – wave
leaf – thief
leave - sleeve

F – V (different phonology / different orthography)
sleeve – thief
safe – cave
safe – slave
leaf – sleeve
wave – safe

Fillers (not rhyming)
rose – rope
bag – back
ape – lake
king – kill
sheep – shield
pig – pin
gum – gun
nut – nun
web – wet
man – map
cage – cave
box – bomb
Appendix C: stimuli experiment Dutch words (+translation)

**T – D (same phonology / same orthography)**

haard – baard (‘fireplace’ – ‘beard’)
wind – kind (‘wind’ – ‘child’)
hoed – bloed (‘hat’ – ‘blood’)
hart – zwart (‘heart’ – ‘black’)
kat – mat (‘cat’ – ‘mat’)

**T – D (same phonology / different orthography)**

lint – kind (‘ribbon’ – ‘child’)
zwart – hard (‘black’ – ‘hard’)
koud – hout (‘cold’ – ‘wood’)
hoed – voet (‘hat’ – ‘foot’)
kat – pad (‘cat’ – ‘toad’)

**P – B (same phonology / same orthography)**

club – schub (‘club’ – ‘scale’)
aap – slaap (‘ape’ – ‘sleep’)
griep – diep (‘flu’ – ‘deep’)
eb – web (‘ebb’ – ‘web’)
pop – kop (‘doll’ – ‘head’)

**P – B (same phonology / different orthography)**

eb – klep (‘ebb’ – ‘valve’)
rob – dop (‘seal’ – ‘top’)
web – schep (‘web’ – ‘scoop’)
club – pup (‘club’ – ‘pup’)
krab – trap (‘crab’ – ‘stairs’)

**S – Z (same phonology / same orthography)**

les – bes (‘lesson’ – ‘berry’)
vis – mis (‘fish’ – ‘wrong’)
gas – was (‘gas’ – ‘laundry’)
bus – kus (‘bus’ – ‘kiss’)

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bos – tros (‘forest’ – ‘cluster’)

*F – V (same phonology / same orthography)*

dief – lief (‘thief’ – ‘dear’)
af – graf (‘off’ – ‘grave’)
stof – hof (‘dust’ – ‘yard’)
braaf – slaaf (‘good’ – ‘slave’)
juf – bluf (‘teacher, miss’ – ‘brag, boast’)

*Fillers (not rhyming)*

mus – mos (‘sparrow’ – ‘moss’)
bus – bos (‘bus’ – ‘forest’)
aap – sleep (‘ape’ – ‘train e.g. of wedding dress’)
kaars – mars (‘candle’ – ‘march’)
koud – roet (‘cold’ – ‘soot’)
hout – huis (‘wood’ – ‘house’)
piep – pijp (‘squeek’ – ‘pipe’)
rijp – reis (‘ripe’ – ‘journey’)
mol – mot (‘mole’ – ‘moth’)
buit – bout (‘loot’ – ‘bolt’)


### Appendix D: stimuli experiment pictures

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