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Bc. Lucie Jiránková

Word-ending perception in second-language learners of English

Vnímání konců slov u studentů angličtiny

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Vedoucí práce: Luca Cilibrasi, Ph.D.

Konzultant: Mgr. Jiřina Popelíková

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DECLARATION

Prohlašuji, že jsem tuto diplomovou práci vypracovala samostatně, že jsem řádně citovala všechny použité prameny a literaturu a že práce nebyla využita v rámci jiného vysokoškolského studia či k získání jiného či stejného titulu.

I declare that the following diploma thesis is my own work for which I used only the sources and literature mentioned, and that this thesis has not been used in the course of other university studies or in order to acquire the same or another type of diploma.

V Praze dne 5. května 2017 ……………………………….

Bc. Lucie Jiránková

PERMISSION

Souhlasím se zapůjčením diplomové práce ke studijním účelům.

I have no objections to the diploma thesis being borrowed and used for study purposes.

THESIS ABSTRACT

Word final positions are sometimes described as optionally salient, depending on the presence or the absence of bound morphology. In fact, word final positions often incur disruptive phonological processes (such as deletion or assimilation) but these processes are partially blocked in the presence of bound morphology. Some evidence suggests that these effects may also be active in the sublexicon (i.e. with no access to semantics). Investigations of this phenomenon so far focused on monolingual speakers, and little is known about the presence of these effects on speakers with English as their L2. This diploma thesis aims at partially filling this gap by focusing on the perceptual salience of word endings as perceived by second-language learners of English having Czech as their L1.

The methodology is based on Cilibrasi (2015). The subjects tested were adult second-language learners of English of different language levels (B1, B2 and C1). In the experimental part, they were asked to listen to pairs of non-words and decide if the non-words are identical or slightly different by pressing one of two keys. There were three conditions: Condition 1 with non-words containing potential morphological information, condition 2 with non-words with no morphological information and condition 3 as a control condition.

We expected reaction times to reflect the presence of bound morphology, with non-words containing bound morphology taking longer to be discriminated. Further, we expected proficiency in English to be a co-predictor of reaction times, with proficient speakers showing a larger (native-like) effect of morphology.

The study also inevitably attempted to find evidence either for the rule-based or for the whole-word processing of words as regards the perceptual decomposition of inflected verbs into stems and affixes. Finally, the study compared the results of Cilibrasi's study of word-ending perception in native speakers of English with the results of this thesis and attempted to interpret any potential differences.

The data analysis confirmed that even for second-language learners word-ending effects apply sublexically and that word endings are optionally salient based on the presence or absence of potential morphosyntactic information. The reaction times reflected the presence of bound morphology, with non-words containing bound morphology taking longer to be discriminated in all language levels. The data also confirmed the influence of phonotactic probabilities on reaction times (item-based reaction times correlated with item-based phonotactic probabilities). This led to the conclusion that there might be some frequency effects running parallel to morpheme stripping that might be similarly effective in predicting reaction times recorded in this task.

Contrary to our hypothesis about proficiency, the differences between individual conditions were identical in each language group. This result suggests that second language learners of English having Czech as L1 behave in the same way as monolingual speakers when processing inflectional bound morphemes in English and that the strategy used during perception is the same from a relatively early language level in the process of language learning. This strategy is used implicitly by all subjects and is likely to be a consequence of automatic unconscious processing.

Key words: perception, second-language learners, verb inflection, sublexicon, rule-based processing, whole-word processing

ABSTRAKT

Konce slov se někdy považují za příležitostně významné v závislosti na přítomnosti či nepřítomnosti vázaných morfémů. U těchto pozic ve slově často dochází k rušivým fonologickým procesům (jako je například vynechání fonémů nebo asimilace), ale ty mohou být částečně blokovány právě přítomností vázaných morfémů. Některé studie naznačují, že tyto procesy by mohly být aktivní i v sublexikonu (bez přístupu k významu slov). Zkoumání tohoto fenoménu se doposud zaměřovalo jen na monolingvní mluvčí, a neexistuje tedy mnoho informací o tom, jestli se tyto efekty vyskytují i u studentů angličtiny jako druhého jazyka. Tato diplomová práce se pokouší tuto mezeru ve výzkumu alespoň částečně zaplnit, a zaměřuje se proto na percepční významnost konců slov u studentů angličtiny jako druhého jazyka, jejichž mateřským jazykem je čeština.

Metodologie této práce je vystavěna na metodologii použité u Cilibrasiho (2015). Testováni byli dospělí studenti angličtiny jako druhého jazyka na rozlišných úrovních jazykové pokročilosti (konkrétně na úrovních B1, B2 a C1). Během experimentu poslouchali dvojice tzv. neslov a stisknutím jedné z kláves se rozhodli, zda jsou tato dvě neslova stejná či jiná. Testovali se také tři odlišné podmínky neslov: neslova s potenciální morfologickou informací, neslova bez morfologické informace a kontrolní skupina.

Očekávali jsme, že reakční časy budou závislé na přítomnosti vázaných morfémů tak, že reakce na neslova s potenciální morfologickou informací bude delší. Naším dalším předpokladem bylo, že svou roli v rychlosti reakce bude hrát také úroveň jazykové pokročilosti v angličtině a že pokročilí studenti angličtiny budou v rychlosti reakce blíže rodilým mluvčím.

Tato studie se nevyhnutelně značila najít také podklady pro jeden ze dvou druhů vnímání slov, co se týče rozkladu ohebných sloves na slovní kmen a afixy: aplikace pravidla či ukládání slov jako jednotek. V neposlední řadě se tato práce pokusila srovnat naše výsledky s výsledky Cilibrasiho studie na vnímání konců slov u rodilých mluvčí angličtiny a interpretovat potenciální odlišnosti.

Datová analýza potvrdila, že i u studentů angličtiny lze pozorovat efekty konců slov v sublexikální rovině a že konce slov jsou i u nich příležitostně významné v závislosti na přítomnosti či nepřítomnosti potenciální morfosyntaktické informace. Reakční časy odrážely přítomnost vázaných morfémů tak, že reakce na neslova s potenciální morfologickou informací byla u všech jazykových úrovní delší. Data také potvrdila vliv fonotaktických pravděpodobností na reakční časy (reakční časy na jednotlivá neslova korelovala s fonotaktickými pravděpodobnostmi těchto neslov). To nás vedlo k závěru, že při percepci konců slov dochází nejen k morfemickému rozkladu, ale projevují se zde i jisté frekvenční efekty, které mají na reakční časy obdobný vliv.

V rozporu s naší hypotézou o jazykové pokročilosti byly rozdíly mezi jednotlivými podmínkami neslov v každé jazykové skupině identické. Tento výsledek naznačuje, že studenti angličtiny jako druhého jazyka se chovají stejně jako monolingviní mluvčí, když v angličtině zpracovávají ohebné vázané morfémy, a že při učení jazyka používají během percepce konců slov stejnou strategii již od relativně nízké jazykové úrovně. Tuto strategii užívají všechny subjekty implicitně, a nejspíše tedy půjde o výsledek automatického nevědomého zpracovávání.

Klíčová slova: percepce, studenti angličtiny, ohebné koncovky, sublexikon, zpracování slov podle pravidel, zpracování slov jako celku

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LIST OF ABBREVIATIONS

ANOVA = Analysis of variance

BSF = Biphone segment frequency

CEFR = Common European framework of reference for languages

CPH = Critical period hypothesis

csv = Comma-separated values

fMRI = Functional magnetic resonance imaging

ID = Identification number

IPM = Information processing model

ISI = Inter-stimulus interval

ISR = Input sublexical representations

L1 = The first (native) language

L2 = The second language

MPs = Minimal pairs

ms = Milliseconds

PSF = Positional segment frequency

RTs = Reaction times

SLI = Specific language impairment

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1. INTRODUCTION

A significant number of linguistic and psycholinguistic studies suggests that different positions in a word are perceived differently (Cilibrasi, 2015: 15). Word-initial positions belong to privileged positions (Beckman, 1998: 1) that enjoy perceptual advantage in the processing system. They are described as strong (Smith, 2004: v) since they maintain contrasts neutralized elsewhere (i.e. marked segments violating certain contrasts), they frequently trigger phonological processes such as assimilation, dissimilation and vowel harmony, and they often block or resist the application of those processes (Beckman, 1998: 1-2). They are also psycholinguistically prominent since they carry the heaviest load of lexical storage, lexical access, and retrieval, which can be manifested by the tip-of-the-tongue phenomenon (i.e. the situation in which a person is trying to recall a word but cannot quite recall it correctly; see for example Browman, 1978). On the contrary, non-initial positions, including bound inflectional morphemes, belong to non-privileged positions – although important, they play a lesser role in the organization of the lexicon (Beckman, 1998: 1). Since they allow for a smaller number of contrasts, they are described as weak. They often tend to reduction or even deletion, i.e. when a sound, such as a stressless syllable or a weak consonant, is not pronounced (Harris, 2011). The example of that would be the elision of /t/ in acts /æks/ due to the no-audible release. However, those effects can be modified by the presence of morphology. In that case, when it comes to verb inflection that is the core of this study, word endings resist phonological processes (such as deletion or merging processes) that would be otherwise active (see above) (Cilibrasi, 2015: 15). While the word-initial positions can thus be described as inherently strong (Beckman, 1998: 2), word-final positions are only optionally strong (Pater, 2006; i.e. they are salient only if morphological information is present).

So far, most attention has been paid to word position effects on the lexicon and on the lexical access (Cilibrasi, 2015: 16). To state a few examples, Brown and McNeill (1966), just like Browman (1978), focused on the "tip of the tongue" phenomenon and on understanding the memory gap, Marslen-Wilson and Zwitserlood (1984) researched the importance of word onsets, and Nooteboom (1981) examined the relative contribution of initial and final fragments of spoken words to lexical retrieval. However, only partial attention has been paid to position effects in the sublexicon, i.e. that part of the mental lexicon with no access to semantics (Cilibrasi, 2015: 16). Out of the few, Pitt and Samuel (1995) focused on sublexical feedback in auditory word recognition, while Marshall and van der Lely (2009) investigated the impact of word position and stress on the production accuracy of onset clusters using a non-word repetition task on children with SLI and dyslexia.

The distinction between the lexicon and the level in which phonology is activated but semantics is not (i.e. the sublexicon) is proposed by several authors (see Cilibrasi, 2015). In this thesis, we will focus on one of them: Ramus et al. (2001, 2010). The authors of this paper developed an information processing model (hereby only IPM) which takes into account not only production, but also perception. The IPM distinguishes between lexicon and sublexicon: While the former contains prototypical word forms, the latter stores information on the phonological rules that are to be applied both in perception and production to map the speech with those prototypical forms (Cilibrasi, 2015: 17 - 18). The IMP also pays attention to the input (perception) pathway represented by a new level of representation called input sublexical representations (hereby ISR) (see Figure 1.1 below by Ramus et al., 2010). ISR are tuned during language acquisition (Cilibrasi, 2015: 18) and contain language-specific phonemes and information about (non)-native contrasts (Ramus et al., 2010: 316).

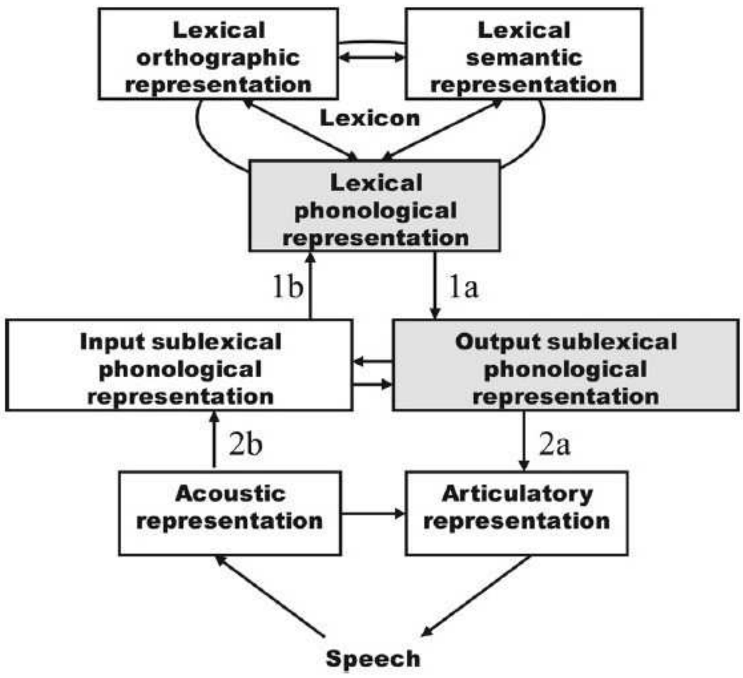

Figure 1.1 An information processing model of speech perception and production used as a reference in this diploma thesis (Ramus et al., 2010: 313)

We have pointed out above the little attention paid to the study of word-position effects in the sublexicon. The same can be said about the research of those effects at the perceptual level, and studies on word-position effects in the sublexicon at the perceptual level are even rarer. Pitt and Samuel, for instance, investigated lexical and sublexical feedback in auditory word recognition using pseudowords (Pitt & Samuel, 1995). Our attention will, however, be paid closely to the research conducted by Cilibrasi, especially to its part concerned with sublexical perception of word endings. Cilibrasi builds on the idea proposed by Grainger and Ziegler (2011) that inflectional morphemes can be detected sublexically. His thesis focuses on the study of accuracy and reaction times in the discrimination of elements in morphosyntactic minimal pairs at the sublexical level. He asks if the presence of potential morphosyntactic features is detected and processed differently by subjects when using sublexical items. To test this, he uses non-words (built up in accordance with English phonology) which differ in phonemes that carry or do not carry potential morphosyntactic information, and presents them to 20 adult native speakers of English. He comes with a conclusion that it takes longer to discriminate elements that may carry morphosyntactic information, and that at the sublexical level, word-final positions are therefore only optionally salient (based on the presence or absence of potential morphosyntactic information) (Cilibrasi, 2015).

In English, word endings are the locus of important morphological processes. Much of the attention is paid to the issue of verb inflection where morphological and phonological processing co-occur and it is thus a suitable ground for investigating both word-position effects and morphology. The focus of this thesis is mainly on regular inflected verbs. Their processing is a strongly-debated issue in psycholinguistics. One group of researchers (such as Stemberger & MacWhinney, 1986; Bertram et al., 2000; Tomasello, 2006) claims that regular inflected verbs are stored as units in the lexicon (i.e. the root and the bound morpheme), which is supported by strong frequency effects in lexical decision tasks with inflected verbs (Cilibrasi, 2015). The other group (such as Berko, 1958; Post et al., 2008; Pinker & Ullman, 2002a; Guasti, 2004) suggests that regular inflected verbs are decomposed into stems and affixes during perception (in a process called morpheme stripping) and generated by the application of a rule in production (e.g. a verb stem + -ed for past simple), as evidenced by such phenomena as over-regularization (Cilibrasi, 2015). Grainger and Ziegler (2011) suggested that morpheme stripping may be taking place also sublexically, at least for reading. Cilibrasi's study (2015) investigated processes underlying morpheme stripping in sublexical items. The aim was to find evidence either for the separation or for the unification of stems and affixes in the processing of sublexical items containing bound morphemes (Cilibrasi, 2015). Non-words with potential morphological information took longer to be discriminated than non-words without it. This suggests that in perception inflected verbs are decomposed into stems and affixes even at the sublexical level, or at least that we are sensible to the presence of morphosyntactic information in non-words (Cilibrasi, 2015).

Cilibrasi has shown that monolingual English speakers are sensible to the presence of bound morphology in non-words, which means that they are sensible to morpho-syntactic properties of the words also in the absence of semantics (Cilibrasi, 2015). Those results correspond to what Post et al. outlined in 2008: They have run a series of experiments on the processing of English regular inflections using, among all, a pseudo-regular past-tense set (with potentially inflectional endings, as in *minned–min* /mɪnd/ /mɪn/), a coronal noninflectional set (with endings that can be regularly inflectional, but not in that context, as in *rint–rin* /rɪnt/ /rɪn/) and a non-coronal set (ending in a voiced consonant with no inflectional value, as in *plamp–plam* /plæmp/ /plæm/). They showed that participants take longer to discriminate non-words that respect the morphophonological rules of regular English inflection rather than non-words that are based on non-productive rules of English morphophonology, and that non-words with potential bound morphology take longer to be discriminated than non-words that do not contain potential bound morphology (Post et al., 2008). Such results are interpreted as evidence for a basic morpho-phonological parsing process, and they also suggest that the morpheme stripping can take place in the absence of meaning. In other words, it suggests that speakers look for the presence of bound morphology in words endings independently of the identity of the verb (Post et al., 2008).

Investigations of this phenomenon so far focused on monolingual speakers only, and little is known about the presence of these effects on speakers of English as their second language. This diploma thesis aims at partially filling this gap by focusing on the perceptual salience of word endings (i.e. the last phoneme of the non-word) as perceived by second-language learners of English having Czech as their native language. Being a highly-inflected language, Czech is an interesting ground to investigate the acquisition of the English inflectional system, which is instead notoriously poor. This diploma thesis develops the research outlined by Cilibrasi (2015) and supplements the section on sublexical word-ending perception with the element of proficiency and the interaction between the native language (hereby L1) and the second language (hereby L2). Considering the mismatch in inflectional richness between Czech and English, one possible hypothesis is that Czech speakers may not perform morpheme stripping to inflected non-words, at least not until they are proficient English speakers, since it may be more economic for them to store inflected forms rather than apply morphological decomposition in perception, or they may not be proficient enough to be aware of various realizations of bound morphology. In contrast, cross-linguistic analyses also show that speakers have better awareness of the morphological processes that are productive in their language (Ku & Andersson, 2003). Considering the inflectional richness of Czech, morphological decomposition may be thus the preferred strategy in L2 learning.

To investigate these hypotheses, this thesis uses an experiment whose methodology is based on Cilibrasi (2015). The subjects recruited for the experiment were 60 adult second-language learners of English having Czech as their L1. Participants had different levels of English proficiency: Twenty of them had a B1 level, another twenty had a B2 level and the last twenty learners were at a C1 level according to the European framework, assessed with a purposely created test. Participants were tested with a minimal pairs discrimination task measuring reaction times (hereby RTs). There were three types of 120 minimal pairs: 40 non-words with potentially inflectional endings (/veld/ - /velz/), 40 non-words with endings that can be regularly inflectional, but not in that context (/velt/ - /vels/), and a (voicing) control condition consisting of 40 non-words ending in a voiced consonant with no inflectional value (/velb/ – /velm/). Subjects were presented half the time with the same non-word and half the time with two different non-words of the pair. They were asked to press "s" button (for "stejné" (same) in Czech) when the two non-words in the sequence were judged identical, "j" (for “jiné” (different) in Czech) when they were judged different. It should be stressed that subjects were not in any way aware of the relation between this test and inflectional morphology beforehand so any measure obtained should be considered a measure of implicit processing. Participants were also assessed with a digit span test to measure their working memory independent of language to test the role of proficiency and their L1.

My hypothesis is that word endings are optionally salient, meaning that they become salient only if they are carrying potential morphosyntactic information. We expect reaction times to reflect the presence of bound morphology, with non-words containing bound morphology taking longer to be discriminated. This hypothesis is based on data gathered from lexical studies (Pater, 2006) and on the idea proposed by Grainger and Ziegler (2011) that inflection morphemes are detected sublexically. Further, we expect proficiency in English to be a co-predictor of reaction times, with proficient speakers showing a larger (native-like) effect of morphology. The study will also inevitably attempt to find evidence either for the rule-based (morpheme stripping) or for the whole-word (stored as unites) processing of words as regards the perceptual decomposition of inflected verbs into stems and affixes. As to my stance, both types of processing will be approached evenly and objectively, with no prior preferences or presumptions. Although morphemic decomposition was shown in monolinguals, there is no specific reason to expect the same process in L2 speakers. The aim of the current study is to investigate the contribution of morphology and frequency effects in the perception of sublexical items containing bound morphemes. Finally, the thesis will compare the results of Cilibrasi’s study (2015) of word-ending perception in native speakers of English with the results of this experiment and attempt to interpret any potential differences. The thesis then aims at answering the following two research questions: Do we find in second-language learners of English evidence for morpheme stripping or for whole-word storing? And if we find evidence for morpheme stripping, are the effects modulated by L2 proficiency?

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 The information processing model by Ramus et al. (2010)

The phonological model proposed by Ramus et al. (2010) will constitute the referential base of this diploma thesis for the reasons outlined in the introduction, i.e. the focus on perception, the inclusion of the input (perception) pathway, and the new level of representation called input sublexical representations.

The original model created by Ramus (2001) (as depicted in Figure 2.1) presents an information processing model of lexical access that offers a bidirectional analysis of representations (Cilibrasi, 2015), differently from previous models, that only focused on production (for instance, Chomsky & Halle, 1968). Crucially for this study, this model distinguishes between lexical and sublexical representations. Lexical representations (often simply called "lexicon") are a long-term memory store, divided into at least three parts that represent different aspects of the word: semantic representations (i.e. abstract representations of meaning), phonological representations (i.e. abstract forms of words in which some phonological features are underspecified) and orthographic representations (i.e. written representations of sounds). They are linked together by arrows; yet, at the same time they are partly separated (Cilibrasi, 2015). The directions of the arrows show how they influence one another.

As Cilibrasi (2015) explains, sublexical representations contain information on "relevant and irrelevant contrasts in a given language and a detailed description of phonemes" (Cilibrasi, 2015: 31). They are directly linked to the level of orthographic sublexical representations, at which point graphemes are associated with phonemes.

Sublexical representations are connected to the phonological lexicon and also to the sublexical orthographic representations (Cilibrasi, 2015). This interconnection is supported by several different studies (e.g. Cheng et al. (2014) showed that information on phonotactic probabilities is embedded sublexically). Still, at the same time, the arrows show that sublexical representations shape sublexical orthographic representations and influence the acquisition of phonological lexicon (by distinguishing possible new words from unlikely new words) (Cilibrasi, 2015).

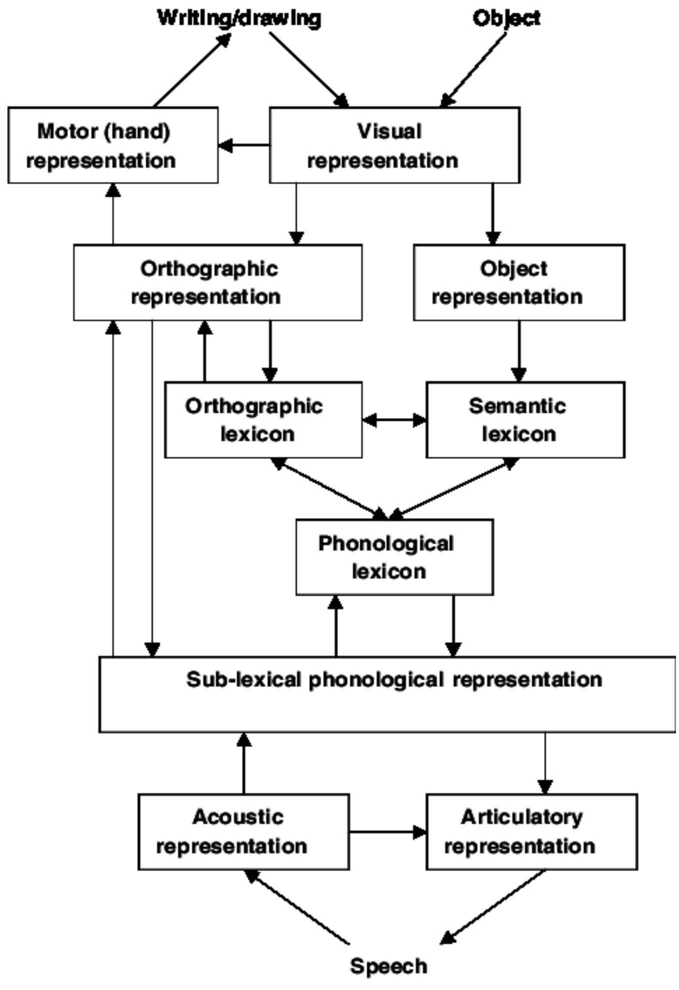

Figure 2.1 An information processing model of lexical access by Ramus et al. (2001)

Although this model takes into account perception, production and sublexicality, it does not, however, differentiate between input (perception) and output (production) sublexical phonological representations and a more detailed and distinct version of this model is needed for this thesis. In 2010, Ramus and his colleagues published a finer version of this model that included input sublexical representations and output sublexical representations.

2.1.1 A revised information processing model (Ramus et al., 2010)

This model is directly inspired by the classic logogen model (Morton, 1969) and its subsequent refinements (e.g. Caramazza, 1997; Coltheart, 1978; Levelt, 1989), as well as from ideas coming from the linguistic literature (Chomsky & Halle, 1968; or Prince & Smolensky, 1993). It preserves the distinction of the "standard model" of phonological theory between two levels of mental representation, an underlying and a surface level – a distinction that has been proposed by the generative phonology and retained in optimality theory as the distinction between the lexicon and the post-lexicon. It is evident that the standard phonological model consists of two of the boxes represented in grey in Figure 2.2, i.e. the lexical phonological representation and the output sublexical phonological representation, with arrow 1a going from the former to the latter representing phonological grammar (Ramus, et al., 2010). Embedding this standard model within the more comprehensive model highlights at least two other characteristics of the model: "First, there is an input pathway, distinct from the output pathway, but linked with it; second, this input pathway is also subdivided into lexical and sublexical" (Ramus, et al., 2010: 314).

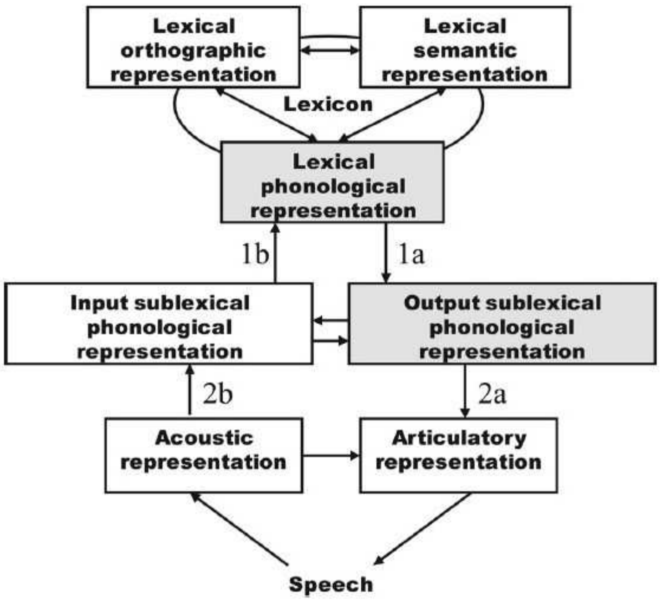

Figure 2.2 A revised information processing model (Ramus et al., 2010)

Ramus et al. describe the model in following words:

> *The boxes in grey represent the standard model of phonological theory. Arrow 1a corresponds to output phonological processes, 2a to output phonetic implementation. 1b corresponds to phonological parsing (inverse phonology) and 2b to perceptual phonetic decoding. In the adult, these four processes are finely tuned to the phonological and phonetic properties to the maternal language(s). They may be mistuned during (first or second) language acquisition, or in cases of brain lesion or learning disability.* (Ramus et al., 2010: 313)

As far as perception is concerned, speech sounds are encoded in a non-specific manner: This is embodied in the model by the acoustic representation. At a later stage of processing, speech must be encoded in a speech-specific manner – in this model by the sublexical phonological representation. The arrow between the sublexical phonological representation and the phonological lexicon then represents auditory word recognition (Ramus et al., 2010: 313).

There has been a considerable debate in speech processing research as to the distinction between input and output sublexical representations. As Ramus et al. point out, these two levels may be virtually indistinguishable during adulthood (Ramus et al., 2010). However, there is evidence to suggest that there may be a distinction between the two. The strongest evidence comes from neuropsychology, and in particular from studies of conduction aphasia. Patients with this condition have a relatively intact comprehension and speech production combined with a severe impairment in the ability to repeat speech, which means that the connection between input and output sublexical representations is impaired (Caramazza et al., 1981). Jacquemot, Dupoux and Bachoud-L´evi (2007) explored the case of a patient who could perceive and produce both real words and non-words, but who could not repeat the non-words. Such a deficit can be accounted for in the model only by ensuring that there are two distinct sublexical phonological representations, one for perception and one for production (Ramus et al., 2010) (Cilibrasi, 2015: 35). As Ramus et al. (2010) point out, the relation between input and output sublexical representations is poorly understood: the levels are not completely independent from each other, but neither completely mirror one another (Ramus et al., 2010). Also, while the two levels may appear indistinguishable in monolingual adults, the two systems may be quite different during second language acquisition. For instance, Sheldon and Strange (1982) showed that late bilinguals are more proficient in the production of foreign contrasts than in their perception (Cilibrasi, 2015: 35). Input representations are thus strongly language dependent, and are shaped during language acquisition according to the contrasts present in the native language. The importance to distinguish input sublexical representations also involves other reasons that will be discussed separately below.

2.1.2 Bound morphemes at the sublexical level in the information processing model (Ramus et al., 2010)

The model of Ramus et al. that we use as a reference in this thesis distinguishes not only lexical and sublexical systems, but also acoustic and orthographic representations. The distinction between phonological and orthographic representations in this model makes it possible to endorse ideas proposed by Grainger and Ziegler (2011) for the processing of polymorphemic words. Most models concentrate on single-word processing only, and even at the single-word level, most models do not take into account word-structure processes, especially morphological derivation (Seidenberg, 2005).

However, many words in English have morphologically complex structures due to phonological attachment of bound morphemes. Linguists distinguish two types of bound morphemes: derivational and inflectional. Derivational morphemes encode lexical meaning and often change the part of speech, i.e. create a new entry in one's mental lexicon. Derivation is not restricted to suffixation only, it can also appear in a prefixational position, e.g. *-ress* in *waitress* or *un-* in *unpleasant*. Inflectional morphemes, on the other hand, do not change the part of speech, i.e. they produce a new word form of an existing lexeme/word. They encode grammatical categories, they are syntactically relevant and always (at least in English) suffixational. An example of an inflectional morpheme would be -s in *waiters* or *-ed* in *played* (Plag, 2003: 17). Grainger and Ziegler (2011) further argue that certain strings of graphemes are stored as morphosyntactic units. For example, *-ed* indicates a high likelihood of the presence of a bound morpheme and may be detected sublexically (i.e. without the need of accessing the lexical entry of the verb). Cilibrasi (2015) proposes that this idea can be extended to certain strings of phonemes as well, and this is the problem investigated in this thesis.

Speech perception models usually overlook morphologically complex words. One of the exceptions is the model proposed by Grainger and Ziegler (2011), and this idea is also endorsed by Ramus et al.'s model (2010) which does not exclude strings of phonemes or graphemes from the processes taking place at the sublexical level. All of this makes the model of information processing proposed by Ramus et al. (2011) the appropriate and efficient model for the research conducted in this diploma thesis.

2.2 Word-ending perception

English inflections are governed by a specific morphophonological rule: They are voiced when applied to a verb stem ending in a voiced consonant, a vowel or a diphthong (e.g. /s/ after /t/ in *hearts* /hɜ:ts/) and voiceless when they follow a stem ending in a voiceless consonant (e.g. /z/ after /g/ in *digs* /dɪgz/) (Dušková et al., 2006: 166). Following this simple rule of regular verb inflection, it is possible to create non-words with potential bound morphemes (e.g. /vɪlz/ or /naɪld/), and non-words ending in phonemes with an inflectional value that is, however, not activated in that specific phonological context (e.g. /vɪls/ or /naɪlt/), which suits our purposes of studying regular verb inflection at the sublexical level.

Word-final positions are of great interest both from the phonological and morphological point of view. Phonologically, word final positions are the locus of a series of processes that are usually not activated in any other word position. They often undergo deletion and assimilate with phonemes at the beginning of following words (Roach, 2000: 124). For instance, the final consonant in *that* /ðæt/, an alveaolar *t*, will in rapid, casual speech become *p* before a bilabial consonant, as in *that person* /ðæp pɜ:sən/; or in clusters of three plosives, the middle plosive may disappear so that *looked back* results in /lʊk bæk/ (Roach, 2000: 124, 127). Morphologically, word-final positions play a significant role in a number of languages (including English and Czech, which are the locus of the present study) since they carry a great amount of morphological information (Pater, 2004). As previously stated, all inflectional bound morphemes in English appear in the word-final position (*-ed, -s, -ing*) and the same can be said also about morphologically richer Czech, which operates with a substantially bigger number of bound inflectional morphemes (for instance, *-a, -e, -ě, -i, -o, -u, -y, -ou, -é, -í, -ů, -ech, -ách, -ích, -em, -ám, -ím, -ům, -mi, -ami, -emi, -ími, -ovi, -ové*) (Šmilauer, 1973), out of which word-final morphemes such as *-eš, -ete, -ej*, or *-l* contribute to the verb conjugation (Melichar & Styblík, 1967: 118 - 120).

The interaction between phonology and morphology has been widely studied (see for instance Pater, 2004) and it is evident that the presence of morphological information undermines the application of phonological processes, i.e. the presence of morphological information can overrule such phonological processes as deletion or assimilation that are often very active at word-final positions (Cilibrasi, 2015). Rice & Wexler (2001) state another example from clinical studies that supports the special status of word final positions with morphological information. There is evidence that English-speaking children with SLI (specific language impairment) struggle with the phonological endings /s/, /z/, /t/, and /d/ only when they also carry morphological information. It may be easier for a child with SLI to produce such sentence as *The bus is fast.* rather than *The coach goes fast.*, with the ending /s/ being critically morphological in the second sentence (Rice & Wexler, 2001) (Cilibrasi, 2015: 43). Marshall & van der Lely (2007) also note that if such a morpheme appears in a phonological cluster, production is even more problematic for children with SLI. In terms of saliency, word endings are normally described as non-salient (Harris, 2011) but they may optionally resist the activation of phonological processes when morphological information is present (Pater, 2006) and are thus usually described as optionally-salient positions.

When it comes to morphological processes in word-ending positions, crucial relevance is given to verb inflection where phonological and morphological processing co-occur. Verb inflection is thus an excellent area of research to investigate the interaction between word-position effects and morphology. The system by which regular inflected forms are generated and processed is still not completely understood. One line of research claims that regular inflected forms are stored in the lexicon as units (i.e. root + bound morpheme; e.g. Bertram et al., 2000). Another line of research suggests that regular inflected forms are decomposed in perception into stems and affixes using rules (morpheme stripping; e.g. Pinker & Ullman, 2002a). We have also stated above that several studies propose that morpheme stripping takes place also sublexically (Grainger & Ziegler, 2011; Cilibrasi, 2015). The experiment designed for this diploma thesis will attempt to contribute to this debate with new data, focusing also on how proficiency acquired during second-language learning influences the issue in question.

2.2.1 Atomist view: Inflected forms stored as units

Most psycholinguistic research of this field has so far focused on English. Since English is a poorly inflected language, the studies could have focussed only on a limited number of inflectional processes (Cilibrasi, 2015). Some authors (Stemberger & MacWhinney, 1988; Bertram et al., 2000; Tomasello, 2006) suggested that inflected forms are stored in the lexicon as units. That means that regular past forms such as *smiled* or *hoped* would be stored in our declarative memory together with their bound morpheme - *ed*. Evidence for this claim comes from strong frequency effects in lexical-access tasks which show that the time needed to access inflected forms is strongly related to the frequency of those inflected forms (compare for instance the relative frequency of *smiled* and *ruminated*) (Stemberger & McWhinney, 1988).

The idea of the storing inflected forms as units is also supported by research in the field of language acquisition (see for instance Tomasello, 2006). Tomasello (2006) believes that at the early stages of language acquisition, children store all inflected forms as units in the lexicon. Only later, they figure out the principle for creating for instance regular past tense (i.e. the adding of *-ed* to the verb stem) and by analogy they extend the principle to other verbs to form the past tense. Cilibrasi (2015), however, points out that the nature of this analogic process is poorly formalised in principle as atomistic views of tense acquisition suggest that many instances of analogy are idiosyncratic to a single item, and creating new past forms from analogy thus does not necessarily mean extracting a general rule and applying it to all other occurrences of past-tense formation. Using the example of his own daughter's early speech, Tomasello points out that there was no evidence that once the child mastered the use of, for example, a locative construction with one verb that she could then automatically use that same locative construction with other semantically appropriate verbs (Tomasello, 2006: 68).

Contrary to Tomasello (2006), Pinker and Ullman (2002b) state that the evidence of the past tense being generated through associations and analogy is not conclusive. They notice that verb frequency effects are dependent on the verb complexity and that the analogical and associative processes that lead to tense generation are processes based on rule formation.

2.2.2 Decompositional view: Inflected forms stored as the stem and the rule

Pinker and Ullman (2002a) suggest that the processes leading to the generation of past tenses resemble rule-formation processes. Regular past tense of an English verb is derived through the addition of the bound inflectional morpheme *-ed* to the stem of the verb. This would suggest that the lexicon contains only non-inflected forms and that in production rules are added to those bare, uninflected forms to create final, inflected past tense forms (the same process, though in reverse, would be applicable to perception). This proposal is supported by the concept of economy. English has only three regular inflections (-s, -ed and -ing) so the advantage of storing the suffixes separately from the stems is not so evident, but it would still be three times more economical than storing all forms individually (Cilibrasi, 2015). However, for highly inflected languages like Czech the economy is even more apparent. Czech verb morphology only inflects verb forms for person, number, tense and mood. There is also a complex and irregular system of aspect marking and 14 main conjugation paradigms in 5 classes defined by different forms in the third person singular and other forms (Smolík & Kříž, 2015). This idea of separate storage would then ensure that a significantly smaller number of words are required to be stored in memory. Storing only stems for verbs would be thus substantially more economical in terms of memory load (Cilibrasi, 2015).

Further evidence for the decompositional theory of storage comes from language acquisition studies. One of the most influential researches in this field is Berko's Wug Test (1958), which used nonsense words to gauge children's acquisition of morphological rules, for instance the rule that regular English plurals are formed by adding an /s/, /z/ or /ɪz/ phonemes. A child was shown simple pictures of an imaginary creature or activity that was given a nonsense name, and was prompted to complete a statement about it, saying "This is a WUG. Now there is another one. There are two of them. There are two________." (Berko, 1958). A critical attribute of the test was that the target word was a non-word, so that the child would never have heard it before. A child who knows that the plural of *witch* is *witches* may have heard and memorized that pair, but a child responding that the plural of *wug* is *wugs* (complete with the correct phonological allophone), has apparently inferred (probably unconsciously) the basic rule for forming plurals. Berko's major finding was that even very young children are able to connect suitable endings (e.g. to produce plurals) to nonsense words they have never heard before, implying that they have already internalized systematic aspects of the linguistic system which no one has necessarily tried to teach them (Rosenbaum, 2011). The Wug Test was the first experimental proof that young children have extracted generalizable rules from the language around them, rather than simply memorizing words that they have heard (Karmiloff & Karmiloff-Smith, 2001). This finding then shows that children at a young age derive inflected forms using rules (Cilibrasi, 2015). Further evidence suggests that at certain age children tend to over-regularise irregular verbs and incorrectly apply the bound morpheme *-ed* to the stems stored in their memory (creating forms such as *rided* or *comed*) (Guasti, 2004).

According to Berko (1958) and Pinker and Ullman (2002a) the inflection of verbs takes place through the application of a rule. Their studies focused on production where the appropriate bound morpheme is added to the stem by a computational system (Cilibrasi, 2015). In perception, this consists of the identification and isolation of bound morphemes from stems, a process called "morpheme stripping". As Cilibrasi (2015) points out, there is evidence that the process of morpheme stripping is not blind, meaning that the parser does not strip the morpheme without analysing the stem as well. Evidence comes from studies of the sublexicon. Caramazza, Laudanna and Romani (1988) showed that in a visual word recognition task morphologically legal non-words (i.e. non-words that are exhaustively decomposable into morphemes) were processed with the greatest difficulty, meaning it takes more time to decompose the non-word if the same morpheme is applied to a real stem than if it is applied to a non-existing stem (Caramazza et al., 1988). Further, they also realized that the analysis of the bound morpheme is synergistic to the analysis of the stem, meaning that the analysis of the affix is not blind but depends on the quality of the stem (Caramazza et al., 1988). However, as Cilibrasi (2015) further points out, the nature of this synergy is poorly understood (Cilibrasi, 2015: 104). An interesting finding that emerges from Caramazza et al.'s work (1988) is that some form of morpheme stripping takes place even sublexically, i.e. without the access to the lexicon. This idea supports work by Grainger and Ziegler (2011) that paid attention to the sublexical processes taking place in reading.

2.2.3 Summary of both approaches

I have shown above that there is evidence that regular inflected forms of verbs may be stored as units (e.g. Stemberger & MacWhinney, 1988; Bertram et al., 2000; Tomasello, 2006). However, there are also contrasting findings which suggest that bound inflection morphemes are stored separately from the stem of the verb (e.g. Pinker & Ullman, 2002a; Berko, 1958; Guasti, 2004). Several studies also show that some form of morpheme stripping takes place at the sublexical level (Grainger & Ziegler, 2011; Caramazza et al., 1988; Cilibrasi, 2015) and that the morpheme stripping is not blind but synergistic to the analysis of the stem (Caramazza et al., 1988). The sublexical processes in perception are, however, still poorly understood. The aim of this diploma thesis is thus to partly fill in the gap in research and investigate the contribution of morphology in the perception of sublexical items containing bound morphemes in second language learners of English.

2.3 The interaction between L1 and L2

This diploma thesis focuses on the analysis of word-ending perception in second-language learners of English with Czech as their L1. Understanding the interaction between L1 and L2 (i.e. Czech and English) is thus its essential part.

2.3.1 Differences between L1 and L2 acquisition

The acquisition of the native language is a complex process and its description would necessarily cover a significant number of pages. For the purposes of this thesis, we will therefore suffice with a simple outline of carefully chosen points that distinguish L1 acquisition from second language learning. Stephen Krashen's Acquisition-learning hypothesis states that there are two independent ways in which we develop our linguistic skills: acquisition and learning. Acquisition of language is a subconscious process and the learner is unaware of the process taking place. This is analogous to the way in which children learn their native language. Learning a language involves formal instruction and is therefore a conscious process. New language forms are represented and possibly contrasted consciously by the learner as rules and grammar (Krashen, 1988). For children, acquiring a language is an effortless achievement that occurs without explicit teaching (i.e. systematic instruction), on the basis of positive evidence (i.e. relying on the utterances they hear around them), under varying circumstances and in a limited amount of time, and in identical ways across different languages (Guasti, 2002). One hypothesis holds that children learn language by imitating what adults say, by trying to repeat what they hear (i.e. learning through imitation). According to another view, children learn language because they are positively reinforced when they produce correct verbal expressions, negatively reinforced when they make errors (i.e. learning through reinforcement; see Skinner, 1957). Another hypothesis about how language acquisition occurs is learning through association or connectionism based on the idea of analogy that refers to the ability of children to generalise phenomena (see for instance Tomasello, 2000). Another proposal (Chomsky, 2000) argues that children acquire language because they have an innate predisposition for it. In its milder version, the theory says that such predisposition results in the ability to combine words; the stronger version claims that there is a system of principles and parameters that allows for the acquisition of language (researchers call this system universal grammar). Innate behaviours are often distinguished by the existence of critical periods during which the ability to acquire the competence reaches its peak; thereafter, the ability to acquire that competence declines (Guasti, 2002). Eric Lenneberg (1967) came up with a critical period hypothesis (hereby CPH) that maintains that a child's ability to learn its native language effectively ends at the onset of puberty, afterwards it becomes impossible (acc. to the strong version of CPH) or very difficult (acc. to the weak version of CPH). In short, we can thus say that language acquisition is probably due to a genetic predisposition (nature) that needs to be triggered by the linguistic environment (nurture). Whether this predisposition is specific to language or a more general predisposition for learning is still an object of an intense debate (Ambridge & Lieven, 2011).

Some researchers believe that L1 acquisition and L2 acquisition are governed by essentially the same principles springing from an identical biological mechanism and that the two processes are basically equal. However, we have to understand how vastly different both processes are, especially in terms of different psychological factors, different contexts, age, environment, goals and motivation. The initial state for second language acquisition already operates with the existence of an L1, and general learning strategies. On the contrary, L2 is usually taught explicitly and on the basis of negative reinforcement. When it comes to the existence of the critical period, it is true that L2 learners are not as uniformly successful as children in the process of L1 acquisition but they definitely can attain native-like proficiency. The reality thus may be somewhere in the middle: There is probably no cut-off point after which L2 acquisition would be impossible, but a gradual decline. Selinger argues that there might actually be different critical periods for different competences (Selinger, 1978). Ellis (2008) thus reformulates the critical period hypothesis into a sensitive period when acquisition is easier and more efficient. The language acquisition device (i.e. the hypothetical module of the human mind posited to account for children's innate predisposition for language acquisition; see Chomsky, 1965) does not disappear with age, but unless the path to it is swept regularly, access becomes difficult (Long, 1996) and language acquisition suffers gradual decline (in adult learners this is combined with external factors such as stress, lack of time, or worries).

2.3.2 Bilingualism

The definition of bilingualism is a subject of intensive debate in the very same way as the definition of language fluency. On one end of the linguistic continuum, one may define bilingualism as complete competence and mastery of both languages. The speaker would presumably have complete knowledge and control over the second language and sound native. On the opposite end of the spectrum would be people who know enough of the language to communicate without insurmountable difficulties with another person using the second language. Since 1992, Vivian Cook has argued that most multilingual speakers fall somewhere between minimal and maximal definitions (Paradowski & Bator, 2016). Bilingualism thus have different degrees. And it also subsumes different types of bilingualism: simultaneous early bilingualism (refers to a child who learns two languages at the same time from birth), consecutive (or successive), or early bilingualism (refers to a child who has already partially acquired a first language and then learns a second language early in childhood), and late bilingualism (when the second language is learned after the age of 6 or 7; especially when it is learned in adolescence or adulthood). Bilingual children show peculiarities from early infancy, such as an interest for unfamiliar languages (Bosch & Sebastián-Gallés, 1997). The age of exposure (not the time of exposure) is important for the acquisition of certain subtle linguistic properties, and for the acquisition of reading (Zevin & Seidenberg, 2002).

Overall, bilingualism has several positive consequences on the mind (such as better attention, problem solving, and short-term memory), including long-term consequences such as a reduced risk of the symptoms of dementia. Researchers have shown that the bilingual brain can have better attention and task-switching capacities than the monolingual brain, thanks to its developed ability to inhibit one language while using another (Bialystok et al., 2012). To maintain the relative balance between two languages, the bilingual brain relies on executive functions, a regulatory system of general cognitive abilities that includes processes such as attention and inhibition. Since both of a bilingual person's language systems are always active and competing, that person uses these control mechanisms every time they speak or listen. This constant practice strengthens the control mechanisms and changes the associated brain regions (Bialystok et al., 2012).

Studies suggest that bilingual advantages in executive function are not limited to the brain's language networks. Researchers have used brain imaging techniques like functional magnetic resonance imaging (hereby fMRI) to investigate which brain regions are active when bilingual people perform tasks in which they are forced to alternate between their two languages. For instance, when bilingual people have to switch between naming pictures in Czech and naming them in English, they show increased activation in the dorsolateral prefrontal cortex, a brain region associated with cognitive skills like attention and inhibition (Hernandez et al., 2000). Beyond differences in neuronal activation, bilingualism seems to affect the brain's structure as well. Higher proficiency in a second language, as well as earlier acquisition of that language, correlates with higher grey and white matter volume (Mechelli et al., 2004). The cognitive and neurological benefits of bilingualism thus extend from early childhood to old age as the brain more efficiently processes information and staves off cognitive decline. What is more, the attention and aging benefits discussed above are not exclusive to people who were raised bilingual; they are also seen in people who learn a second language later in life.

2.3.3 Second language acquisition in adult age

As it has been previously mentioned, L2 can be acquired fully in adulthood. There still exists the sensitive period in which language acquisition is more automatic. Children are not quicker in the acquisition of their L1 (both L1 and L2 acquisitions last approximately 5 years in ideal conditions) but the process is more automatic for children. This is especially noticeable in the acquisition of L2 pronunciation (phonology). Hyltenstam and Abrahamsson conducted a research to discuss critical period hypothesis with specific focus on pronunciation and founded out that “learners who have been identified as indistinguishable from native speakers characteristically exhibit non-native features that are unperceivable except in detailed and systematic linguistic analyses” (Hyltenstam & Abrahamsson, 2000: 130). Subtle differences in pronunciation will then always remain but may not be perceived. Successful L2 acquisition then depends on a number of factors, such as the aptitude of the learner, their motivation, the fluency in L1, or the nature of the learning program (Alsayed, 2003).

2.3.4 Word-ending (bound morphology) acquisition

Czech is generally much richer in inflections than English and the explanation is quite simple: Czech is regarded as a mainly inflection language while English belongs to isolating languages. However, for a child, the word ending is an essential carrier of function cross-linguistically. Numerous examples show that the child commits shortening, in which they leave out lexical syllables but preserve word endings (Lopatová, 2012). Smolík (2002) focused in his research on the analysis of verb endings from the recordings of two two-year-old Czech girls. He came up with the conclusion that at a certain age grammar will not allow children a free usage of all morphological persons and numbers but that they are endowed with a mechanism that prevents them from using incorrectly the inflectional forms that they already know and use. He also pointed out that in Czech, as well as in other languages, children often start with using the 3rd person singular of present tense and frequently overuse the infinitive and past participle (Smolík, 2002).

Research on English indicates there is a predictable pattern in the acquisition of inflectional affixes (*-s, -ed* and *-ing*). Brown (1973) studied children’s language development between the age of 20 months and 36 months and found the sequence shown below occurred regularly. The features are also listed in the order in which they were acquired:

1. *-ing*
2. plural *-s*
3. possessive *-s*
4. *the*, *a*
5. past tense *-ed*
6. third person singular verb ending *-s*
7. auxiliary verb *be*

It is therefore evident that children pay attention to word endings from an early age and their acquisition is essential for further language development. Cruttenden (1979) divided the acquisition of inflections into three stages. In the first stage, children memorise words on an individual basis. In the second stage, they show an awareness of the general rules of inflections. They observe that past tense forms usually end in *-ed* so instead of *ran* they say *runned* (this kind of error is known as overgeneralisation, see above). In the third stage, correct inflections are used (Cruttenden, 1979).

This diploma thesis studies the perception salience of word-endings in second language learners of English with Czech as their L1. Considering the apparent mismatch in the inflectional richness between the two languages, it will be extremely interesting to see whether the L1 experience of rich inflection will influence the subjects' perception of English non-word endings and whether their performance will be in any way different from the performance of native speakers subjected to the same experiment (see Cilibrasi, 2015).

2.4 Hypotheses

Since both atomist and decompositional theories of inflection storing are approached with equal probability in this diploma thesis, our research does not operate with a single hypothesis but it needs to take into consideration several possible outcomes. If inflections are stored with stems as units (e.g. Tomasello, 2006), time needed to discriminate non-words with and without potential morphological information will be predicted by phonotactic probabilities (i.e. restrictions in a language on the permissible combinations of phonemes) and shorter reaction times will be recorded for items with high phonotactic probabilities. In contrast, if inflections and stems are stored separately (e.g. Pinker & Ullman, 2002a; Berko, 1958; Guasti, 2004), and morpheme stripping takes place during perception, time needed to discriminate non-words with and without potential morphological information will be predicted by the presence of potential morphemes and longer reaction times will be recorded if potential morphemes are present (Cilibrasi, 2015: 107).

Further, I expect proficiency in English to be a co-predictor of reaction times, with proficient speakers showing a larger (native-like) effect of morphology. Then, one possible hypothesis is that Czech speakers may not perform morpheme stripping to inflected non-words, at least not until they are proficient English speakers, since it may be more economic for them to store inflected forms rather than apply morphological decomposition in perception, or they may not be proficient enough to be aware of various realizations of bound morphology. In contrast, cross-linguistic analyses also show that speakers have better awareness of the morphological processes that are productive in their language (Ku & Andersson, 2003). Considering the inflectional richness of Czech and the fact that similar morphological processes are productive in Czech, morphological decomposition may be thus the preferred strategy in L2 learning.

All those features therefore need to be taken into consideration. The experiments will attempt to respond to the questions raised and to come up with an answer that will enable us to improve our understanding of sublexical perceptual processing of L2 learners of English.

3. METHODOLOGY

The methodology of this diploma thesis is based on the methodology used in Cilibrasi (2015), including the set of stimuli and the procedure.

3.1 Ethics

The experiment conducted in this thesis was approved by Charles University Ethics Committee, and as it met all necessary requirements on anonymization and careful treatment of personal data, it was given a favourable opinion to proceed.

3.2 Recruitment

The participants were recruited by an e-mail containing information about the task and the research project. B1- and B2-level participants were mainly students of the faculty language school who had been recently tested for English language level by a placement test created by Gráf (2015). Those who scored B1 and B2 levels were addressed directly and kindly asked to participate in the experiment.

Since Gráf's placement test was created only for levels A1 to B2, a new test had to be created for the C1 level, following the same principle as Gráf's test, i.e. it was also built on the basis of the English Grammar and Vocabulary Profile.[1] Since we needed to find proficient students of English for this part of the experiment, a short ad was posted on a Facebook page

[1] English Profile describes what lexical and grammatical aspects of English are typically learned at each CEFR level. It is a searchable database that gives one free access to the research findings on what English vocabulary and grammar is suitable for teaching at each CEFR level. The research was led by two departments of the University of Cambridge and collected data from learners all over the world to inform the research.

of students of English at Charles University. All participants were instructed not to use a dictionary or any other language material during the testing.

Since we were short of three more B1-level students, we asked a secondary school in Kolín for advertising the experiment in fourth-grade classes and tested three adult learners of English there.

All participants could decide voluntarily whether to participate in this study or not and each testing session was scheduled individually according to the participant's availability. All subjects were offered a small fee for the participation.

3.3 Participants

Sixty adult second-language speakers of English with Czech as their L1 were recruited for the experiment, with 20 participants for each language level. Mean age was 30.7 years (see the age distribution in Figure 3.1 below), standard deviation 8.7 years.[2] Forty-eight were female, twelve were male. One participant had to be excluded from the testing due to severe hearing problems and substituted by a new subject. The subjects used had no known hearing deficits.

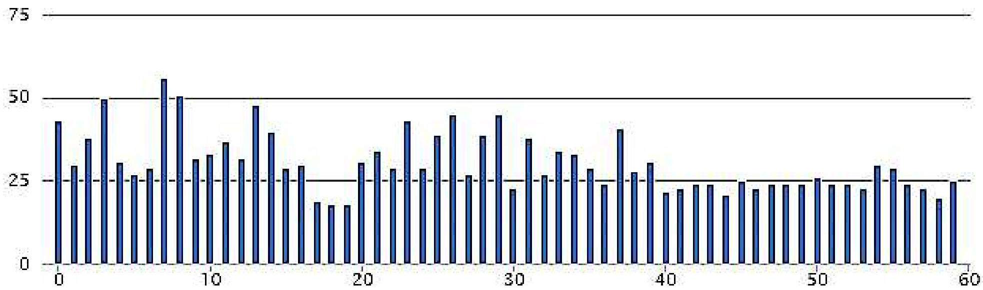

Figure 3.1 Standard deviation of the sample in terms of age

[2] Calculated online at http://www.calculator.net/standard-deviation-calculator.html.

3.4 Consent

Once the participants arrived at the testing room (which was always a quiet room either at the Faculty of Arts or in the secondary-school classroom), they were asked to sit comfortably in front of the computer and re-read the information sheet. After that, they were asked to sign a consent form by which they consented to participate in the experiment under conditions specified in the information sheet. If the subjects agreed to take part in the study, they added their name, date of birth and e-mail address, and signed the form.

All data were afterwards stored in a locked filing cabinet. Participants were given a random five-digit number[3] which was used to anonymise the data. The information linking participants to this numeric identifier was stored in a separate and secure location.

3.5 Stimuli

The stimuli used in this diploma thesis were created by Cilibrasi (2015) and only adopted for the purposes of this study. However, it is essential to explain the principles on which the stimuli were built to gain the study effect we wanted.

We have already established in the theoretical chapter that English inflections are governed by a specific morphophonological rule: They are voiced when applied to a verb stem ending in a voiced consonant, a vowel or a diphthong (e.g. /s/ after /t/ in *hearts* /hɜ:ts/) and voiceless when they follow a stem ending in a voiceless consonant (e.g. /z/ after /g/ in *digs* /dɪgz/) (Dušková et al., 2006: 166). Following this simple rule of regular verb inflection, it is possible to create non-words with potential bound morphemes (e.g. /vɪlz/ or /naɪld/), and non-words ending in phonemes with an inflectional value that is, however, not activated in that

[3] Generated at https://www.random.org/ with min. 10,000 and max. 99,999.

specific phonological context (e.g. /vɪls/ or /naɪlt/), i.e. although morphological in other contexts, /t/ and /s/ do not bring grammatical information when following /l/. This suits our purposes of studying regular verb inflection at the sublexical level.

In this experiment, we investigated morpheme stripping effects using sublexical items. Therefore, we paid attention to the discrimination of non-words ending in /ld/ vs. /lz/ and non-words ending in /lt/ vs. /ls/. In English, regular verbs ending in /ld/ or /lz/ carry morphological information, as in *filled* /fɪld/ or *fails* /feɪlz/. While verbs such as *spilt* /spɪlt/ or *felt* /felt/ may carry morphological information even when ending in /lt/, they are irregular, marked and not the focus of our study of regular verb inflection (in which the endings /lt/ and /ls/ are not deemed morphological). All non-words designed by Cilibrasi (2015) were deemed phonotactically legal using an online database called the Phonotactic Probability Calculator (Vitevitch & Luce, 2004) (see the Appendix for a full list of all non-words). This database contains phonotactic probability values for phonological segments (referred to as positional segment frequency which is the probability of occurrence of a particular sound in a particular word position) and segment sequences (referred to as biphone frequency which is the probability of co-occurrence of two adjacent sounds within a word) for 20,000 words from an online version of Webster's Pocket Dictionary (Anderson & Byrd, 2008). All non-words were phonetically transcribed and then translated into a computer-readable transcription referred to as Klattese prior to obtaining their log-based values for positional and biphone segment frequency from the database (Vitevitch & Luce, 2004).

The creation of stimuli was a complex process that started with the choice of four starting consonants, which were: /v/, /n/, /θ/, and /dʒ/. The choice was motivated by two factors: For one, all these consonants are allowed in word-initial position in English, as evidenced by the fact that the positional segment frequency value for these consonants in initial position is never zero. In the entire test, the value was never zero. At the same time, though, the consonants chosen had a relatively low frequency in word-initial positions with the values of positional segment frequencies varying between .02 and .006 for word-initial phonemes in the test. Cilibrasi (2015) defends this choice of having word beginnings with a relatively low frequency by the subsequent advantage in terms of non-words generation since having infrequent word beginnings substantially reduced the risk of creating already existing words.

All non-words created for this experiment are monosyllabic and as such they contain only one vowel in each non-word. The vowels used are /ɪ/, /aɪ/, /æ/, /ɔ/, /ʌ/ due to their biphone and positional segment frequencies. All these vowels are allowed in the second position of a word and as the second phoneme of a biphone with any of the previous consonants as their first phoneme. This is demonstrated by the fact that the positional segment frequency of these vowels and the biphone segment frequency of these biphones are never zero (the values are presented in the Appendix). The onset and nucleus of the non-words were then combined with the potentially morphological /lz/ and /ld/ codas and non-morphological codas /ls/ and /lt/ presented at the beginning of this section.

Following the productive rules of onset, nucleus and coda combination, each non-word onset was combined with each nucleus which gave us twenty base forms to which four different codas were added, thus generating eighty non-words. Half of these (40) contained potential morphological information, and the other half (40) did not contain morphological information.

At this stage, the experiment had two conditions in which the contrast between potentially morphosyntactic and non-morphosyntactic minimal pairs could be explained by the fact that the two final phonemes in the first condition are both voiced, while the two final phonemes in the second condition are not. Therefore, a third (control) condition was added to control for voicing effects. In the control condition, the two final phonemes are both voiced but, contrary to the previous voiced condition, they do not carry morphological information. The codas used in the control condition were /lb/ and /lm/, to which the base forms were applied to create the control condition, leading to another forty non-words. The final version of the experiment thus contained 120 non-words. All items were based on matched monosyllabic and monomorphemic stems, to avoid any confound between morpho-phonological decomposition of inflections and other morphological or phonological processes. A summary of all conditions used in the test is presented in Table 3.1.

Condition	**Potentially morphosyntactic minimal pairs**	**Non-morphosyntactic minimal pairs**	**Voicing control condition**
Example	/vɪld/ - /vɪlz/	/vɪlt/ - /vɪls/	/vɪlb/ - /vɪlm/
Features	plosive/fricative at the end voicing coherent morphological ending	plosive/fricative at the end voicing incoherent non-morphological ending	plosive/nasal voicing coherent non-morphological ending

Table 3.1 Types of minimal pairs used in the experiment (from Cilibrasi, 2015)

We have thus examined the contribution of morphological and phonological factors to regular inflectional verb processing by systematically manipulating a set of non-words: (i) potentially morphosyntactic MPs, (ii) non-morphosyntactic MPs, and (iii) voicing control. The full list of stimuli is available in the Appendix. There were 60 pairs of different items (with a minimally different first and second non-word ending) and 60 pairs of identical items (in which the first word was repeated as the second word), out of each 20 fell into each condition presented above ((i) to (iii)).

The productive rules of combination ensured the generation of a large number of non-words. However, some of the non-words had to be created with different vowels because the productive rules led to the generation of real words (e.g. the block starting with /dʒ/ could not be followed by /ɪ/ and had to be replaced by /ɑ/ because the use of /ɪ/ would have led to /dʒɪlz/, which is an existing word – the plural of Jill or the possessive form of Jill). Other non-words had to be edited because one of its values of biphone segment frequency was equalling zero, e.g. in the block starting with /v/, /aɪ/ had to be replaced by /ɛ/ to avoid zero frequency.

3.5.1 Stimuli recording

The stimuli were recorded in the sound booth of the School of Psychology and Clinical Language Sciences at the University of Reading and uttered by a trained female linguist who was also a native speaker of English. She was instructed to record the stimuli in pairs, reading them row by row from a list of all non-words. She was informed beforehand about the nature of the task so that she could focus on producing subtle vowel lengthening in the morphological condition typical of a vowel preceding a lenis (i.e. a voiced consonant).

3.5.2 The purpose of using minimal pairs for the investigation of phonological contrast perception

The experiment used in this diploma thesis is based on minimal pairs distinction. Minimal pairs are defined as "pairs of words in which a difference in meaning depends on the difference of just one phoneme" (Roach, 2000: 63) as in *sin* /sɪn/ vs. *sing* /sɪŋ/ where the final phoneme differentiates between two semantically different words. The two words differ only in one phonological element (e.g. the final sound), and as such they form a minimal pair. The contrast generated by such a minimal pair, i.e. the fact that the difference in one phonological element is able to generate two different meanings, is used as evidence for the existence of phonemes (McGregor, 2009), i.e. the smallest units of sound which can differentiate one word from another, in other words to make lexical distinctions (Ogden, 2009). The minimal pair presented above, “sin” vs. “sing” thus underlines the existence of the phonemes /n/ and /ŋ/ in English. They are differentiated based on the place of articulation (/n/ being alveolar and /ŋ/ velar). The fact that this feature is distinctive in English means that the input sublexical representations (see Chapter Two) are shaped according to it (Ramus et al., 2010). The contrast between those two phonemes is then perceived sublexically. At the sublexical level, meanings are not activated (Ramus, 2001), so we refer to minimal contrasts as pairs of non-words which differ in only one phonological element (Wedel, 2012).

Morphosyntactic minimal pairs (Law & Strange, 2010) refer to the condition in which words differ in one phoneme that is also an inflectional morpheme. In their study, Law and Strange (2010) showed that words belonging to a morphosyntactic minimal pair are difficult to distinguish for L2 speakers if the inflectional morphemes leading to the difference are in a position that is not allowed in their L1 and therefore that perception of bound morphemes in morphosyntactic minimal pairs is influenced by the L1 in L2 speakers (Cilibrasi, 2015: 48).

The use of minimal pairs was also highly motivated by methodological reasons. From a methodological point of view, minimal pairs allow for a coherent study of word position since the contrast can be moved to different positions in the word, complexity can be controlled changing the nature of the contrasts, and sublexical representations can be tested with the use of non-words (Cilibrasi, 2015).

3.6 Procedure

The participants have first signed the consent form and then they were verbally instructed by the researcher about each task. After that, DigitSpan Tester[4] was launched to measure participants' working memory independent of language. Researches show that second language learners have better executive functions than monolinguals (Bialystok et al., 2012). Therefore, we wanted to include an executive-functions test in our study to see whether performance on that changes in correlation with performance in the language tasks. First, we ran a trial version of the task with the participant. The software was set into a custom mode with a set size at 3, minimal length 2 and maximal length 3. Results were to be shown after the testing in a form of log results. Error limit was fixed at 2 (after that the test ended), stimuli time and pause time were fixed at 750ms. Digits were run backwards with no auditory aid. The digits were run backwards because we were not trying to measure linguistic abilities, but only cognitive abilities. With digits run forward, subjects with better verbal working memory could store the sequence "as a sentence". Both during the trial and during the actual testing, the subjects wrote down the numbers on a sheet of paper (after all digits were run and not sooner to test the working memory properly), and they were not supposed to put the numbers in the test themselves; the numbers they wrote were immediately inserted into the software by the researcher. After the trial, the setting was reset into: set size 5, minimal length 2 and maximal length 9 (see the setting in Figure 3.2). The numbers then appeared (digit by digit) in groups of five from two-digit numbers up to nine-digit numbers (provided the respondent did not make more than two errors in a set), i.e. 40 numbers in total. When the test finished, the result file was saved by the ID of the participant.

[4] DigitSpan Tester is a test of working memory for cognitive research. It was designed to perform automated digit span tests to evaluate on working memory function. The task was run on a 2.1.3 version released in 2011.

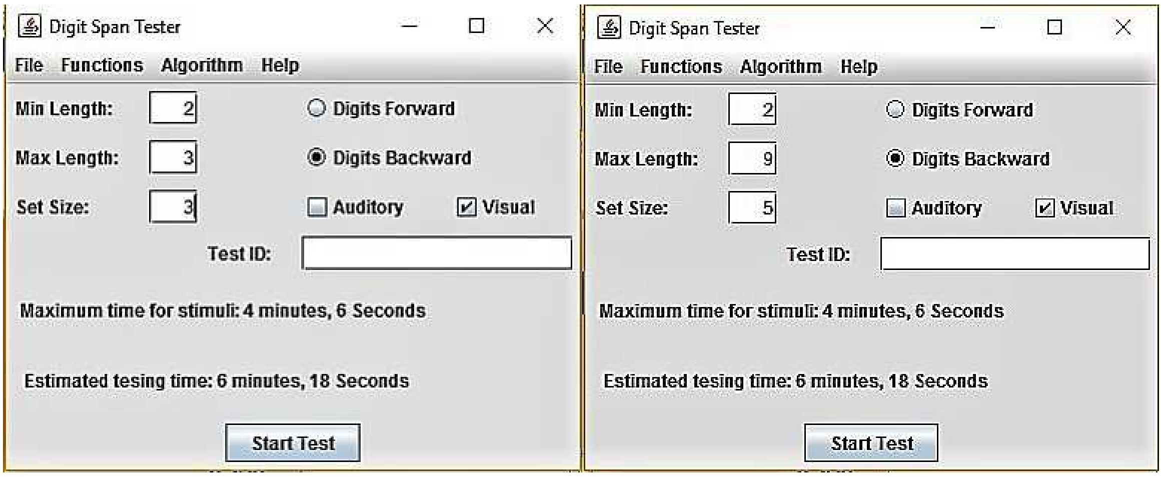

Figure 3.2 The setting of the Digit-Span Tester with the trial setting on the left and the testing setting on the right

After that, PsychoPy[5] was launched and the participant was left alone to complete the task. Participants were tested in quiet conditions, wearing headphones. The researcher's prior instructions appeared on the screen again and guided the participant through the testing session. To ensure understandability and equal conditions for all language levels, all instructions were presented in Czech only. The information they received was the following: "Vítejte u tohoto experimentu. Uslyšíte dva zvuky za sebou. Stiskněte co nejrychleji S, pokud si myslíte, že tyto dva zvuky jsou STEJNÉ, nebo J, pokud si myslíte, že jsou JINÉ." The two keys, 's' and 'j' were chosen for two reasons: First, they are in an optimal distance from each other on the keyboard and also in the same row, which allowed for a comfortable hand position, and secondly, they were also chosen as linguistic mnemotechnic aids with 's' standing for 'stejné' in Czech ('same' in English) and 'j' for 'jiné' ('different' in English). The participants were given one free trial to get accustomed to the task. In this free trial, they were presented with a different minimal pair and were therefore supposed to press the 'j'

[5] PsychoPy is an open-source application allowing scientists to run a wide range of neuroscience, psychology and psychophysics experiments. It's a free and written in Python. The experiment was run on a 1.84.0 version released in August 2016.

button. After the press, the right answer was presented. When the participants were ready, they were asked to press the space bar to start the testing.

Participants were then presented with a same/different task. The experiment was conducted using 180 trials (pairs) of non-words and 3 conditions with 60 items per a condition (for the full description of each condition see above). In each trial, the participant was presented with two non-words that could be either identical or that could differ in the final phoneme. Each trial started with inter-stimulus interval (ISI) that allows to have a period during which no other subjects are being presented. This static component allowed for smoother transition between individual trials. It started at 0.0 seconds, lasted for 1000ms and as with all trials, the screen appeared completely grey. At the same time (i.e. starting at 0.0 seconds), the minimal pair of non-words was played (labelled as sound_1 in PsychoPy) which lasted for 2500ms. At 1.0 second, the period for key press started (labelled as key_resp_2 in PsychoPy), lasting for 2 seconds (for a full PsychoPy setting of the trial part see Figure 3.3). Allowed keys for pressing were 's' and 'j' and the software stored only the last key press, discarding all previous ones. The reaction times (RTs, i.e. the amount of time it takes to respond to a stimulus) were synchronized with the screen. Participants were thus given time to press either of the keys to express their judgment on the non/similarity of the non-words. The reaction times were stored and synchronized with the screen.

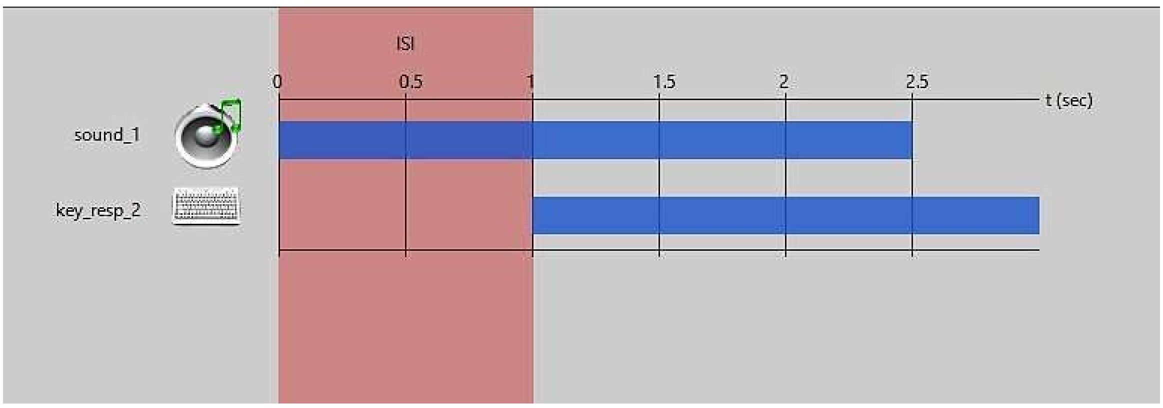

Figure 3.3 The trial setting as depicted in PsychoPy Builder

In the PsychoPy routine, we created a loop that enabled the repetition of the trial part (see the loop in Figure 3.4) in which various sounds were randomly chosen from a list of all 120 minimal pairs entered into an Excel file called Pairs (a new minimal pair was chosen on every repeat). Each pair was never presented to the same participant more than once. As a consequence, the order of presentation of the trials was different for each participant. The whole experiment lasted approximately seven minutes and it was ended by the appearance of the following text: "Konec experimentu. Moc Vám děkuji za účast!" which lasted for 4 seconds. The participants could then take out the ear buds and leave.

Figure 3.4 The experiment routine as depicted in PsychoPy Builder

3.7 Scoring

DigitSpan Tester was set to record any answer given and stop after two errors in a given set (sets of five numbers of the same number of digits were programmed). The log files then gave us the final score of the participant, showing us how many digits each participant managed to get right with at least 60% accuracy (which accounts for 3 correct numbers out of 5 in a particular set).

PsychoPy was set to record the answer given (i.e. the last key press), be it either 's' or 'j', a non-valid key or no answer. No answer was coded when participants did not press any key for the entire duration of key press period (2000ms). For any type of a given answer, PsychoPy measured the reaction time (in ms) that the subjects took to make their choice and press the button. The list of pairs was enriched with two additional parameters, congruence and correct answer, which were recorded alongside the reaction times: Congruence was appointed 0 if the two sounds in the minimal pair were different (the correct answer for this condition would be 'j') and 1 if the two sounds were the same (the correct answer being 's'). This simplified further data analysis since we could easily compare if the anticipated correct answer matched the answer given.

Data from each session were named according to the participant's numeric identifier (the session name was always *session 001*) and saved in an Excel file, csv file (both summaries and trial-by-trial), psydat file and a log file. Apart from the congruence, correct answer, pressed key and reaction times, the software also recorded the order of sound presentation. The data with which we subsequently worked were taken from raw reaction times saved in an Excel file.

3.8 Outcome measures

The aim of the first task (the digit-span test) was to measure participants' working memory independent of language. Researches show that second language learners have better executive functions than monolinguals. Therefore, we wanted to run an executive-functions test to see whether performance on that (here, working memory) changes in correlation with performance in the language tasks. Individual scores were summoned from each participant in each language level.

The aim of the second task was to assess the ability to discriminate different non-words designed as minimal pairs; our analysis was thus mainly preoccupied with the data gathered from the different MPs. Previous studies showed that the processing of morphological information requires more time so we coded the responses to have a time measure of successful discrimination. For each participant, we calculated (i) the average reaction times needed to successfully discriminate elements in the three different conditions. This was done by dividing the sum of the RTs in which the participant successfully discriminated different non-words by the number of successful discriminations. We also calculated (ii) item-based reaction times by dividing the sum of RTs obtained across participants for a successful discrimination of a non-word by the number of times that non-word was successfully discriminated.

4. RESEARCH PART

Our experiment used a same/different paradigm. There were three different English language levels (B1, B2 and C1) and three conditions defined by the type of information carried by the items: (i) condition 1 in which the elements carried potential morphological information, (ii) condition 2 in which the elements did not carry any morphological information, but where the word endings could potentially be morphological in isolation, and (iii) condition 3 in which the elements did not carry any morphological information, and which was controlled for voicing effects (see Table 4.1).

Level (number of participants)	Conditions	Mean RTs (s)	Standard deviation
B1 level (20)	Morphological	1.366	0.107
	Non-morphological	1.172	0.105
	Control	1.308	0.078
B2 level (20)	Morphological	1.330	0.095
	Non-morphological	1.117	0.106
	Control	1.248	0.107
C1 level (20)	Morphological	1.331	0.134
	Non-morphological	1.137	0.108
	Control	1.266	0.119

Table 4.1 Descriptive statistics of the experiment

Since both atomist and decompositional theories of bound inflection storing are approached with equal probability in this diploma thesis, our research does not operate with a single hypothesis but it needs to take into consideration several possible outcomes. This data analysis is therefore divided into two parts: morpheme stripping analysis and unit storing analysis.

4.1 D-prime analysis

First, we carried out a D-prime analysis to see whether participants engaged significantly in the task. We did this by using hit rates and false alarm rates, as suggested by MacMillan and Creelman (2005). The hit rate refers to the number of times the participants detected the contrast correctly (i.e. upon hearing non-identical non-words they pressed J for "different"), and the false alarm rate refers to the number of times the participants perceived that there was a contrast while the two stimuli were actually identical (i.e. they pressed J for "different" even though the non-words were identical). Using those two measures, it is possible to assess whether participants engaged in the task significantly and whether they answered the task randomly or not.

D-prime values were significantly different from 0 and significantly bigger than 3, $t (59) = 16.16$, $p < 0001$, two tailed; $t (59) = 7.51$, $p < 0001$, two tailed. According to MacMillan and Creelman (2005) those results indicate that not only the participants did not answer randomly to the stimuli, but they were very engaged in the task.

4.2 Hypothesis 1: Morpheme stripping analysis

As stated in the theoretical background, if inflections and stems are stored separately (see for instance Pinker & Ullman, 2002a; Berko, 1958; or Guasti, 2004), and morpheme stripping takes place during perception, time needed to discriminate non-words with and without potential morphological information will be predicted by the presence of potential morphemes.

Since there were 3 conditions for each group of participants in the study and each language level was analysed separately, reaction time data were compared using a three-factor ANOVA. There, the three factors refer to the three conditions used in the experiment: the presence of potential morphological information, the absence of any morphological information and control condition. Since the task was predominantly meant to assess the ability to discriminate the contrast in minimal pairs, we focused our analysis on pairs in which the two non-words were different (i.e. on 60 pairs in total).

To test this hypothesis, first, mean RTs were counted for each condition at each participant. The mean RTs were then used for further analysis. We also had to take into consideration the duration of our non-words and what role the voicing of the final consonant played in it (Gimson, 1961), given that we used both voiced (/z/ and /d/) and voiceless (/s/ and /t/) final consonants as non-word endings. In English, vowels that precede a voiceless consonant are shorter (this effect is called pre-fortis shortening) than vowels which precede voiced material (in this case the vowel is longer, e.g., *plate* is much shorter than *played* (Wiik, 1965)). We have therefore lowered the mean RTs of morphological and control conditions by 30ms (Klatt, 1975) so that the voicing did not influence the final analysis and we could approach all three conditions equally and compare them. This was done in all three language levels.

4.2.1 B1 level

There was a significant difference between the three conditions at the B1 level, $F(2, 38) = 14.45$, $p < .001$. Pairwise comparisons conducted by a post-hoc t-test show that the elements with potential morphological information took more time to be discriminated than the non-morphological elements, $t(19) = 9.07$, $p < .001$, two-tailed. The results also show a larger amount of time needed to discriminate the elements with potential morphological information than the phonological control condition, $t(19) = 3.32$, $p = .004$, two-tailed.

Further, the data show that the elements in the non-morphological condition were discriminated more quickly than elements in the phonological control condition, t (19) = -7.59, p < .001, two-tailed. Mean RTs for the discrimination of the morphological, non-morphological and control conditions were 1.33s, 1.17s and 1.27s respectively. The results are presented visually in Figure 4.1.

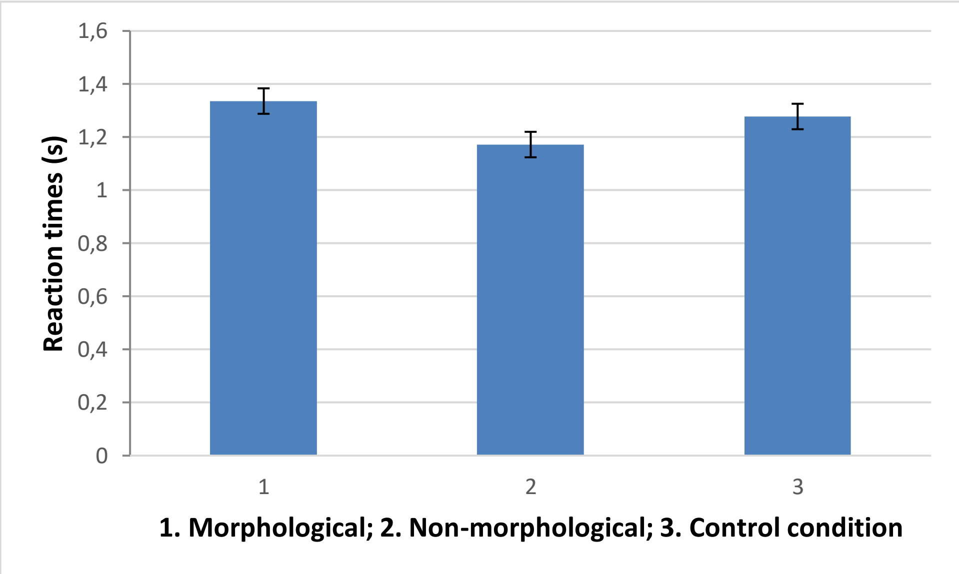

Figure 4.1 Reaction times needed for the discrimination of morphological, non-morphological and control conditions at the B1 level

4.2.2 B2 level

Similar distribution of reaction times among individual conditions was recorded in the B2 level. There was a significant difference between the three conditions, F (2, 38) = 15.91, p < .001. Pairwise comparisons show that the elements with potential morphological information took more time to be discriminated than the non-morphological elements, t (19) = 20.39, p < .001, two-tailed. The data also show a larger amount of time needed to discriminate the elements with potential morphological information than the phonological control condition, t (19) = 6.31, p < .001, two-tailed. Further, the results show that the elements in the non-morphological condition were once again discriminated more quickly than elements in the phonological control condition, t (19) = -8.25, p < .001, two-tailed. Mean RTs for the discrimination of the morphological, non-morphological and control conditions were 1.3s, 1.12s and 1.22s respectively. The results are presented visually in Figure 4.2.

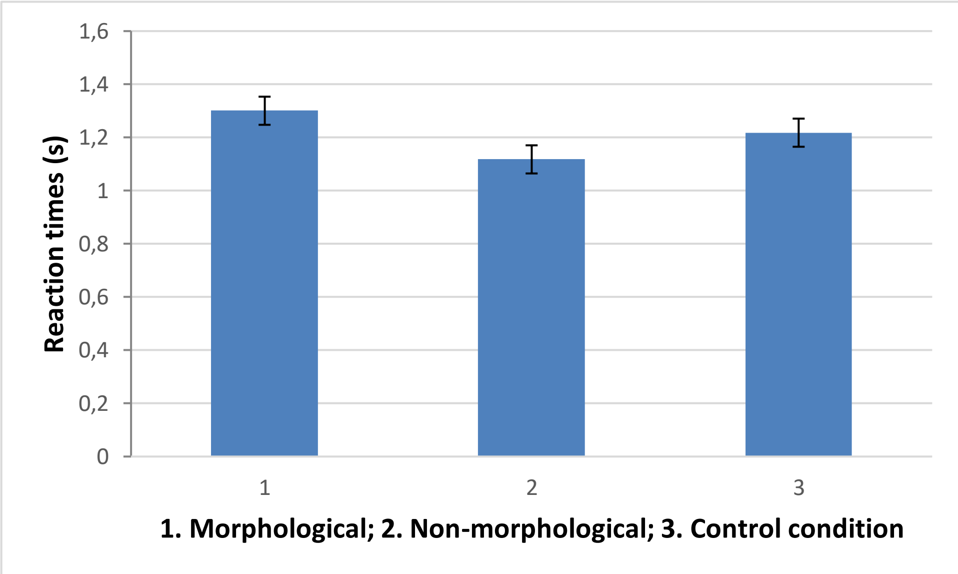

Figure 4.2 Reaction times needed for the discrimination of morphological, non-morphological and control conditions at the B2 level

4.2.3 C1 level

Similar results were recorded at the C1 level. Once again, there was a significant difference between the three conditions, F (2, 38) = 9.38, p < .001. Post-hoc t-tests show that the elements with potential morphological information took more time to be discriminated than the non-morphological elements, t (19) = 10.79, p < .001, two-tailed. The results also show a larger amount of time needed to discriminate the elements with potential morphological information than the phonological control condition, $t(19) = 5.79$, $p < .001$, two-tailed. Further, the t-tests show that the elements in the non-morphological condition were discriminated more quickly than elements in the phonological control condition, $t(19) = -8.85$, $p < .001$, two-tailed. Mean RTs for the discrimination of the morphological, non-morphological and control conditions were 1.3s, 1.14s and 1.24s respectively. The results are presented visually in Figure 4.3.

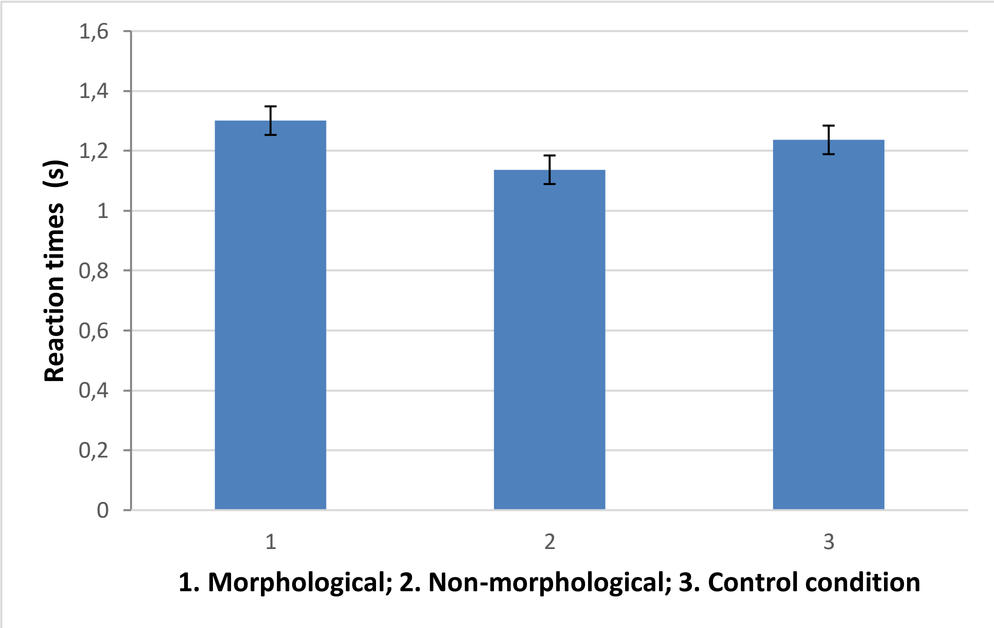

Figure 4.3 Reaction times needed for the discrimination of morphological, non-morphological and control conditions at the C1 level

4.2.4 Interim summary of RT analyses

All language levels showed similar distribution of RTs between individual conditions with the morphological condition taking most time, followed by the phonological control condition and then the non-morphological condition. We then calculated mean RTs for each level (dividing the sum of RTs of all three conditions by the number of conditions) and ran a three-factor ANOVA test (for the three language levels), F (2, 38) = 1.3, p = 0.28. The p-value in this test was not significant; we have thus failed to reject the null hypothesis and may assume that the three language groups performed similarly. The B1-level group took longest to respond to the oral stimuli, followed by the C1-level group and the B2-level group. Mean RTs for each level group were 1.26s, 1.22s and 1.21s respectively. The results are presented visually in Figure 4.4.

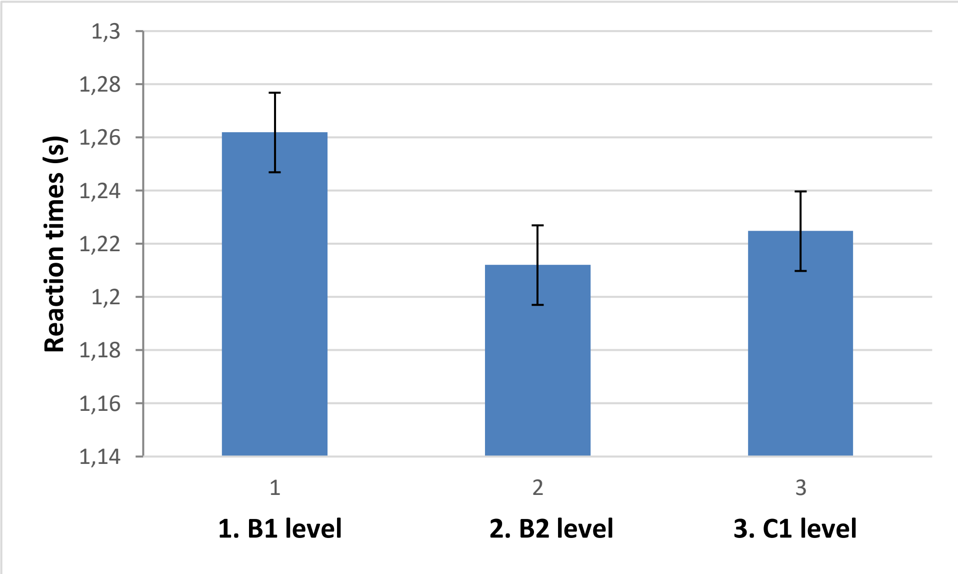

Figure 4.4 Mean reaction times needed for the discrimination of stimuli at each language level

4.2.5 Accuracy

Alongside reaction times, we also counted the number of correct answers (i.e. accuracy) for each participant in each language level (i.e. how many correct answers the participant got out of sixty). We then ran another three-factor ANOVA test (for three language groups) to see if the language groups performed any differently, F (2, 38) = 1.91, p = 0.16. The p-value in this test was not significant; we have thus failed to reject the null hypothesis of no effect and we may assume that the three language groups performed similarly (i.e. they were similarly accurate in discriminating different bound inflectional morphemes). The B1-level group was least accurate, followed by the C1-level group and the B2-level group. Mean accuracy rates for each level group were 55.7, 56.65 and 57.55 (out of 60) respectively. The results are presented visually in Figure 4.5.

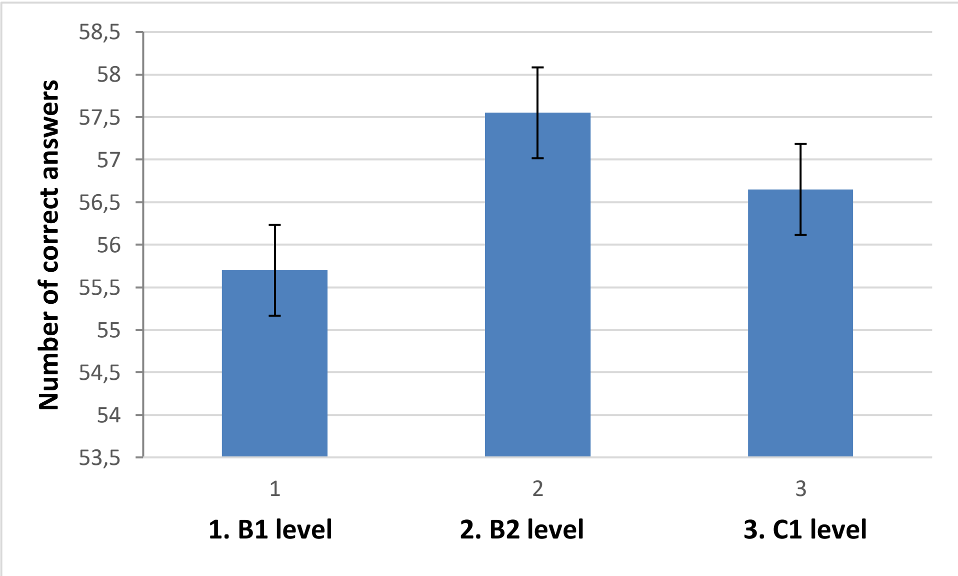

Figure 4.5 Mean accuracy rates for each language group

To make sure that the accuracy of individual participants in each language group was not influenced by age, placement-test percentage or their non-verbal working memory, we ran correlations between accuracy and age, placement-test percentage and digit-span test results for each language level separately. In none of the groups was the p-value significant. For the B1 level, the correlation between accuracy and non-verbal working memory had $r(18) = -0.24$, $p = 0.298$, between accuracy and age $r(18) = 0.28$, $p = 0.22$, and between accuracy and placement-test percentage $r(18) = 0.14$, $p = 0.55$. For the B2 level, the correlation between accuracy and non-verbal working memory had $r(18) = 0.02$, $p = 0.92$, between accuracy and age $r(18) = 0.08$, $p = 0.71$, and between accuracy and placement-test percentage $r(18) = 0.32$, $p = 0.17$. For the C1 level, the correlation between accuracy and non-verbal working memory had r (18) = -0.26, p = 0.33, between accuracy and age r (18) = -0.14, p = 0.55, and between accuracy and placement-test percentage r (18) = -0.23, p = 0.33.

4.2.6 Working memory

The results of the digit-span test show similar tendencies as the distribution of accuracy between each language group. A three-factor ANOVA test showed a significant difference between the three language levels, F (2, 38) = 5.43, p = .007. Pairwise comparisons show that the B1 level managed to keep a significantly smaller number of digits in their non-verbal working memory than the B2 level, t (19) = -3.5, p = .002, two-tailed, and also than the C1 level, t (19) = -2.68, p = .014, two-tailed. The data, however, show no significant difference between the number of digits memorized by the B2 and the C1 level, t (19) = 0.53, p = .6, two-tailed. Mean numbers of memorized digits for the B1, B2 and the C1 levels were 5.5, 6.85 and 6.6 digits respectively. The results are presented visually in Figure 4.6.

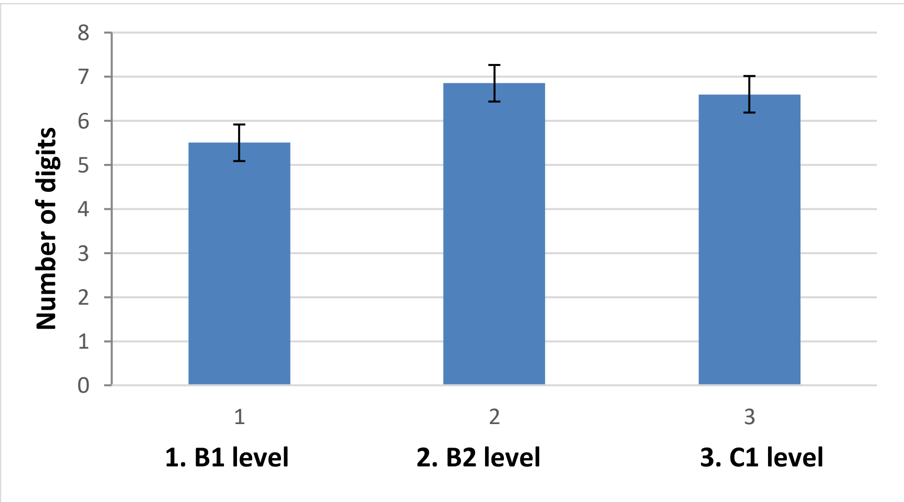

Figure 4.6 Mean numbers of memorized digits for each language level

We then ran correlations between digit-span test results of individual language groups and their mean RTs and none of the correlations turned out to be significant. For the B1 level, the correlation result was r (18) = 0.16, p = 0.49; for the B2 level it was r (18) = 0.17, p = 0.47; and for the C1 level it was r (18) = -0.07, p = 0.77. The number of digits memorized by individual language groups thus does not correlate with the groups' mean RTs and the participants' reaction to the stimuli was not influenced by their respective non-verbal working memory skills. The results of these correlations are presented visually in Figures 4.7 to 4.9.

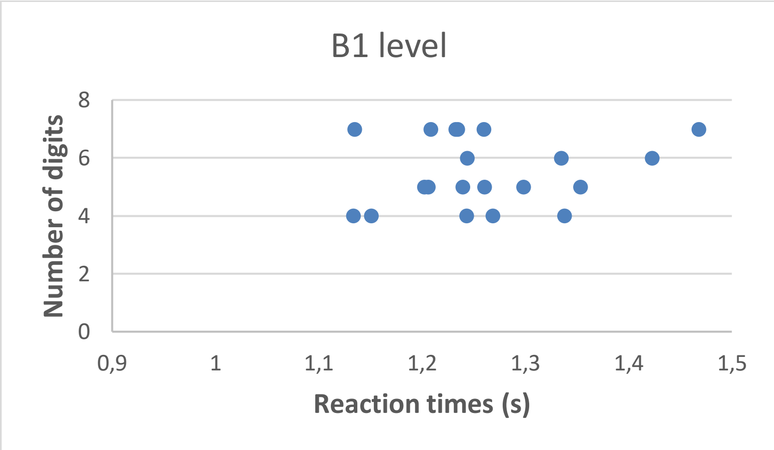

Figure 4.7 Visualization of the correlation between digit-span test results and mean RTs at the B1 level

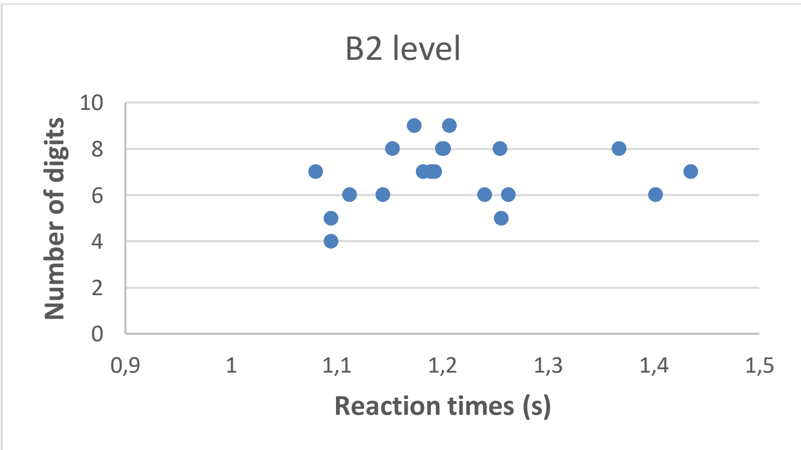

Figure 4.8 Visualization of the correlation between digit-span test results and mean RTs at the B2 level

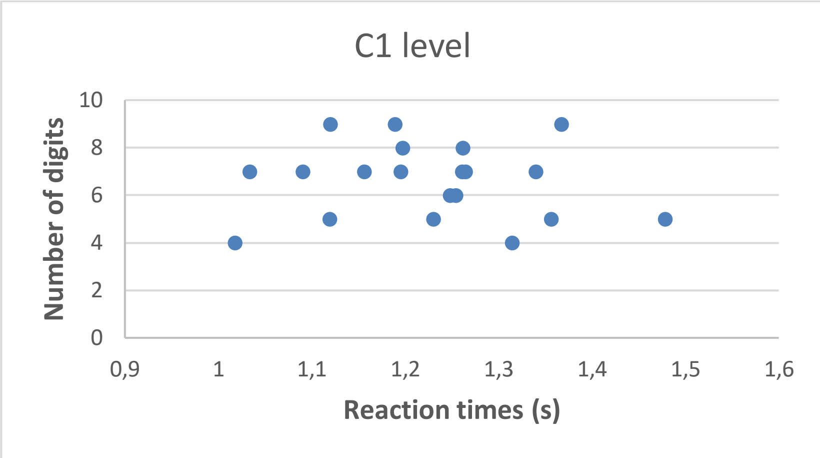

Figure 4.9 Visualization of the correlation between digit-span test results and mean RTs at the C1 level

4.3 Hypothesis 2: Unit storing analysis

As stated in the theoretical background, if inflections are stored with stems as units (see for instance Tomasello, 2006), time needed to discriminate non-words with and without potential morphological information will be predicted by phonotactic probabilities (i.e. restrictions in a language on the permissible combinations of phonemes) and shorter reaction times will be recorded for items with high phonotactic probabilities.

To test this hypothesis, first, we had to obtain item-based RTs by calculating the number of correct answers for each specific non-word in each language level. The sum of RTs across participants for each specific non-word was then calculated and divided by the number of correct answers. The values obtained for each non-word in each language level were then correlated with the positional segment frequency and biphone segment frequency relative to that specific item (PSF and BSF values were taken from Cilibrasi, 2015; for the full list see the Appendix). Again, this analysis was done separately for each language level.

Item-based correlations were then run between RTs and positional segment frequency and biphone segment frequency. For the B1 level, the correlation between RTs and PSF was significant, r (58) = -0.37, p = 0.003, while the correlation between the RTs and BSF was not, r (58) = -0.14, p = 0.26. Similar results were recorded for the B2 level: the correlation between RTs and PSF was significant, r (58) = -0.41, p = 0.001, while the correlation between the RTs and BSF was not, r (58) = -0.15, p = 0.23. The C1 level showed a similar tendency: the correlation between RTs and PSF was significant, r (58) = -0.32, p = 0.01, while the correlation between the RTs and BSF was not, r (58) = -0.06, p = 0.65. The results of these correlations are presented visually in Figures 4.10 to 4.12.

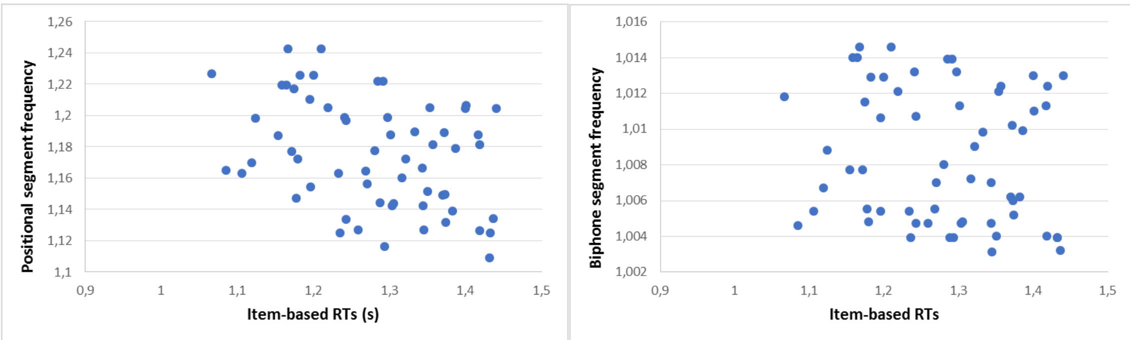

Figure 4.10 Visualization of the correlation between positional segment frequency (left)/biphone segment frequency (right) and item-based RTs at the B1 level

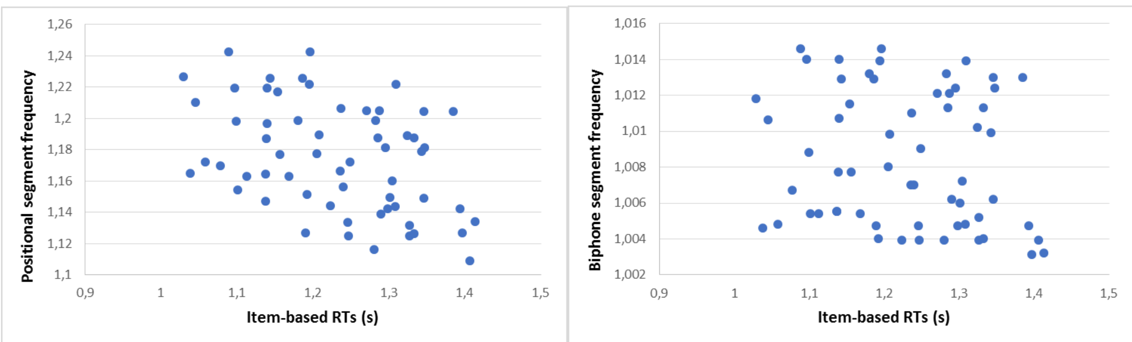

Figure 4.11 Visualization of the correlation between positional segment frequency (left)/biphone segment frequency (right) and item-based RTs at the B2 level

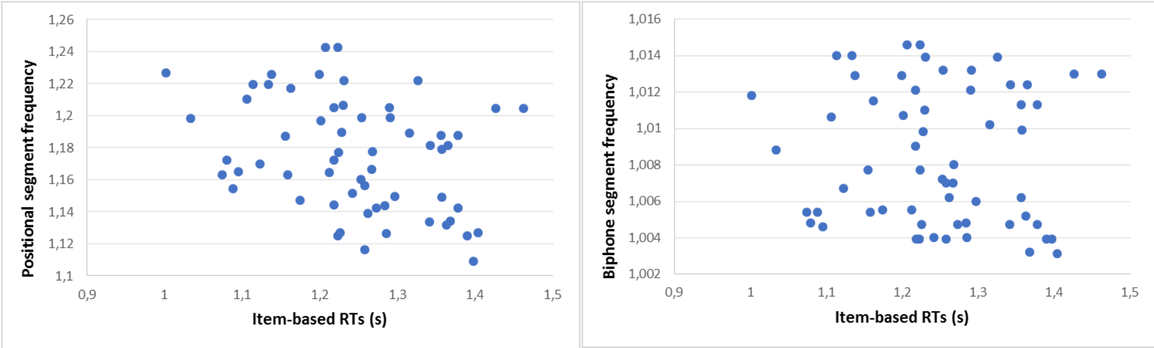

Figure 4.12 Visualization of the correlation between positional segment frequency (left)/biphone segment frequency (right) and item-based RTs at the C1 level

Apart from individual correlations, we also ran a three-factor ANOVA test between item-based RTs of each language level. There was a significant difference between the three conditions, $F\ (2, 38) = 3.69$, $p = .027$. Pairwise comparisons conducted by a post-hoc t-test show that at the B1 level it took participants more time to discriminate various items than at the B2 level, $t\ (59) = 7.76$, $p < .001$, two-tailed. The results also show that at the C1 level it took participants a larger amount of time to discriminate various items than at the B2 level, $t\ (59) = -2.99$, $p = .003$, two-tailed. Further, the data show that the participants at the C1 level needed less time to discriminate various items than the B1-level participants, $t\ (59) = 4.64$, $p < .001$, two-tailed. Mean RTs for the discrimination at the B1, B2 and the C1 level were 1.28s, 1.23s and 1.25s respectively. The results are presented visually in Figure 4.13.

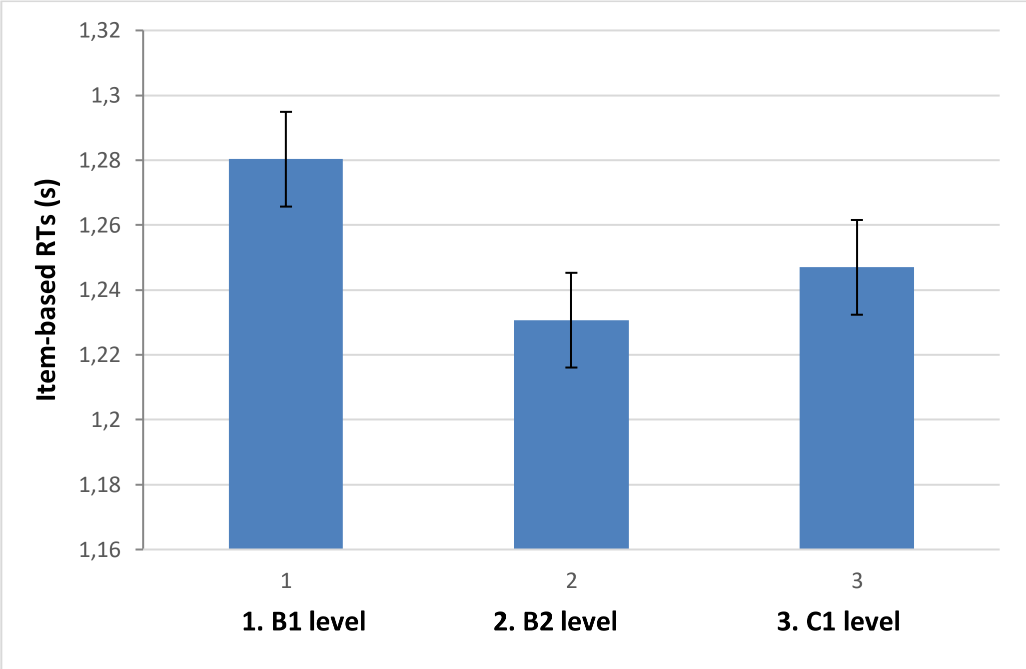

Figure 4.13 Mean item-based reaction times needed for the discrimination of various items at each language level

4.4 Discussion

The aim of this project was to investigate morpheme stripping phenomena with sublexical items, using both reaction time measures and accuracy. One of the main findings is that non-words with potential morphological information take longer to be discriminated than those without morphological information. The significant contrast between potentially morphological items and non-morphological items with similar voicing characteristics suggests that a purely phonological explanation cannot be used and morpheme stripping is involved in the process.

The data also show that the morpheme stripping is not blind, i.e. that the participant (or their language parser) does not rely on the word ending in isolation when doing the parsing. This means that there seems to be an interaction between phonology and morphology during the morpheme stripping. In (i) /naɪld/ or /naɪlz/, the word endings are potentially morphological because any regular English verb ending in /l/ would take these word endings. As we have stated before, in English, regular verbs ending in /ld/ or /lz/ carry morphological information, as in *filled* /fɪld/ or *fails* /feɪlz/. While verbs such as *spilt* /spɪlt/ or *felt* /felt/ may carry morphological information even when ending in /lt/, they are irregular, marked and not the focus of our study of regular verb inflection (in which the endings /lt/ and /ls/ are not deemed morphological). The endings such as in (ii) /naɪlt/ or /naɪls/ can carry morphological information in English when following a regular voiceless verb ending (e.g. /k/, /t/ or /p/ as in *killed, sits* or *sleeps*). However, these endings cannot bring morphological information when following a regular voiced verb ending in /l/. If morpheme stripping was blind, i.e. if the parser relied simply on the morphosyntactic information at the end of the word, then the perception of (i) and (ii) would not make any difference as all four non-words end in a phoneme which is in isolation potentially morphological. However, the significant difference in reaction times in the discrimination of elements in (i) and (ii) suggests that we are faced with a different perceptual process. Morpheme stripping has to be integral to the analysis of the stem. Inflectional morphemes are then most likely analysed by a combination of the bound-morpheme analysis and the stem analysis. During the stripping, the parser must follow morpho-phonological rules, i.e. consider which regular bound morpheme can phonologically follow which stem. The results of our experiment thus suggest that morpheme stripping takes place sublexically and that the process is synergetic to the phonological analysis of the stem also in L2 speakers of English, similarly to what was observed in monolingual English speakers (Post et al., 2008; Cilibrasi, 2015).

In the experiment, a significant contrast was detected between the non-morphological condition and the phonological control condition. This result is not predicted by the presence of morphology as none of the conditions contains elements carrying (potential) morphological information. In fact, the reason for the difference between non-morphological condition and phonological control condition is likely to be phonological. The difference between the two conditions might be caused by the fact that the contrast in voicing feature (i.e. voiced consonant being followed by a voiceless one) is present only in the non-morphological condition. This finding may easily undermine the conclusions reached in the rest of the analysis since one could further argue that the difference between the morphological and the non-morphological conditions is strongly influenced by the same phonological effect, which we tried to eliminate by creating the control condition in the first place. So far, with the current state of research, we are not completely sure how big an impact phonology and morphology play in the generation of the difference between morphological and non-morphological conditions.

Interestingly enough, the differences between individual conditions were identical in each language group, with the morphological condition taking most time, followed by the control condition and the non-morphological one. The fact that all language groups performed similarly and that there was not much difference between the reaction times of individual language groups is striking since the C1 group consisted mostly of trained linguists. The results are even more intriguing because they show that second language learners (and also non-proficient L2 speakers) performed similarly (and with the same difference between the three conditions) to the monolingual speakers tested in Cilibrasi (2015). The results are presented visually in Figure 4.14.

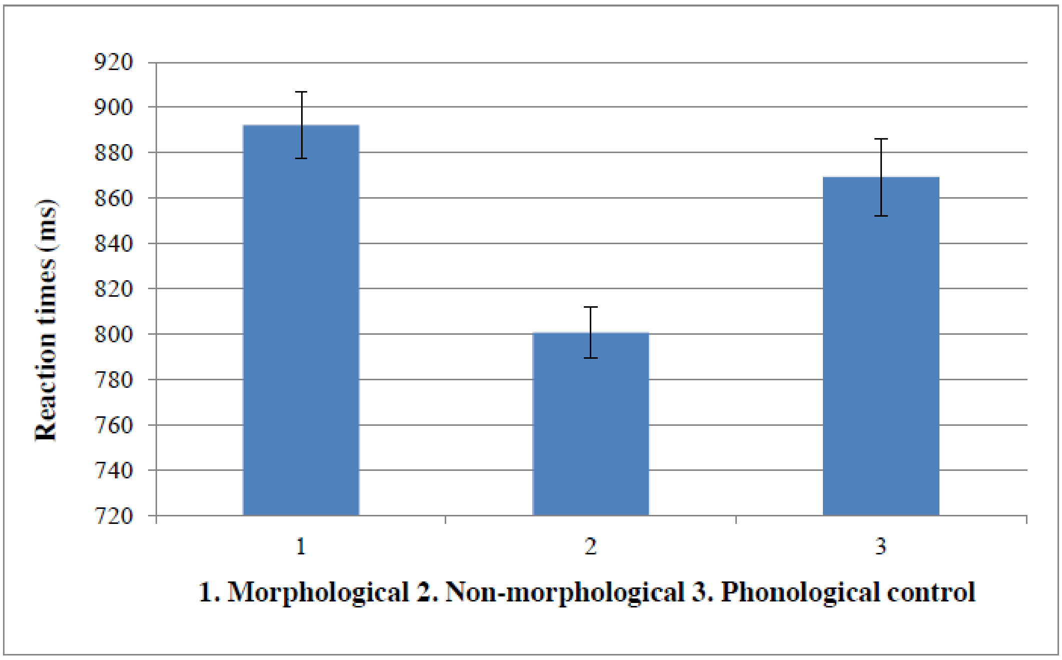

Figure 4.14 Reaction times needed for the discrimination of morphological, non-morphological and control conditions in native speakers (Cilibrasi, 2015)

Interestingly, English proficiency did not generate any interaction: Participants with an intermediate command of English showed a pattern of performance comparable to that of upper-intermediate and advanced students. However, it should be noted that even if the pattern observed at the B1 level is identical to the one observed at the B2 and C2 levels (with morphosyntactic non-words taking longer), participants with lower proficiency took a marginally larger amount of time to perform to the task overall. Even though p-value in the ANOVA test was not significant, it is nonetheless interesting to notice the B2 group was the quickest in the discrimination of stimuli, followed by the C1 level and the B1 level (see Figure 4.4). This distribution is found also in the mean item-based reaction times of the three language levels, as well as in the accuracy and non-verbal working memory results (in both tests the B2 level gained highest scores). From the psycholinguistic point of view, there is no precise explanation for this distribution.

This result suggests that second language learners of English having Czech as L1 behave in the same way as monolingual speakers when processing inflectional bound morphemes in English. The fact that the pattern observed at the B1, B2 and C1 levels is the same is of crucial importance: it suggests that the strategy (the morpheme stripping processes and phonological stem analysis) used during perception is the same from a relatively early language level in the process of language learning. This may be explained by the explicitness of regular verb inflection in English teaching since such phenomena as the addition of *-s* in present simple in the third person singular is taught already at the A1 level. Another explanation is closely tight to the inflectional richness of Czech and the consequent high morphological awareness of Czech native speakers. As stated already in the theoretical chapter, Czech children learn inflections very early on since their addition to the word stem is essential for the overall meaning and sentence structure (with no fixed word order in Czech as opposed to English). Czech speakers may thus be already used to paying close attention to word endings, be it in Czech or English, and this could have been projected to the results of our experiment. This strategy is used implicitly by all subjects, since participants were not aware of what they were being tested on, so they could not apply rules that they learnt in class. Further, due to the speed of the task, it is unlikely for the effect observed to be a consequence of internal reflection, and it is more likely for this effect to be a consequence of automatic unconscious processing.

For the item-based correlations, Cilibrasi (2015) used a software developed by Moreland (2011) to calculate positional segment frequency and positional biphone frequency for each non-word. Positional segment frequency measures how often a specific phoneme appears in a specific position in the corpus. It treats positions in a purely ordinal way, i.e. with no relation to the syllabic structure. Cilibrasi (2015) uses an example of *stop* and *atrium* to show that according to PSF, the phoneme /t/ appears in the second position in the word in both cases. However, when we consider their syllabic structures, in *stop* /t/ is the second consonant of a syllable initial onset cluster, while in *atrium* /t/ is the first consonant of a cluster in a non-initial syllable (Cilibrasi, 2015). Moreland (2011) states, there is evidence that phoneme processing depends on syllabic rules rather than ordinal rules, meaning that we process phonemes as syllable parts, not autonomously. However, our results show that PSF was a significantly predictive measure in all language levels and that all of our PSFs significantly correlate with item-based reaction times. This clearly shows the effect of lexical frequencies in the sublexicon. Thus, it seems that there might be some frequency effects (as proposed by the atomist theory) that run parallel to the morpheme stripping hypothesis (as proposed by the decompositional theory) and that might be similarly effective in predicting reaction times recorded in this task.

In summary, in this experiment we showed that participants are generally quicker in discriminating non-words with no morphological information than in discriminating non-words with potential morphological information. The data make it evident that the morpheme stripping is not blind but synergic to the phonological analysis of the stem. We also showed that all three language groups performed similarly, with no significant difference and identically to native speakers of English. Overall, our data suggest that a form of morpheme stripping is taking place, from which we assume that inflected forms are decomposed into stems and affixes (as outlined by Pinker & Ullman, 2002a). The fact that these effects apply also to non-words suggests that what Grainger and Ziegler (2011) proposed for reading, i.e. that morphemes can be detected sublexically, may be as well extended to speech perception. Interestingly enough, the presence of some frequency effects with sublexical items suggests that a form of whole-form processing may be active as well (as proposed for instance by Bertram et al., 2000). The results thus suggest that morpheme stripping is not the only predictor of the reaction times. Cilibrasi (2015) proposes the idea that there may be a redundant system in our mind, in which morpheme stripping co-exists with whole-form processing in speech perception, and which may accommodate our data and previous data available.

5. CONCLUSION

The aim of this project was to investigate word-ending perception of sublexical items in second-language learners of English with Czech as their L1. It is widely and cross-linguistically observed that word-final positions are, contrary to word beginnings, prone to different phenomena, and their saliency depends on the presence or the absence of morphosyntactic information. Their tendency to reduction or even deletion (Harris, 2011) is usually blocked when morphological information is present (Pater, 2006). So far, main attention has been paid to word-position effects in the lexicon and only partial attention to such effects in the sublexicon (i.e. at a level of representation in which meaning is not activated). This project was designed to address this problem by extending Cilibrasi's PhD thesis (2015) to second language learners of English with rich L1 (in this case Czech), and by analysing their perception of bound inflectional morphemes.

As a reference model for speech perception, we used the information processing model of speech perception and production by Ramus et al. (2010; see Figure 1.1). Differently from other models, this model embraces not only perception but also input sublexical representation. It is also the model used as a reference point in Cilibrasi (2015). Cilibrasi (2015) builds on the idea proposed by Grainger and Ziegler (2011) that inflectional morphemes can be detected sublexically. His thesis focuses on the study of accuracy and reaction times in the discrimination of elements in morphosyntactic minimal pairs at the sublexical level. He asks if the presence of potential morphosyntactic features is detected and processed differently by subjects when using sublexical items. He tested 20 adult native speakers of English using non-words and came to the conclusion that it takes longer to discriminate elements that may carry morphosyntactic information, and that at the sublexical level, word-final positions are therefore only optionally salient (based on the presence or absence of potential morphosyntactic information) (Cilibrasi, 2015).

Focusing our attention on regular verb inflection, bound inflectional morphemes and their perception at the sublexical level, we inevitably had to approach the question of inflection storage in the mental lexicon. We proceeded from the theoretical debate of whether regular inflected verbs are stored as units (atomist theory; e.g. Stemberger & MacWhinney, 1988; Bertram et al., 2000; Tomasello, 2006) or whether they are decomposed into stems and affixes during perception (decompositional theory of morpheme stripping; e.g. Pinker & Ullman, 2002a; Berko, 1958; Guasti, 2004). The aim of this project was to find evidence either for the separation or for the unification of stems and affixes in the processing of sublexical items containing bound morphemes, and both sides of the debate were approached with equal probability.

Cilibrasi has shown that monolingual English speakers are sensible to the presence of bound morphology in non-words, which means that they are sensible to morpho-syntactic properties of the words also in the absence of semantics (Cilibrasi, 2015). Our research aimed to develop this idea and pay attention to second-language learners of English and their perception of word endings. Considering the mismatch in inflectional richness between Czech and English, we assumed two possible outcomes: (i) Czech speakers may not perform morpheme stripping to inflected non-words until proficient, or (ii) given the inflectional richness of Czech, Czech students may have better awareness of the morphological processes that are productive in their language (Ku & Andersson, 2003) and prefer morphological decomposition in L2 learning.

The hypotheses were based on the analysis of the linguistic and psycholinguistic literature available on lexical word-position effects, combined with the results of Cilibrasi's study (2015) of the same phenomena in native speakers of English. Our main hypothesis was that word endings will be optionally salient based on the presence/absence of potential morphosyntactic information. We also expected reaction times to reflect the presence of bound morphology, with non-words containing bound morphology taking longer to be discriminated. Further, we expected proficiency in English to be a co-predictor of reaction times, with proficient speakers showing a larger (native-like) effect of morphology. As to the two theoretical approaches to bound inflection storage, our prediction was that (i) if the anatomist theory was applicable, reaction times would be predicted by phonotactic probabilities, and (ii) if decompositional theory was applicable, reaction times would be predicted by the presence of potential morphological information.

The hypotheses were tested using a carefully-designed experiment, which consisted in the discrimination of minimal pairs differing only in one phonological unit. Given that the focus of this thesis was the sublexicon, the task was run using non-words designed to fall into three different conditions (non-words with potential morphosyntactic information, non-words without morphosyntactic information, and a control condition). Three different language groups (B1, B2 and C1 levels) were tested with a minimal pairs discrimination task measuring reaction times and accuracy. Interestingly, both hypotheses were confirmed. Hypothesis (i) was confirmed by the item-based reaction times analysis and correlations with the PSF and BSF. The reaction times obtained for each item significantly correlated with the phonotactic probabilities of that specific item. Hypothesis (ii) was confirmed by the analysis of the subjects' reaction times to the three conditions. The main hypothesis of the optional salience of word endings was confirmed as well. Overall, the discrimination of elements carrying potential morphological information took longer in terms of reaction times than the discrimination of elements without morphology.

5.1 Findings consistent with our hypotheses

Our data confirmed that word endings are optionally salient based on the presence or absence of potential morphosyntactic information. The reaction times reflected the presence of bound morphology, with non-words containing bound morphology taking longer to be discriminated in all language levels. The evidence for higher complexity in morphological word endings is in line with a number of theoretical linguistics and cross-linguistic analyses (e.g. Pater, 2006 or Harris, 2011) and also with the results obtained by Cilibrasi (2015) in his PhD thesis. This suggests that what Grainger and Ziegler (2011) proposed for reading is likely to apply to speech perception as well. In their connectionist model of reading, Grainger and Ziegler (2011) suggest that bound morphemes (such as *-ed* or *-s* in English) may be detected by readers before the word is actually accessed. They suggest the existence of "a fine-grained parser" who detects grapheme chunks representing morphological information. Our analysis of speech perception suggests that the participants use the strategy of morpheme stripping and phonological stem analysis implicitly from a relatively early language level in the process of language learning as a consequence of automatic unconscious processing.

Our data also confirmed our second hypothesis, i.e. the influence of phonotactic probabilities on reaction times. PSF was a significantly predictive measure in all language levels and significantly correlated with item-based reaction times. This clearly showed the effect of lexical frequencies in the sublexicon. It seems that there might be some frequency effects running parallel to the morpheme stripping that might be similarly effective in predicting reaction times recorded in this task.

5.2 Findings not consistent with our hypotheses

Contrary to our hypothesis of proficiency, the differences between individual conditions were identical in each language group. All language groups performed similarly and there was not much difference between the reaction times of individual language groups. This fact is all the more striking since the C1 group consisted mostly of trained linguists. The results are even more intriguing because they show that our second language learners performed similarly to the monolingual speakers tested in Cilibrasi (2015). It is thus evident that English proficiency did not generate any interaction since the participants with an intermediate command of English showed a pattern of performance comparable to that of upper-intermediate and advanced students. However, it should be noted that even if the pattern observed at the B1 level is identical to the one observed at the B2 and C2 levels (with morphosyntactic non-words taking longer), participants with lower proficiency took a marginally larger amount of time to perform to the task overall.

This result suggests that second language learners of English having Czech as L1 behave in the same way as monolingual speakers when processing inflectional bound morphemes in English and that the strategy used during perception is the same from a relatively early language level in the process of language learning. In the discussion, we have offered two explanations for this outcome: (i) the explicitness of English teaching and (ii) the inflectional richness of Czech and the consequent high morphological awareness of Czech native speakers. This strategy is used implicitly by all subjects and is likely to be a consequence of automatic unconscious processing.

5.3 Final reflections

With this experiment, we have confirmed that even for second-language learners word-ending effects apply sublexically and that word endings are optionally salient (the optional sublexical salience of word endings for native speakers of English was noted by Cilibrasi, 2015). Our results suggest that morpheme stripping applies sublexically, with no activation of the lexicon or the lexical meaning. Our data contribute to the constant debate of anatomist or decompositional storage, suggesting that certain rule-like processes take place sublexically and that they are accompanied by some frequency effects. The results thus show that morpheme stripping can operate in a separate fashion from the lexicon, but also that some forms may be stored as units. As Cilibrasi (2015) suggests, if a large number of forms are not derived with a sublexical rule but rather stored in their inflected form, it may be argued that both theories are valid since the system is redundant.

5.4 Further research

It would be interesting to see if the same pattern of word-ending perception can be perceived also at lower levels of English. For this purpose, it would be good to recruit A1- and A2-level students of English and test them with the same experiment. This would give us an opportunity to see whether the strategy of morpheme stripping and stem analysis is being used from the very beginnings of L2 learning or not.

Further, we could attempt recruiting students of various English levels with an L1 that is significantly poorer in terms of inflectional richness than Czech. This would give us the chance to see if the perception pattern is the same as for the Czech students and native speakers of English or if this group of students differs. We could thus potentially speculate about the influence of inflectional richness of Czech on the present experiment.

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RÉSUMÉ

Cílem této práce bylo prozkoumat vnímání konců sublexikálních jednotek u studentů angličtiny jako druhého jazyka, jejichž mateřským jazykem je čeština. Je známým a mezijazykově uznávaným poznatkem, že konce slov, v porovnání se začátky slov, mají sklony k odlišným jevům a jejich významnost závisí na přítomnosti či nepřítomnosti morfosyntaktické informace. Jejich tendence ke krácení či úplnému vynechání (Harris, 2011) je většinou blokována, pokud je přítomna morfologická informace (Pater, 2006). Doposud se většina pozornosti koncentrovala na efekty slovních pozic v lexikonu a už se jí tolik nedostávalo těmto efektům v sublexikonu (tj. úrovni reprezentace, v níž nedochází k aktivaci významu). Tato práce je navržena tak, aby se tomuto problému aktivně věnovala a rozšířila disertační práci Lucy Cilibrasiho (2015) o údaje o studentech angličtiny, jejichž mateřštinou je flektivně bohatý jazyk (v tomto případě čeština), a o jejich vnímání vázaných ohebných morfémů.

Jako referenční model řečové percepce nám posloužil model Ramuse et al. (2010) na zpracování informací z řečové percepce a produkce. Na rozdíl od jiných modelů je do tohoto modelu zahrnuta nejen percepce, ale i vstupní sublexikální reprezentace. Tento referenční model využívá ve své disertační práci i Cilibrasi (2015). Ten navazuje na myšlenku Graingera a Zieglera (2010) o tom, že ohebné morfémy mohou být zaznamenávány sublexikálně. Cilibrasiho práce se zaměřuje na studii přesnosti a reakčních časů v rozpoznávání prvků morfosyntaktických minimálních dvojic na sublexikální úrovni. Pokládá si zde otázku, zda je přítomnost potenciálních morfosyntaktických informací subjekty zaznamenávána a zpracovávána odlišněji, pokud použije sublexikální jednotky. Otestoval proto neslovy 20 dospělých rodilých mluvčí angličtiny a došel k závěru, že rozpoznání neslov s potenciální morfosyntaktickou informací trvá déle, a že konce slov jsou na sublexikální úrovni tedy také

jen příležitostně významné (v závislosti na přítomnosti či nepřítomnosti potenciální morfosyntaktické informace) (Cilibrasi, 2015).

V naší práci jsme se zaměřili na pravidelnou slovesnou flexi, vázané ohebné morfémy a jejich vnímání na sublexikální rovině, nevyhnutelně jsme se tedy museli věnovat i otázce úložiště ohebných tvarů v mentálním lexikonu. Vycházeli jsme z teoretické debaty, zda se pravidelné flektivní konce sloves ukládají jako celé jednotky (což odpovídá anatomistické teorii zastoupené např. Stembergerem & MacWhinneym, 1988; Bertramem et al., 2000; Tomasellem, 2006) či zda se během percepce rozkládají slovesa na kmeny a afixy (což odpovídá rozkladové teorii morfologického rozkládání zastoupené např. Pinkerem & Ullmanem, 2002a; Berkem, 1958; Guasti, 2004). Cílem tohoto projektu bylo najít podklady buď pro rozklad, nebo sjednocování kmene a afixů během zpracovávání sublexikálních jednotek s vázanými morfémy, a k oběma pólům teto debaty bylo přistupováno se stejnou pravděpodobností.

Cilibrasi ve své práci dokázal, že monolingvní mluvčí angličtiny jsou citliví na přítomnost vázaných morfému v neslovech, což znamená, že jsou citliví na morfosyntaktické vlastnosti slov bez přítomnosti sémantiky (Cilibrasi, 2015). Náš výzkum měl za cíl rozvést tuto myšlenku a věnovat pozornost studentům angličtiny a jejich vnímání konců slov. Přihlédneme-li k nesouladu ve flektivní bohatosti češtiny a angličtiny, předpokládali jsme dva možné závěry: (i) čeští mluvčí nemusí být schopní morfemického rozkladu flektivních neslov, dokud nejsou v angličtině dosti pokročilí, (ii) vzhledem k flektivní bohatosti češtiny mohou mít čeští studenti větší povědomí o morfologických procesech, které jsou produktivní v jejich rodném jazyce (Ku & Andersson, 2003), a v angličtině tak upřednostňovat morfologický rozklad.

Naše hypotézy se zakládaly na studiu lingvistické a psycholingvistické literatury, které byla na dané téma dostupná, a také na výsledcích Cilibrasiho studie (2015) stejného fenoménu u rodilých mluvčí angličtiny. Naší hlavní hypotézou bylo, že konce slov budou příležitostně významné v závislosti na ne/přítomnosti potenciální morfosyntaktické informace. Očekávali jsme také, že reakční časy budou odrážet přítomnost vázaných morfémů tak, že rozpoznání neslov s vázaným morfémem bude trvat déle. Dále jsme očekávali, že pokročilost v angličtině bude spolu-ukazatelem reakčních časů a že pokročilejší studenti budou blíže rodilým mluvčím. Co se týče dvou zmíněných teoretických přístupů k ukládání vázáné flekce, náš předpoklad byl, že (i) pokud je anatomistická teorie pravdivá, reakční časy budou závislé na fonotaktických pravděpodobnostech, a (ii) pokud je pravdivá rozkladová teorie, reakční časy budou záviset na přítomnosti potenciální morfosyntaktické informace.

Tyto hypotézy jsme testovali pomocí pečlivě navrženého experimentu, který se skládal z rozpoznávání minimálních dvojic, které se lišily jen v jedné fonologické jednotce. Jelikož se tato práce zaměřuje na sublexikon, při experimentu byly použity neslova se třemi podmínkami (neslova s potenciální morfosyntaktickou informací, neslova bez morfosyntaktické informace a kontrolní skupina). Testovaly se tři jazykové úrovně (B1, B2 a C1) pomocí úlohy zaměřené na rozpoznávání minimálních dvojic, u níž se měřily reakční časy a přesnost. Obě hypotézy se překvapivě potvrdily. Hypotézu (i) jsme potvrdili analýzou reakčních časů na jednotlivá neslova a korelací s poziční segmentovou frekvencí a dvoufónovou segmentovou frekvencí. Reakční časy získané z každého neslova významně korelovaly s fonotaktickými pravděpodobnostmi jednotlivých neslov. Hypotéza (ii) se potvrdila analýzou reakčních časů subjektů na tři podmínky. Potvrdila se nám i hlavní hypotéza o příležitostné významnosti konců slov. Studentům trvalo celkově déle rozpoznat dvojice neslov s potenciální morfologickou informací než těch bez ní.

Výsledky shodné s našimi hypotézami

Naše data potvrdila, že konce slov jsou příležitostně významné v závislosti na přítomnosti či nepřítomnosti morfosyntaktické informace. Reakční časy odrážely přítomnost vázaných morfémů tak, že reakce na neslova s vázanými morfémy trvala všem jazykovým úrovním déle. Důkaz o vyšší zatíženosti morfologických konců slov odpovídá řadě lingvistických a mezijazykových analýz (např. Pater, 2006 nebo Harris, 2011) a taky výsledkům Cilibrasiho studie (2015). Tato skutečnost naznačuje, že Graingerův a Zieglerův (2011) návrh ohledně zpracovávání čtení je pravděpodobně aplikovatelný i na řečovou percepci. Ve svém souvislostním modelu čtení naznačují, že vázané morfémy (v angličtině např. *-ed* nebo *-s*) dokáží čtenáři rozpoznat, ještě než vyhodnotí celé slovo. Přicházejí s existencí citlivého čtenáře, který dokáže rozpoznat grafemické části slova, jež reprezentují morfologickou informaci. Naše analýza řečové percepce naznačuje, že studenti angličtiny používají během procesu učení jazyka strategii morfologického rozkladu a fonologické analýzy slovního kmene implicitně již od nízké úrovně jazykové pokročilosti jako výsledek automatického nevědomého zpracovávání řeči.

Naše data potvrdila také druhou hypotézu, tedy vliv fonotaktických pravděpodobností na reakční časy. Poziční segmentová frekvence byla významným předpovědním prvkem a významně korelovala s reakčními časy neslov. Tato skutečnost jasně prokázala efekt lexikálních frekvencí v sublexikonu. Zdá se, že k morfologickému rozkladu se zároveň přidávají i některé frekvenční efekty, které mohou mít na předpoklad reakčních časů obdobný vliv.

Výsledky odlišné od našich hypotéz

V rozporu s našimi hypotézami o jazykové pokročilosti byly rozdíly mezi jednotlivými podmínkami na každé jazykové úrovni stejné. Všechny jazykové skupiny podaly podobný výkon a mezi reakčními časy jednotlivých skupin nebyl přílišný rozdíl. Tento fakt je o to pozoruhodnější, že úroveň C1 se skládala převážně z trénovaných lingvistů. Výsledky jsou zajímavé i tím, že ukazují, že studenti angličtiny dosahovali podobných výsledků jako monolingvní mluvčí testovaní Cilibrasim (2015). Je tedy zřejmé, že jazyková pokročilost nehrála žádnou roli, jelikož subjekty s mírně pokročilou angličtinou dosahovali podobných výsledků jako studenti pokročilí a vysoce pokročilí. Měli bychom ale připomenout, že i když je situace u skupiny B1 identická s tou u skupin B2 a C2 (tj. že morfosyntaktická neslova jsou rozpoznávána déle), subjektům s nižší pokročilostí jazyka trvala úloha celkově o trochu déle.

Tento výsledek naznačuje, že studenti angličtiny s českým mateřským jazykem zpracovávají anglické vázané morfémy obdobně jako monolingvní mluvčí a tato strategie je stejná od relativně nízké jazykové úrovně. V práci jsme nabídli dvě možná vysvětlení: (i) explicitní styl výuky angličtiny a (ii) flektivní bohatost češtiny a následně vysoké morfologické povědomí rodilých mluvčí češtiny. Tato strategie je všemi subjekty používána implicitně a pravděpodobně bude výsledkem automatického nevědomého zpracovávání řeči.

Závěrečné úvahy

Tímto experimentem jsme potvrdili, že efekty konců slov platí sublexikálně i pro studenty angličtiny a že konce slov jsou příležitostně významné (tuto problematiku u rodilých mluvčí angličtiny zkoumal Cilibrasi, 2015). Naše výsledky naznačují, že k morfologickému rozkladu dochází v sublexikální rovině bez aktivace lexikonu či lexikálního významu. Naše data přispívají k debatě mezi anatomistickým a rozkladovým ukládáním flektivních konců slov a naznačují, že v sublexikonu se mohou odehrávat některé procesy založené na pravidlech a že je doprovází některé frekvenční efekty. Naše výsledky tak dokazují, že morfologický rozklad může fungovat bez lexikonu, ale že některé formy se mohou ukládat jako jednotky. Cilibrasi (2015) naznačuje, že pokud by se velké množství forem ukládalo jako celek bez odvozování sublexikálního pravidla, mohli bychom argumentovat tím, že obě teorie jsou platné, jelikož jejich systém je redundantní.

Další možnosti výzkumu

Bylo by zajímavé podívat se, jestli se stejný vzorce vnímání konců slov objevuje i u nižších úrovní angličtiny. Pro tyto účely bychom mohli sehnat studenty angličtiny na úrovni A1 a A2 a provést s nimi stejný experiment. To by nám dalo příležitost zjistit, jestli se strategie morfologického rozkladu a analýzy kmene používá již od úplných počátků studia druhého jazyka či nikoli.

Mohli bychom také zkusit sehnat studenty s různorodými úrovněmi angličtiny, jejichž rodným jazykem ale bude jazyk flektivně méně bohatý než čeština. Tím bychom mohli zkoumat to, jestli jsou pro ně percepční vzorce stejné jako pro české studenty a rodilé mluvčí nebo jestli se od těchto skupin liší. Mohli bychom pak potenciálně spekulovat o vlivu flektivní bohatosti češtiny na předkládaný experiment.

APPENDIX

Table 7.1 Non-words used in the experiment (from Cilibrasi, 2015)

Stem number	Morpho	Morpho	Non-morpho	Non-morpho	Control	Control
1	1 vɪld	2 vɪlz	41 vɪlt	42 vɪls	81 vɪlb	82 vɪlm
2	3 vɛld	4 vɛlz	43 vɛlt	44 vɛls	83 vɛlb	84 vɛlm
3	5 væld	6 vælz	45 vælt	46 væls	85 vælb	86 vælm
4	7 vɔld	8 vɔlz	47 vɔlt	48 vɔls	87 vɔlb	88 vɔlm
5	9 vʌld	10 vʌlz	49 vʌlt	50 vʌls	89 vʌlb	90 vʌlm
6	11 nɪld	12 nɪlz	51 nɪlt	52 nɪls	91 nɪlb	92 nɪlm
7	13 naɪld	14 naɪlz	53 naɪlt	54 naɪls	93 naɪlb	94 naɪlm
8	15 næld	16 nælz	55 nælt	56 næls	95 nælb	96 nælm
9	17 nɔld	18 nɔlz	57 nɔlt	58 nɔls	97 nɔlb	98 nɔlm
10	19 nʌld	20 nʌlz	59 nʌlt	60 nʌls	99 nʌlb	100 nʌlm
11	21 θɪld	22 θɪlz	61 θɪlt	62 θɪls	101 θɪlb	102 θɪlm
12	23 θaɪld	24 θaɪlz	63 θaɪlt	64 θaɪls	103 θaɪlb	104 θaɪlm
13	25 θæld	26 θælz	65 θælt	66 θæls	105 θælb	106 θælm
14	27 θɔld	28 θɔlz	67 θɔlt	68 θɔls	107 θɔlb	108 θɔlm
15	29 θʌld	30 θʌlz	69 θʌlt	70 θʌls	109 θʌlb	110 θʌlm
16	31 dʒɑld	32 dʒɑlz	71 dʒɑlt	72 dʒɑls	111 dʒɑlb	112 dʒɑlm
17	33 dʒaɪld	34 dʒaɪlz	73 dʒaɪlt	74 dʒaɪls	113 dʒaɪlb	114 dʒaɪlm
18	35 dʒæld	36 dʒælz	75 dʒælt	76 dʒæls	115 dʒælb	116 dʒælm
19	37 dʒɔld	38 dʒɔlz	77 dʒɔlt	78 dʒɔls	117 dʒɔlb	118 dʒɔlm
20	39 dʒʌld	40 dʒʌlz	79 dʒʌlt	80 dʒʌls	119 dʒʌlb	120 dʒʌlm

Table 7.2 PSF and BSF values used in the experiment (from Cilibrasi, 2015)

Klattese transcription	Positional segment frequency (PSF)	Biphone segment frequency (BSF)
v@lz	1,2044	1,013
vclz	1,1811	1,0124
vIlz	1,1876	1,0113
vElz	1,1247	1,0039
v@lz	1,2044	1,013
vclz	1,1811	1,0124
nclz	1,1876	1,0113
n^lz	1,1247	1,0039
TIlz	1,1261	1,004

TYlz	1,1488	1,0062
JYlz	1,1887	1,0102
J@lz	1,1268	1,0031
Jclz	1,1338	1,0032
J^lz	1,1789	1,0099
T@lz	1,116	1,0039
Tclz	1,1387	1,0062
T^lz	1,172	1,009
Jalz	1,109	1,0039
vIls	1,1317	1,0052
vEls	1,16	1,0072
v@ls	1,2424	1,0146
vcls	1,219	1,014
vIls	1,2256	1,0129
vEls	1,1627	1,0054
v@ls	1,2424	1,0146
vcls	1,219	1,014
ncls	1,2256	1,0129
n^ls	1,1627	1,0054
TIls	1,1641	1,0055
TYls	1,1868	1,0077
JYls	1,2267	1,0118
J@ls	1,1648	1,0046
Jcls	1,1718	1,0048
J^ls	1,2169	1,0115
T@ls	1,154	1,0054
Tcls	1,1767	1,0077
T^ls	1,21	1,0106
Jals	1,147	1,0055
vIlm	1,1697	1,0067
vElm	1,198	1,0088
v@lm	1,2218	1,0139
vclm	1,1985	1,0132
vIlm	1,205	1,0121
vElm	1,1421	1,0047
v@lm	1,2218	1,0139
vclm	1,1985	1,0132
nclm	1,205	1,0121
n^lm	1,1421	1,0047

TIlm	1,1435	1,0048
TYlm	1,1662	1,007
T@lm	1,2062	1,011
Tclm	1,1442	1,0039
T^lm	1,1894	1,0098
Jalm	1,1265	1,0047
JYlm	1,1492	1,006
J@lm	1,1775	1,008
Jclm	1,1512	1,004
J^lm	1,1964	1,0107
v@lz	1,1334	1,0047
vclz	1,1562	1,007