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# Perception of word-final voicing in English and Czech

(diplomová práce)

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Prohlašuji, že jsem tuto diplomovou práci vypracovala samostatně a předepsaným způsobem v ní uvedla všechnu použitou literaturu.

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## Contents

# 1 Introduction

This thesis consists of four major parts – introduction, methods, results and discussion. The introduction contains a review of literature devoted to the topic of this thesis and it is divided into chapters which focus on particular issues connected to the main theme. The first chapter (1.1) reviews the main topic of the thesis as such – the vowel duration variation caused by coda voicing – whereas the following section (1.2) deals with the question of whether this phenomenon is language specific or universal. The next chapter (1.3) explores the interaction between the effect under investigation, *word-final voicing* and the issue of *incomplete neutralization*. Another part of the introduction is focused on the issue of second language acquisition (1.4) as well as the native vs. non-native use of the vowel duration as a cue to final voicing (1.5). There is also a minor chapter devoted to the issue of markedness of word-final voicing (1.6). At the end of the introduction there is a section (1.7) summarizing all the research questions. The part devoted to methods (section 2) describes in detail the participants, the stimuli and the procedure of the experiment itself. It is followed by a section (3) which presents the obtained results. These results are evaluated and interpreted in the Discussion (section 4).

## 1.1 Vowel duration variation caused by coda voicing

In English there is a well-known and rather well-examined phenomenon of variable vowel duration depending on the voicing of the following obstruent.[1] That is to say, vowels are generally longer

[1] For the purpose of this thesis, this phenomenon is going to be referred to as *vowel duration variation caused by coda voicing* and will be abbreviated into *VDVCV*, since as the key term, it will be frequently mentioned throughout the whole study.

before voiced consonants and shorter before voiceless consonants. This phenomenon has already been investigated and experimentally verified in many studies and numerous articles have been dedicated to this matter. One of the first works which examined the effect of this phenomenon on perception of English speech was the one by P. Denes (1955) which proved that "the relative durations of vowel and final consonant can be used as a cue for hearing the final sound as voiced or unvoiced" (Denes 1955: 761). In 1960, Peterson and Lehiste published an article which has been referred to by many authors since then. In their study, they came to the conclusion that the durations of all syllable nuclei in English are significantly affected by the nature of the consonants that follow. For their set of data, the ratio of a vowel before a voiceless consonant to a vowel before a voiced consonant was approximately 2:3 (Peterson and Lehiste 1960: 700). Most of such early studies focused mostly on English, which naturally brought up the question whether *VDVCV* is a phenomenon inherent only to English or if it applies cross-linguistically (to be discussed in detail in section 1.2).

Generally, we can say that the whole process of *VDVCV* takes place in two stages. The first stage, which can be considered to be universal and applies in most of the languages, is the variation at the phonetic level (i.e. the variation in the surface realization of phonemes which can be a result of the articulatory implementation). English is supposed to be the language where this process proceeded (gradually in the course of its diachronic development) to the second stage where this variation became phonologized. That is to say, it is possible that the speakers and listeners of English have gradually started utilizing the phonetic variation in vowel duration to enhance the contrast (i.e. something phonological) between a voiced and a voiceless obstruent in the coda. In other words, it can be assumed that a change in 'cue weighting' took place and instead of using the actual voicing in the coda, listeners started to rely more on the duration of the preceding vowel. By designing an experiment focusing on how LI (= first/native language) and L2 (=second/acquired language) English speakers rank their perceptual cues to final voicing in English, Broersma (2005a) found out that L1 English listeners had a tendency to use the vowel duration as a cue to voicing in the coda even if the duration was uninformative and sometimes even mismatched other voicing characteristics. In contrast, the Dutch speakers (i.e. L2 English listeners) used in this experiment did not seem to use the vowel duration as a cue to final voicing and thus sometimes (in cases when the duration was a misleading cue) even outperformed the L1 English listeners.

It seems to be evident that in English the voicing in coda itself as a cue gave its way to the duration of the preceding vowel even though there is no direct evidence that would prove this kind of diachronic change of 'cue weighting' since the research into speech perception does not date back enough. Due to the fact that any kind of investigation following this line would be based on speculations (because of the lack of needed evidence), not many studies were specifically dedicated to this probable diachronic change or they referred to it only marginally (see e.g. Nearey 1997: 3243). No matter what the reason for such a change in cue preference might have been, English listeners have moved from a phonetic voicing distinction of phonologically voiced and voiceless codas rather to a vowel-duration-based distinction between them.

One of the reasons for this change might have been that voicing contrasts located in coda are marked (see De Lacy: 15; the issue of markedness to be discussed in section 1.6) and the voicing difference disappears easily in this position. E.g. Ladefoged (2001) concludes that obstruents – stops and fricatives – classified as voiced are voiced through only a small part of the articulation when they occur at the end of an utterance or before a voiceless sound (Ladefoged: 57). In some languages, underlying (phonological) voicing contrasts are *neutralized* word-finally which means that they are supposed to disappear completely on the surface level (to be discussed in section 1.3). However, in English, such *neutralization* does not take place because underlying coda voicing distinctions are marked by vowel duration differences on the surface. Neutralization is perhaps avoided because of the pressure of the lexicon: there are many minimal pairs which differ only in the voicing of the coda and neutralization would result in a large number of homonyms. These homonyms would be a source of ambiguity which might be difficult to resolve on the basis of context. As Vachek (1961) suggests, the rise in the amount of homonyms would have affected the grammatical plan since English lacks inflection (unlike e.g. Czech where thanks to the case endings it is for instance clear what the subject and object of a sentence are) and above all: "the ModE sentence context is burdened by a relatively high number not only of stylistic, but mainly grammatical functions" (p. 56). That is to say, by overloading the sentence context (which is already burdened enough with a considerable number of tasks) with a great deal of homonyms, the main task of a language (i.e. mutual communication and expression) would have been threatened.

However, there are languages like Czech, Slovak and Russian that allow neutralization of word-final voicing contrasts. How is this possible when we consider the fact that such neutralization inevitably leads to an increase in the number of homonyms as in English? For instance in Czech, the sentence context is not as burdened as in English especially thanks to inflectional endings and suffixes which help to distinguish word functions (Vachek 1961: 57). Also the word order is relatively free (in comparison to the situation in English where it is rather fixed) and therefore the position of sentence elements does not have to signal syntactic functions (as it does in English). It is obvious that due to the relatively small number of tasks imposed on the Czech sentential context, the increased number of homonyms should not represent a threat to the communicative function of the language as such.

To summarize, it is probable that in English, there were (and are) two contradictory tendencies: (i) a tendency to neutralize voicing contrasts in marked positions and (ii) a tendency to preserve contrasts in meaning (and thus the voiced, i.e. marked elements). Speakers of English managed to reconcile these two drives. They noticed a phonetic regularity (which had presumably been unintentional) and incorporated it into the phonology of English by turning it into a phonological rule. This is most probably the reason why in English, the discussed effect of *VDVCV* is larger than in other languages (see e.g. Chen 1970).

In general, the tendency across languages for vowels to be shorter before voiceless and longer before voiced obstruents is still not fully understood and it deserves attention and further examination. This thesis will try to both sum up the previous findings and hypotheses dedicated to the topic and, above all, bring new insights and experimental results into this field of investigation.

## 1.2 Is *VDVCV* language-specific or language universal and what is its cause?

One of the first attempts to address the issue of the cross-linguistic occurrence of *VDVCV* was made by Chen (1970). By investigating either its presence or absence in various languages, he wanted to examine if it is a learned speech habit which is *language-specific* just for English or if it is (in case it is attested in other languages) a *language-universal* phenomenon. French, Russian and Korean were submitted to analysis and provided evidence for the presence of the variable vowel duration influenced by the voicing of the following consonantal environment, which convinced Chen to formulate a tentative conclusion that the investigated phenomenon is *language-universal* even though the extent to which it applies is *language-specific*.

However, Chen’s study has faced some criticism since its publication. For instance, Keating (1985) questioned some of Chen’s conclusions and above all the method which he used to obtain and analyze the results. According to Keating, the main problem with Chen’s comparisons between languages was that he was not consistent in choosing the stimuli for the analysis. While in some languages he examined the vowels in monosyllabic words, in others he chose disyllabic words (where he focused on the vowel within the first syllable and thus it did not precede the final consonant anymore) which conflicts with the well-known fact that the difference in vowel duration varies with respect to its position in the word even within a single language.

What is more, Keating attempted to verify Chen’s proposal in languages such as Czech and Polish and came to the conclusion that “in Polish vowel duration does not vary systematically according to the voicing of the following consonant” (Keating: 121) and that “there is a slight tendency for vowels to be shortened before voiceless consonants but the difference in durations did not reach statistical significance” (Keating: 122). These conclusions are based on production data which the author obtained by measuring vowel durations before voiced and voiceless consonants produced by 24 Polish and 3 Czech speakers. However, especially the number of the Czech speakers was not satisfactory enough to provide relevant results and it is also important to point out that due to the word-final devoicing in these languages (i.e. no voicing in coda is expected to exist), Keating averted her view from vowels and consonants in word-final position and focused only on those in word medial position (i.e. on the first vowel in the CVCV word structure).

Slowiaczek and Dinnsen (1985) reacted to Keating's findings in their paper and confronted them with their own examination of the status of word-final devoicing as an example of a neutralization process. They concluded (after conducting a production experiment in which they measured durations of vowels preceding the word final consonant produced by 5 Polish speakers) that there is evidence proving that in Polish, the word-final devoicing rule is non-neutralizing and therefore suggested that Keating's conclusion might not hold, i.e. there is a chance that in Polish we can observe the phenomenon of *VDVCV* as well. As it was already suggested, one of the aims of this study is to experimentally verify if there is any vowel duration variation dependent on the final obstruent voicing in Czech. If *VDVCV* is found (i.e. statistically significant), it will be another argument favouring its status of a language-universal tendency.

The previous discussion about the potential 'language-universality' of *VDVCV* brings up another important issue - the question of what its actual cause is. The assumption that it is a universal tendency which occurs in various languages would suggest that it is based on some physiological basis and that "some common inherent articulatory factor(s) must underlie the widely observable durational differential" (Chen 1970: 139). Also Kluender *et al.* (1988) developed this line of reasoning pointing out that: "phoneticians have tended to view language specific effects as 'learned' and language-universal effects as 'physiological', with the latter term carrying a clear implication that the effects (i.e. vowel length effect) are articulatory (or phonatory) in origin" (p. 154). Chen (1970) represents one of those authors proposing a physiological explanation to this effect. He suggested that vowels are shortened before voiceless consonants because the closing gesture [2] requires a bigger force executed by the articulatory muscles when the obstruent is voiceless than when it is voiced and hence a greater acceleration is produced. Such greater force is created to overcome the higher intraoral air pressure (due to an open glottis) during the production of a voiceless stop.

This hypothesis proposed by Chen (1970) represents an 'articulatory' explanation of the effect of variable vowel duration, i.e. it takes into account the point of view of production. But what if the explanation lies in the perception? What if the reasons are 'auditory' rather than articulatory? It is possible that the speakers lengthen the vowel because they *perceive* it as lengthened and in the production they simply copy what they assume to have heard. This assumption would be consistent with the hypothesis that sound change is 'driven' by listeners who reinterpret the variation in sound patterns they encounter as produced by speakers (see Ohala 1974, 1981). The proponents of the listener-oriented account of the development of *VDVCV* in English are, for instance, Kluender *et al.* (1988). Their paper summarized various theories that until then had attempted to explain the phenomenon of *VDVCV* in terms of "assumed physical or physiological constraints" (p. 153) and confronted them with their own auditory explanation. The authors point out that voiced obstruents

[2] voiceless consonant is more closed than a vowel and thefore we talk about the 'closing gesture'

have shorter constriction periods than voiceless obstruents and propose “the alternative hypothesis that language communities intentionally vary vowel length[3] in order to enhance auditorily the closure-duration cue for voicing distinctions” (ibid.). They start from the assumption that humans perceive duration of speech sounds in relative rather than absolute terms and therefore (due to the principle of durational contrast) a longer vowel should make the following short closure interval seem even shorter and hence more easily perceptible as voiced, whereas a shorter vowel should make the following long closure interval appear longer and hence more easily perceptible as voiceless.

There are three factors having influence on the perception of underlying voicing of a syllable coda in English: the presence or absence of voicing during the constriction, the duration of the constriction and the duration of the preceding vowel (see e.g. Watson 1983). All of them can be considered to be natural results of the physiology of speech production but at the same time, speakers still can control and therefore manipulate them to some extent. Consequently, they can combine them to signal voicing and listeners can use these ‘cues’ to recover intended voicing. That would suggest that the *VDVCV* is not just a matter of physiology but in fact “a result of a strategy by the listener to make consonantal contrasts cued by duration more distinctive... If there is a reliable VLE [“vowel length effect”], then there will be inverse differences in closure duration for voiced and voiceless consonants” (Kluender *et al.* 1988: 163). This hypothesis clearly draws on the auditory account and departs from the explanations based on production (e.g. Chen).

[3] ‘length’ usually means ‘phonological length’ / ‘quantity’ whereas the temporal lasting of a segment in a phonetic sense is usually referred to as ‘duration’ (and which will be closely connected to the main topic of this thesis )

As is obvious from the debate between proponents of various hypotheses (attempting to explain *VDVCV*) which has just been briefly summarized above, the experimental evidence that would favour one hypothesis over others has not been successfully given yet. As far as the present thesis is concerned, its results will probably not bring any significant evidence to either prove or disprove any of the account explaining the origin of *VDVCV* since it is not its primary objective but, nevertheless, it will hopefully help to shed more light on the topic by presenting new and possibly useful experimental results from Czech language.

## 1.3 The interaction of *VDVCV* with word-final devoicing and the issue of incomplete neutralization

Another key concept of this study will be *final devoicing* since this paper will be focused on Czech language and its L1 (= first/native language) speakers acquiring L2 (= second/learnt language) English. Czech belongs to a group of languages with the word-final devoicing rule. That means that all the voiced consonants at the end of the word are devoiced (e.g. *led* is pronounced as /let/). Besides Czech, this rule applies e.g. in German, Polish, Catalan, Dutch and Russian (for a list of references to particular studies conducted in the languages mentioned see Myers 2008). In all these languages, voiced obstruents in the syllable coda (or at the end of the word) become voiceless. That might lead to the *neutralization of contrast* (i.e. two phonemes which contrast on the phonological/underlying level become identical on the phonetic/surface level, which means when pronounced). If the surface forms are completely identical and the contrast is lost, then we talk about *complete neutralization*. In languages with the *final devoicing* rule, *complete neutralization* was generally considered to be its consequence.

However, in some recent studies this hypothesis was questioned by obtaining experimental evidence of the fact, that in some languages (in which the *final devoicing* rule operates), the *neutralization* might be *incomplete*. For instance, Warner *et al.* (2004) found that in Dutch, "under identical prosodic circumstances, the same surface string segments may be realized with slight differences in duration" (p. 251) which means that although both underlyingly voiced and voiceless word-final obstruents are realized as voiceless, vowels preceding underlyingly voiced obstruents are slightly longer. The authors of the study suggested that in Dutch "durational differences of the type which have been called incomplete neutralization (...) are pervasive, if often extremely small" (p. 273). However, due to a particular inconsistency in the data obtained from their experiments, the authors concluded that in Dutch *incomplete neutralization* effects are small, variable and task dependent (ibid.). Nevertheless, the asset of this study into the field of investigation of *incomplete neutralization* is the demonstration of the sub-phonemic durational differences in a language in which previous research has not found such effects. What is more, the authors tested whether the sub-phonemic durational differences are perceptible which makes this study highly relevant for this thesis since investigating perception of durational variation is its major aim.

Besides Dutch, *incomplete neutralization* was also observed in German, Polish, and Catalan (see Warner *et al.* 2004: 252 for references). The study by Slowiaczek and Dinnsen (1985), which has already been mentioned in the previous chapter, focused on the effect of word-final devoicing in Polish. The results they obtained in their experiment (focusing on production, not perception) showed that vowels before underlyingly voiced – i.e. devoiced – word-final obstruents were approximately 10% longer than those followed by their underlyingly voiceless counterparts. Since in Czech vowel duration serves to signal phonemic quantity (i.e. distinctions between long and short vowels), such extent of duration variation induced by the following devoiced obstruent as the one found by Slowiaczek and Dinnsen is not expected to be revealed in Czech. Even though the duration variation found by Slowiaczek and Dinnsen in Polish was not as large as in English, it would suggest that the neutralization process in Polish is not complete or even that the whole phenomenon of word-final devoicing cannot be categorized among neutralizing processes. The reason why this particular study is mentioned here is that Polish and Czech both belong to the same language family of West Slavic languages and they share the rule of *final devoicing*. Since there have not been many studies focusing on the phenomenon of *incomplete neutralization* in Czech, the findings provided by Slowiaczek and Dinnsen could be somehow relevant for the investigation in Czech language.

Some experiments focusing on the possible existence of *incomplete neutralization* have already been conducted in Czech. Using data obtained in a production experiment, Podlipský and Chládková (2007) came up with the tentative conclusion that: "in Czech a vowel is relatively short when followed by a voiceless obstruent, longer when followed by a devoiced (underlyingly voiced but phonetically voiceless) obstruent (in other words that *incomplete neutralization* takes place), and even longer when followed by a phonetically voiced obstruent" (p. 70). On the basis of this assumption, the authors addressed the question whether this *VDVCV* affects the perception of vowel quantity, i.e. the perceptual categorization of short and long vowels in Czech. The data from their perceptual experiment suggested that vowel quantity does not interact with *incomplete neutralization* (i.e. the presumed vowel lengthening before a devoiced vs. voiced obstruent was not reflected in the perception of vowel quantity). Nevertheless, as the authors themselves claim, it is possible that the design of the experiment, where underlying voicing was evoked by spelling, was not good enough to discover the interaction (p. 71). However, the results obtained in their second experiment revealed that the perceptual boundary between a short and long vowel was shown to shift slightly (and significantly) when a voiceless vs. voiced context was compared (p. 74). This experimental evidence indirectly supports the hypothesis that the effect of vowel lengthening caused by voiced obstruent in coda is observable also in Czech. However, no satisfactory evidence has been provided yet for voiceless vs. devoiced contexts. One of the main objectives of this study is to contribute to this investigation and bring new observations and experimental results to the research on this topic.

One experiment intended for the purpose of this study is going to be designed in a way similar to the one used by Warner *et al.* (2004). Specifically, it will test if variation in vowel duration caused by coda voicing is perceptible for Czech listeners and thus can be used as one of the cues to the underlying voicing in coda. However, it is important to point out that my experiment will be focused mainly on perception, not production (as it was e.g. in the case of the study in Polish done by Slowiaczek and Dinnsen). Generally, if Czech listeners are able to perceive such slight variation in vowel duration (in case such variation occurs at the production level) and use it as a cue to the voicing of the following consonant (as it happens in English), then *incomplete neutralization* occurs also in Czech. If the variation in vowel duration is neither produced and therefore nor perceived by Czech speakers and listeners, then the *neutralization* would seem to be complete. The relation between *VDVCV* and *final devoicing* will generally be one of the main foci of this thesis. Theoretically, *final devoicing* should prevent *VDVCV* because it removes its source (i.e. differences in coda voicing). However, it seems that the relationship between these two processes is not straightforward (see e.g. the paper by Warner *et al.* 2004, which has just been described in this section).

## 1.4 The influence of the native language (L1) on the second language (L2) acquisition

So far I have examined the phenomenon of *VDVCV* only within the scope of one particular language or with regards to its cross-linguistic validity. But the way in which one language treats sound segments and their properties (in this case vowel duration) is not necessarily the same as in another language, which becomes an undoubtedly interesting topic when a speaker starts to acquire another language. In the process of learning L2, the differences between L1 and L2 surface in various ways and offer a chance to examine language phenomena from a new point of view outside the borders and limitations of a single language. Another purpose of this paper is to examine the effect of *VDVCV* in the context of L1-Czech speakers acquiring English as their L2.

Extensive research has been made on second language speech learning and the way how non-native production and perception of L2 are influenced by the native L1 background. James Emil Flege published many papers devoted to this. In his article "Second-language Speech Learning: Theory, Findings, and Problems" (1995) he came up with several postulates and hypotheses which aimed to predict the way people acquire L2. According to him, for instance, one of the typical problems in language acquisition usually originates in the absence of a particular phoneme of L1 in L2. New L2 learners are supposed to use their existing L1 categories and assimilate the new L2 sounds into them (p. 238). This may be a disadvantage for learners who do not have a complex L1 phonemic system because the chance of multiple sounds assimilating into the same category is bigger in such case. What is more, according to Iverson and Evans (2007) listeners with more complex L1 vowel system are ‘privileged’ in acquiring L2 vowel sounds since they are accustomed to use more cues and therefore they do not need to learn so many new ones when acquiring L2. But on the other hand, having a complex L1 phonemic system may represent a disadvantage as well because learners may be more likely to assimilate the unknown L2 sounds to their existing L1 sound categories (since they have a wider range of them than listeners with less complex L1 inventories) rather than to create an absolutely new (and supposedly more accurate) L2 sound category. As Flege (1995) has already argued, the further the new L2 sounds are from the existing L1 categories, the easier it is to learn them because learners are more likely to notice the difference and hence establish a new category.

When we consider this aspect of L2 acquisition, we might expect that it should not be so difficult for the Czech speakers who will listen to English (this group will be labelled as NatCZ-EN) in my experiment to categorize the stimuli they will be provided with accurately because the vowels included into the experiment should not be absolutely unknown to them. For the English stimuli, the vowel pairs under investigation will be /ɪ/, /iː/, /ʌ/, /ɑ/, /ɛ/ and /æ/. Except for the relatively ‘new’ vowel /æ/, the others are ‘similar’ to Czech vowels[4]. However, since the emphasis will be placed upon the duration of the vowel which serves for different purposes in both languages, the perception of the stimuli might not be accurate in case of L1 Czech listeners categorizing L2 English stimuli. In Czech vowel duration serves for distinction between long vs. short vowels (Palková 1994), whereas in English (among other things) it serves as a cue to voicing of the following consonant (see Ladefoged 1993: 90). The matter of non-native perception of vowel duration serving as a cue to final voicing will be addressed in a separate chapter later on (see chapter 1.5).

Whether Czech listeners are able to perceive and produce word final voicing which is absent in their L1 is connected to a question essential to second language learning which is: does the production precede perception in L2 learning or vice versa? In other words, if these two abilities are not acquired simultaneously, which one is more likely to become more native-like first? Flege (1995) has proposed a speech learning model (SLM for short) that aims to account for age-related limits on the ability to produce L2 vowels and consonants in a native-like fashion (p. 237). The assumption that learners are not able to produce properly what they cannot perceive accurately is central to this model. That is to say, perception is believed to precede production. For instance, Flege *et al.* (1997) carried out an experiment aiming to test the predictions of SLM and by investigating both production and perception of English vowels by experienced and relatively inexperienced non-native speakers of English (their L1s being German, Spanish, Mandarin and Korean), they observed that the accuracy of the speakers depended on the L1 background, namely on the perceived relation between English vowels and vowels in the

[4] This claim is based on textbook descriptions of Czech and English vowel systems (see e.g. Palková 1994, Dankovičová 1999) according to which the selected English vowels have relatively close counterparts in Czech

inventory of the L1 (p. 437). The obtained experimental results which revealed that, for instance, non-native subjects did not produce significant temporal or spectral differences between some vowel pairs such as e.g. /ɪ/-/i/. The authors suggested that non-native production errors can be a reflection of inaccurate speech perception which is in line with the predictions of the SLM. As the authors concluded in the end: “non-natives' production and perception of L2 vowels do not always match perfectly... the perception may be somewhat more native-like than the production” (p. 465).

In contrast, there have been studies that brought up contradictory experimental results and favoured the opposite idea that it is the production that precedes perception. For instance, Bohn and Flege (1997) examined the ability of German learners of English to perceive and produce English /æ/ - a vowel which is not present in the German inventory. This vowel was placed in opposition with /ɛ/. What the authors placed under investigation was the perception of the /æ/-/ɛ/ continuum as well as the production of both vowels by native English speakers and experienced vs. inexperienced German learners of English. The results suggested that in case of the experienced German learners, the production was more native-like than their perception. However, in case of the inexperienced German learners the perception seemed to precede production. That is to say, even from this single study it is obvious that the relationship between perception and production of speech sounds in L2 acquisition is not simple and straightforward.

Højen (2003) attempted to review various papers which provided experimental results that favoured either of the two approaches suggested. He concluded that: “In relatively inexperienced L2 learners, perception abilities exceed production abilities, while in relatively experienced L2 learners production abilities exceed perception abilities” (p. 69) and in line with other authors (see references therein) he offered a speculative explanation that learners who reach some functional perceptual level might have less motivation to improve this skill further and since mispronunciations and various production errors impair their performance, they might focus on improving their production skills instead (ibid.). What is more, it seems that it is much easier to intentionally try to improve production rather than perceptional skills. Nevertheless, no experimental evidence which would undoubtedly prove whether production or perception (or even both of them simultaneously) become first native-like in the course of L2 learning has been presented yet. This thesis does not directly aim to answer this question since it is predominantly focused on L2 speech perception, not production. However, it might bring some interesting results at least to the field of investigation of Czech L1 speech perception of L2 English and therefore be useful for further possible research within the particular field.

## 1.5 Native vs. non-native use of vowel duration as a cue to final voicing

Since one of the main foci of this thesis is the usage of vowel duration, it is necessary to discuss its function in Czech and English in greater detail. When we compare the Czech vowel inventory to the English one, not only that the phonemes themselves are not identical as well as the number of the vowels differ (English has more of them) but above all, in English there is nothing like minimal pairs contrasting in length. Even though there is a division of vowels to tense and lax ones (for instance, the vowel in *beat* being the tense one as opposed to the vowel in *bit* being the lax one) which might resemble the short vs. long distinction, the ‘tenseness’ is in fact related to vowel quality (the formant structure) rather than to its duration.

The whole concept of segmental/vowel duration works differently in English. Unlike in Czech, where it plays an important phonemic role (distinguishes two contrasting phonemes), in English the vowel duration is functional on an allophonic level and is influenced by many factors. One of them is stress in spite of the fact that it is a suprasegmental feature which means that it is not directly connected to separate phonemes but rather to the whole segments like syllables etc. Czech and English differ significantly in relation to stress. While Czech regularly places stress on the first syllable of the word, in English stress placement is largely unpredictable (i.e. lexically-based). A syllable can be emphasized by being stressed or on the contrary there are syllables within a sentence that are unstressed and have reduced vowels (such as schwa or /ɪ/). In English there is a close connection between the vowel duration and stress – vowels become longer in stressed syllables (Ladefoged 1993: 95). Vowels present in unstressed syllables tend to be reduced in English or at least shorter than vowels which occur in stressed syllables. This is not true of Czech (Palková 1994). In order to prevent the stimuli from being subject to any prosodic effects, the experiment will be designed in such a way which should eliminate the influence of stress and other suprasegmentals as much as possible.

It is certain that in English vowel duration is used as one of the cues to final voicing (see e.g. Denes 1955, Raphael 1972). However, it is not the only cue used and also the extent to which listeners rely on it varies. Besides the vowel duration, the duration of consonantal obstruction and the presence or absence of vocal folds vibrations – all of these can be used as cues to final voicing and listeners are expected to decide on it by either combining them or choosing one of them as the most important cue over the others (for a review of the cues to voicing contrast see Watson 1983).

One of the articles dedicated to the significance of the preceding vowel duration for the perception of the voicing of word-final consonants (specifically in American English) was written by Lawrence J. Raphael (1972). In his study, he used synthetic minimal CVC(C) pairs in which he manipulated the vowel duration to find out to which extent the listeners rely on this cue and use it for discrimination. All final consonants and clusters in his discrimination test were perceived as voiceless when preceded by vowels of short duration and as voiced when preceded by vowels of long duration. Thus, he drew the following conclusions: "(1) preceding vowel duration is a sufficient [and for the types of stimuli employed in his test] a necessary cue to the perception of the voicing characteristic of a word-final stop, fricative, or cluster; (2) the presence of voicing during the closure period of a final consonant or cluster does have some cue value, although it is minor compared to that of vowel duration and (...) (3) perception cued by the preceding vowel duration is continuous rather than categorical" (Raphael 1972: 1301). As it was already mentioned, it seems that English speakers gradually (in the course of a long historical development) started to rely on the preceding vowel duration more than on the actual final voicing and by doing so, they underlined the importance of the vowel duration variation for the discrimination of final voicing.

In Czech, the status of vowel duration is quite different. Since it plays a different role there, Czech speakers and listeners have not been shown to employ durational differences with regard to cueing the voicing of the following consonant (even though it is the topic of present investigation, no evidence for the confirmation of existence of such process has been found yet). The system of Czech vowels differs from the English vowel inventory especially with respect to the role of length (i.e. quantity) of vowels. There are 10 of them in Czech – 5 short and 5 long – which create minimal pairs contrasting in length. The long ones are approximately twice as long as their voiceless counterparts (Palková 1994).

These members of minimal pairs have always been supposed to differ exclusively with respect to their quantity (marked by duration). However, recent findings have suggested that especially the pair /ɪ/-/iː/ might also differ qualitatively. The results obtained by Podlipský (2009) suggested that for this particular Czech vowel pair /ɪ/-/iː/ vowel duration is more free. The author proposed that the contrast between these two phonemes, which has traditionally been described as quantitative, might be in fact rather qualitative for some speakers (p. 38). In other words, some speakers can use the spectral difference rather than the durational difference which was supposed to be the right cue for discrimination of these two vowels contrasting in length. Such process would therefore result in weakening of the durational differentiation in production (ibid.). From this finding, I can draw an assumption that the likelihood that coda voicing will be reflected in duration of the preceding vowel is greater for this pair than for other pairs, where the main function of vowel duration is still to mark the difference between them (i.e. the phonological length difference). This is one of the hypotheses tested in the present study.

Talking of the final voicing as such, Czech learners are not used to encounter voicing in word-final codas at all (unless they are resyllabified to the next onsetless syllable, which happens in Moravian pronunciation, e.g. *pod oknem* [po.dok.nɛm]). We might assume that Czech learners of English as an L2 will decide on the final voicing in English words by using their experience with contrasting pairs of consonants in non-final positions. Or are there any other acoustic cues they might use for discrimination? Will it be the voicing during constriction of the obstruent in coda itself [5] or will they make use of the additional cue of the vowel duration, which they are not used to rely on for this purpose and use it extensively for marking vowel quantity? When perceiving English, will they transfer the phonological rule of *final devoicing* from their L1 or will they establish a new rule of using the vowel duration as a cue?

It can be observed that some Czech learners of L2 English transfer the phonological rule of *final devoicing* into their production (i.e. they might incorrectly devoice the final consonant and pronounce e.g. the word *dog* as [dok]) but there is a question how they would transfer it into their perception of English. It might be assumed that in such case they would expect some words with phonetically voiceless codas to have underlyingly voiced codas. This hypothetical effect might be reflected in the results which will be obtained in the perceptual experiment designed for this thesis, in which Czech speakers will listen to English words and their task will be to categorize the final consonant of stimuli presented to them as voiceless or voiced. If the Czech speakers used the rule of *final devoicing* in the perception L2 English (but basically in reverse – going from the surface to the underlying form) and showed a bias to 'voiced' responses, it might suggest that the transfer from L1 had occurred in the perception. Therefore, when evaluating the results of the perceptual tests, in which native Czech speakers will listen to English, attention will be paid to the way how they had categorized

[5] However, also in English there is a tendency to devoice word-final obstruents (see Ladefoged 2001: 73, where the author suggests that voiced obstruents in English are in fact voiced through only a small part of articulation – at the end of the utterance or before a voiceless sound).

(and with what accuracy) the stimuli with voiceless consonants in coda.

In general, even if experienced Czech learners of English may not categorize voiced and voiceless word-final obstruents in English with as much accuracy as native English listeners, it is worth investigating whether they are able to acquire the particular phonological rule of *VDVCV* (i.e. notice the variation in vowel duration cueing the voicing of the following consonant) within the process of second language learning and therefore they will be able perform above chance in an experiment testing their accuracy of perception of English (the design of the experiment will be described in detail in section 2 devoted to the methodology).

The question connected to the use of the perceptual cues is whether they can be used by non-native listeners in a native-like manner. This kind of experiment was already undertaken for Dutch by Broersma (2005a – mentioned already in chapter 1.1). The author investigated how Dutch and English listeners categorized English word-final voicing taking into consideration the fact that: (i) Dutch belongs to languages with *final devoicing* and therefore allows only voiceless obstruents in word-final position; and (ii) vowel duration serving as a prominent cue to final voicing in English was often uninformative or mismatched for the purpose of the experiment. As it was already mentioned in chapter 1.1, the Dutch participants outperformed the English ones because they did not rely on the (intentionally) misleading cue (vowel duration) to such an extent. In a follow-up paper (Broersma 2008), Broersma tried to examine whether non-native listeners can be more flexible than native listeners in their use of perceptual cues used for phoneme distinction. In other words, she wanted to find out whether Dutch listeners were more accurate in deciding on final voicing because they gradually discovered that vowel duration was not a helpful cue to final voicing in the particular test and thus reduced its use until they completely ignored it which helped them to outperform native speakers of English who heavily relied on the misleading cue of manipulated vowel duration. After reanalyzing the results of Broersma (2005a), the author concluded that Dutch listeners initially used vowel duration as a cue to final /v/-/f/ categorization to the same extent as English listeners did but they reduced their use of vowel duration rapidly. Therefore, while the English listeners used it as a cue to final voicing persistently (having more experience with this cueing), the Dutch listeners adapted their use of perceptual cues in order to enhance their accuracy in categorization.

Non-native listeners might be supposed to be much less certain about which perceptual cues they should use and their limited experience might sometimes make it easier for them to ignore some cues which are used persistently by native listeners who have an extensive experience with utilization of such cues (which e.g. happened in case Broersma’s experiment just mentioned above). When we consider the fact that variation in vowel duration exists both in English and Czech but it just serves for different purposes in both languages respectively, we can assume that Czech speakers simply have to ‘adjust’ their use of vowel duration as a cue to be able to successfully acquire English as their L2.

To sum up, in Czech, the vowel duration cues the long vs. short vowel contrast. In English it is used (apart from other things) as a cue to coda obstruent voicing. Whereas in English, duration is also used suprasegmentally (e.g. in connection to the issue of stress – stressed syllables containing longer vowels in comparison to the unstressed ones), in Czech it is used contrastively (i.e. to distinguish phonemes). Generally, it is supposed that the greater is the role of duration in L1, the more successful is its acquisition in L2 (McAllister *et al.* 2002) which suggests that Czech learners of English should learn to use vowel duration relatively easily (vowel duration being as important as it is in Czech). However, due to the differences in the treatment of vowel duration between English and Czech, Czech L1 learners of L2 English might encounter difficulties in assigning the vowel duration the correct role. The way Czech listeners treat the vowel duration will also be tested by manipulating it. In the experiment, the duration of some vowels will be lengthened to find out if such variation might affect the categorization (i.e. increase the number of 'voiced' responses). The obtained results should help us to understand whether Czech listeners notice the variation in vowel duration and utilize it in some way or whether they simply ignore its potential to serve as a cue to voicing of the following consonant.

## 1.6 Markedness of word-final voicing

This minor chapter is supposed to relate the topic of the presented thesis to the phonological theory called Optimality Theory[6] and investigate it from the point of view of markedness – an issue connected to neutralizing processes such as *final devoicing* which is one of the central concepts of this thesis. Segments or features can be referred to be either *marked* (those structures which are usually avoided in language/s) or *unmarked* (the preferred ones). Traditionally, grammars tend to eliminate highly marked structures by applying the principle called *markedness reduction*. However, there is a reverse principle of *preservation of the marked* (abbreviated as PoM, see DeLacy 2006: 11, 22-23) which favours the more marked

[6] a linguistic model proposed by Prince and Smolensky in 1993

elements over the less marked ones and prevents them from being eliminated in processes like neutralization or assimilation. Therefore, e.g. voiced obstruents, which – if they are in coda - are more marked than their voiceless counterparts, are preserved in some languages thanks to the dominance of the PoM principle.

The opposite process to the PoM principle can be observed in case of *final devoicing* in such languages as German or Czech which might be considered to be an example of neutralization (i.e. 'loss of contrast' – the 'marked' element). The output of any phonological process in fact depends on dominance of particular hierarchies over another (DeLacy: 122-123). In case of the *final devoicing* we have two of them – the *voicing* and *sonority hierarchy*. Whereas *voicing hierarchy* favours voiceless obstruents over the voiced ones, *sonority hierarchy* prefers high sonority elements to less sonorous ones (i.e. since voiced obstruents are more sonorous than voiceless ones, the output should be voiced in this case). Therefore, in languages with *final devoicing*, the *voicing hierarchy* dominates over the sonority one and the coda is always voiceless. In contrast, in English the marked (i.e. voiced) codas exist due to the fact that the extent, to which the contrast of two words (e.g. *bit* vs. *bid*) can be distinguished on the basis of the context, is not that large as e.g. in languages like Czech (see the discussion in chapter 1.1 or [Vachek 1961: 56] for particular references).

## 1.7 Research questions and hypotheses

The results of the experiment conducted for the purpose of this study are supposed to evaluate several hypotheses. The central one stems from the possibility that in Czech the *neutralization* process of *final devoicing* is *incomplete*, i.e. vowels before voiced consonants in coda are slightly longer than those before voiceless consonants. Even though such durational variation is not expected to be large, I suggest that there is a possibility that listeners are able to utilize it when deciding on the phonological final voicing (just like Dutch listeners are, Warner *et al.* 2004, see section 1.3). To test this assumption, I am going to manipulate the vowel duration and lengthen the vowel preceding the final consonant which should result in an increase in the number of cases when listeners judge the coda as voiced.

As suggested above in section 1.5, another hypothesis tested in this study is connected to the issue of the vowel pair /ɪ/-/iː/. It has been suggested (Podlipský 2009) that this pair contrasts not only with respect to quantity but rather to quality and therefore the durational difference (which usually serves as a cue for discrimination of vowels as long or short) might be in this case more likely to be exploited for cueing the underlying word-final voicing than in other Czech vowels. In other words, in the perception test for native Czech listeners listening to Czech I will try to determine if the level of success in distinguishing underlyingly voiced from voiceless word-final obstruents will be greater when the nucleus contains the vowel pair /ɪ/-/iː/ than when it contains other Czech vowels.

Another assumption presented in section 1.5 dealt with the issue of the possible transfer of the *final devoicing* rule from L1 Czech into the perception of L2 English. I hypothesize that when categorizing the stimuli, the NatCZ-EN group might be more accurate in perceiving voiced codas (since they might apply the reversed form of *final devoicing* and judge some of the phonetically voiceless coda as devoiced – i.e. underlyingly voiced).

The last two hypotheses presented in this study deal with the process of second language acquisition. The first one is based on the question of whether L2 learners (in this case Czech native speakers) are able to perceive final voicing in English correctly (despite the fact that they are not familiar with voicing in coda in their L1) and at the same time if they are able to use the variable duration of the preceding vowel as a cue to this voicing (when in their L1 they might not use it for this purpose). I do not expect the Czech listeners to perform in the same way as the native English listeners, as well as I do not expect them to use *VDVCV* as a primary cue. Nevertheless, I suggest that thanks to the process of L2 learning, the group of experienced Czech learners of English should perform above chance when deciding on the final voicing regardless of which cue they will use for such discrimination. Recall from section 1.1 and 1.5, that this was true of Dutch learners of English in Broersma's (2005a, 2008) studies.

The next issue connected to the process of L2 learning is the question of whether there will be any difference in accuracy of perception between English words that contain vowels similar to those in the Czech vowel inventory (namely Czech vowels /ɪ/-/iː/ and /a/-/aː/ and /ɛ/ - i.e. the vowels included in the testing materials) and those words containing relatively 'new' vowel for native Czech listeners (/æ/). This implies that the vowel /æ/ is more distant from the closest Czech vowels than other English vowels that will be used in the perception test (/ɪ/, /i/, /ɛ/, /ʌ/, and /ɑ/) and therefore there is a greater probability that learners have established /æ/ as a new L2 vowel category. For this we, indeed, do not have any direct evidence. I base this assumption on textbook descriptions of English and Czech vowel systems (e.g. Palková 1994, Ladefoged 2001). What I specifically hypothesize is that Czech learners of English (who have established /æ/ as an L2 vowel phoneme) will be more accurate in perception of its durational variation than of the more ‘similar’ vowels[7]. Such assumption matches the basic idea of the Speech Learning Model (Flege 1995; this model has been discussed above in section 1.4) as well as the results obtained by Nenonen *et al.* (2005). What Flege (1995) suggested was that ‘new’ L2 sounds should be easier to acquire than L2 sounds which are ‘similar’ to L1 sounds. Nenonen *et al.* (2005) used “the mismatch negativity (MNM) component of the auditory even-related brain potential (ERP) to determine the effect of native language, Russian, on the processing of speech-sound duration in a second language, Finnish, that uses duration as a cue for phonological distinction” (p. 26). In other words, they monitored the changes within the reactions of listeners’ brains when repetitive standard stimuli were replaced by deviant stimuli (the ‘oddball paradigm’). What they found out was that the perception of duration of L2 (Finnish) sounds that did not have an equivalent in the L1 (Russian) was more accurate than of those that could be categorized through L1 sound categories. That is to say, they suggested that the perception of duration was in fact inhibited by categorizing the sound through L1. What relates their study to this thesis is the fact that two languages were compared – Finnish as a quantity language (like Czech) to Russian, which does not use vowel duration to contrast phonemes (like English). However, whereas Nenonen *et al*. used the quantity language (Finnish) as the L2, in this study it (Czech) will be the L1 but this fact should not hamper the similar effect I expect to occur.

In summary, this thesis will aim to provide answers for the following research questions:

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[7] With respect to this hypothesis dealing with the vowel /æ/, I would like to point out that there is a possibility that the scores I will obtain for words containing this vowel might not be significantly higher than for those containing the other vowels simply because the test might be so easy for the listeners that all the scores will be “at ceiling” for all vowels (i.e. a so called ‘ceiling effect’ will occur).

i) Are Czech listeners able to distinguish underlying word-final voicing accurately in (a) their L1 Czech, and (b) in L2 English? When perceiving word-final voicing in Czech, will they be only guessing at chance or will they perform above chance?

ii) Are Czech listeners listening to Czech stimuli more likely to respond that the coda C is ‘voiced’ when the duration of the nuclear vowel is longer? In other words, is there a correlation between the number of ‘voiced’ responses and duration of the nuclear vowel? This can be expected if Czech listeners use vowel duration also as a cue for underlying word-final voicing. Will there also be a greater number of 'voiced' responses when the nuclear vowel is phonologically ‘long’ (and hence longer in the phonetic sense than phonologically ‘short’ vowels)?

iii) Will the level of success in recovering Czech intended word-final voiced or voiceless obstruents be greater when the nucleus contains the Czech vowels /ɪ/ or /iː/ than when it contains other vowels (in other words, since /ɪ/-/iː/ are no longer supposed to differ only in length but also in quality, is vowel duration more likely to acquire other functions than phonological length distinction for these two particular vowels?)

iv) Will the level accuracy be higher for ‘voiced’ codas (in comparison to ‘voiceless’ ones which might be incorrectly judged as devoiced i.e. underlyingly voiced)?

v) Will the level of success in recovering English intended word-final voiced or voiceless obstruents be greater when the preceding vowel is English /æ/ considering the fact that it is a relatively ‘new’ vowel for Czech listeners?

# 2 Method

One aim of the present thesis is to test whether Czech learners of English can successfully perceive word-final voicing contrasts in their L2 if their L1 has *final devoicing* and vowel duration serves as the main perceptual cue for vowel quantity contrasts. In order to address this issue, baseline data about L1 Czech perception must be obtained.

There are two possible ways how to test whether in Czech vowels last longer before voiced obstruents than before voiceless ones. The first is the direct one, which would draw from production data and involve undertaking an experiment based on recording speech of chosen participants for the purpose of measuring the duration of the recorded vowels. There are several reasons why this study preferred the indirect approach (i.e. focusing on perception rather than production) since the direct method involves certain difficulties which were aimed to be circumvented. Among others, they are related to the fact, that:

a) even if *VDVCV* does operate in Czech, the vowel duration variation can be supposed to be very slight and therefore a very large sample of spoken language data would be necessary to observe a statistically significant difference

b) different vowels (of different phonological length – i.e. long vs. short contrast) are likely to be affected in various ways by different consonants (having various places and manners of articulation) which can have different effect upon them (see Machač and Skartnitzl 2007); this variability would significantly multiply the minimum data required to reach a plausible conclusion

c) when trying to answer if word-final devoicing is ‘incomplete’, we cannot be sure that the difference between the pronunciation of such word pairs as *let* and *led* (in case it exists in Czech) lies solely in the duration of the vowel or whether there are other differences and therefore we would need to perform many acoustic measurements

d) there is the possibility that there is no difference between the pronunciation of such word pairs as *let* and *led* at all; that being said, it is very difficult to prove that something does not exist – the only really reliable way to do so would be to look at every single instance of the phenomenon under investigation, which is impossible of course.

This is why the indirect method, focusing on perceptual testing, was chosen for the purpose of this study in order to avoid difficulties which have been just suggested. Also some of the papers cited throughout the thesis which preferred the direct method and focused on production might serve as an illustration of possible difficulties. Keating (1985) attempted to verify if *VDVCV* operates in Polish and Czech and by using recordings of speakers of both languages, she ended up with statistically insignificant results (but it is important to point out that in her experiment, she recorded only 3 Czech speakers – in comparison to 24 Polish speakers). A perceptual experiment should provide the chance to obtain the required and necessary results which will either prove or disprove all the hypotheses formulated above. If Czech listeners perform above chance when trying to decide upon word-final underlying voicing of an obstruent, then the word pairs such as 'let' or as 'led' have to sound differently in the first place (i.e. they are in fact pronounced differently and listeners' perceptual strategies reflect this). If Czech listeners perform at chance only (i.e. they cannot tell whether e.g. 'let' or 'led' was intended by the speaker), it suggests that either there is no difference between the pronunciation of such words or that there is a difference so slight that Czech listeners do not find it useful as a perceptual cue and ignore it. If Czechs are found to perform above chance in distinguishing voiceless from devoiced codas, valuable conclusions about perceptual patterns of Czech listeners can be made. Indirect conclusions about Czech production can also be drawn, as suggested above, although it must be kept in mind that these conclusions will only be indirect and should be supplemented with actual production measurements. This is not the aim of the present study however.

## 2.1 Participants

Five groups of participants took part in the experiments: two groups of speakers (native Czech and native English speakers) and three groups of listeners: native Czech listeners who listened to Czech stimuli and native English listeners and Czech learners of English who both listened to English stimuli.

For recording the stimuli for the perceptual tests, the following groups of **speakers** were used:

**(1) English speakers**

This group consisted of three male and two female native speakers of American English. One male speaker came from Michigan, the rest of the group from Nebraska. None of the speakers showed any significant non-standard accent. The average age was 20.6 years. The stimuli obtained from this group were presented to native English listeners and the group of Czech learners of English.

**(2) Czech speakers**

This group consisted of three male and two female speakers, the average age of all members of this group was 25.8 years. None of the speakers showed any significant non-standard accent even though all of them came from various regions all over the country. The stimuli obtained from this group were presented to the group of monolingual Czech listeners.

The following groups of participating **listeners** took part in the perceptual tests:

**(3) Native English Listeners (NatEN)**

Since the effect of *VDVCV* in English has already been experimentally verified in many studies, this group served just as a control group and consisted only of two members – native speakers of American English. The first was a male listener from Ohio and the second a female listener from Massachusetts. The average age was 24.5 years. These listeners were assumed to decide on the voicing of the final obstruent by using the vowel duration as a perceptual cue.

**(4) Monolingual Czech Listeners (NatCZ)**

Morrison (2006) suggested that before one can interpret L2 speech perception results, it is important to have a full accurate model of L1 speech perception (p. 44), especially in order to create an appropriate experimental design. Therefore, I focused not only on how Czech listeners perceive coda voicing in English (see the previous NatCZ-EN group) but also on the way how they do so in Czech since the knowledge of the way how speech is perceived in L1 is a precondition for understanding the results of second language perception.

This group consisted of monolingual Czech listeners who had only little or (if possible) absolutely no knowledge of other languages, especially English. The most important aspect being taken into consideration with respect to this group was the length of their stay abroad (i.e. how much time they spent under the influence of some foreign language/s). None of the participating NatCz listeners has ever lived abroad or spent more than few days in a foreign country. The listeners within this group were provided with stimuli obtained from Czech speakers.

The group consisted of 20 native Czech speakers – 13 female and 7 male – the youngest member was 12 and the oldest 55 years old (the average age being 29.15 years). Ten participants came from and currently lived in Hranice, one was from Jeseník and the rest from Prague and its surroundings. Biographical information can be found in Appendix 4.

**(5) Czech Listeners learning English (NatCZ-EN)**

This group of listeners consisted of Czech native speakers who had at least slightly advanced knowledge of English and therefore, to a certain extent, were expected to be aware of the particular phonological rule in English (i.e. lengthening of the vowel before voiced consonants in coda). There were 10 male and 10 female participants coming from different regions of the country. The youngest member was 20 years old and the oldest was 41 years old. The mean age within this group was 26.

All the participants were asked to evaluate their level of experience in English on the scale from 1 (= beginner) to 10 (= native speaker) and their answers ranged from 5 to 9, i.e. they might be considered to be quite experienced in English. Some of the listeners even spent some time abroad – the list of places of their stay is included in the information tables in Appendix 4.

## 2.2 Stimuli

Both real and nonsense words were used in the experiment. Majority of the stimuli were monosyllabic words. Only words ending in obstruents were used for the purpose of the experiment (because only obstruents form voiced vs. voiceless oppositions in English as well as in Czech) and obstruents were also strongly preferred syllable initially to minimize difficulties with measuring the duration of the preceding vowel since e.g. in the sequence of sonorant + vowel, the actual boundaries of the vowel are difficult to be recognized on a spectrogram (e.g. Machač and Skarnitzl 2009).

### 2.2.1 Czech stimuli

Only the vowel pairs /ɪ/-/iː/, /ɛ/-/ɛː/ and /a/-/aː/ contrasting in length were included into the Czech stimuli. As it was already suggested (see chapter 1.5), the vowel pair /ɪ/-/iː/ is somehow special. The variation in duration is freer for this pair (Podlipský 2009) and hence I suppose that the chance that final voicing might be reflected in the duration of the preceding vowel could be bigger for this particular vowel pair. Therefore, in the process of assessment of the results, two explicit groups of stimuli were created: one containing the vowels /ɛ/, /ɛː/, /a/, or /aː/ and the other containing /ɪ/ or /iː/.

For the Czech real words set, no non-obscure words containing /ɛ/ and /ɛː/ were found in Czech and therefore, the total number of real words was only 20 (not 24) – see Appendix 1. For the nonsense words set, only one contrasting pair was used (i.e. the total number was 12 words) and all the vowels were embedded into the same CVC structure (*g__t* vs. *g__d*). All the nonsense words were monosyllabic as well as the set of real words which, however, contained also one pair of disyllabic words.

### 2.2.2 English stimuli

The English stimuli contained the following vowels: /ɪ/, /i/, /ɛ/, /æ/, /ʌ/, and /ɑ/. Like in the case of the Czech stimuli, two explicit groups of words were created: the first containing a 'new' sound /æ/ which is not present in the Czech vowel inventory, and the second group containing the rest of the vowels which are relatively similar to the closest Czech vowel sound categories (see section 1.4 above). Such division should make it easier to evaluate the results and answer one of the research questions – i.e. whether the perception of final voicing has changed in case of words containing the 'new' vowel.

Two words of the same structure but contrasting in the voicing of the final obstruent were included into the real words set where the total number was supposed to be 24 words per speaker (6 vowels x 4 words, e.g. *kit-kid and bit-bid*). However, there are only 22 words in case of two speakers. Speaker number 1 did not produce *clog-clock* as a minimal pair and all the *cap-cab* tokens from speaker number 2 were clipped and therefore could not be used. Thus, the total number of all real words in the experiment was only 116 (not 120 as planned).

The same structure of a word contrasting in the vowel in the nucleus was used for the nonsense words set. All the vowels were embedded into a following CVC structure: *g__tch* vs. *g__dge*. Every speaker produced 12 tokens, the total number of all words in the nonsense words part of the experiment was 60 words.

### 2.2.3 Fillers and carrier phrase

No fillers within the stimuli were used for listeners but they were included into the set of words for the speakers to minimize the possibility that they would find out the objective of the test and their pronunciation would be influenced by such awareness. The examined and measured stimuli had a CVC structure (except for the Czech real words pair – *polib –polyp* – which was disyllabic and had CVCVC structure) whereas the fillers included many polysyllabic (mostly disyllabic) words to minimize the chance that the speakers would reveal the objective of the experiment.

In order to eliminate the influence of suprasegmental features, the speakers were asked to embed all the words into the following structure:

"_______. *Vyslov* _______ *správně."* (for Czech speakers)

*"_______. Say* _______ *softly"* (for English speakers).

The first occurrence of the needed word was used because it was pronounced with a falling intonation thanks to the influence of the following full stop.

## 2.3 Procedure

The procedure consisted of several stages. The first one was recording the stimuli. Both Czech and English speakers were given the list of stimuli (including fillers) printed out on sheets of paper and they were asked to produce them while they were being recorded. The program used for recording was Audacity (version 1.2.6) and the speakers wore a head-mounted microphone (Koss SB/45).

After the stimuli had been obtained from the speakers, the recordings were processed in Praat (version 5.1.30, Boersma and Weenink 2008). The words were cut out of the carrier phrases and vowel durations were measured. The rules for segmentation of the vowels from the neighbouring sounds were taken over from Machač and Skarnitzl (2009).

Since one of the aims of this thesis is to find out if lengthening of the vowel duration might increase the probability of 'voiced' response by the listener, the vowels in all nonsense Czech words (i.e. those produced by NatCZ speakers) were resynthesized in Praat (using the Pitch-Synchronous-Overlap-and-Add method) and lengthened and therefore listeners were presented with two forms of the same word – the original and the edited form with a lengthened vocalic nucleus. The lengthening ratio was 1.310405 for all vowels which corresponded to 5JND (JND = just-noticeable difference). The formula in (1) was used for calculation of this constant ratio (based on the formula used in Morrison 2009: 447):

$$\mathrm{dur} = 90\left(1+\frac{5}{90}\right)^{\left(dur\ JND\ +\log_{\left(1+\frac{5}{90}\right)}\ \frac{80}{90}\right)} \qquad (1)$$

Formula 1 – *used for calculation the constant ratio of vowel lengthening; 80 represents the duration of the original V (in ms), 'dur JND' is the durational increment expressed in JND units (5 was used), and 'dur' is the duration of the lengthened V. The lengthening ratio is the ration between the duration of the lengthened V and the duration of the original V, and since the function is logarithmic, it is constant (5 JND corresponding to 1.310405) whatever the duration of the original vowel.*

The stimuli were blocked by speaker and presented to the participating listeners in a randomized order within blocks as well as between blocks (each listener had a different randomization). The order of the tests presented to these listeners was counterbalanced as well as the order of real and nonsense words parts (i.e. half of the speakers started the perceptual test listening to real words whereas the second half started with nonsense words). The order of the tests for particular listeners can be found in appendix 4 together with other.

The test itself was also created in Praat (Boersma and Weenink 2008; see the script in Appendix 2). Listeners were provided with headphones and their task was to judge if the word they had just heard was the word shown on one of two buttons (which had a voiced coda) or the word shown on the other button (which had a voiceless coda). They indicated their response by clicking on the corresponding button. In other words, two 2-alternative forced-choice tasks were conducted one for each language.

# 3 Results

In this section, the results obtained from all three participating groups of listeners will be discussed separately since different research questions were assigned to the individual groups. For the detailed summary of results, see tables in Appendix 3.

## 3.1 Native English Listeners (NatEN group)

Since these participants served only as a control group, only two subjects were asked to take part in the listening task. The main aim was to make sure that the stimuli recorded by the native English speakers could be categorized accurately. A high level of success in judging the final voicing was expected from this group. This assumption was successfully validated because both listeners reached the top level of correct answers. The male participant scored 114 correct answers out of 116 (i.e. 98.30%) real word tokens and 58 out of 60 (i.e. 96.70%) nonsense word tokens. The female listener produced similar scores: 115/116 (i.e. 99.10%) correct answers for real words and 58/60 (i.e. 96.70%) for nonsense words. The proportions of correct responses were the only data needed from this group (for control and comparison with NatCZ-EN results). No research questions were asked with respect to this group.

## 3.2 Monolingual Czech Listeners (NatCZ)

This group of listeners categorized Czech real and nonsense words recorded by 5 native Czech speakers. The main research question connected to the results obtained from the perceptual tests was aimed at the investigation of the presence/absence of *VDVCV* in Czech. In other words, it was examined whether:

a) the recorded speakers enhanced the duration of the vowel before voiced consonants in coda in comparison to vowels before voiceless consonants
b) the listeners performed above chance when categorizing the coda as voiced or voiceless
c) the number of ‘voiced’ responses given by the listeners increased after i) phonologically long vowels and ii) lengthened vowels (in the nonsense words part)

In addition to this, it was also investigated whether the level of success was different for the tokens containing the vowel /ɪ/ or /iː/. The obtained results were following:

There were 5 speakers – 3 male and 2 female – who provided the stimuli. All the vowels were measured in Praat (version 5.1.30, Boersma and Weenink 2008) and it was checked if the effect of *VDVCV* occured already at the production level (i.e. if the vowels produced by the speakers were longer before voiced and shorter before voiceless consonant in coda). When the speakers were producing the real words tokens, they performed in the following way: speakers number 1, 2 and 5 produced only small and non-significant differences in vowel durations before voiced/voiceless consonants. Even though speaker number 4 produced larger differences, they were still non-significant. What is more, speaker number 3 showed the opposite tendency – her vowels were longer before voiceless than before voiced consonants and again, no significant effect was found.

The speakers produced the nonsense words tokens in the following way: speaker number 1 showed bigger (but still non-significant) differences in vowel duration before voiced and voiceless coda, speakers number 2 and 5 showed smaller difference and speakers number 3 and 4 showed the opposite tendency. For all speakers (and both real and nonsense words), repeated measures ANOVA were performed. However, in all cases the results were not significant.

Now the results of the perception test will be reported. The results of the overall accuracy in categorizing the voicing in coda revealed that generally, the NatCZ listeners did not perform above chance. In the nonsense words part, the proportion of correct responses was 52.13%. With respect to the voicing in coda, the level of success was higher for tokens containing voiceless coda (71.67% of correct responses) than for those containing voiced coda (32.58% of correct responses). The proportions are illustrated in Figure 1:

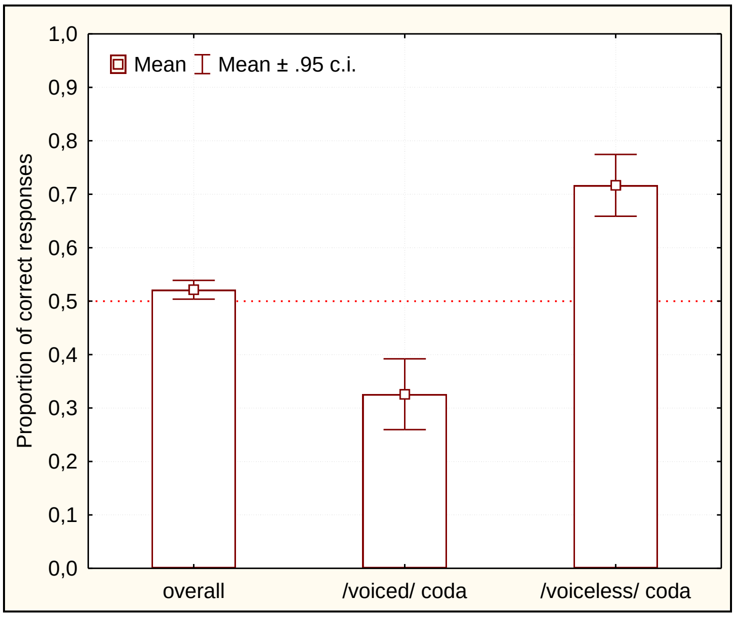


Figure 1: *Overview of the proportions of correct answers for the nonsense words (NatCZ listeners); (Overall = the proportion of correct responses overall, /voiced/ coda = proportion of correct responses when coda was phonologically voiced, /voiceless/ coda = proportion of correct responses when coda was phonologically voiceless, c.i. = confidence intervals).*

In the real-words part, the overall proportion of correct responses was similar – only 52.00%. Again, the proportion was higher for the tokens containing voiceless coda (66.80%) than for those with voiced coda (37.20%) – see the following figure:

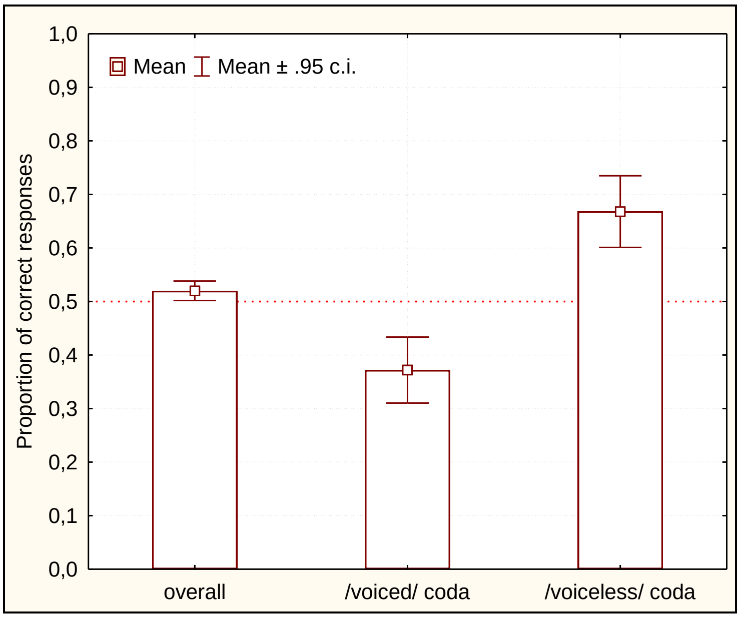


Figure 2: *Overview of the proportions of correct answers for the real words (NatCZ listeners); (Overall = the proportion of correct responses overall, /voiced/ coda = proportion of correct responses when coda was phonologically voiced, /voiceless/ coda = proportion of correct responses when coda was phonologically voiceless, c.i. = confidence intervals).*

The obtained results were analyzed further to investigate the effect of vowel duration (i.e. phonologically [and hence also phonetically] long vs. short vowel and edited [lengthened by a factor of 5 JNDs] vs. unedited [original] vowel) on listeners' responses categorizing a particular coda as voiced or voiceless. Another repeated measures ANOVA was used for this. For the nonsense words set, the effect of phonological vowel length in nucleus on the proportion of 'voiced' responses was significant ($p < .01$). This is because the number of ‘voiced’ responses was significantly higher for the tokens containing phonologically long vowels in comparison to those containing short vowels in the nucleus in the nonsense set (see Figure 3).

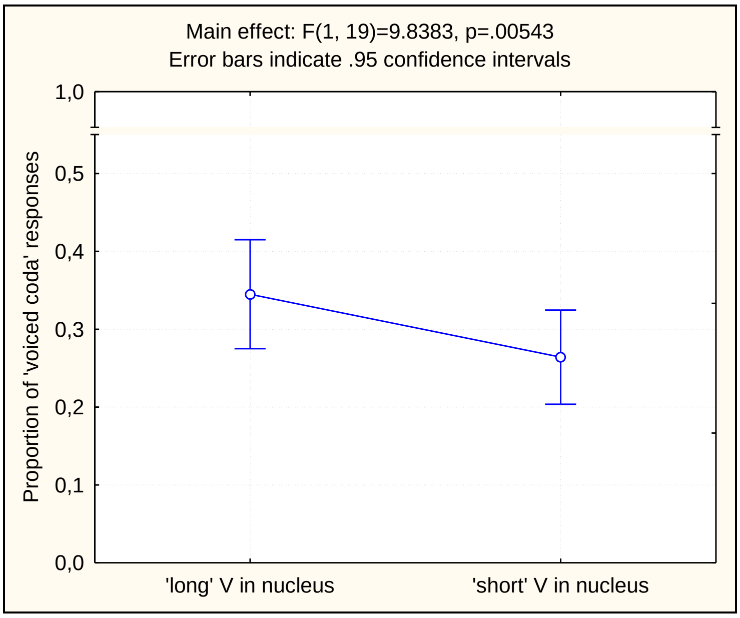


Figure 3: *The proportion of ‘voiced coda’ responses plotted against the phonological length of the nuclear vowel in nonsense words set (NatCZ listeners); (c.i. = confidence intervals)*

As regards the effect of vowel editing (lengthening), NatCZ listeners indeed displayed a tendency to judge the coda preceded by a lengthened vowel as voiced more often than the coda preceded by the original unedited vowel. However, in a repeated-measures ANOVA the effect did not reach significance ($p = .09$; see Figure 4).

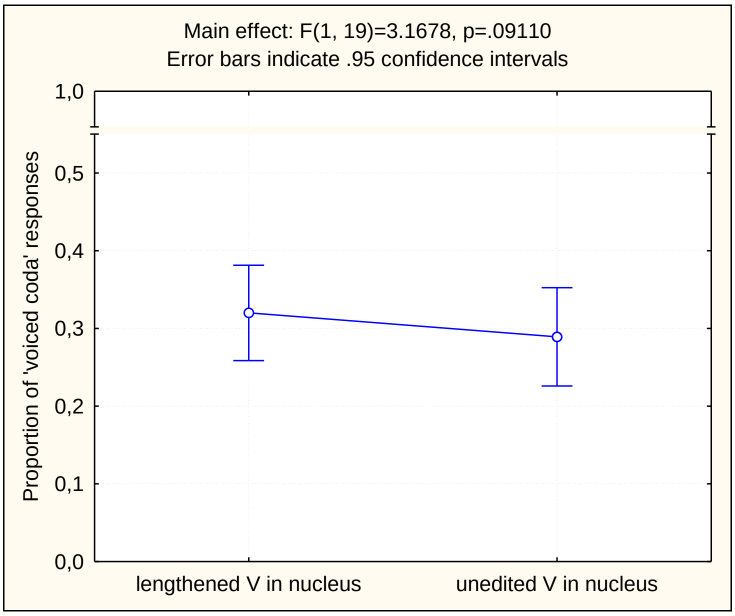


Figure 4: *Proportion of 'voiced coda' responses plotted against the lengthened vs. unedited vowel in the nonsense words set (NatCZ listeners); (c.i. = confidence intervals)*

The repeated measures ANOVA was also used for real words. I expected that – like in the case of nonsense words – the proportion of voiced responses would be higher for the tokens containing phonologically long vowels. However, the results revealed opposite tendency. Nevertheless, the effect was not significant (see Figure 5). (This was the only effect tested – recall that in the real-words set, only unedited vowels had been used.)

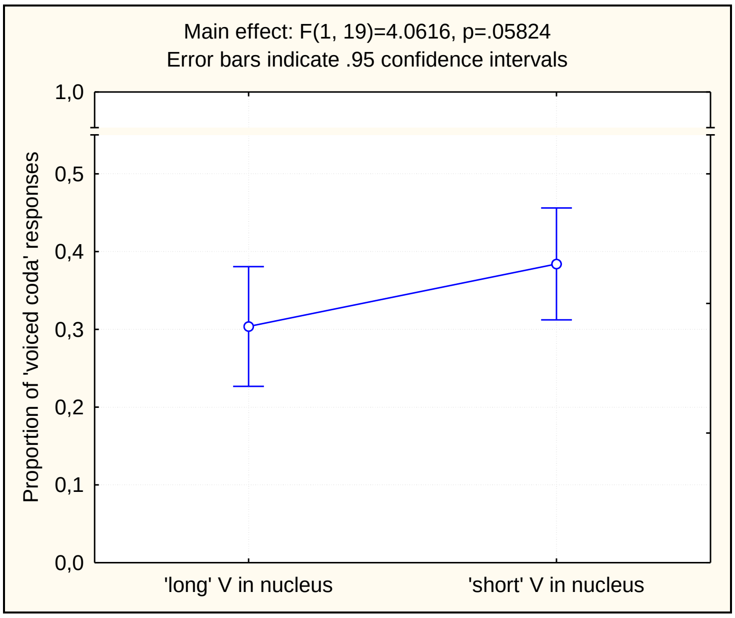


Figure 5: *Proportion of 'voiced coda' responses plotted against phonologically long or short vowel in the real words set (NatCZ listeners); (c.i. = confidence intervals)*

In addition to ANOVAs, *Point Biserial Correlations* ($r_{pb}$) were calculated to investigate the correlation between vowel duration (ms) and 'voicing-in-coda' response. My null hypothesis ($H_0$) stated that the likelihood of 'voiced' response would not increase with increasing vowel duration (i.e. this likelihood would be the same or it would decrease). The alternative hypothesis ($H_1$) stated that the likelihood of 'voiced' response would increase with increasing vowel duration.

The correlations were computed for the individual listeners (and following groups of vowels: phonologically short vowels, phonologically long vowels and all vowels together) and then used for the calculation of the result for the whole group. The *sign test* was performed – i.e. it was tested whether significant and nonsignificant results per listener were equally likely in the group (if they were, then $p > 0.05$). The following results were obtained:

For nonsense words:

- for phonologically short vowels, p = 0.0414, i.e. the correlation for the whole group was nonsignificant
- for phonologically long vowels, p = 0.0118, i.e. the correlation for the whole group was nonsignificant as well
- for all vowels together, p = 0.824, but since the nonsignificant and significant results were distributed equally within the group, it cannot be said whether the correlation for the whole group was significant or not

For real words

- for phonologically short vowels, p = 0.0025, i.e. the correlation for the whole group was nonsignificant
- for phonologically long vowels, p = 0.0414, i.e. the correlation for the whole group was nonsignificant as well
- for all vowels together, p = 0.503, and again (like in the case of nonsense words), the distribution of significant and nonsignificant results was almost the same and thus it cannot be said whether the correlation for the whole group was significant or not

The last issue which was investigated with respect to this group of listeners was based on my assumption that the level of accuracy might increase for the vowels /ɪ/ or /iː/. In the nonsense words part of the test, the proportion of correct responses for tokens containing /ɪ/ or /iː/ was 51.50% and 52.44% for words containing the other vowels (i.e. /ɛ/-/ɛː/ and /a/-/aː/). Repeated measures ANOVA revealed that the main effect was not significant (F [1, 19] = .2376, p = .6316).

On the other hand, in the real words part of the test, the proportion of correct responses for tokens containing /ɪ/ or /iː/ was 48.50% and 54.33% for words containing the other vowels and repeated measures ANOVA revealed a significant main effect ($F[1, 19] = 5.8887$, $p = .0245$, see Figure 6).

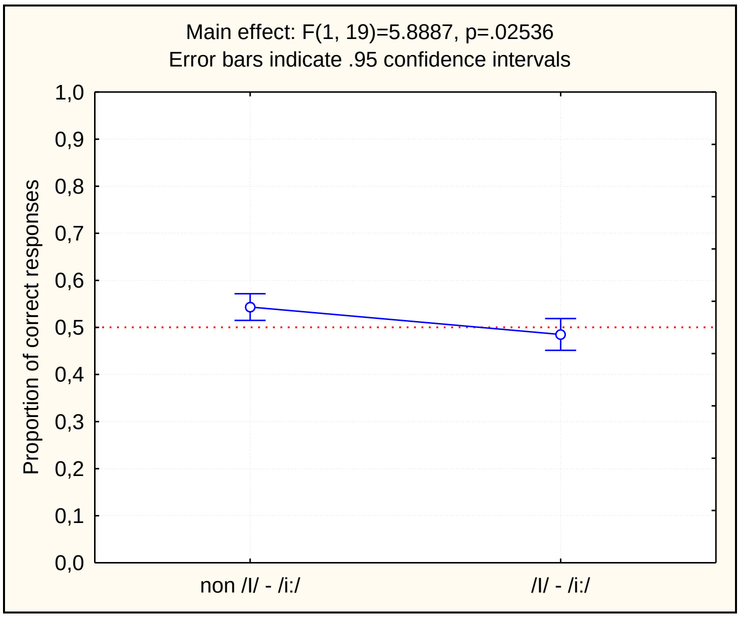


Figure 6: *Proportion of 'voiced coda' responses plotted against the absence/presence of the vowel* /ɪ/ or /iː/ *in the nucleus of the real words (NatCZ listeners); (c.i. = confidence intervals)*

However, the real-words results contradict my hypothesis that for tokens containing the vowel /ɪ/ or /iː/, the accuracy of categorization of the final voicing will be better. What is more, the proportion of correct responses is generally around the level of chance.

## 3.3 Native Czech Listeners learning English (NatCZ-EN)

The results obtained from this group were supposed to provide answers to two of the research questions formulated in this thesis. The first one was connected to the level of success of categorization of final voicing. This group reached 72.58% of overall accuracy of categorization in the nonsense words part and 84.18% in the real words part. Repeated measures ANOVA showed that the difference in the level of success between real and nonsense words was highly significant (main effect of word status $F[1, 19] = 69.592$, $p < .0001$).

ANOVA also revealed a slightly significant main effect ($F[1, 19] = 4.578$, $p = .0456$) of phonological voicing in coda on the proportion of correct answers in the nonsense words part, where the listeners scored 77.17% when the coda was voiced and 68.0% when the coda was voiceless (see Figure 7):

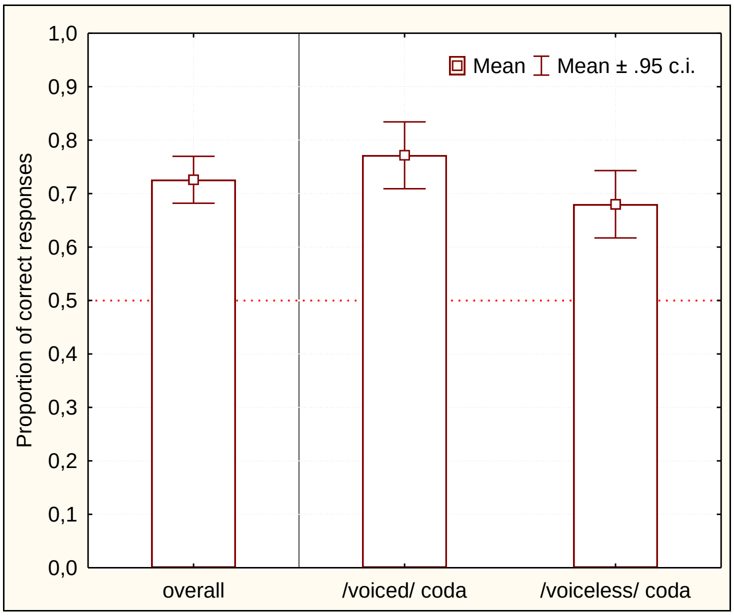


Figure 7: *Overview of the proportions of correct answers for the nonsense words (NatCZ-EN listeners); (Overall = the proportion of correct responses overall, /voiced/ coda = proportion of correct responses when coda was phonologically voiced, /voiceless/ coda = proportion of correct responses when coda was phonologically voiceless, c.i. = confidence intervals).*

What is more, when listeners were categorizing the real words, the effect phonological voicing in coda on the proportion of correct responses was even stronger ($F[1, 19] = 30.855$, $p = .00002$): 94.14%

of correct answers when coda was voiced and 74.22% when coda was voiceless (see Figure 8):

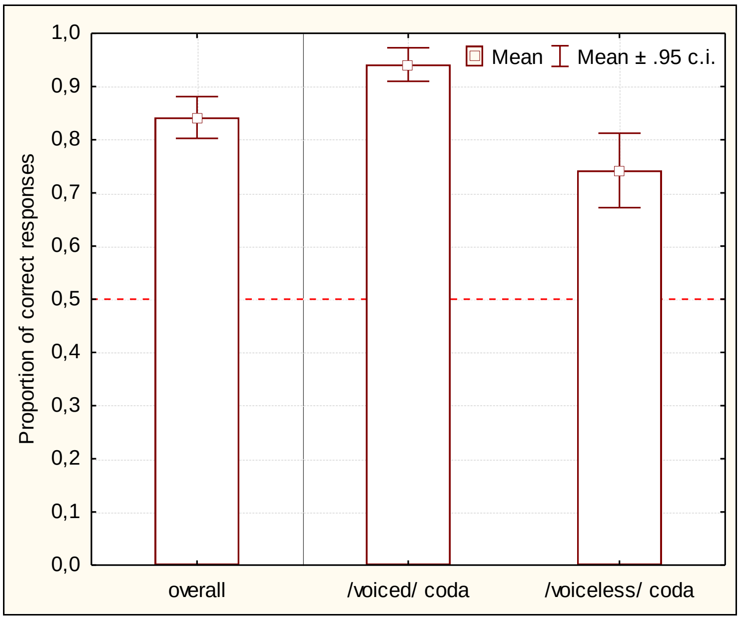


Figure 8: *Overview of the proportions of correct answers for the real words (NatCZ-EN listeners); (Overall = the proportion of correct responses overall, /voiced/ coda = proportion of correct responses when coda was phonologically voiced, /voiceless/ coda = proportion of correct responses when coda was phonologically voiceless, c.i. = confidence intervals).*

The second research question was connected to the assumption that for tokens containing /æ/, the level of success will be higher than for the words which have any of the other selected vowels (i.e. /ɪ/, /i/, /ɛ/, /ʌ/ and /ɑ/) in the nucleus. When categorizing nonsense words, the proportion of correct answers for words containing the ‘new’ /æ/ vowel was 66.50% in comparison with 74.40% for the words containing other vowels. A repeated-measures ANOVA revealed a significant main effect of vowel status (new/similar) ($F [1, 19] = 5.6631$, $p = .0279$). However, it showed the opposite tendency than it was hypothesized (see figure 9).

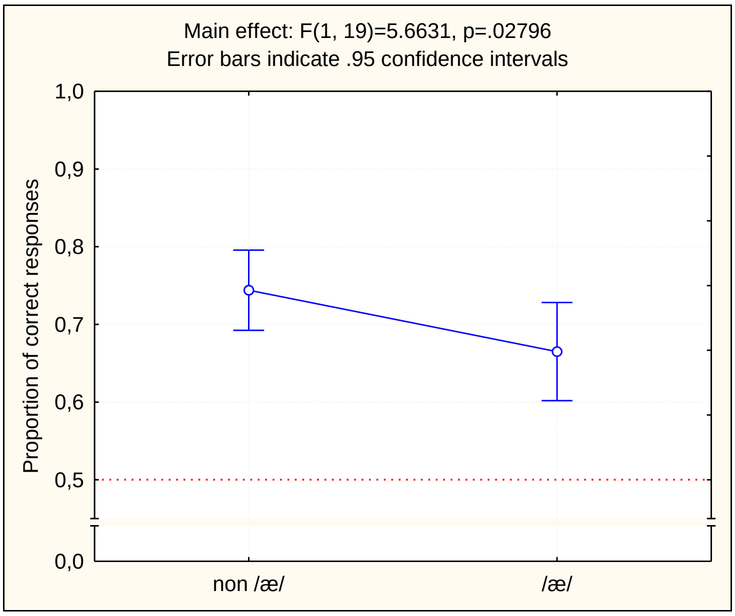


Figure 9: *The proportion of correct responses when the nucleus was the 'new'* (/æ/) *and when it was the 'similar'* (/ɪ/, /i/, /ɛ/, /ʌ / *and* /ɑ/) *vowel in the nonsense words set (NatCZ-EN listeners); (c.i. = confidence intervals)*

When the listeners were categorizing real words, the proportion of correct answers was 86.94% for words containing /æ/ and 83.67% for the words containing other vowels. Here the effect of vowel status was not significant (F[1, 19] = 3.044, p = .0972, see Figure 10). However, unlike in the case of the nonsense words, the results showed the expected tendency (i.e. level of success was higher for the tokens containing the 'new' vowel).

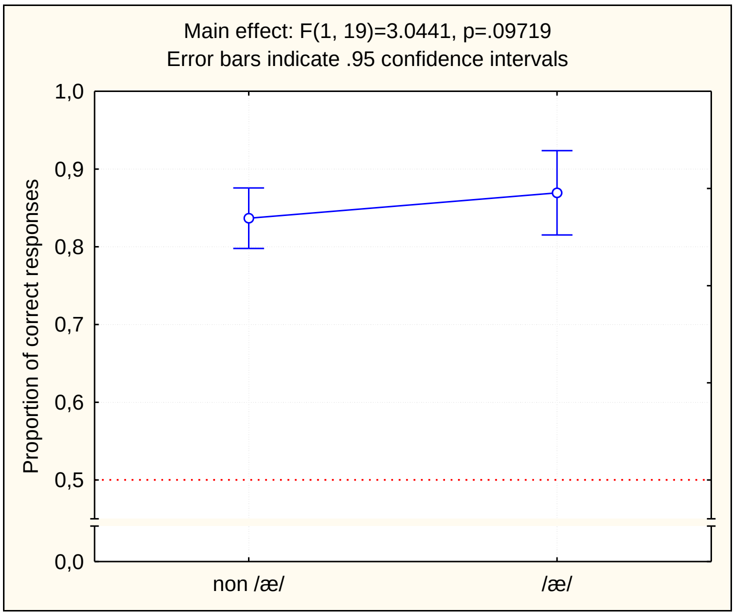


Figure 10: *The proportion of correct responses when the nucleus was the 'new'* (/æ/) *and when it was the 'similar'* (/ɪ/, /i/, /ɛ/, /ʌ / *and* /ɑ/) *vowel in the real words set (NatCZ-EN listeners); (c.i. = confidence intervals)*

# 4 Discussion

In this section, all the results obtained in the experiment will be discussed and interpreted. Since different research questions were connected to different groups of listeners, the findings will be analyzed separately. A conclusion will be provided at the end of this chapter in order to evaluate how all the research questions presented in this thesis were answered and whether the hypotheses were validated or rejected.

## 4.1 Native English Listeners (NatEN group)

Both control listeners reached the top level of accuracy in perception of the nonsense and the real words. Even though I did not directly measure the durations of the vowels in the English stimuli (in other words I did not check if vowels were actually longer before voiced than before voiceless consonants), I assume that native English listeners used the *VDVCV* as a cue for discrimination and since their scores were so high, this effect had supposedly occurred.

## 4.2 Monolingual Czech Listeners (NatCZ)

Several issues were examined in the data obtained from this group of listeners.

### 4.2.1 The vowel duration variation produced by the speakers

Five speakers performed in the recordings of the stimuli for the listening task and none of them produced a significant variation in vowel duration before voiceless vs. voiced coda. In other words, it was tested with repeated measures ANOVA whether the phonological voicing affected the vowel duration and for all speakers no significant effects were found. What is more, one of the speakers (namely speaker no. 3) even showed the opposite tendency and made vowels before voiceless consonants longer than those before voiced consonants when she produced both real and nonsense words. Generally, I conclude that the effect of *VDVCV* did not occur at the production level which might imply that *neutralization* seems to have been *complete* in this case. However, the effect of *VDVCV* was not supposed to occur within the production of the speakers and, above all, the main purpose of this study was to examine perception, not production.

### 4.2.2 The achieved accuracy of categorization of final voicing

Overall, the listeners performed completely at chance in categorizing the voicing both in real and nonsense words. Therefore it seems that without the necessary context, final voicing simply cannot be perceived accurately in Czech since there might be no relevant cues to it.

With respect to the phonetic voicing in coda, the listeners were generally more successful in its categorization when the coda was voiceless. In the nonsense part of the test, they achieved 71.67% of correct responses when the coda was voiceless in comparison to only 32.58% when the coda was phonologically voiced. When categorizing the real words, the proportion was slightly lower (66.80% for words with voiceless coda versus 37.20% for those with phonologically voiced coda) but it still showed that the level of success was significantly higher for the tokens containing voiceless coda. The possible explanation for such tendency might be the fact that Czech listeners are familiar with exclusively devoiced (i.e. voiceless) consonants in coda and therefore they might simply have preferred to categorize the coda as voiceless. Such tendency is also obvious when we compare the number of 'voiced' versus 'voiceless' responses given by all the listeners. In general, 'voiceless' responses prevailed, sometimes even very significantly.

### 4.2.3 The correlation between vowel duration and the likelihood of 'voiced' response

One of the central hypotheses of this paper suggested that the likelihood of 'voiced' response would increase with increasing vowel duration. In other words, I hypothesized that for 'phonologically long' (and in case of the nonsense words also lengthened) vowels, the proportion of 'voiced' responses will be bigger. The obtained results varied in the real-words and nonsense-words parts of the test.

When listeners were categorizing nonsense words, my hypothesis was validated in case of the phonologically short vs. long vowels because ANOVA revealed highly significant effect. In addition to that, the vowels in nonsense words were manipulated and lengthened to observe if such artificial lengthening might increase the number of 'voiced' responses as well. However, the effect revealed by ANOVA was not significant in this case even though the hypothesized tendency was clear again. On the other hand, the results of categorizing the real words revealed exactly opposite (and for my hypothesis a contradicting) tendency. Even though the effect revealed by ANOVA was not significant, it was obvious that the proportion of 'voiced' responses was higher for phonologically short, not long vowels as it was assumed.

This hypothesis was tested not only by using ANOVA but also with calculating *Point Biserial Correlation* ($r_{pb}$) which was supposed to investigate the correlation between vowel duration and 'voiced' responses. The null hypothesis ($H_0$) was based on the suggestion that the likelihood of 'voiced' response would not increase with increasing vowel duration whereas the alternative hypothesis ($H_1$) was based on the claim that the likelihood of 'voiced' response would increase with increasing vowel duration. The correlations were computed for the individual listeners and then used for the calculation of the result for the whole group. On the basis of the obtained results I draw the conclusion for both real and nonsense words and say that my null hypothesis $H_0$ cannot be excluded in favour of the alternative hypothesis $H_1$ and thus, $H_0$ is still plausible. In other words, my suggestion that the increase in vowel duration would increase the likelihood of 'voiced' response from the speaker was not validated by *Point Biserial Correlation.*

Generally, after the evaluation of both ANOVA and *Point Biserial Correlation* results, I conclude that the hypothesis suggesting that the likelihood of 'voiced' response would increase with vowel duration was not validated, even though partial results were in favour of it. Such results that supported the hypothesis might be considered to be a suggestion for further and more extensive research on this issue.

### 4.2.4 /ɪ/-/iː/ vs. other vowels

With respect to the question of whether the accuracy of perception of the final voicing might increase for words containing the vowels /ɪ/ or /iː/, in the nonsense-words part of the test, repeated measures ANOVA revealed that the main effect was not significant. On the contrary, in the real words part of the test, a significant main effect was revealed. However, in both cases the obtained results contradicted the hypothesis formulated for this issue and revealed the opposite tendency. In other words, listeners were more successful when they were categorizing tokens containing the other selected vowels, not those containing /ɪ/ or /iː/ as it was hypothesized. In general, I conclude that this hypothesis was not successfully validated by the obtained results. Nevertheless, the level of success when categorizing both tokens with or without /ɪ/ - /iː/ (as well as the overall proportion of correct answers) was at chance and thus such findings might not be considered to be relevant.

## 4.3 Native Czech Listeners learning English (NatCZ-EN)

Two research questions were connected to the results obtained from this group:

i) what was the level of achieved accuracy of categorization of final voicing

ii) if there was a difference in categorizing the tokens containing the relatively ‘new’ vowel /æ/ and the vowels having their counterparts in Czech inventory (i.e. /ɪ/, /i/, /ɛ/, /ʌ/ and /ɑ/). The obtained results are discussed in following sections.

### 4.3.1 The achieved accuracy of categorization of final voicing

The first was the question of whether the accuracy of categorization of voicing will be above chance which would suggest that the perception of voicing in coda might improve with L2 learning. Whereas NatCZ listeners (who, however, listened to Czech, not English stimuli) scored only 52.13% of overall correct responses in the nonsense words part and 52.00% in the real words part (i.e. their scores were not significantly above chance), the NatCZ-EN group reached 72.58% of accuracy in the nonsense words part and 84.18% of accuracy in the real words part. Such results suggest that even though the level of success was not as high as in the case of NatEN listeners, it seems that native speakers of Czech – the language which allows no phonetically voiced obstruents in coda – were able to adapt to L2 rules within the course of the second language acquisition and thus perceive the voicing in coda accurately. However, to determine with confidence that the relative success of the NatCz-En listeners was the result of L2 learning, naïve Czech listeners (inexperienced in English) should be tested on the English stimuli, because there is the possibility that the 'marked' voiced codas are perceptible to listeners with L1s lacking them even without prior experience.

With respect to the phonological voicing in coda, there was a significant difference in the level of accuracy. In the nonsense-words test, the results revealed a higher level of accuracy in case of the tokens with voiced coda (which does not exist in Czech) and in the perception of the real words, the scores were even higher for tokens with voiced coda in comparison to those with voiceless coda. This represents an interesting finding – Czech speakers, who are not used to encounter voicing in coda from their L1, were more likely to correctly recognize the voiced coda rather than voiceless final consonant in L2.

The possible explanation for such results might be that the Czech listeners simply ignored the effect of *VDVCV* and focused exclusively on the phonetic voicing itself. Similar situation was described in Broersma (2005a – this article was already discussed in sections 1.1 and 1.5) where the non-native listeners outperformed the native listeners in the accuracy of perception of final voicing by ignoring the cue of *VDVCV* which was manipulated in that experiment in order to be uninformative and even misleading. What is more, even though e.g. Ladefoged (2001: 73) suggested that in English voiced obstruents are actually voiced through only a small part of the articulation (when they occur at the end of an utterance or before a voiceless sound), the speakers from whom the stimuli for the perceptual experiment were elicited did not devoice to such extent. A post-hoc analysis was performed to check whether the English speakers devoiced the final consonants or not using Praat (Boersma and Weenink 2010) where all the words with phonologically voiced codas were displayed in spectrograms and according to the presence/absence of the pitch contour (displayed using Praat default settings) in the obstruent (the segmentation of individual words was based on Machač and Skarnitzl [2009]), the consonant was judged as phonetically voiced or voiceless. Whereas in nonsense words, the number of phonetically voiced codas was only slightly higher (out of 30 tokens with voiced coda, 18 of them were fully voiced and 12 devoiced or partially voiced), in case of real words, the tokens with fully realized voicing in coda prevailed (out of 58 tokens with voiced coda, approximately two thirds were fully voiced and one third was devoiced or partially voiced). Such finding supports the assumption that within the stimuli used in my experiment, the phonetic quality of the consonant itself was sufficient to cue the voicing.

A related possible explanation of the fact that the Czech speakers listening to English were more successful in categorizing voiced codas is connected with the issue of markedness (see chapter 1.6). Since in Czech, the rule of *final devoicing* eliminates the voicing in coda and the English stimuli contained a large amount of fully voiced codas, the word-final voicing might have been easily noticeable for L1 speakers of a language without this marked phenomenon. Such perceptual salience would be a possible interpretation of ‘markedness’.

The different level of accuracy in categorizing phonologically voiced versus voiceless coda is also connected to the hypothesis (see section 1.5) suggesting that if L1 Czech listeners of L2 English transferred the rule of *final devoicing* from their L1 to the perception of L2, they might expect some of the phonetically voiceless codas to be underlyingly voiced (in other words, they would apply the rule in the reverse order – from surface to the underlying form). This would imply that they might 'prefer' the 'voiced' response for some of the phonetically voiceless coda simply because they would assume that it does not have a voiceless but a *devoiced* consonant. Generally, this would result in a decreased level of accuracy when categorizing phonologically voiceless codas. With respect to the results obtained in the perceptual test, it might be claimed that this hypothesis has been confirmed since the Czech speakers listening to English showed higher level of accuracy for phonologically voiced codas (see the exact proportions above). On the other hand, the possible reason for better categorization of voiced consonants in coda might as well be the one suggesting that the listeners scored so well simply because they paid attention to the voicing itself and used it as a sufficient cue. Or there is even a possibility that both of the situations just described above happened at the same time. In other words, the listeners were so accurate in categorizing voiced codas because the phonetic voicing was present and thus noticeable and marked and their accuracy in categorizing voiceless codas was lower because they transferred the *final devoicing rule* from their L1 (see the explanation above).

With respect to the level of accuracy, it is also worthy of notice that the NatCZ-EN listeners showed a higher level of success in the perception of real words rather than nonsense words. One of the reasons for this might have been the difference in number of tokens. Whereas the real words part consisted of 116 tokens in total, there were only 60 nonsense words in the particular test. What is more, all the nonsense words shared the same pattern (i.e. all the selected vowels were embedded into the same structure: *g__tch* or *g__dge*), whereas the real words were generally more varied (all the selected vowels were embedded into various word patterns). Besides, the real words were all high frequency words which means that the listeners had experience with them (and the way they sound like when they are pronounced by natives) whereas the nonsense words were heard for the first time ever. In general, the results of the real words tests were more important since they can be considered to be more relevant for the research of natural speech in comparison with the artificially created nonsense words.

### 4.3.2 Categorizing tokens containing the 'new' vowel /æ/

The second research question posed with respect to this group of listeners aimed to validate the hypothesis that for tokens containing /æ/, the level of success will be higher than for the words containing the other selected vowels (i.e. /ɪ/, /i/, /ɛ/, /ʌ/ and /ɑ/). When categorizing nonsense words, the proportion of correct answers for words containing the 'new' /æ/ vowel was 66.50% in comparison with 74.40% for the words containing other vowels. Here, the results revealed a significant effect of the presence/absence of the new vowel on the proportion of correct responses. However, they contradict my assumption that the accuracy should increase for the tokens containing the new vowel.

Nevertheless, for the reasons which have just been mentioned above, I was more interested in the results of the real words tests, where the difference in proportion of correct answers was smaller – 86.94% for words containing /æ/ and 83.67% for the words containing other vowels and the effect revealed by ANOVA was not significant. However, unlike in the case of nonsense words, here the results revealed the hypothesized tendency.

Generally, I conclude that the hypothesis suggesting that the level of success would be higher for words containing the 'new' vowel was not validated by obtaining highly significant results. But it should be pointed out that the amount of words containing /æ/ was relatively small – there were only 18 tokens (in comparison to 98 words with other vowels). Therefore, the interpretation of the obtained results might be questioned due to the unsatisfactory size of the sample. Conducting a similar experiment with bigger amount of stimuli might be considered to be a suggestion for future research.

## 4.4 Conclusion

Several research questions were presented in this thesis and by conducting a perceptual experiment and obtaining particular results, I aimed to provide satisfactory answers to them. Some of the hypotheses were successfully validated or the results at least suggested possibilities for future research. On the other hand, several hypotheses were rejected by obtaining results that contradicted some of the central assumptions.

The hypothesis suggesting that in Czech the process of *neutralization* might be *incomplete* and the listeners might be able to utilize the effect of variable vowel duration as a cue for accurate categorization of final voicing was not validated. In their L1, the Czech listeners did not perform above chance in perceiving both real and nonsense words. Such finding suggests that without a particular context, the native Czech listeners are not able to distinguish the voicing in coda accurately and therefore the *neutralization* seems to be *complete*.

On the other hand, the native Czech listeners performed above chance when they were categorizing the voicing in coda in their L2 English and the assumption suggesting that the accuracy of perception might improve in the course of the second language acquisition was validated. However, even though in L2 the listeners achieved high scores in the accuracy of perception, it is not clear if the vowel duration variation was used as a cue to final voicing (which, however, was not the aim of this thesis). Nevertheless, in their L1 (Czech) the correlation between the vowel duration and the likelihood of ‘voiced’ response was not revealed to be generally significant.

Another hypothesis, which suggested that for the vowels /ɪ/ - /iː/ the accuracy might increase in Czech, was not validated. The obtained results contradicted this assumption and even revealed opposite tendency. When categorizing the English stimuli, the Czech native listeners were expected to be more successful in perceiving the tokens containing the relatively ‘new’ vowel /æ/. This hypothesis was rejected as well because no highly significant results were obtained to validate it.

To summarize, I would like to conclude that even though many of the presented hypotheses were not validated, this thesis should rather serve as an inspiration for further investigation within this field because some of its findings suggest that interesting (and possibly different) results might be obtained by extending the experiment to a larger extent.

# 5 Appendices

## 5.1 Appendix 1: The set of stimuli for the perceptual test:

**The stimuli for Czech speakers and NatCZ listeners:**

**Selected vowels:**

/ɪ/

/i:/

/ɛ/

/ɛ:/ – no real words pairs included

/a/

/a:/

**Real words (20):**

vis – viz, polyp - polib

spíš – spíž, sníš – s níž

les – lez, let – led

mas – maz, kas - kaz

stát – stád, vás – váz

**Nonsense words (12):**

git – gid

gít – gíd

get – ged

gét – géd

gat – gad

gát – gád

**The stimuli for English speakers and NatCZ-EN and NatEN listeners:**

**Selected vowels:**

/ɪ/

/i/

/ɛ/

/æ/

/ʌ /

/ɑ/

**Real words (24):**

bit – bid, kit – kid

seat –seed, leek - league

bet – bed, peck - peg

lap – lab, cap - cab

bop – Bob, clock - clog

pup – pub, buck – bug

**Nonsense words (12):**

gitch – gidge

geetch – geedge

getch – gedge

gatch – gadge

gutch – gudge

gotch - godge

## 5.2 Appendix 2: The script for the perceptual tests

This is a script for the speech analysis and synthesis software Praat (Boersma and Weenink 2010). It was used for the perceptual experiment and both the English and Czech parts were blocked by speakers and presented to listeners in a randomized order. I present only a sample for one speaker since the files were almost the same for all speakers (they differed only in the names of the stimuli file names which referred to different speakers).

**A sample script for the Czech speakers – nonsense words**

```
File type = "ooTextFile"
Object class = "ExperimentMFC 5"

stimuliAreSounds? <yes>
stimulusFileNameHead = "Stimuli/"
stimulusFileNameTail = ".wav"
stimulusCarrierBefore:
    name = ""
stimulusCarrierAfter:
    name = ""
stimulusInitialSilenceDuration = 0.5
stimulusMedialSilenceDuration = 0
numberOfDifferentStimuli = 24
    stimulus [1]:
        name = "gad1a"
        visibleText = "|gad|gat"
    stimulus [2]:
        name = "gad1ae"
        visibleText = "|gad|gat"
    stimulus [3]:
        name = "gat1a"
        visibleText = "|gad|gat"
    stimulus [4]:
        name = "gat1ae"
        visibleText = "|gad|gat"
    stimulus [5]:
        name = "gád1a"
```

```
        visibleText = "|gád|gát"
    stimulus [6]:
        name = "gád1ae"
        visibleText = "|gád|gát"
    stimulus [7]:
        name = "gát1b"
        visibleText = "|gád|gát"
    stimulus [8]:
        name = "gát1be"
        visibleText = "|gád|gát"
    stimulus [9]:
        name = "ged1b"
        visibleText = "|ged|get"
    stimulus [10]:
        name = "ged1be"
        visibleText = "|ged|get"
    stimulus [11]:
        name = "get1a"
        visibleText = "|ged|get"
    stimulus [12]:
        name = "get1ae"
        visibleText = "|ged|get"
    stimulus [13]:
        name = "géd1b"
        visibleText = "|gét|géd"
    stimulus [14]:
        name = "géd1be"
        visibleText = "|gét|géd"
    stimulus [15]:
        name = "gét1a"
        visibleText = "|gét|géd"
    stimulus [16]:
        name = "gét1ae"
        visibleText = "|gét|géd"
    stimulus [17]:
        name = "gid1b"
        visibleText = "|git|gid"
    stimulus [18]:
        name = "gid1be"
        visibleText = "|git|gid"
    stimulus [19]:
        name = "git1b"
        visibleText = "|git|gid"
    stimulus [20]:
        name = "git1be"
        visibleText = "|git|gid"
    stimulus [21]:
        name = "gíd1a"
        visibleText = "|gít|gíd"
    stimulus [22]:
        name = "gíd1ae"
        visibleText = "|gít|gíd"
    stimulus [23]:
        name = "gít1b"
        visibleText = "|gít|gíd"
    stimulus [24]:
        name = "gít1be"
        visibleText = "|gít|gíd"
numberOfReplicationsPerStimulus = 1
breakAfterEvery = 0
randomize = <PermuteBalancedNoDoublets>
startText = "Klikněte pro zahájení testu."
runText = "Co jste slyšeli?"
pauseText = "Teď je čas na pauzu. Klikněte pro
pokračování"
endText = "Tato část je hotová. Odpočiňte si.Pro
pokračování klikněte."
maximumNumberOfReplays = 3
replay_left = 0.1
replay_right = 0.9
```

```
replay_bottom = 0.1
replay_top = 0.17
replay_label = "Klikněte sem (nebo zmáčkněte mezerník)
pro zopakování věty"
replay_key = " "
ok_left = 0
ok_right = 0
ok_bottom = 0
ok_top = 0
ok_label = ""
ok_key = ""
oops_left = 0
oops_right = 0
oops_bottom = 0
oops_top = 0
oops_label = ""
oops_key = ""
responsesAreSounds? <no>
responseFileNameHead = ""
responseFileNameTail = ""
responseCarrierBefore:
    name = ""
responseCarrierAfter:
    name = ""
responseInitialSilenceDuration = 0
responseMedialSilenceDuration = 0
numberOfDifferentResponses = 2
response []:
    response [1]:
        left = 0.15
        right = 0.45
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "left"
    response [2]:
        left = 0.55
        right = 0.85
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "right"
numberOfGoodnessCategories = 0
goodness []: (empty)
```

**A sample script for the Czech speakers – real words**

```
File type = "ooTextFile"
Object class = "ExperimentMFC 5"

stimuliAreSounds? <yes>
stimulusFileNameHead = "Stimuli/"
stimulusFileNameTail = ".wav"
stimulusCarrierBefore:
    name = ""
stimulusCarrierAfter:
    name = ""
stimulusInitialSilenceDuration = 0.5
stimulusMedialSilenceDuration = 0
numberOfDifferentStimuli = 20
    stimulus [1]:
        name = "kas1a"
```

```
        visibleText = "|kas|kaz"
    stimulus [2]:
        name = "kaz1b"
        visibleText = "|kaz|kas"
    stimulus [3]:
        name = "led1a"
        visibleText = "|led|let"
    stimulus [4]:
        name = "les1a"
        visibleText = "|les|lez"
    stimulus [5]:
        name = "let1a"
        visibleText = "|let|led"
    stimulus [6]:
        name = "lez1b"
        visibleText = "|lez|les"
    stimulus [7]:
        name = "mas1a"
        visibleText = "|mas|maz"
    stimulus [8]:
        name = "maz1a"
        visibleText = "|maz|mas"
    stimulus [9]:
        name = "polib1a"
        visibleText = "|polib|polyp"
    stimulus [10]:
        name = "polyp1a"
        visibleText = "|polyp|polib"
    stimulus [11]:
        name = "s níž1a"
        visibleText = "|s níž|sníš"
    stimulus [12]:
        name = "sníš1b"
        visibleText = "|sníš|s níž"
    stimulus [13]:
        name = "spíš1b"
        visibleText = "|spíž|spíš"
    stimulus [14]:
        name = "spíž1b"
        visibleText = "|spíš|spíž"
    stimulus [15]:
        name = "stád1b"
        visibleText = "|stát|stád"
    stimulus [16]:
        name = "stát1b"
        visibleText = "|stád|stát"
    stimulus [17]:
        name = "vás1b"
        visibleText = "|vás|váz"
    stimulus [18]:
        name = "váz1a"
        visibleText = "|váz|vás"
    stimulus [19]:
        name = "vis1a"
        visibleText = "|vis|viz"
    stimulus [20]:
        name = "viz1b"
        visibleText = "|viz|vis"
numberOfReplicationsPerStimulus = 1
breakAfterEvery = 0
randomize = <PermuteBalancedNoDoublets>
startText = "Klikněte pro zahájení testu."
runText = "Co jste slyšeli?"
pauseText = "Teď je čas na pauzu. Klikněte pro
pokračování"
endText = "Tato část je hotová. Odpočiňte si.Pro
pokračování klikněte."
maximumNumberOfReplays = 3
replay_left = 0.1
replay_right = 0.9
```

```
replay_bottom = 0.1
replay_top = 0.17
replay_label = "Klikněte sem (nebo zmáčkněte mezerník)
pro zopakování věty"
replay_key = " "
ok_left = 0
ok_right = 0
ok_bottom = 0
ok_top = 0
ok_label = ""
ok_key = ""
oops_left = 0
oops_right = 0
oops_bottom = 0
oops_top = 0
oops_label = ""
oops_key = ""
responsesAreSounds? <no>
responseFileNameHead = ""
responseFileNameTail = ""
responseCarrierBefore:
    name = ""
responseCarrierAfter:
    name = ""
responseInitialSilenceDuration = 0
responseMedialSilenceDuration = 0
numberOfDifferentResponses = 2
response []:
    response [1]:
        left = 0.15
        right = 0.45
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "left"
    response [2]:
        left = 0.55
        right = 0.85
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "right"
numberOfGoodnessCategories = 0
goodness []: (empty)
```

## A sample script for the English speakers – nonsense words

```
File type = "ooTextFile"
Object class = "ExperimentMFC 5"

stimuliAreSounds? <yes>
stimulusFileNameHead = "Stimuli/"
stimulusFileNameTail = ".wav"
stimulusCarrierBefore:
    name = ""
stimulusCarrierAfter:
    name = ""
stimulusInitialSilenceDuration = 0.5
stimulusMedialSilenceDuration = 0
numberOfDifferentStimuli = 12
    stimulus [1]:
        name = "gadge1b"
```

```
        visibleText = "|gadge|gatch"
    stimulus [2]:
        name = "gatch1b"
        visibleText = "|gadge|gatch"
    stimulus [3]:
        name = "gedge1b"
        visibleText = "|getch|gedge"
    stimulus [4]:
        name = "getch1b"
        visibleText = "|getch|gedge"
    stimulus [5]:
        name = "geedge1a"
        visibleText = "|geedge|geetch"
    stimulus [6]:
        name = "geetch1a"
        visibleText = "|geedge|geetch"
    stimulus [7]:
        name = "gidge1b"
        visibleText = "|gitch|gidge"
    stimulus [8]:
        name = "gitch1b"
        visibleText = "|gitch|gidge"
    stimulus [9]:
        name = "godge1b"
        visibleText = "|godge|gotch"
    stimulus [10]:
        name = "gotch1b"
        visibleText = "|godge|gotch"
    stimulus [11]:
        name = "gudge1a"
        visibleText = "|gutch|gudge"
    stimulus [12]:
        name = "gutch1a"
        visibleText = "|gutch|gudge"
numberOfReplicationsPerStimulus = 1
breakAfterEvery = 0
randomize = <PermuteBalancedNoDoublets>
startText = "Click to start the test."
runText = "What did you hear"
pauseText = "It´s time for a break. Click to continue."
endText = "This part has been completed. Have a break.
Click to continue."
maximumNumberOfReplays = 3
replay_left = 0.1
replay_right = 0.9
replay_bottom = 0.1
replay_top = 0.17
replay_label = "Click here (or press spacebar) to repeat
the word"
replay_key = " "
ok_left = 0
ok_right = 0
ok_bottom = 0
ok_top = 0
ok_label = ""
ok_key = ""
oops_left = 0
oops_right = 0
oops_bottom = 0
oops_top = 0
oops_label = ""
oops_key = ""
responsesAreSounds? <no>
responseFileNameHead = ""
responseFileNameTail = ""
responseCarrierBefore:
    name = ""
responseCarrierAfter:
    name = ""
responseInitialSilenceDuration = 0
```

```
responseMedialSilenceDuration = 0
numberOfDifferentResponses = 2
response []:
    response [1]:
        left = 0.15
        right = 0.45
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "left"
    response [2]:
        left = 0.55
        right = 0.85
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "right"
numberOfGoodnessCategories = 0
goodness []: (empty)
```

**A sample script for the English speakers – real words**

```
File type = "ooTextFile"
Object class = "ExperimentMFC 5"

stimuliAreSounds? <yes>
stimulusFileNameHead = "Stimuli/"
stimulusFileNameTail = ".wav"
stimulusCarrierBefore:
    name = ""
stimulusCarrierAfter:
    name = ""
stimulusInitialSilenceDuration = 0.5
stimulusMedialSilenceDuration = 0
numberOfDifferentStimuli = 22
    stimulus [1]:
        name = "bed1a"
        visibleText = "|bed|bet"
    stimulus [2]:
        name = "bet1a"
        visibleText = "|bed|bet"
    stimulus [3]:
        name = "bid1b"
        visibleText = "|bid|bit"
    stimulus [4]:
        name = "bit1b"
        visibleText = "|bid|bit"
    stimulus [5]:
        name = "Bob1a"
        visibleText = "|bop|Bob"
    stimulus [6]:
        name = "bop1a"
        visibleText = "|bop|Bob"
    stimulus [7]:
        name = "buck1a"
        visibleText = "|buck|bug"
    stimulus [8]:
        name = "bug1a"
        visibleText = "|buck|bug"
    stimulus [9]:
        name = "cab1a"
        visibleText = "|cab|cap"
```

```
        stimulus [10]:
            name = "cap1a"
            visibleText = "|cab|cap"
        stimulus [11]:
            name = "kid1a"
            visibleText = "|kid|kit"
        stimulus [12]:
            name = "kit1b"
            visibleText = "|kid|kit"
        stimulus [13]:
            name = "lab1a"
            visibleText = "|lap|lab"
        stimulus [14]:
            name = "lap1b"
            visibleText = "|lap|lab"
        stimulus [15]:
            name = "league1a"
            visibleText = "|league|leek"
        stimulus [16]:
            name = "leek1b"
            visibleText = "|league|leek"
        stimulus [17]:
            name = "peck1b"
            visibleText = "|peg|peck"
        stimulus [18]:
            name = "peg1a"
            visibleText = "|peg|peck"
        stimulus [19]:
            name = "pub1a"
            visibleText = "|pup|pub"
        stimulus [20]:
            name = "pup1a"
            visibleText = "|pup|pub"
        stimulus [21]:
            name = "seat1a"
            visibleText = "|seat|seed"
        stimulus [22]:
            name = "seed1b"
            visibleText = "|seat|seed"
    numberOfReplicationsPerStimulus = 1
    breakAfterEvery = 0
    randomize = <PermuteBalancedNoDoublets>
    startText = "Click to start the test."
    runText = "What did you hear"
    pauseText = "It´s time for a break. Click to continue."
    endText = "This part has been completed. Have a break.
    Click to continue."
    maximumNumberOfReplays = 3
    replay_left = 0.1
    replay_right = 0.9
    replay_bottom = 0.1
    replay_top = 0.17
    replay_label = "Click here (or press spacebar) to repeat
    the word"
    replay_key = " "
    ok_left = 0
    ok_right = 0
    ok_bottom = 0
    ok_top = 0
    ok_label = ""
    ok_key = ""
    oops_left = 0
    oops_right = 0
    oops_bottom = 0
    oops_top = 0
    oops_label = ""
    oops_key = ""
    responsesAreSounds? <no>
    responseFileNameHead = ""
    responseFileNameTail = ""
```

```
responseCarrierBefore:
    name = ""
responseCarrierAfter:
    name = ""
responseInitialSilenceDuration = 0
responseMedialSilenceDuration = 0
numberOfDifferentResponses = 2
response []:
    response [1]:
        left = 0.15
        right = 0.45
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "left"
    response [2]:
        left = 0.55
        right = 0.85
        bottom = 0.7
        top = 0.8
        label = ""
        fontSize = 40
        key = ""
        name = "right"
numberOfGoodnessCategories = 0
goodness []: (empty)
```

## 5.3 Appendix 3: Tables with results

**Table 1 – Summary of results obtained from NatCZ-EN listeners (nonsense words)**

| Listener | Percentage of correct responses overall | proportion of correct responses when coda was voiced | proportion of correct responses when coda was voiceless | Proportion of correct responses when the vowel was different than /æ/ | Proportion of correct responses when the vowel was /æ/ |
|---|---|---|---|---|---|
| Adéla | 76,67% | 73,33% | 80,00% | 80,00% | 60,00% |
| Honza | 80,00% | 83,33% | 76,67% | 96,00% | 60,00% |
| Jakub F | 55,00% | 70,00% | 40,00% | 58,00% | 40,00% |
| Jakub N | 70,00% | 70,00% | 70,00% | 72,00% | 60,00% |
| Jakub S | 90,00% | 90,00% | 90,00% | 92,00% | 80,00% |
| Jana | 71,67% | 73,33% | 70,00% | 72,00% | 70,00% |
| Jirka | 71,67% | 100,00% | 43,33% | 72,00% | 70,00% |
| Klára | 73,33% | 86,67% | 60,00% | 74,00% | 70,00% |
| Lucie P | 68,33% | 90,00% | 46,67% | 72,00% | 50,00% |
| Lucie W | 80,00% | 73,33% | 76,67% | 76,00% | 70,00% |
| Markéta | 73,33% | 76,67% | 70,00% | 78,00% | 50,00% |
| Martina | 75,00% | 83,33% | 66,67% | 74,00% | 80,00% |
| Michal | 65,00% | 56,67% | 73,33% | 68,00% | 50,00% |
| Miloš | 58,33% | 56,67% | 60,00% | 56,00% | 70,00% |
| Nela | 86,67% | 86,67% | 86,67% | 90,00% | 70,00% |
| Petr T | 60,00% | 50,00% | 70,00% | 62,00% | 50,00% |

| | | | | | |
|---|---|---|---|---|---|
| Petra W | 75,00% | 80,00% | 80,00% | 78,00% | 90,00% |
| Radek | 61,67% | 63,33% | 60,00% | 58,00% | 80,00% |
| Zdenek | 85,00% | 93,33% | 76,67% | 86,00% | 80,00% |
| Zuzka | 75,00% | 86,67% | 63,33% | 74,00% | 80,00% |
| **average** | **72,58%** | **77,17%** | **68,00%** | **74,40%** | **66,50%** |

**Table 2 – Summary of results obtained from NatCZ-EN listeners (real words)**

| Listener | Percentage of correct responses overall | proportion of correct responses when coda was voiced | proportion of correct responses when coda was voiceless | Proportion of correct responses when the vowel was different than /æ/ | Proportion of correct responses when the vowel was /æ/ |
|---|---|---|---|---|---|
| Adéla | 86,21% | 96,55% | 75,86% | 85,71% | 88,89% |
| Honza | 87,07% | 100,00% | 74,14% | 84,69% | 100,00% |
| Jakub F | 74,14% | 87,93% | 60,34% | 74,49% | 72,22% |
| Jakub N | 92,24% | 96,55% | 87,93% | 92,86% | 88,89% |
| Jakub S | 96,55% | 96,55% | 96,55% | 95,92% | 100,00% |
| Jana | 86,21% | 94,83% | 77,59% | 86,73% | 83,33% |
| Jirka | 76,72% | 100,00% | 53,45% | 76,53% | 77,78% |
| Klára | 81,90% | 98,28% | 65,52% | 80,61% | 88,89% |
| Lucie P | 75,00% | 100,00% | 50,00% | 74,49% | 77,78% |
| Lucie W | 92,24% | 94,83% | 89,66% | 91,84% | 94,44% |
| Markéta | 82,76% | 96,55% | 68,97% | 81,63% | 88,89% |
| Martina | 85,34% | 93,10% | 77,59% | 84,69% | 88,89% |
| Michal | 70,69% | 84,48% | 56,90% | 73,47% | 55,56% |
| Miloš | 71,55% | 70,69% | 72,41% | 68,37% | 88,89% |
| Nela | 91,38% | 96,55% | 86,21% | 91,84% | 88,89% |
| Petr T | 71,55% | 96,55% | 46,55% | 71,43% | 72,22% |
| Petra W | 88,79% | 94,83% | 82,76% | 86,73% | 100,00% |
| Radek | 86,21% | 91,38% | 81,03% | 86,73% | 83,33% |
| Zdenek | 89,66% | 96,55% | 82,76% | 87,76% | 100,00% |
| Zuzka | 97,41% | 96,55% | 98,28% | 96,94% | 100,00% |
| **average** | **84,18%** | **94,14%** | **74,22%** | **83,67%** | **86,94%** |

**Table 3 – Summary of results obtained from NatCZ listeners (nonsense words)**

| Listener | proportion of voiced responses when long | proportion of voiced responses when short | proportion of voiced responses when edited | proportion of voiced responses when not edited | proportion of correct responses overall | proportion of correct responses when coda was voiced | proportion of correct responses when coda was voiceless | Proportion of correct responses when the vowel was different than /i-i/ | Proportion of correct responses when the vowel was /i-i/ |
|---|---|---|---|---|---|---|---|---|---|
| Adam | 35,00% | 21,67% | 28,33% | 28,33% | 51,67% | 30,00% | 73,33% | 50,00% | 55,00% |
| David | 5,00% | 21,67% | 16,67% | 10,00% | 53,33% | 16,67% | 90,00% | 56,25% | 47,50% |
| Eliška | 41,67% | 43,33% | 50,00% | 35,00% | 55,83% | 48,33% | 63,33% | 53,75% | 60,00% |
| Hela | 38,33% | 18,33% | 31,67% | 25,00% | 51,67% | 30,00% | 73,33% | 53,75% | 47,50% |
| Helena | 18,33% | 16,67% | 21,67% | 13,33% | 52,50% | 20,00% | 85,00% | 50,00% | 57,50% |
| Iveta | 30,00% | 31,67% | 35,00% | 26,67% | 47,50% | 28,33% | 66,67% | 47,50% | 47,50% |
| Jana M. | 16,67% | 6,67% | 15,00% | 8,33% | 55,00% | 16,67% | 93,33% | 55,00% | 55,00% |
| Jarda | 36,67% | 15,00% | 31,67% | 20,00% | 47,50% | 23,33% | 71,67% | 50,00% | 42,50% |
| Karolína | 55,00% | 48,33% | 56,67% | 46,67% | 56,67% | 58,33% | 55,00% | 57,50% | 55,00% |
| Kristýna | 35,00% | 11,67% | 25,00% | 21,67% | 48,33% | 21,67% | 75,00% | 50,00% | 45,00% |
| Lída | 58,33% | 28,33% | 40,00% | 46,67% | 53,33% | 46,67% | 60,00% | 55,00% | 50,00% |
| Martina N. | 36,67% | 38,33% | 38,33% | 36,67% | 50,83% | 38,33% | 63,33% | 46,25% | 60,00% |
| Monika | 30,00% | 20,00% | 23,33% | 26,67% | 43,33% | 18,33% | 68,33% | 42,50% | 45,00% |
| Pavel | 41,67% | 43,33% | 36,67% | 48,33% | 55,83% | 48,33% | 63,33% | 55,00% | 57,50% |
| Pavla | 20,00% | 5,00% | 11,67% | 13,33% | 54,17% | 16,67% | 91,67% | 53,75% | 55,00% |
| Petr H. | 46,67% | 35,00% | 45,00% | 36,67% | 55,83% | 46,67% | 65,00% | 63,75% | 40,00% |
| Petr P. | 6,67% | 15,00% | 8,33% | 13,33% | 50,83% | 11,67% | 90,00% | 51,25% | 50,00% |
| Petra K. | 38,33% | 33,33% | 43,33% | 28,33% | 57,50% | 43,33% | 71,67% | 60,00% | 52,50% |
| Václav | 46,67% | 38,33% | 40,00% | 45,00% | 47,50% | 40,00% | 55,00% | 42,50% | 57,50% |
| Věra | 53,33% | 36,67% | 41,67% | 48,33% | 53,33% | 48,33% | 58,33% | 55,00% | 50,00% |
| **average percentage** | **34,50%** | **26,42%** | **32,00%** | **28,92%** | **52,13%** | **32,58%** | **71,67%** | **52,44%** | **51,50%** |

**Table 4 – Summary of results obtained from NatCZ listeners (real words)**

| Listener | proportion of voiced responses when long | proportion of voiced responses when short | Proportion of correct responses when coda was voiced | Proportion of correct responses when coda was voiceless | proportion of correct responses overall | Proportion of correct responses when the vowel was different than /i-i/ | Proportion of correct responses when the vowel was /i-i/ |
|---|---|---|---|---|---|---|---|
| Adam | 25,00% | 41,67% | 40,00% | 70,00% | 55,00% | 50,00% | 62,50% |
| David | 17,50% | 21,67% | 26,00% | 86,00% | 56,00% | 60,00% | 50,00% |
| Eliška | 47,50% | 48,33% | 52,00% | 56,00% | 54,00% | 56,67% | 50,00% |
| Hela | 12,50% | 31,67% | 18,00% | 70,00% | 44,00% | 41,67% | 47,50% |
| Helena | 7,50% | 43,33% | 38,00% | 80,00% | 59,00% | 58,33% | 60,00% |
| Iveta | 37,50% | 43,33% | 40,00% | 58,00% | 49,00% | 53,33% | 42,50% |
| Jana M. | 15,00% | 30,00% | 26,00% | 78,00% | 52,00% | 53,33% | 50,00% |
| Jarda | 17,50% | 28,33% | 30,00% | 82,00% | 56,00% | 60,00% | 50,00% |
| Karolína | 35,00% | 41,67% | 38,00% | 60,00% | 49,00% | 55,00% | 40,00% |
| Kristýna | 32,50% | 26,67% | 30,00% | 72,00% | 51,00% | 48,33% | 55,00% |
| Lída | 65,00% | 36,67% | 56,00% | 60,00% | 58,00% | 61,67% | 52,50% |
| Martina N. | 47,50% | 45,00% | 48,00% | 56,00% | 52,00% | 68,33% | 27,50% |
| Monika | 20,00% | 45,00% | 38,00% | 68,00% | 53,00% | 56,67% | 47,50% |
| Pavel | 50,00% | 61,67% | 54,00% | 40,00% | 47,00% | 48,33% | 45,00% |
| Pavla | 12,50% | 3,33% | 6,00% | 92,00% | 49,00% | 51,67% | 45,00% |
| Petr H. | 50,00% | 15,00% | 32,00% | 74,00% | 53,00% | 53,33% | 52,50% |
| Petr P. | 17,50% | 36,67% | 32,00% | 74,00% | 53,00% | 56,67% | 47,50% |
| Petra K. | 42,50% | 66,67% | 58,00% | 44,00% | 51,00% | 53,33% | 47,50% |
| Václav | 40,00% | 60,00% | 48,00% | 44,00% | 46,00% | 45,00% | 47,50% |
| Věra | 15,00% | 41,67% | 34,00% | 72,00% | 53,00% | 55,00% | 50,00% |
| **average percentage** | **30,38%** | **38,42%** | **37,20%** | **66,80%** | **52,00%** | **54,33%** | **48,50%** |

**Table 5 – Point Biserial Correlations (rpb) between 'V duration' (ms) and 'Voicing-in-coda response' ('voiced'-'voiceless') - The Czech Nonsense Words:**

| | phonologically Short V | | phonologically Long V | | all Vs together | |
|---|---|---|---|---|---|---|
| **Listener** | **rpb** | **p (one-tailed)** | **rpb** | **p (one-tailed)** | **rpb** | **p (one-tailed)** |
| Adam | | n.s. | | n.s. | 0.2 | 0.013151 |
| David | | n.s. | | n.s. | 0.3 | 0.0004025 |
| Eliska | 0.28 | 0.0162795 | | n.s. | | n.s. |
| Hela | | n.s. | | n.s. | 0.2 | 0.0148775 |
| Helca | 0.25 | 0.025656 | | n.s. | | n.s. |
| Ivet | | n.s. | | n.s. | | n.s. |
| Jana M | -0.23 | 0.0354435 | | n.s. | 0.16 | 0.0431225 |
| Jarda | | n.s. | 0.23 | 0.036195 | 0.31 | 0.0003175 |
| Kaja | | n.s. | | n.s. | 0.15 | n.s. |
| Kristyna | 0.24 | 0.0339795 | 0.23 | 0.037739 | 0.35 | <.0001 |
| Liduska | | n.s. | | n.s. | 0.29 | 0.000705 |
| Marta | | n.s. | | n.s. | | n.s. |
| Monca | | n.s. | | n.s. | 0.15 | 0.046834 |
| Pavel | | n.s. | | n.s. | | n.s. |
| Pavla | -0.34 | 0.0044165 | 0.25 | 0.0268095 | 0.24 | 0.0042075 |
| Petr H | | n.s. | | n.s. | 0.14 | n.s. |
| Petr P | | n.s. | 0.23 | 0.040157 | | n.s. |
| Petra | | n.s. | | n.s. | | n.s. |
| Vaclav | | n.s. | | n.s. | | n.s. |
| Vera | -0.2 | n.s. | | n.s. | | n.s. |
| | | | | | | |
| **as a group*** | | n.s. | | n.s. | | Impossible to tell if the result for the whole group is sign. or n.s. |
| | | p= 0.0414 | | p= 0.0118 | | p= 0.824 |

* sign test were conducted for the whole group (i.e. it was tested whether signif. results and non. sig. results are equally likely in the group, if they were then the p is > 0.05)

**Table 6 – Point Biserial Correlations (rpb) between 'V duration' (ms) and 'Voicing-in-coda response' ('voiced'-'voiceless') - The Czech Real Words:**

| | phonologically Short V | | phonologically Long V | | all Vs together | |
|---|---|---|---|---|---|---|
| **Listener** | **rpb** | **p (one-tailed)** | **rpb** | **p (one-tailed)** | **rpb** | **p (one-tailed)** |
| Adam | | n.s. | -0.39 | 0.00598 | -0.26 | 0.0043185 |
| David | 0.4 | 0.00078 | | n.s. | 0.27 | 0.003078 |
| Eliska | | n.s. | | n.s. | | n.s. |
| Hela | | n.s. | | n.s. | -0.17 | 0.043389 |
| Helca | | n.s. | 0.53 | 0.000201 | -0.23 | 0.009624 |
| Ivet | | n.s. | | n.s. | | n.s. |
| Jana M | -0.25 | 0.0286235 | | n.s. | -0.25 | 0.00553 |
| Jarda | | n.s. | | n.s. | | n.s. |
| Kaja | | n.s. | | n.s. | | n.s. |
| Kristyna | | n.s. | | n.s. | | n.s. |
| Liduska | | n.s. | | n.s. | 0.25 | 0.0065 |
| Marta | | n.s. | | n.s. | | n.s. |
| Monca | | n.s. | | n.s. | -0.16 | n.s. |
| Pavel | | n.s. | -0.56 | <.0001 | -0.23 | 0.010656 |
| Pavla | | n.s. | | n.s. | | n.s. |
| Petr H | | n.s. | | n.s. | 0.23 | 0.0120825 |
| Petr P | | n.s. | -0.33 | 0.019418 | -0.3 | 0.001385 |
| Petra | | n.s. | | n.s. | -0.22 | 0.0130175 |
| Vaclav | | n.s. | -0.43 | 0.0029285 | -0.29 | 0.0017115 |
| Vera | 0.33 | 0.0051785 | | n.s. | -0.19 | 0.031539 |
| | | | | | | |
| **as a group*** | | n.s. | | n.s. | | Impossible to tell if the result for the whole group is sign. or n.s. |
| | | p= 0.0025 | | p= 0.0414 | | p= 0.503 |

* sign test were conducted for the whole group (i.e. it was tested whether signif. results and non. sig. results are equally likely in the group, if they were then the p is > 0.05)

## 5.4 Appendix 4: Bio info – speakers and listeners

[Note: languages spoken – scale 1 (starter) – 10 (native speaker)]

**NatEn speakers**

| | |
|---|---|
| Speaker no.: | 1 |
| Name: | Travis |
| Sex: | Male |

| | |
|---|---|
| Age: | 23 |
| Place of birth: | California |
| So far has lived in: | California (2 years)<br>Michigan (20 years)<br>The Czech Republic (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 2 |
| Name: | Jenny |
| Sex: | Female |
| Age: | 22 |
| Place of birth: | Nebraska |
| So far has lived in: | Nebraska (22 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 3 |
| Name: | Laura |
| Sex: | Female |
| Age: | 19 |
| Place of birth: | Nebraska |
| So far has lived in: | Nebraska (19 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 5 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 4 |
| Name: | Chase |
| Sex: | Male |
| Age: | 19 |
| Place of birth: | Nebraska |
| So far has lived in: | Nebraska (19 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 5 |
| Name: | Caleb |
| Sex: | Male |
| Age: | 20 |
| Place of birth: | Nebraska |
| So far has lived in: | Nebraska (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

## NatEn listeners

| | |
|---|---|
| Listener no.: | 1 |
| Name: | Jason |
| Sex: | Male |
| Age: | 23 |
| Place of birth: | Cleveland, OH |
| So far has lived in: | Cleveland (22 years)<br>Prague (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 5-3-1-4-2 |
| Correct responses (real w.) | 114/116 |
| Correct responses (nons. w.) | 58/60 |

| | |
|---|---|
| Listener no.: | 2 |
| Name: | Kelly |
| Sex: | Female |
| Age: | 26 |
| Place of birth: | Boston, MA |
| So far has lived in: | Boston (24 years)<br>Prague (2 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | English – 10<br>Spanish – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-4-5-2-1 |
| Correct responses (real w.) | 115/116 |
| Correct responses (nons. w.) | 58/60 |

## NatCz-En listeners

| | |
|---|---|
| Listener no.: | 1 |
| Name: | Martina |
| Sex: | female |
| Age: | 32 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (24 years)<br>Brno (5 years)<br>Ostrava (3 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English - 5<br>German - 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons.words |
| Order of the tests/speakers | 5-1-4-2-3 |
| Correct responses (real w.) | 99/116 |
| Correct responses (nons. w.) | 45/60 |

| | |
|---|---|
| Listener no.: | 2 |
| Name: | Jirka |
| Sex: | Male |
| Age: | 24 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (19 years)<br>Praha (4 years)<br>El Paso, Texas, USA (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>Spanish – 3<br>German - 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-4-2-5-1 |
| Correct responses (real w.) | 89/116 |
| Correct responses (nons. w.) | 43/60 |

| | |
|---|---|
| Listener no.: | 3 |
| Name: | Michal |
| Sex: | Male |
| Age: | 31 |
| Place of birth: | Přerov |
| So far has lived in: | Přerov (18 years)<br>Ostrava (13 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 5 |

| | |
|---|---|
| | German - 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 4-2-5-3-1 |
| Correct responses (real w.) | 82/116 |
| Correct responses (nons. w.) | 39/60 |

| | |
|---|---|
| Listener no.: | 4 |
| Name: | Adéla |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Ústí nad Orlicí |
| So far has lived in: | Ústí nad Orlicí (13 years)<br>Velké Poříčí (12 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English - 5 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-4-2-3-5 |
| Correct responses (real w.) | 100/116 |
| Correct responses (nons. w.) | 46/60 |

| | |
|---|---|
| Listener no.: | 5 |
| Name: | Nela |
| Sex: | Female |
| Age: | 20 |
| Place of birth: | Jičín |
| So far has lived in: | Jičín (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 8<br>French – 7<br>Spanish – 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 5-3-1-2-4 |
| Correct responses (real w.) | 106/116 |
| Correct responses (nons. w.) | 52/60 |

| | |
|---|---|
| Listener no.: | 6 |
| Name: | Miloš |
| Sex: | Male |
| Age: | 29 |

| | |
|---|---|
| Place of birth: | Jihlava |
| So far has lived in: | Jihlava (24 years)<br>Olomouc (5 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 5<br>German - 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 2-5-3-4-1 |
| Correct responses (real w.) | 83/116 |
| Correct responses (nons. w.) | 35/60 |

| | |
|---|---|
| Listener no.: | 7 |
| Name: | Zuzana |
| Sex: | Female |
| Age: | 21 |
| Place of birth: | Český Brod |
| So far has lived in: | Český Brod (20 years)<br>South Dakota, USA (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 8<br>Spanish – 2<br>German - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 1-4-5-3-2 |
| Correct responses (real w.) | 113/116 |
| Correct responses (nons. w.) | 45/60 |

| | |
|---|---|
| Listener no.: | 8 |
| Name: | Jana |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Ústí nad Labem |
| So far has lived in: | Ústí nad Labem (20 years)<br>Olomouc (5 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>Polish – 7<br>English – 6<br>German – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 4-2-1-3-5 |

| | |
|---|---|
| Correct responses (real w.) | 100/116 |
| Correct responses (nons. w.) | 43/60 |

| | |
|---|---|
| Listener no.: | 9 |
| Name: | Klára |
| Sex: | Female |
| Age: | 26 |
| Place of birth: | Příbram |
| So far has lived in: | Příbram (19 years)<br>Plzeň (3 years)<br>Olomouc (4 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 8<br>French – 5 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 5-2-4-1-3 |
| Correct responses (real w.) | 95/116 |
| Correct responses (nons. w.) | 44/60 |

| | |
|---|---|
| Listener no.: | 10 |
| Name: | Markéta |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Olomouc |
| So far has lived in: | Olomouc (25 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 6<br>German – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-2-5-3-4 |
| Correct responses (real w.) | 96/116 |
| Correct responses (nons. w.) | 44/60 |

| | |
|---|---|
| Listener no.: | 11 |
| Name: | Petra W. |
| Sex: | Female |
| Age: | 27 |
| Place of birth: | Bruntál |
| So far has lived in: | Bruntál (20 years)<br>Olomouc (5.5 years)<br>Aarhus, Dánsko (0.5 year)<br>Michigan, USA (0.5 year) |

| | |
|---|---|
| | Manchester (0.5 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 9<br>Danish - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-1-4-2-5 |
| Correct responses (real w.) | 103/116 |
| Correct responses (nons. w.) | 45/60 |

| | |
|---|---|
| Listener no.: | 12 |
| Name: | Lucie W. |
| Sex: | Female |
| Age: | 30 |
| Place of birth: | Bruntál |
| So far has lived in: | Bruntál (20 years)<br>Opava (10 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 9 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | 1-5-3-2-4 |
| Order of the tests/speakers | Nons. words |
| Correct responses (real w.) | 107/116 |
| Correct responses (nons. w.) | 48/60 |

| | |
|---|---|
| Listener no.: | 13 |
| Name: | Jakub S. |
| Sex: | Male |
| Age: | 22 |
| Place of birth: | Třinec |
| So far has lived in: | Třinec (15 years)<br>Nový Jičín (7 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 8 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 112/116 |
| Correct responses (nons. w.) | 54/60 |

| | |
|---|---|
| Listener no.: | 14 |
| Name: | Jakub F. |

| | |
|---|---|
| Sex: | Male |
| Age: | 27 |
| Place of birth: | Bystřice p.Hostýnem |
| So far has lived in: | Bystřice p.Hostýnem (20 years)<br>Olomouc (3 years)<br>Iceland (1 year)<br>Praha (3 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English - 6 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 2-3-4-1-5 |
| Correct responses (real w.) | 86/116 |
| Correct responses (nons. w.) | 33/60 |

| | |
|---|---|
| Listener no.: | 15 |
| Name: | Jakub N. |
| Sex: | Male |
| Age: | 25 |
| Place of birth: | Uherské Hradiště |
| So far has lived in: | Uherské Hradiště (22 years)<br>Praha (3 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English - 7 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-4-5-1-2 |
| Correct responses (real w.) | 107/116 |
| Correct responses (nons. w.) | 42/60 |

| | |
|---|---|
| Listener no.: | 16 |
| Name: | Zdeněk |
| Sex: | Male |
| Age: | 25 |
| Place of birth: | Jevíčko |
| So far has lived in: | Jevíčko (19 years)<br>Olomouc (4.5 years)<br>Scotland (0.5 year)<br>Praha (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>German - 7 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |

| | |
|---|---|
| Order of the tests/speakers | 4-5-1-2-3 |
| Correct responses (real w.) | 104/116 |
| Correct responses (nons. w.) | 51/60 |

| | |
|---|---|
| Listener no.: | 17 |
| Name: | Petr T. |
| Sex: | Male |
| Age: | 41 |
| Place of birth: | Praha |
| So far has lived in: | Praha (41 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 6 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-1-5-2-4 |
| Correct responses (real w.) | 83/116 |
| Correct responses (nons. w.) | 36/60 |

| | |
|---|---|
| Listener no.: | 18 |
| Name: | Honza |
| Sex: | Male |
| Age: | 26 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (20 years)<br>Brno (6 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 6<br>German - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-2-4-1-5 |
| Correct responses (real w.) | 101/116 |
| Correct responses (nons. w.) | 48/60 |

| | |
|---|---|
| Listener no.: | 19 |
| Name: | Radek |
| Sex: | Male |
| Age: | 27 |
| Place of birth: | Přerov |
| So far has lived in: | Hranice (18 years)<br>Praha (8.5 years)<br>New Jersey (0.5 year) |

| | |
|---|---|
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>German – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 5-1-4-2-3 |
| Correct responses (real w.) | 100/116 |
| Correct responses (nons. w.) | 37/60 |

| | |
|---|---|
| Listener no.: | 20 |
| Name: | Lucie P. |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Praha |
| So far has lived in: | Praha (7 years)<br>Jindřichův Hradec (12 years)<br>Olomouc (5 years)<br>Mexico (0.5 year)<br>Luxembourg (0.5 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 8<br>Spanish – 8 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 5-4-3-2-1 |
| Correct responses (real w.) | 87/116 |
| Correct responses (nons. w.) | 41/60 |

## NatCz speakers

| | |
|---|---|
| Speaker no.: | 1 |
| Name: | Zdeněk |
| Sex: | Male |
| Age: | 25 |
| Place of birth: | Jevíčko |
| So far has lived in: | Jevíčko (19 years)<br>Olomouc (5 years)<br>Praha (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>German - 7 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 2 |
| Name: | Radek |
| Sex: | Male |
| Age: | 27 |

| | |
|---|---|
| Place of birth: | Přerov |
| So far has lived in: | Hranice (18 years)<br>Praha (9 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>German – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 3 |
| Name: | Anna |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (20 years)<br>Praha (5 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 7<br>German – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 4 |
| Name: | Kateřina |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Hodonín |
| So far has lived in: | Hodonín (15 years)<br>Šternberk (4 years)<br>Olomouc (6 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 6<br>German – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| Speaker no.: | 5 |
| Name: | Jakub |
| Sex: | Male |
| Age: | 27 |
| Place of birth: | Bystřice p.Hostýnem |
| So far has lived in: | Bystřice p.Hostýnem (20 years)<br>Olomouc (4 years)<br>Praha (3 years) |
| Languages spoken | Czech - 10 |

| | |
|---|---|
| (1 = beginner, 10 = native speaker) | English - 6 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

## NatCz listeners

| | |
|---|---|
| Listener no.: | 1 |
| Name: | Iveta |
| Sex: | Female |
| Age: | 20 |
| Place of birth: | Kolín |
| So far has lived in: | Kolín (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2<br>Russian – 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 49/100 |
| Correct responses (nons. w.) | 57/120 |

| | |
|---|---|
| Listener no.: | 2 |
| Name: | Martina N. |
| Sex: | Female |
| Age: | 20 |
| Place of birth: | Cheb |
| So far has lived in: | Cheb (19 years)<br>Praha (1 year) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2<br>German – 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 2-1-4-5-3 |
| Correct responses (real w.) | 52/100 |
| Correct responses (nons. w.) | 61/120 |

| | |
|---|---|
| Listener no.: | 3 |
| Name: | Kristýna |
| Sex: | Female |
| Age: | 22 |
| Place of birth: | Praha |
| So far has lived in: | Praha (22 years) |

| | |
|---|---|
| | |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 3<br>French – 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-5-1-4-2 |
| Correct responses (real w.) | 51/100 |
| Correct responses (nons. w.) | 58/120 |

| | |
|---|---|
| Listener no.: | 4 |
| Name: | Lída |
| Sex: | Female |
| Age: | 22 |
| Place of birth: | Český Brod |
| So far has lived in: | Český Brod (22 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 3<br>German – 1<br>Russian - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 4-3-2-1-5 |
| Correct responses (real w.) | 58/100 |
| Correct responses (nons. w.) | 64/120 |

| | |
|---|---|
| Listener no.: | 5 |
| Name: | David |
| Sex: | male |
| Age: | 20 |
| Place of birth: | Praha |
| So far has lived in: | Praha (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2<br>German – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 56/100 |
| Correct responses (nons. w.) | 64/120 |

| | |
|---|---|
| Listener no.: | 6 |
| Name: | Pavel |
| Sex: | Male |
| Age: | 21 |
| Place of birth: | Třebíč |
| So far has lived in: | Velké Meziříčí (15 years)<br>Kolín (6 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2<br>German - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 47/100 |
| Correct responses (nons. w.) | 67/120 |

| | |
|---|---|
| Listener no.: | 7 |
| Name: | Jarda |
| Sex: | Male |
| Age: | 24 |
| Place of birth: | Praha |
| So far has lived in: | Praha (24 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>German – 6<br>English – 3<br>Spanish - 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 56/100 |
| Correct responses (nons. w.) | 57/120 |

| | |
|---|---|
| Listener no.: | 8 |
| Name: | Petr |
| Sex: | Male |
| Age: | 21 |
| Place of birth: | Rakovník |
| So far has lived in: | Nové Strašecí (21 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 3<br>German - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |

| | |
|---|---|
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 2-4-1-5-3 |
| Correct responses (real w.) | 53/100 |
| Correct responses (nons. w.) | 67/120 |

| | |
|---|---|
| Listener no.: | 9 |
| Name: | Adam |
| Sex: | Male |
| Age: | 21 |
| Place of birth: | Jeseník |
| So far has lived in: | Jeseník (21 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 3<br>German - 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-5-2-4-1 |
| Correct responses (real w.) | 55/100 |
| Correct responses (nons. w.) | 62/120 |

| | |
|---|---|
| Listener no.: | 10 |
| Name: | Karolína |
| Sex: | Female |
| Age: | 20 |
| Place of birth: | Praha |
| So far has lived in: | Praha (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2<br>German – 4 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 1-3-5-4-2 |
| Correct responses (real w.) | 49/100 |
| Correct responses (nons. w.) | 68/120 |

| | |
|---|---|
| Listener no.: | 11 |
| Name: | Věra |
| Sex: | Female |
| Age: | 54 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (36 years)<br>Odry (16 years) |

| | |
|---|---|
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>Russian – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 4-3-2-1-5 |
| Correct responses (real w.) | 53/100 |
| Correct responses (nons. w.) | 64/120 |

| | |
|---|---|
| Listener no.: | 12 |
| Name: | Václav |
| Sex: | Male |
| Age: | 55 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (37 years)<br>Odry (16 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>Russian - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 5-2-4-3-1 |
| Correct responses (real w.) | 46/100 |
| Correct responses (nons. w.) | 57/120 |

| | |
|---|---|
| Listener no.: | 13 |
| Name: | Monika |
| Sex: | Female |
| Age: | 20 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (20 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 5-4-3-2-1 |
| Correct responses (real w.) | 53/100 |
| Correct responses (nons. w.) | 52/120 |

| | |
|---|---|
| Listener no.: | 14 |
| Name: | Helena |
| Sex: | Female |
| Age: | 12 |
| Place of birth: | Hranice |

| | |
|---|---|
| So far has lived in: | Hranice (12 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>Russian- 2<br>German - 3 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 2-1-4-5-3 |
| Correct responses (real w.) | 59/100 |
| Correct responses (nons. w.) | 63/120 |

| | |
|---|---|
| Listener no.: | 15 |
| Name: | Hela |
| Sex: | Female |
| Age: | 43 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (43 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>German – 1<br>Russian - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 1-2-3-4-5 |
| Correct responses (real w.) | 44/100 |
| Correct responses (nons. w.) | 62/120 |

| | |
|---|---|
| Listener no.: | 16 |
| Name: | Petra K. |
| Sex: | Female |
| Age: | 25 |
| Place of birth: | Uničov |
| So far has lived in: | Uničov (2 years)<br>Hranice (19 years)<br>Ostrava (4 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>German – 2<br>Russian - 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 2-1-4-5-3 |
| Correct responses (real w.) | 51/100 |
| Correct responses (nons. w.) | 69/120 |

| | |
|---|---|
| Listener no.: | 17 |
| Name: | Pavla |
| Sex: | Female |
| Age: | 47 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (47 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>German – 2<br>Russian - 5 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 3-5-1-4-2 |
| Correct responses (real w.) | 49/100 |
| Correct responses (nons. w.) | 65/120 |

| | |
|---|---|
| Listener no.: | 18 |
| Name: | Petr P. |
| Sex: | Male |
| Age: | 51 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (51 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>Russian - 2 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 4-3-2-1-5 |
| Correct responses (real w.) | 53/100 |
| Correct responses (nons. w.) | 61/120 |

| | |
|---|---|
| Listener no.: | 19 |
| Name: | Eliška |
| Sex: | Female |
| Age: | 12 |
| Place of birth: | Hranice |
| So far has lived in: | Hranice (12 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 4<br>Russian - 1 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Real words |
| Order of the tests/speakers | 5-2-4-3-1 |

| | |
|---|---|
| Correct responses (real w.) | 54/100 |
| Correct responses (nons. w.) | 67/120 |

| | |
|---|---|
| Listener no.: | 20 |
| Name: | Jana M. |
| Sex: | Female |
| Age: | 53 |
| Place of birth: | Přerov |
| So far has lived in: | Hranice (41 years)<br>Plzeň (12 years) |
| Languages spoken<br>(1 = beginner, 10 = native speaker) | Czech - 10<br>English – 1<br>Russian - 5 |
| Language Dysfunctions | No |
| Hearing Impairment | No |
| List. experiment started with | Nons. words |
| Order of the tests/speakers | 3-2-1-4-5 |
| Correct responses (real w.) | 52/100 |
| Correct responses (nons. w.) | 66/120 |

# 6 Shrnutí v češtině

### Úvod

V své diplomové práci jsem se zaměřila na percepci znělosti na konci slova v angličtině a češtině. Právě znělost na konci slova (a v kodě obecně) je v angličtině úzce spjata s délkou předcházející samohlásky, která pro rodilé mluvčí tohoto jazyka slouží jako klíč k identifikaci znělosti následující souhlásky. Tato studie si kladla za cíl prozkoumat, jsou-li rodilí mluvčí češtiny schopni rozlišovat fonologickou znělost na konci slova v češtině i za předpokladu, že tento jazyk znělost neutralizuje a umožňuje tak pouze výskyt foneticky neznělých samohlásek v koncové pozici. Dalším cílem této práce bylo zkoumání toho, jaká je schopnost rodilých mluvčích češtiny správně rozlišovat znělost na konci slova v angličtině, která na této pozici umožňuje výskyt jak znělých, tak neznělých samohlásek.

### Přehled literatury

V teoretickém úvodu byly jmenovány klíčové studie zabývající se problematikou proměnlivé délky samohlásky ovlivněné znělostí následující souhlásky – pro zjednodušení ji nahraďme, stejně jako ve zbytku práce, anglickou zkratkou *VDVCV* (= 'vowel duration variation induced by coda voicing'). Mezi jinými byly např. zmíněny studie autorů jako Denes (1954), Peterson a Lehiste (1970) nebo Chen (1970), který svou pozornost zaměřil na to, je-li *VDVCV* jazykovou univerzálií nebo jen jevem specifickým pro určité jazyky. Tomuto tématu a shrnutí příslušné literatury byla věnována samostatná kapitola (viz kapitola 1.2). Vzhledem k tomu, že předmětem zkoumání byla znělost na konci slova, tedy jev, k němuž oba zkoumané jazyky přistupují odlišně, jedna z kapitol se soustředila na vztah *VDVCV* (jakožto jevu vlastnímu angličtině) a pravidla neutralizace znělosti na konci slova (jakožto jevu inherentnímu češtině) – viz kapitola 1.3. Jedním z cílů této práce bylo zjistit, dochází-li v češtině k danému jevu variabilní délky samohlásky závislé na znělosti následující souhlásky, jehož přítomnost by implikovala, že proces neutralizace není úplný.

Vliv rodného jazyka na proces percepce cizí řeči byl dalším z těžišť celého výzkumu. Percepční experiment nezkoumal jen to, jakým způsobem a s jakou úspěšností vnímají rodilí mluvčí češtiny znělost na konci slova v jejich jazyce, ale také jsou-li ji schopni správně posuzovat v angličtině, která narozdíl od češtiny znělost v kodě obecně umožňuje. Teoretická část práce odkazovala především na studie Jamese Flegeho (např. Flege 1995, Flege *et al.* 1997), který se vlivem rodné řeči na proces osvojování si jiného jazyka ve své práci zabývá soustavně.

Hlavním centrem zájmu ovšem byl již zmíněný efekt *VDVCV*. Jedním z cílů percepčního experimentu bylo zjistit: a) jestli se jím mluvčí češtiny budou řídit při určování znělosti na konci slova v angličtině (jinými slovy jsou-li schopni si osvojit příslušné pravidlo a účelně ho využívat pro kategorizaci znělosti koncových souhlásek); a b) jestli fonologická délka (tzn. opozice dlouhá vs. krátká samohláska) nebo uměle prodloužená délka samohlásky bude mít vliv na způsob, jakým budou rodilí mluvčí určovat znělost na konci slova v češtině. Experiment si kladl za cíl ověřit následující hypotézy:

- neutralizace v češtině je neúplná, tzn. rodilí mluvčí češtiny jsou schopni využít délky předcházející samohlásky ke kategorizaci znělosti následující souhlásky na konci slova (což bude testováno tím způsobem, že budou porovnána data o správnosti percepce pro fonologicky krátké, dlouhé a uměle prodloužené samohlásky)

- protože dvojice fonémů /ɪ/ a /iː/ se v češtině neliší jen kvantitativně, ale výrazně i z hlediska kvality, předpokládám, že úspěšnost v rozlišování fonologické koncové znělosti pro slova obsahující samohlásku z toho páru vzroste, protože v případě této dvojice samohlásek není jejich fonologická délka klíčová pro kategorizaci zvuků a může tak být použita (jako tomu je v angličtině) k signalizaci znělosti následující souhlásky
- rodilí mluvčí češtiny budou schopni správně rozlišovat znělost na konci slova v angličtině, protože se v průběhu jejího osvojování byli schopni naučit aplikovat její fonologická pravidla a nedojde tak k transferu pravidel z jejich rodné řeči (konkrétně neutralizace znělosti v koncové pozici)
- úspěšnost v rozlišování znělosti na konci slova v angličtině se u rodilých mluvčích českého jazyka zvýší u těch slov, která obsahují „novou“ (tedy v češtině neexistující a žádné jiné se nepodobající) samohlásku /æ/, protože v tomto případě by nemělo docházet k transferu vnímání fonologické délky z rodného jazyka, který může často nepříznivě ovlivňovat správnost percepce cizí řeči

Tyto hypotézy poté byly experimentálně testovány provedením percepčního testu, kterého se zúčastnily tři skupiny posluchačů: rodilí mluvčí angličtiny (sloužící ovšem jen jako kontrolní skupina) a dvě skupiny rodilých mluvčích češtiny. První z nich bude tvořena posluchači s žádnou nebo značně omezenou znalostí angličtiny, kteří se zúčastní české části testu. Druhá skupina bude složena z posluchačů s pokročilou znalostí angličtiny, jejich úkolem bude kategorizovat anglická slova. Data získaná od všech těchto skupin pak byla analyzována z hlediska příslušných otázek, které si výzkum kladl.

## Závěr

Analýzou získaných dat bylo dosaženo následujících dílčích výsledků. Rodilí mluvčí angličtiny dosáhli v kategorizaci znělosti na konci slova nejvyšší hranice úspěšnosti a vzhledem k tomu, že sloužili pouze jako kontrolní skupina, jejich výsledky měly pouze zaručit, že správná kategorizace znělosti je u použitých stimulů možná. Přestože nebylo přímo měřením ověřeno, jestli se efekt *VDVCV* u anglické části nahraných stimulů skutečně projevil, z vysokého procenta úspěšnosti této skupiny usuzuji, že k němu docházelo, protože rodilí mluvčí anglického jazyka jej považují za nezbytný klíč k určování znělosti (viz např. Broersma 2005a) a předpokládám tak, že bez něj by jejich úspěšnost percepce nebyla zdaleka tak vysoká.

Skupina rodilých mluvčích češtiny s pokročilou znalostí angličtiny, která se účastnila anglické části experimentu, dosáhla v kategorizaci koncové znělosti výrazně nad úroveň náhody. Procento úspěšnosti pro neexistující slova bylo 72.58% a pro reálná slova dokonce 84.14%. Přestože dosažené výsledky nebyly na úrovni skupiny rodilých mluvčích anglického jazyka, jejich vysoká hodnota potvrzuje hypotézu týkající se schopnosti osvojení si fonologických pravidel cizího jazyka a jejich úspěšné aplikace v jeho percepci. Data odhalila pozoruhodný výsledek, podle kterého byli NatCZ-EN posluchači úspěšnější v rozpoznání znělé souhlásky v kodě, přestože ta se v jejich rodném jazyce v této pozici zásadně nevyskytuje. Stejně jako Miriam Broersma (2005a) si vysvětluji tento výsledek tím, že posluchači jednoduše ignorovali efekt *VDVCV* a zaměřovali se čistě na fonetickou znělost příslušné koncové souhlásky, která byla v případě použitých stimulů dostatečným klíčem ke správné kategorizaci.

Data srovnávající úspěšnost v rozlišování znělosti u slov obsahující relativně „novou“ samohlásku (versus slova obsahující samohlásky podobné nebo totožné s jejich českými protějšky) odhalila, že hypotéza přisuzující slovům s „novou“ samohláskou větší pravděpodobnost úspěšnosti se nepotvrdila. Dosažený efekt byl nesignifikantní pro reálná slova a u slov neexistujících dokonce vykazoval opačnou tendenci. Tato hypotéza by si však zasloužila rozsáhlejší výzkum vzhledem k tomu, že v případě mého experimentu byl vzorek slov obsahujících „novou“ samohlásku /æ/ relativně malý.

Co se týče skupiny rodilých mluvčích českého jazyka, kteří v testu poslouchali češtinu, jejich výsledná úspěšnost v rozlišování znělosti na konci slova v češtině se pohybovala na hranici náhody. Stejně tak přímé měření délek samohlásek u mluvčích neodhalilo přítomnost efektu *VDVCV* v nahraných stimulech. Z těchto výsledků tedy usuzuji, že proces neutralizace znělosti na konci slova je v češtině úplný a bez příslušného kontextu není možné správně určit fonologickou znělost na konci slova. Obecně byla úspěšnost kategorizace vyšší pro slova obsahující neznělou koncovou souhlásku, což by mohlo být způsobeno tím, že rodilí mluvčí češtiny nejsou na znělost na konci slova zvyklí a proto preferovali odpověď „neznělá“. Tato tendence byla zjevná z porovnání podílů odpovědí „znělá“ vs. „neznělá“.

Jedna z klíčových hypotéz předpokládala, že počet odpovědí „znělá“ u českých posluchačů vzroste úměrně s prodlužující se délkou samohlásky - tzn. u slov obsahujících fonologicky dlouhou nebo uměle prodlouženou samohláskou. Tato hypotéza nebyla potvrzena, přestože některé z dílčích výsledků hovořily v její prospěch (např. vysoce signifikantní efekt u vztahu „znělá odpověď“ – „fonologicky krátká/dlouhá samohláska“ u nereálných slov). Užitím opakovaných měření ANOVA a korelací *Point Biserial Correlation* bylo dosaženo výsledků, na jejich základě nebyla daná hypotéza jednoznačně potvrzena, ale různorodost těchto výsledků naznačuje možnosti dalšího výzkumu tohoto problému.

Poslední hypotéza formulovaná v této práci přisuzovala českým slovům obsahujícím samohlásku z páru /ɪ/ a /iː/ vyšší pravděpodobnost správné kategorizace. Data odhalila opačnou tendenci a tato hypotéza tak byla vyvrácena. Tento výsledek však může být považován za nesměrodatný vzhledem k tomu, že celková úspěšnost kategorizace koncové znělosti v češtině se pohybovala u všech posluchačů na úrovni náhody.

Obecně lze tedy říci, že některé hypotézy byly pomocí experimentálních výsledků potvrzeny zatímco jiné zpochybněny a celkově by měla tato práce sloužit především jako zdroj dat a inspirace pro další a pokud možno rozsáhlejší výzkum daných otázek.

# 7 Annotation

- *Author*: Bc. Eva Sehnalíková
- *Faculty and Department*: Philosophical Faculty, Department of English and American Studies
- *Title*: Perception of word-final voicing in English and Czech
- *Supervisor*: Mgr. Václav Jonáš Podlipský, Ph. D.
- *Number of characters*: 103 708 (without appendices)
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- *Keywords*: speech perception, word-final voicing, vowel duration variation induced by coda voicing, complete vs. incomplete neutralization of voicing, second language acquisition
- *Description*: The aim of this thesis was to investigate how Czech native speakers perceive word-final voicing in Czech (their native language) and in English (their second language). The main focus was the vowel duration variation which serves as a cue to final voicing in English. This thesis tried to examine if such effect exists also in Czech which would imply that regardless the *final devoicing* rule which operates in this language, the neutralization of the word-final voicing is incomplete. It was also examined how the accuracy of the perception of final voicing would change in the course of second language acquisition.

**Anotace**

- *Autor*: Bc. Eva Sehnalíková
- *Název fakulty a katedry*: Filozofická fakulta, Katedra anglistiky a amerikanistiky

- *Název práce*: Percepce znělosti na konci slova v angličtině a v češtině
- *Vedoucí práce*: Václav Jonáš Podlipský, Ph. D.
- *Počet znaků*: 103 708 (bez příloh)
- *Počet příloh*: 4
- *Počet titulů použité literatury*: 40
- *Klíčová slova*: percepce řeči, znělost na konci slova, závislost délky samohlásky na znělosti v kodě, úplná vs. neúplná neutralizace znělosti, proces osvojování si cizího jazyka
- *Charakteristika*: Cílem této práce bylo zkoumat, jakým způsobem vnímají rodilí mluvčí češtiny znělost na konci slova v češtině a angličtině. Pozornost byla soustředěna na proměnlivost délky předcházející samohlásky, která v angličtině slouží jako klíč i identifikaci znělosti následující souhlásky v kodě, a to, zda se tento jev vyskytuje i v češtině, která tuto koncovou znělost nedovoluje. Nalezení tohoto jevu by implikovalo, že neutralizace znělosti na konci slova je v češtině neúplná. Dále bylo zkoumáno to, zda se promění přesnost rozlišování znělosti na konci slova v průběhu procesu osvojování si cizího jazyka (v tomto případě angličtiny).

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