

**Univerzita Karlova v Praze
Fakulta humanitních studií**

Bakalářská práce

**Grammatical case interference in Czech
spoken word production**

Interference gramatických pádů při produkci českých slov

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podpis

Poděkování

Na tomto místě bych rád poděkoval svému vedoucímu PhDr. Filipu Smolíkovi, PhD za návrh experimentu, dohled a rady ve všech krocích při jeho přípravě, sběru dat, zpracování výsledků a nakonec i sepsání této práce a za přístup, který mne celou dobu inspiroval.

Také bych rád poděkoval Laboratoři behaviorálních a lingvistických studií za to, že poskytla možnost provést experiment na její zázemí a zajistila i participanty.

Abstrakt

Modely řečové produkce se mimo jiné liší v popisu procesů selekce gramatických rysů slov. Podle jedné z představ (Bordag & Pechmann 2009) je selekce vnitřních gramatických rysů slova (*intrinsic grammatical features*) kompetitivní proces, tj. různé hodnoty soupeří o aktivaci, zatímco selekce vnějších gramatických rysů slova (*extrinsic grammatical features*) kompetitivní není. Tato práce si klade za cíl nahlédnout do selekce jednoho z vnějších gramatických rysů, který se zatím nezkoumal – gramatického pádu, a to na příkladu češtiny. V experimentální úloze účastníci měli za úkol pojmenovat obrázek v určitém gramatickém pádu a při tom ignorovat současně prezentované psané slovo buď ve stejném nebo v odlišném gramatickém pádu. Sledovali jsme, jestli bude docházet k interferenci zapříčiněné odlišností v gramatických pádech. Srovnání reakčních časů v různých podmínkách neodhalilo žádné statisticky signifikantní rozdíly, což je v souladu s výše popsanou představou. Nicméně, tyto výsledky nemůžeme považovat za dost důvěryhodné, protože rozdíly nebyly statisticky významné ani ve srovnání s kontrolními podmínkami, u kterých jsme očekávali, že reakční časy budou odlišné.

Klíčová slova: produkce řeči, gramatické pády, morfologické kódování, čeština

Abstract

Spoken word production models differ in their description of the processes of a word's grammatical feature selection. According to one of the accounts (Bordag & Pechmann 2009), the selection of the intrinsic grammatical features of a word is a competitive process whereas the selection of its extrinsic grammatical features is not. The present paper aims at shedding some light on the selection of an extrinsic grammatical feature that has not been studied so far – grammatical case. A picture-word interference experiment was conducted to investigate whether there will be interference in grammatical case selection in highly inflected Czech. Participants were asked to produce an inflected form of the name of a picture while ignoring simultaneously presented distractor words that were either in the same grammatical case or in a different one. Results showed no significant difference in naming latencies as is predicted by the above-mentioned account. However, the results can not be fully trusted since the difference were not significant in the case of the control conditions either suggesting a problem with the experiment.

Keywords: speech production, grammatical case, morphological encoding, Czech

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Introduction

Among other aspects of language processing, the field of psycholinguistics tries to understand speech production. Vast amounts of research during the last several decades aimed at establishing a model of spoken word production that would represent this process as close to reality as possible. The basic question the research aims to answer is *how do we generate spoken words?* Owing to the origin and the places of work of researchers working on spoken word production, the models they postulate are mainly designed to account for speech production in Germanic and Romance languages. There was not much investigation of some phenomena that do not occur in these language groups, but may be fairly spread in others. The present paper, and the reported experiment, aimed at investigating one of such omitted phenomena – grammatical case inflection of nouns. Using the example of Czech, one of the highly inflected Slavic languages, I looked for a possible place of the grammatical case selection in spoken word production models and conducted an experiment to see whether there is any competition for selection of this feature.

The paper is structured as follows. First, I discuss two prominent spoken word production models in general and their possible implementation in grammatical case selection in noun production in Czech. Second, I report my own experiment on grammatical case interference. In the final discussion section I attempt to clarify why the results obtained in the experiment cannot be decisive with regard to the effect I was looking for and give some suggestions for the improvement of the experiment setting and future research on this topic.

Models of spoken word production and grammatical case selection

Spoken word production: what is it, why and how is it studied

First, it is necessary to make clear what exactly is meant by *spoken word production*. Words are usually produced as parts of larger utterances. Each such utterance is meant to convey a certain message and this message is composed of the meanings of each word and the way they are combined together and articulated. Spoken word production models try to explain the process going on in our mind starting from the point where we choose a lexical concept that is supposed to play a role in conveying a certain meaning, and ending by articulation of the corresponding word.

What fascinates researchers in word production is how quick and accurate it is. It is estimated that an English-speaking adult person produces 2 to 4 words per second in normal fluent conversation (Levelt, 1989). These words are chosen from a “mental lexicon” which is estimated to contain 50 to 100 thousand words (Miller, 1996). Nonetheless, the occurrence of errors is seldom – people make errors only once or twice per 1,000 produced words (Garnham, Shillcock, Brown, Mill & Cutler, 1981). The complexity of the process is imagined better if we take into consideration the fact that all the words have to be retrieved with their syntactic and phonological properties in order

for them to be composed together and articulated in a right way. Knowledge about these processes is clearly crucial for understanding the human language faculty.

There are three traditional ways of investigating spoken word production: analysis of speech errors in normal conversation; of the speech produced by brain-damaged patients and of naming latencies in different kinds of picture- naming tasks (Levelt, 1999). All these methods are behavioural – they reach conclusions about the processes of speech production based on the properties of the output of the “system”. Today neuroimaging methods like positron emission tomography (PET), functional magnetic resonance imaging (fMRI), magnetoencephalography recordings (MEG), etc. are being used for studies of some of the aspects as well (e.g. Indefrey & Levelt 2000, 2004).

In the present state of the field, there are several prominent models of spoken word production with which psycholinguists work. These are *Interactive activation model* by G. Dell (1986), the so-called *Levelt’s model* (Levelt, Roelofs & Meyer 1999) and *Independent network model* by A. Caramazza (1997). The latter two will be discussed further in this paper.

Levelt’s model of spoken word production

In my descriptions of the models, I will try not to give more detail than is necessary for understanding the experiment reported here, but at the same time I will try to outline the whole theory in order for the reader to have an image of the entire supposed process. Since other versions might differ, it is important to note that I base my summary of Levelt’s model on the description given in Levelt, Roelofs & Meyer (1999) (an older version of the model is given in Levelt, 1989).

This model is mainly based on psycholinguistic experimentation where the exact timing of the processes of word production has been studied. Such experiments usually measure naming latencies (also referred to as reaction times, RT). Participants may be presented with a picture and/or a word or words and asked to name the picture, to make decisions about the grammatical features of its name, about the initial and final phonemes, etc. Comparison of naming latencies in different circumstances can reveal some characteristics of the processes going on during speech production. One of the classic methods, the picture-word interference paradigm, is described in detail further in this paper, as it is employed in the experiment reported.

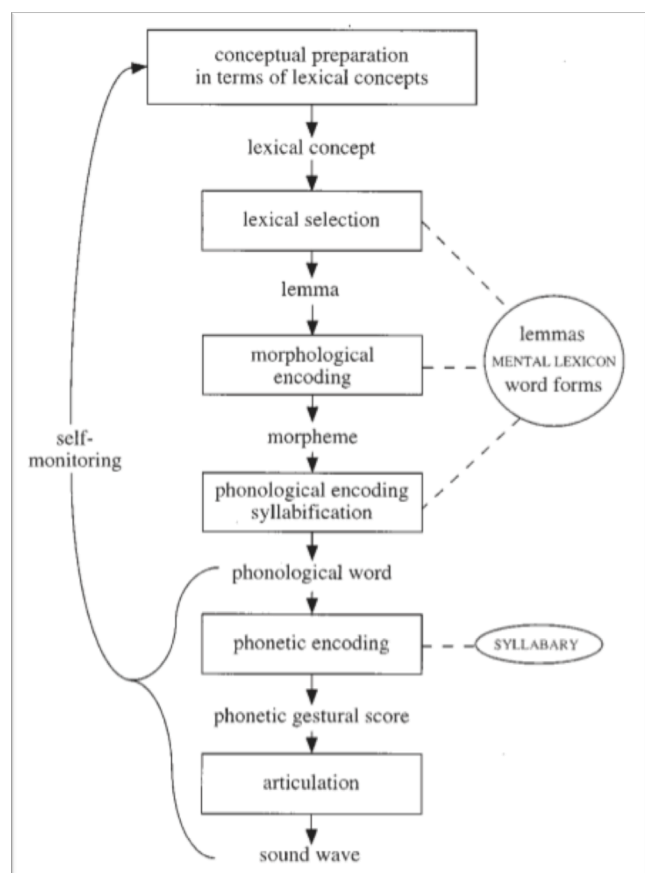
Levelt’s model sees word production as the processes taking place in a speaker’s mind in the following sequence: conceptual preparation, lexical selection, morphological and phonological encoding, phonetic encoding and, finally, articulation. (See Figure 1 for the schematic depiction of the model.) In each of these steps, a certain type of representation is activated. Every stage has a certain output that then serves as an input for the next one.

Word production here starts at the level of conceptual preparation where a speaker decides what meaning is to be expressed. A lexical concept has to exist in a speaker’s mental lexicon in order to be selected. For instance, for an English speaker there is a lexical concept for a meaning of female horse (examples in this paragraph are taken from Levelt et al. 1999) and it can be selected. As a result, the word “mare” shall be produced later. However, in English there is no one word to express, for instance, a meaning of female elephant. In this case two lexical concepts forming a phrase “female elephant” later

will have to be selected. There is no simple answer to the question of how exactly the speaker gets from the meaning which is intended to be expressed to the lexical concept for it. The authors of the theory discuss pragmatic, semantic and other causes of activation of a certain lexical concept (see the original paper for the detailed discussion).

After the speaker has selected the lexical concept, a specific word for it should be selected. In Levelt's model, the word's lemma is selected first. Lemmas represent words; they are specified semantically and syntactically, but not yet phonologically. The lexical concept at

Figure 1. Schematic representation of the stages in Levelt's model of spoken word production. Source: Levelt et al. (1999).



the level of conceptual selection spreads its activation to other lexical concepts and each of them gives some amount of activation to the next level to its respective lemma (each lexical concept can give its activation to one lemma only). The lemma with the highest activation here is selected for further encoding and this will almost always (errors in lexical selection are seldom) be the one for the selected lexical concept, because it had the biggest amount of activation to give.

As soon as the lemma is selected, its syntactic features become available and are then used to build a grammatically correct phrase. For instance, once a verb is selected, the information about its transitivity¹ becomes available. Many lemmas have diacritic parameters that have to be set for each case individually (the word "diacritic" here does not refer to a sign added to a letter like, for instance, an acute accent or a caron used in Czech). Only after all diacritic parameters are set, the word production process can proceed further. In the case

of the lemmas of English verbs, their features for number, person, tense, and mood have to be set as they are inevitable for further encoding. For instance, in the case of the lemma *sleep*, depending on the values of these diacritic features it can be then phonologically realized as *sleep*, *sleeps*, *slept* or *sleeping*. Some of these values are specified on the basis of the conceptual preparation level information – for instance tense, as it is the speaker who decides when the action takes place. Others are set on the basis of syntactic context – for instance the verb's number has to be in agreement with that of its subject – or once the grammatical features of the word are known.

Constant grammatical features for each word like the gender of nouns, the transitivity of verbs and case-dependent features like number and tense are all treated as diacritic

¹ The transitivity of a verb tells us about whether it requires just a subject or both subject and object or a subject and two objects (e.g. John sleeps; Mary bought *chocolate*; Peter gave *a banana to his friend*.)

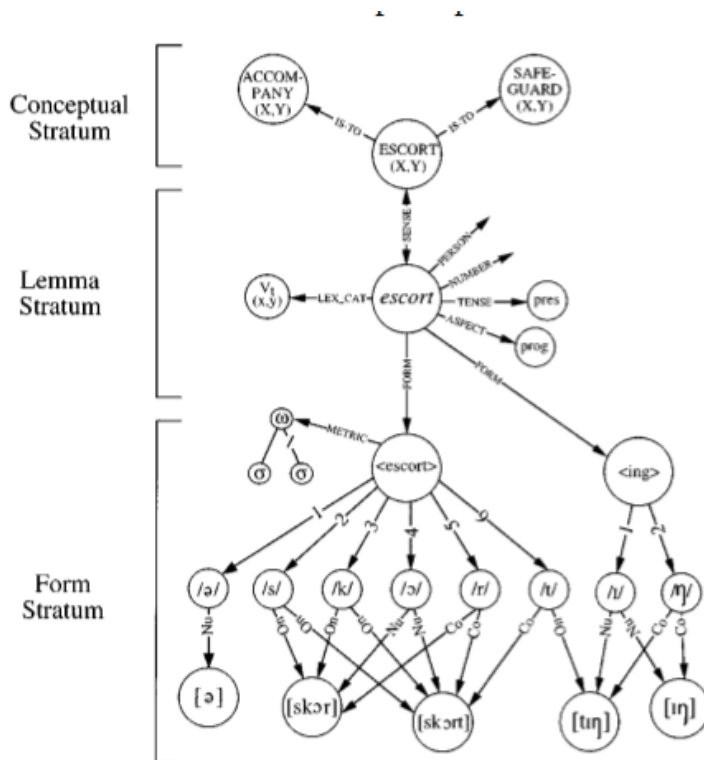


Figure 2. Schematic representation of the processes during the production of the word "escorting" according to Levelt's model. Source: Levelt et al. (1999).

parameters in Levelt's model. We may want to distinguish them however. One of the ways to do it is to distinguish extrinsic and intrinsic grammatical features (Caramazza, 1997). I will discuss this distinction in detail later in this paper.

An output of the lexical selection phase is the selected lemma with all the diacritic parameters set. The speaker's next step is to determine the phonological form of the word. Word form activation involves activation of its morphological structure, features of each morpheme and segmental makeup. For instance, when the speaker intends to say "escorting" (the example is also taken from Levelt et al. 1999), he/she first needs to access morphemes <escort> and <ing>. In the next step each

morpheme's metrical shape is determined – in case of the morpheme <escort> it is, for instance, that it is disyllabic, stress-final and free²; in case of the morpheme <ing> that it is monosyllabic, unstressed and bound. And, finally, the segmental spell-out for <escort> will be /ə/, /s/, /k/, /ɔ/, /r/, /t/, and for <ing> it will be /I/, /ŋ/. An output in this stage is called "phonological word" or "lexeme".

Next step is phonetic encoding where it is determined which articulatory gestures will be used to articulate the word. The word's gestural score is then executed by the articulatory system.

The Independent network model of lexical access

The second model I shall discuss is the *Independent network model of lexical access* by A. Caramazza. It can be taken as a modification of the previous one. My summary of the model is based on Caramazza (1997).

There is an important difference in the data on which Caramazza and Levelt and colleagues base their models. Whereas the Levelt's model is mainly based on the naming latencies in experiments, the Independent network model is based on the analysis of the

² Two types of morphemes are usually distinguished. A free morpheme is one which can appear as a word by itself. For instance, "house" in "houses". A bound morpheme is one which cannot appear as a word by itself – it has to be attached to a root. For instance, "-s" in "houses".

“errors” of aphasic³ patients in naming, reading, and writing tasks. For instance, some brain-damaged patients were observed to have difficulty with the production of the words of a certain grammatical class – they had no problems in producing nouns, but were unable to produce verbs; some had it vice versa; others were able to pronounce a word of

a certain grammatical class but were unable to write it down. Based on such cases, Caramazza concluded that syntactic knowledge is represented independently of both semantic and word form information; the latter, in its turn, is stored independently for different modalities – oral and written.

Thus, the Independent network model assumes the existence of three different independent levels of word representation: syntactic, semantic and phonological (or orthographical) and does not assume the existence of the lemma level between lexical concept selection and phonological encoding (lexeme level). There is an ongoing debate on the necessity of lemma representation (e.g. Caramazza, 1997, Caramazza & Miozzo 1997, Roelofs, Meyer & Levelt, 1998, Caramazza & Miozzo, 1998), but since the experiment

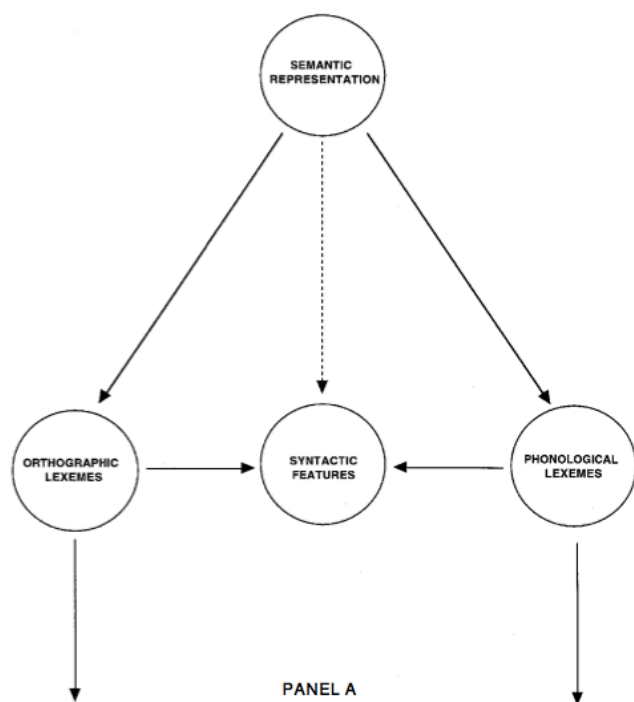


Figure 3. Schematic representation of word production process in the Independent network model of lexical access. Source: Caramazza (1997).

reported here does not require that much detail, I will skip this issue.

Let us have a look at the organisation of lexical access in this model in more detail. As I said, there are networks of word representation that are independent of each other. The lexical-semantic network – using Caramazza’s terminology – represents the meanings of words. The lexical-syntactic network represents their syntactic features – for instance, grammatical category, gender, auxiliary type, tense, etc.

“The nodes in this network are organised in subnetworks corresponding to the different syntactic functions. Thus, there is a subnetwork consisting of category nodes (noun, verb, etc.); one consisting of gender nodes (masculine, feminine etc.); one consisting of auxiliary types (be, have); and so on. Nodes within a subnetwork have inhibitory links since they are in competition.” (Caramazza 1997, p. 194).

Two further modality specific networks contain orthographic and phonological representations (O-Lexemes and P-Lexemes of words correspondingly). Caramazza considers it important to stress the existence of the distinct networks for two different modalities since these two modalities of word production are stored and accessed independently from each other, as evidenced by his patients.

³ Aphasia is an acquired impairment of language production and/or comprehension caused by damage to the brain. There are different types and categorizations of aphasia. Aphasia is usually a result of head injury or stroke or can develop from a brain tumor, infection, or dementia.

During the word production process, a node in the lexical-semantic network is activated first, then it spreads its activation to the lexical-syntactic network and modality-specific network (i.e. the P- and O-networks) simultaneously. The model assumes that some of the syntactic features of the word are activated by the lexical-semantic network (in accordance with Levelt's model). For example, grammatical category or tense are activated by the semantic network, whereas the grammatical gender feature is usually not. Other necessary syntactic features of the word are activated only after one of the modality-specific nodes for it has been selected but not yet the specific phonological or orthographic content of the word. It is possible since the syntactic and modality-specific node activations are parallel processes. And only after the selection of all its grammatical features, the word's specific phonological/orthographic content is activated for further encoding.

There are other aspects in which the Independent network model differs from the Levelt's model, but they are not as important for the present paper.

Inflection of nouns in Czech

Before going further on to the speculations on grammatical case selection according to these models, we need to have a look at some characteristics of noun inflection in Czech.

In general, Czech is a highly inflected language – nouns, adjectives, verbs, most pronouns and numerals are inflected. Nouns always have to appear in one of the grammatical cases. Which exact grammatical case is used depends on the speaker's intended meaning and syntactic context. Since Czech belongs to the free word order language group, inflection plays a significant role in establishing relations between words in the sentences.

There are seven grammatical cases in Czech – nominative, genitive, dative, accusative, vocative, locative and instrumental. The inflection is marked by a suffix added to the end of the noun. One suffix only is added and along with the grammatical case it expresses the information about the gender, number and animacy of the noun. Which exact suffix is needed to form a specific grammatical case is determined by which declensional class the noun belongs to (there are 14-20 declensional classes according to different grammarians) and its number feature (or information about the declensional class can actually be enough if we say that the declensional classes for singular and plural are distinct). Another important characteristic of noun inflection in Czech is that one inflectional suffix may be used to form different or the same grammatical cases in different declensional classes. An overview of declensional classes of nouns in Czech is given in Bordag and Pechmann (2009).

Implications of the models on the grammatical case selection in Czech

Neither of the models makes explicit claims about the grammatical case selection of nouns. However, how and when these processes take place may be deduced from the assumptions which the models make about other grammatical features.

The grammatical case in which the noun shall be produced is determined by the syntactic context and is known prior to the word retrieval. As we saw, grammatical case is expressed in Czech by a morpheme at the end of the word. But the exact morpheme that is

to be used depends on which declensional class the word belongs to and its number feature. Thus, the word's declensional class and number have to be activated along with the grammatical case feature before a specific grammatical case-marking morpheme is selected. Czech nouns always have to appear in a certain grammatical case and, thus, all these features always have to be activated before the further encoding.

The distinction between extrinsic and intrinsic grammatical features is also important for the discussion on the grammatical case selection. Both Bordag and Pechmann (2009) and Schiller and Caramazza (2002), whose studies I discuss here, make such a distinction along with Caramazza (1997). The extrinsic grammatical features of a word depend on the syntactic and concept-level context; can be different in different cases; are specified before the word itself is retrieved and thus would have been applied to any selected lemma/lexeme. These are, for instance, number and grammatical case. The intrinsic features of a word are, on the contrary, constant for each word and may be activated only after the word itself has been activated. These are, for instance, grammatical gender or declensional class. This obvious difference indicates that the extrinsic features might be processed differently and in different time order than the intrinsic features. As I already mentioned, no such distinction is explicitly made in Levelt et al. (1999) and it is assumed that all such grammatical features are treated as diacritic parameters on the lemma level and have the same "status". In the Independent network model all these features are activated in the lexical-syntactic network. Caramazza mentions however that extrinsic features can be activated before a modality-specific lexeme is chosen and the intrinsic ones after that.

In Levelt's model, the declensional class information of a noun is likely to be stored together with its lemma, as it is a constant grammatical feature, and to be set as a diacritic parameter. The exact grammatical case is set as another diacritic parameter at the same level, but is determined by the syntactic context. Number feature is the third diacritic parameter we need and is activated by the conceptual preparation level. We can expect that the exact morpheme that is to be used is activated at the next level of morphological encoding, based on the setting of these diacritic parameters. The chosen morpheme is then added to the phonological form of the word at the level of phonological encoding.

Levelt and others proposed a more detailed model, the so-called "slot-and-filler" to account for how exactly an inflected word form is composed of morphemes (see Janssen, Roelofs, & Levelt 2002 for an overview and application to Levelt's model). Applied to Levelt's model, it would mean that the morphological level of a word contains the specific morpheme for its stem and all the morphemes that can be used with it in case they are required. When a lemma is selected, its stem is activated along with slots that can be filled with these morphemes. The slots are filled on the basis of the values of the diacritic parameters at the lemma level. When all the slots are filled by the appropriate elements, the process proceeds with phonological specification.

In the case of the Independent network model, information about the declensional class of nouns is stored at one of the sub-networks of the lexical-syntactic network as this is the one where other syntactic features are stored. This information is however activated only after one of the modality-specific networks activates the noun's phonological and orthographic properties (as declensional class depends on the exact word). The information about which exact grammatical case is to be used and number feature is likely to be specified by the syntactic network information as well, but unlike the specification of

declensional class feature, they do not depend on the exact word retrieval and thus can be activated somewhat earlier. Based on the activated declensional class then, the information about the exact morpheme to be used is given “back” to the phonological and orthographic networks for further encoding.

In a more recent publication, Caramazza and colleagues (Shapiro, Shelton, & Caramazza 2000) proposed a model accounting for the morphological composition of a word. According to that account, there is a morphological subsystem of the lexical-syntactic network that is activated by the grammatical class information (because the inflectional features of a word pertain specifically to its grammatical class). This subsystem is responsible for choosing an appropriate morpheme. Extrinsic grammatical properties of the required morpheme are derived from the syntactic structure or semantic content of the phrase. Based on this information about the extrinsic features, the set of allomorphs⁴ that can form a specific inflected form is activated. Intrinsic grammatical features of a word are activated after the activation of one of the modality-specific lexemes. They are then used to select one of the morphemes from the set (the task of the above-mentioned morphological subsystem). It is then combined with the lexeme to generate a required inflected word form. In our case the intrinsic feature activated would be the declensional class and contextually activated extrinsic feature would be the grammatical case and number.

“Once the [morphological] subsystem is online, it ought potentially to be able to accomplish three tasks: first, it must match the intrinsic grammatical features of the lexeme that has been selected to those of a contextually activated syntactic morpheme; second, it must arbitrate among the morpheme’s allomorphs on the basis of phonology; and third, it must allow for the concatenation of the proper allomorph with the lexeme. (...) For instance, grammatical discrimination among allomorphs may follow directly from the selection of the syntactic features of a lexeme.” (Shapiro et al. 2000, p. 679).

Applying the above-given proposition to our case, declensional class is the syntactic feature of a lexeme based on which the morphological subsystem chooses one of the already activated allomorphs that mark the required grammatical case.

An important question for the models and the following experiment is how the grammatical features of the word are activated and whether it is a competitive process, i.e. whether grammatical features compete for selection. In the case of the Levelt’s model, all the grammatical features are treated in the same way and they are all supposed to be activated by competition. In his original model, Caramazza assumes competition for the selection within the sub-networks of the lexical-syntactic network as well and does not explicitly differentiate between extrinsic and intrinsic features in this aspect. Thus, the declensional class feature should compete for the selection within its sub-network, the number feature should compete for the selection within its sub-network, the grammatical case feature within its sub-network, and so on. From later evaluation of the results of their own experiments on number feature selection and gender congruency effect, Schiller and Caramazza (2003) however propose that the word-specific grammatical features automatically become available as part of the selection of lexical nodes and the rest is set

⁴ Allomorphs are morphemes having the same function but different form. For instance, all the morphemes that are used to mark the genitive case in nouns are allomorphs.

extra-lexically and, thus, is not competitive either (or at least the competition does not take place during the lexical selection processes). The following experiment aimed at investigating the nature of specifically grammatical case feature selection.

Research question and hypothesis

Relevant previous research

I will first outline the task used in the two studies I describe and by my own experiment – the so-called “picture-word interference task”. This paradigm has been widely used for psycholinguistic experimentation for the last several decades. In it, participants are asked to name aloud the objects depicted in the given picture or pictures while ignoring a distractor word or words presented on the screen at the same time. These distractors superimpose on the target picture or are located under or above it. The distractors may also be presented auditorily. Studies show that the mere presence of a distractor word influences the speed with which participants name the target objects (for a review of the picture-word interference paradigm see MacLeod, 1991). In fact, as experiments show, the naming latencies are strongly influenced by the different aspects of the distractor word. Thus, by manipulating the distractor words, their forms, using the time asynchrony – when the distractor is presented, before or after the appearance of the target on the screen – we can derive how the properties of the distractors influence the target word retrieval and make assumptions about the timing of the spoken word production process. Picture-word interference is a combination of production and perception and it is assumed that the perception of the distractor influences the production of the target. This paradigm is well-grounded and widely used for the spoken word production studies (Levelt et al. 1999).

Plural marking noun morphemes in German

One branch of research closely related to grammatical case selection is the one investigating morphemes which denote plural in nouns.

Schiller and Caramazza (2002) wanted to see whether number feature selection is a competitive process. They looked for a number congruency effect particularly in German. Participants were asked to name pictures either in singular or plural depending on how many instances of one picture are presented on the screen while ignoring distractor words of either the same or different number (congruent and incongruent condition respectively). Additionally, distractor words formed the plural using either the same suffix as the target word or a different one (there are several different allomorphs for plural marking in German). If the number feature selection of nouns is a competitive process, the interference should be observed – the RTs should be slower in the incongruent in comparison to the congruent condition. Similarly, if there is competition between plural forming suffixes, the RTs should be slower in the condition where the target and the distractor require different suffixes to form plural in comparison to the condition where they require the same suffix. The interference was not observed in either case. To make sure that participants actually did process distractors during the experiment, they repeated the experiment using the same tools, but tried to obtain the well-evidenced semantic interference (see further) and succeeded in it. Thus, participants did actually

process distractor words and the experiment setting would have obtained significant results if there were competition in number feature selection.

The results were interpreted as demonstrating that the selection of the number feature diacritic parameter is not a competitive process and that the number feature is set extralexically.

Both number feature and grammatical case are extrinsic features and are known prior to lemma activation and both have to be selected before the encoding process can go on. An important difference, however, is that the number feature is derived from the conceptual level (e.g. a speaker decides whether he/she wants to say something about one or more occurrences of something) whereas the grammatical case is rather derived from the syntactic context and that is why their selection may differ. Another important difference is in that whereas number feature can be seen just as a binary opposition, in Czech there are 7 (or even 14 if we count plural forms) possible grammatical cases among which the "system" is selecting. That is why it can be assumed the process of grammatical case selection is a more sophisticated one with more options.

Declensional class in Czech

Bordag and Pechmann (2009) conducted an important study on declensional class in Czech. They looked for possible declensional class interference in Czech noun production and the exact phase in which that interference takes place.

In their experiment, participants were asked to produce certain inflected forms out of the names of the pictures while ignoring distractor nouns that belonged to either the same (congruent condition) or different (incongruent condition) declensional class. For instance, in the congruent condition they saw a picture of a castle ("hrad" in Czech) and were supposed to produce its genitive form ("hrad-u" where "u" is an inflectional suffix) while seeing the distractor word "nos" [nose] that belongs to the same declensional class and thus would have formed the genitive with the same inflectional suffix ("nos-u"). In the incongruent condition the distractor word was of another declensional class and thus would have used a different suffix to produce the genitive form (for instance, "stroj" [machine] the genitive form of which is "stroj-e", where "e" is an inflectional suffix). It turned out that the RTs were slower in incongruent condition in comparison to congruent condition. This suggests that there is a competition in activating the declensional class feature during speech production (since all other grammatical features of the words were the same). Another experiment included a condition in which target and distractor words belonged to different declensional classes but required the same inflected suffixes to mark the same grammatical case. It turned out that even in this case the RTs were slowed down in the incongruent condition. It suggests that the competition was not due to different phonological realizations of the suffixes but actually takes place at the level of abstract declensional class feature selection.

Declensional class feature is undoubtedly related to grammatical case. Both grammatical case and declensional class necessarily have to be determined in the course of noun production and they are used for determining the required suffix. However, whereas declensional class is an intrinsic feature, grammatical case is an extrinsic one and that is why their processing may differ.

One of the main goals of Bordag and Pechmann's study was to investigate the "competition problem" for different kinds of grammatical features. In accordance with both Levelt's and the Independent Network models, and contrary to what Schiller and Caramazza suggested later, they did observe competition in activation of one of the grammatical features. However, as we saw, number feature activation does not seem to have any competition at the same level. Thus, it seems as though some but not all of the grammatical features are activated automatically. The key might be in the distinction between extrinsic and intrinsic features differentiation. Bordag and Pechmann (2009) interpret their results by saying that the declensional class is an intrinsic feature, whereas number is an extrinsic one. Thus it seems probable that in word production intrinsic feature selection is competitive and extrinsic feature selection is not. In the experiment reported here, another extrinsic feature selection was addressed.

The present experiment

Similarly to the two studies described above, the present experiment attempted to investigate whether grammatical case selection is a competitive process. According to both the Levelt's and the original Independent network models the process should be competitive. Judging by later corrections (Schiller & Caramazza 2003; Bordag & Pechmann 2009), there should be no competition for the activation as it is an extrinsic feature. But this has not been explicitly tested on grammatical case and there is a chance that we will, in fact, observe interference.

To investigate grammatical case selection, a picture-word interference experiment was conducted. Participants were asked to name target pictures while ignoring distractor words. In all conditions target and distractor words belonged to different declensional classes. The distractor appeared in either the same grammatical case as the target word to be produced (congruent condition) or in a different one (incongruent condition). The cases used were nominative (NOM) and accusative (ACC). The experiment was designed in such a way that in one of the incongruent conditions there was an orthographical and phonological match in the suffixes that are used to mark the different grammatical cases of the target and the distractor. Two additional control conditions had a verb in third person singular form (verb 3.sg) as a distractor.

In total, the experiment included six different conditions: a) a target noun was to be produced in NOM and a noun distractor appeared in NOM; b) target – NOM, distractor – ACC; c) target – NOM, distractor – verb 3.sg; d) target – ACC, distractor – NOM; e) noun – ACC, distractor – ACC; f) noun – ACC, distractor – verb 3.sg. See Table 1 for a schematic overview and an example for each condition.

Table 1. Overview of the conditions used in the experiment.

| Condition | Distractor | Preceding phrase | Target |
|-----------|------------------------------------|------------------|--|
| a | noun in NOM <i>hračka</i> [toy] | to je [this is] | picture - noun in NOM <i>slon</i> [elephant] |
| b | noun in ACC <i>hračku</i> | | |

| | | | |
|---|--|-----------------|--|
| c | verb 3.sg <i>prosí</i> [to ask for] | | |
| d | noun in NOM <i>hračka</i> | vidím [(I) see] | picture - noun in ACC <i>slona</i> |
| e | noun in ACC <i>hračku</i> | | |
| f | verb 3.sg <i>prosí</i> | | |

In my hypothesis I will assume competition as suggested by the original models I discussed. If grammatical case feature setting is a competitive process and the competition takes place during the lexical selection processes, then in cases where the distractor is presented in a different grammatical case, the interference effect can be observed: different grammatical cases of the target and distractor should cause slowing down of the selection of the correct form of the target. Alternatively, a distractor presented in the same grammatical case as the one in which the target should be produced may boost the selection of this grammatical case. In both cases, competition will result in shorter reaction times in the congruent in comparison to the incongruent condition. Thus, the hypothesis is: *Pictures should be named more slowly in the condition b) than in the condition a) and more slowly in the condition e) than in the condition d).*

An additional feature of the experiment design is the mismatch between grammatical case congruency and phonological/orthographical forms in the condition d). Comparing reaction time in conditions d) and e) will be helpful in detecting whether the interference is not simply caused by the different phonological forms of the suffixes. If this is the case, we should observe no difference in reaction times between conditions a) and b) and in condition d) pictures should named faster than in condition e). If there is interference in both grammatical case selection and phonological realization of the suffix, pictures should be named faster in condition a) than in condition b) and the difference between reaction times in conditions d) and e) should be determined by the relative strength of each of the effects or, if they are equally strong, we should observe no difference.

In order to make sure that the distractors were actually processed by the participants and the different naming latencies were caused by their grammatical case, we included two control conditions with verb distractors. Because of the experiment setting (see further) the participants will be seeing an ungrammatical sequence in incongruent conditions and a grammatical one in congruent conditions and we wanted to make sure that the differences in reaction times are not caused just by that ungrammaticality. Thus, two other conditions contained an ungrammatical sequence in order to be able to compare them to the ones where we assume to observe the grammatical case interference. We expected the reaction times to be longer in the conditions c) and f) in comparison to the remaining conditions. However, they can actually turn out to be shorter since Vigliocco, Vinson and Siri (2005) observed that naming latencies were faster when target and distractor words were of different grammatical class in comparison to the condition when they were of the same grammatical class.

Method

Participants

Forty-three native speakers of Czech from the participant pool of the Laboratory of behavioral and linguistic studies (joint workplace of the Institute of Psychology, Academy of Sciences of the Czech Republic and the Faculty of Arts, Charles University in Prague) took part in the experiment. These, with the exception of a few curious ones from elsewhere, were undergraduate students of psychology or language and literature programmes at Charles University in Prague and received course credit for participation. The age of participants ranged from 19 to 33 ($M=21.5$, $SD= 2.5$). All participants had normal or corrected-to-normal vision.

Materials

Thirty nouns belonging to the masculine animate declensional class *pán* [Mr., lord] (I am using traditional Czech examples for pointing at the declensional classes here as they do not have any names) were chosen as target picture names. The same amount of nouns belonging to the feminine declensional class *žena* [woman] was chosen as noun distractors (the first group of distractors). Thirty verbs were further chosen as the second group of distractors used in control conditions. (See Appendix for the full list of the targets, distractors and their frequencies.) These particular declensional classes were chosen due to the fact they use different inflectional suffixes to mark ACC; additionally, nouns belonging to masculine animate declensional class *pán* form ACC by adding the inflectional ending “-a” and all the nouns belonging to the declensional class *žena* have the ending “-a” in NOM. The target and distractor words were selected using the Czech National Corpus (Czech National Corpus – SYN 2010).

In order to make participants produce targets in a required grammatical case, the picture naming was preceded by production of a phrase requiring a particular case after it. Before naming the picture, participants saw on the screen and were instructed to pronounce either “to je” [this is] after which a noun has to be produced in NOM or “vidím” [(I) see] after which a noun has to be produced in ACC.

As I already mentioned, verb distractors were presented in the third person singular form. This particular form was chosen due to the fact that the appearance of a verb in this form after the above-mentioned preceding phrases was evaluated to be more ungrammatical than the appearance of a verb in the infinitive form. The ungrammaticality of such combinations was verified by the results of a grammaticality judgement questionnaire completed by five native Czech speakers. In this questionnaire, the combinations were presented as sentences and were mixed with normal sentences and sentences with different types of errors in order to encourage participants to use the whole scale given. Verb distractors in the third person singular form after “vidím” or “to je” were assessed as being less grammatical ($M=7.0$ in seven points scale where 1 is a normal sentence and 7 is a completely ungrammatical one) than verb distractors in infinitive form in the same position ($M=6.84$). In addition, if the reaction times in control conditions are to be shorter, the study by Vigliocco, Vinson and Siri (2005) demonstrated that the grammatical class of a word influences naming latencies only when produced in an inflected form.

The properties of the target and distractor words have to be carefully controlled in this type of experiment. One of the main factors to be controlled is their frequency. The frequency of the target word has been repeatedly shown to have a robust effect on naming latencies (e.g. Oldfield & Wingfield, 1965, Jescheniak & Levelt 1994). As for the frequency of the distractors, Miozzo and Caramazza (2003) observed that high-frequency distractors interfere less than low-frequency distractors both in case of high-frequency and medium-frequency targets. In the experiment reported here, the target-noun distractor pairs always had similar lemma frequency in order to avoid frequency effects.

Another factor considered to influence naming latencies is the length of the words – an assumption made, for instance, by Miozzo & Caramazza, (2003) or Jescheniak & Levelt, (1994); see Meyer, Roelofs, & Levelt (2003) for more detailed investigation of this effect. In this experiment, the length of a target was within the range 4-7 phonemes with the mean length 5.1 phonemes, noun distractor length was within the range 5-8 phonemes with the mean 5.7 phonemes. Verb distractors had an average of 5.7 phonemes (range – 4-8) in third person singular form. Czech diphthongs /ou/ and /au/ were counted as one phoneme. In most of the conditions in this experiment, participants had to add an extra phoneme to the target noun, thus the difference of approximately one phoneme between the length of target and distractor is rather useful.

Further, the target and distractor pairs did not coincide in the initial phoneme. This was controlled due to the fact that previous studies (e.g. Rayner & Springer, 1986, Lupker, 1982) demonstrated that orthographically or phonologically similar distractor words speed up the reaction times in comparison to unrelated words.

The imageability of the distractors has, as well, been shown to influence the naming latencies (Mahon, Costa, Peterson, Vargas & Caramazza, 2007). That is why we tried to choose distractors that would be possible to draw if needed. Due to other limitations, it was difficult to do in some cases, but since these are only a few, it is not expected that they will influence the result. Verb distractors were chosen to represent a concrete action.

The semantic relation of the target-distractor pairs was controlled as well, since there is a vast amount of research indicating that semantic relation between target and distractor influences reaction times (e.g. Rosinski 1977; Lupker, 1979; La Heij, 1988; Glaser & Glaser, 1989; Costa, Alario & Caramazza, 2005; Mahon et. al 2007). In order to avoid any semantic facilitation or interference, targets and distractors were not related semantically as judged by the experimenter. It was further demonstrated that even in the case of verb distractors, semantically close ones cause shorter RTs in comparison to semantically distant ones (Mahon et al. 2007, Vigliocco et al. 2005). For this reason, the verb distractors used in this experiment were not semantically related to the targets either.

The pictures used as targets were black-and-white drawings. They were unambiguous representations of the objects and included just enough detail in order to be recognized. Part of them was taken from Snodgrass and Vanderwart (1980) and the International Picture Naming Project (Szekely et al. 2004), the rest were created to look similar to the pictures from these sets in terms of the drawing style and visual complexity. In accordance with Snodgrass and Vanderwart (1980), animals were depicted in sideways view and approximately equal numbers of them faced left and right; human-like objects

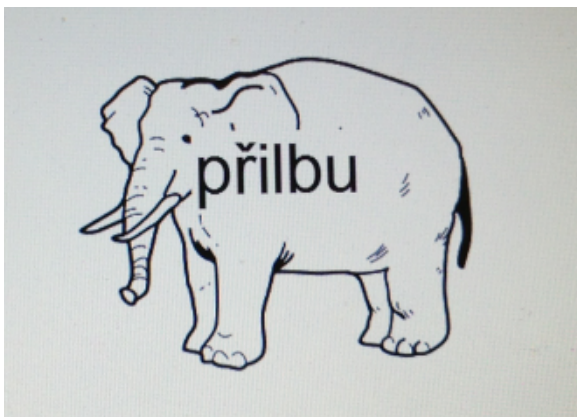
were oriented at a 45° angle and again with approximately equal numbers facing in each orientation. In order to prevent the inclusion of pictures with ambiguous names, four native Czech speakers, who did not participate in the following experiment, were asked to name them. Their responses were in accordance with the expected names. A familiarization phase was further included in the experiment design to avoid ambiguity in picture names.

Apparatus

The experiment was conducted using the facilities of the above-mentioned Laboratory of behavioral and linguistics studies. Participants were tested individually in two sound-attenuated rooms. The pictures were presented in 300 x 300 pixels (they had black outlines and white surfaces) with white background in the centre of the monitor with the resolution 1280 × 800 pixels. Participants were seated approximately 60-70 cm. from the screen.

The distractor words (presented in black 20 point Geneva font) were superimposed on the pictures and located in the centre of the screen. See Picture 1 for the example. The preceding phrases “vidím“ and “to je“ (presented in black 18 point Geneva font) appeared in the centre of the screen and with white background as well.

The experiment was conducted using DMDX software (Foster & Foster 2003). The naming latencies were evaluated using a voice trigger that was tuned for each participant individually before the experiment by the experimenter. It was tuned to record the reaction time for a trial once it heard the participant pronounce something and not to react to simple breathing. The participants' responses were also recorded. These recordings were then manually evaluated for the presence of the errors.



Picture 1. An example of the simultaneous presentation of a picture and a distractor word.

Procedure

A total number of 180 experimental items (30 target nouns in 6 conditions each) was presented in six blocks. The item had the following structure. Blank screen appeared for 1000 ms. followed by the fixation point (plus sign in the centre of the screen) for another 1000 ms. Then either “to je” or “vidím“ depending on the condition appeared in the centre of the screen until the participant pronounced it (but a maximum of 1500 ms.) Fixation

point appeared again for another 500 ms. and, finally, target picture appeared along with the distractor word superimposing it (there was no time asynchrony in target picture and distractor word presentation). As soon as the participant pronounced something or if there was no response for 3000 ms. after the appearance of the target and distractor, the next item was presented.

Each block started with 2 warm-up items and included 30 experimental items. Each condition appeared in each block the same number of times – five. Each target appeared in each block only once and each time with a different distractor. None of the distractors appeared in one block more than once. The same target never appeared with the same distractor more than once. This was done by pairing each target with 4 different noun distractors and 2 different verb distractors. Pairing was done in groups of 5 in order to fulfil all the above criteria; these groups are shown in the Appendix. For instance, target number 1 appeared with the noun distractors 1, 3, 4, 5 and verb distractors 41, 43; target number 5 appeared with noun distractors number 2, 3, 4, 5 and verb distractors number 42, 45. There were 4 versions of the experiment that differed in the exact condition in which a target-distractor pair appeared. For instance, target number 1 appeared with the distractor number 1 in condition a) in the first version, in condition e) in the second version, in condition d) in the third version and in condition b) in the fourth version. As for the verbs, the target number 1 appeared with the verb distractor number 41 in condition c) in the first and second version and in condition f) in the third and fourth version. Each participant took only one version of the experiment. Each version of the experiment was administered approximately the same number of times. Familiarization and training phases preceded the experiment. In the familiarization phase, participants saw all the pictures used in the experiment with their expected names shown under them in a random order and were instructed to pronounce the expected names and try to memorize them. As soon as a participant pressed the spacebar, the next picture appeared on the screen. Besides the experimental pictures, the familiarization phase included 6 additional pictures that were further used in the training phase and warm-up items at the beginning of each block. Each participant saw these filler pictures 8 times overall, but the experimental pictures 7 times overall (once in the familiarization phase and once in each of 6 blocks). Trials in the blocks as well as blocks themselves were presented in randomized order.

Participants were told without any further explanation that the experiment investigates aspects of picture naming. They were asked to produce the name of the objects in the pictures in a corresponding inflected form as quickly and as accurately as possible using the names shown in the familiarization phase and ignoring distractor words. The instructions were given orally by the experimenter. The experimenter was present in the room and corrected potential errors up until the beginning of the experimental blocks. The whole session lasted approximately 30 minutes.

Results

The recordings of participants' responses made by DMDX were listened to and evaluated for the presence of errors. The response was marked as an error in following cases: the voice key was triggered incorrectly; an unexpected word was used to name the picture; an incorrect inflectional form was produced; the reaction time was longer than the response

deadline of 3000 ms. (i.e. no response was recorded). On the basis of these criteria 736 responses (9.5%) out of the total number of 7740 was excluded from further analysis.

Linear mixed effects analysis (Bates, 2012; Baayen, 2008) was used to test the hypotheses. Traditionally, in studies like the one reported here, analysis of variance (ANOVA) was used for hypothesis testing (e.g. Bordag & Pechmann, 2009, Schiller & Caramazza, 2002). There are, however, a number of disadvantages to using that method – for instance, the impossibility of adequately treating the absence of observations. The mixed effect model does not have these “weak” sides (see Baayen, Davidson & Bates, 2008 for a more detailed discussion of its advantages and examples of use).

The mixed effect model is a type of regression that takes into consideration variations that cannot be treated as independent variables. In the experiment reported here, the grammatical cases of target and distractor words (or whether the distractor is a verb) are independent variables. We also need to include in the analysis differences between participants and target words (as, for instance, different people may need different times to start speaking and the initiation of different words may involve different muscular groups; there are many factors resulting in individual differences between participants and words the presence of which should be taken into account). However, we cannot treat both differences in conditions and in participants and targets as independent variables because differences in conditions are *repeatable* (called “random” in traditional ANOVA), whereas participants and targets are not. In this context, a factor is repeatable “if the set of possible levels for that factor is fixed, and if, moreover, each of these levels can be repeated” (Baayen 2008, p. 263). Put simply, we can potentially recruit more participants or add more words, but the grammatical cases of target and distractor in different conditions would be the same (in order for it to be a part of this experiment). The target words and participants, on the other hand, would have to have another identifier and that is why they are not repeatable. The factors with repeatable levels are called fixed-effect and the factors with non-repeatable levels are called random-effect (as they are randomly chosen from a larger set or population). Mixed effect model analysis incorporates both random and fixed effects.

The data were analysed using R (R Core team 2013) and R packages *lme4* (Bates, Maechler & Bolker, 2013) and *languageR* (Baayen, 2011). In the analysis, form of the target (either NOM or ACC – two levels) and form of the distractor (NOM, ACC or verb 3.sg – three levels) were entered as fixed effects with interaction. The individual participants and target words were entered as random effects. Reaction time is the dependent variable. Fulfilment of the assumptions of homoscedasticity and normality as required by the linear mixed model analysis was verified by visual inspection of residual plots.

The mean reaction times and standard deviations in each condition are presented in Table 2 and graphically depicted in Figure 4. Error rates are presented in Table 3. The results of mixed-effect model analysis are presented in Table 4 along with p-values that are Markov Chain Monte Carlo-estimated and would be considered significant at the $\alpha=0.05$ level. As we see, none of the factors turned out to have a significant influence on the reaction times.

Table 2. Mean reaction times (standard deviations) in ms. for each condition

| | | Distractor | | |
|--------|-----|------------|-----------|-----------|
| | | NOM | ACC | Verb 3.sg |
| Target | NOM | 839 (225) | 837 (215) | 835 (237) |
| | ACC | 846 (233) | 847 (233) | 831 (223) |

Table 3. Error rates in responses in each condition

| Condition | Target | Distractor | Number of errors |
|-----------|--------|------------|------------------|
| a | NOM | NOM | 128 (9.9 %) |
| b | NOM | ACC | 118 (9.1 %) |
| c | NOM | verb 3.sg | 124 (9.6 %) |
| d | ACC | NOM | 109 (8.4 %) |
| e | ACC | ACC | 136 (10.5 %) |
| f | ACC | verb 3.sg | 117 (9.0 %) |

Figure 4. Graphic depiction of the mean reaction times in each condition.

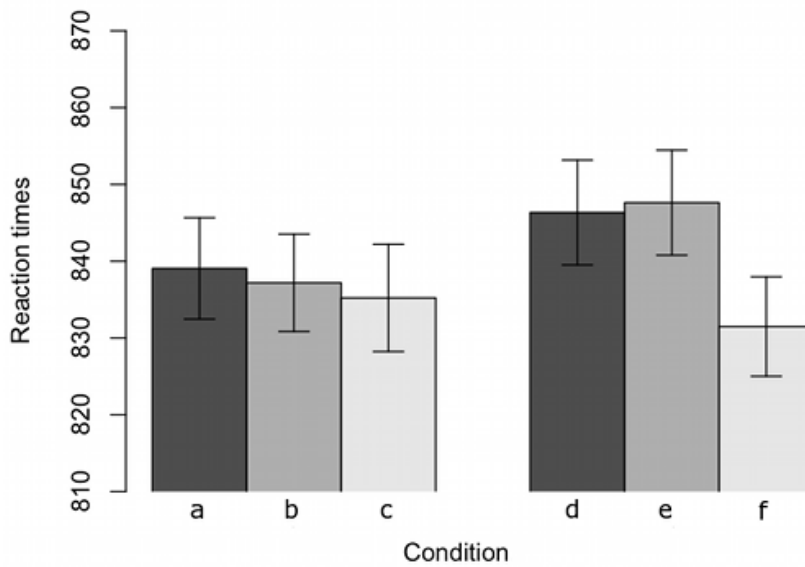


Table 4. Estimates made by the model, t values and MCMC-estimated P-values for each factor. Factors are what is changed in comparison to intercept or in comparison to the change in one

| Factor | Estimate | Standard error | t value | p value |
|--|-----------------|-----------------------|----------------|----------------|
| Intercept - NOM target and NOM distractor | 846.611 | 20.840 | 40.62 | - |
| ACC target (in comparison to intercept) | 4.411 | 8.039 | 0.55 | 0.56 |
| ACC distractor (in comparison to intercept) | -2.426 | 8.072 | -0.30 | 0.76 |
| Verb 3.sg distractor (in comparison to intercept) | -5.914 | 8.061 | -0.73 | 0.47 |
| ACC distractor and ACC target interaction (in comparison to ACC target and NOM distractor) | 4.652 | 11.387 | 0.41 | 0.69 |
| Verb 3.sg distractor and ACC target interaction (in comparison to ACC target and NOM distractor) | -9.052 | 11.359 | -0.80 | 0.41 |

Discussion

The fact that the differences are not significant means that either grammatical case selection is not a competitive process or the experiment setting failed to observe it.

Due to the failure to observe significant differences in comparison to control conditions c) and f), the results cannot be decisive. Judging by the mean naming latencies, the participants were somewhat faster in these conditions. This is contrary to what we expected, but consistent with the results obtained by Vigliocco, Vinson and Siri (2005). These differences in reaction times are however not significant, suggesting that the experiment design may not be sensitive enough (which prevented us from the observation of the effect). Another explanation may be in the conflict between these two factors – ungrammaticality slowing down the naming latencies and difference in grammatical class boosting it. Yet another explanation may lie in that grammatical class effect is for some reason absent in Czech or cannot be observed with the distractor in the inflected form. In any case the obtained results cannot be fully trusted. The possible solution for this might be to try to obtain the well-documented semantic interference effect instead in the same experiment setting (as Schiller & Caramazza 2002 did in their study).

The failure to observe any effect cannot be due to incorrect understanding of the task by the participants (cf. Bordag & Pechmann 2009, where error rates are similar or higher); nor to the number of participants (forty three is a high number in comparison to 15-25 that is usual for this kind of psycholinguistic experiment); nor to false voice key records (some of the reaction times recorded by DMDX were randomly chosen for the inspection of the correctness and were correct). One possibility is that this specific list of target words caused some other processes to interfere in naming. Some weak aspects of the

target word list were observed during experiment conduction. Specifically, for instance, some participants had problems distinguishing between different species of cat (*jaguár* [jaguar] and *tygr* [tiger] were present among experimental items and *lev* [lion] among training items) or had never seen some of the animals (for instance, in case of *lemur* [lemur]) and so their names were not as easy to bring up as the names of others. It might be useful to try to conduct the same experiment setting with a different set of target words.

Schiller and Caramazza (2002) suggest another reason for the effect not to be obtained:

“Although we can be sure that participants processed the distractor words lexically, because we obtained a semantic interference effect, we cannot be sure that participants also processed the fact that the distractor words had been either in the singular or in the plural. Plural in German is marked at the end of words. Therefore, it may be the case that participants recognized the distractors without processing the ends of words.” (p. 350).

For the same reason, the results might not have been significant in the present experiment. One way to address this issue might be to present distractor words with unexpected ungrammatical endings (suffixes which are not used to mark any grammatical case of the word of this declensional class) and see whether there is any influence of this factor on the reaction time. If there is, we can be sure participants processed the endings of the words.

In case we are not making Type II error, the absence of the competition might support the assumption that extrinsic grammatical feature selection is not a competitive process, whereas intrinsic feature selection is – as suggested by Bordag and Pechmann (2009). Or at least such competition does not occur during lexical selection processes. As proposed by Schiller and Caramazza (2003) about the number feature, the activation of grammatical case may be extra-lexical as well.

In fact, one can expect there not to be any competition at the lexical selection level in the case of the features that are already set prior to that. Extrinsic features are already selected before lexical selection processes (as, for instance, grammatical case already was once participants saw the phrase preceding the picture in the experiment reported here) and are, thus, can automatically be set without any further doubts while the information cascades down to the level of phonological encoding. Since a participant was ready to produce whichever word in a certain grammatical case prior to seeing it, he/she immediately activated this information and conducted the inflection processes.

Even if the grammatical case of the distractor was to interfere in the process of grammatical case setting, the participants might not have had enough time to process the distractor word as far as decoding its grammatical case feature. To investigate this, it might be useful to conduct similar experiments with time asynchrony – presenting distractors somewhat earlier than targets.

Summary.

In this paper I tried to look at the implementations of the spoken word production models on grammatical case selection processes in Czech and experimentally verify whether there

is competition for activation between different grammatical cases during word production. Previous research observed competitive processes in declensional class selection and the absence of competition in number feature selection. The latter finding is inconsistent with the Level's model of spoken word production that treats both features in the same way and thus expects that they will be processed in similar ways. It is problematic too for the Independent network model that assumes selection of words via competition in different sub-networks of the lexical-syntactic network. The explanation of the observed difference might be in that selection of the intrinsic grammatical features of a word is a competitive process whereas the selection of the extrinsic ones is not. The conducted experiment aimed to find competition in one of the other extrinsic features of nouns in Czech – grammatical case. The results seem to suggest that there is no competition in the selection of this extrinsic feature. We should not rush however to firm conclusions, as there seem to be problems with experiment setting. Further experiments must be conducted in order to make sure we are not making a Type II error.

Appendix. List of the target and distractor words.

All the target and distractor words used in the experimental conditions are presented in the table below. Target and distractor nouns are presented in nominative case, verb distractors are in the third person singular form (as it is the only form in which they were presented). Frequency is the number of occurrences per one million words (information about the frequency is from Czech National Corpus – SYN 2010). The groups of five items within which the targets and distractors were paired are represented here by the background colour.

| Target | Target lemma frequency | Noun distractor | Noun distractor lemma frequency | Verb distractor |
|---------------------|-------------------------------|------------------------|--|-------------------------|
| robot [robot] | 24.08 | bomba [bomb] | 24.78 | vylézá [protrudes] |
| čert [devil] | 24.07 | nádoba [container] | 24.44 | plave [swims] |
| mnich [monk] | 21.48 | puška [rifle] | 20.99 | otáčí [rotates] |
| tygr [tiger] | 14.19 | kulka [bullet] | 14.57 | obléká [puts on] |
| motýl [butterfly] | 13.79 | panenka [doll] | 13.21 | buší [pounds (on smth)] |
| králík [rabbit] | 12.12 | motorka [motorcycle] | 12.71 | uklízí [cleans up] |
| slon [elephant] | 12.07 | hráčka [toy] | 11.75 | čistí [cleans] |
| pirát [pirate] | 11.32 | jehla [needle] | 11.32 | ukrývá [hides (smth)] |
| žralok [shark] | 10.61 | přilba [helmet] | 10.41 | odděluje [separates] |
| brouk [bug] | 9.95 | vesta [waistcoat] | 9.92 | fouká [blows] |
| kohout [rooster] | 9.57 | loutka [marionette] | 9.53 | tancuje [dances] |
| delfín [dolphin] | 9.44 | palma [palm] | 9.41 | vchází [comes in] |
| holub [pigeon] | 9.36 | sopka [volcano] | 9.30 | svazuje [ties] |
| pavouk [spider] | 9.01 | římsa [ledge] | 8.83 | myje [washes] |
| kapr [carp] | 8.91 | šipka [arrow] | 8.30 | balí [packs] |
| velbloud [camel] | 8.07 | synagoga [synagogue] | 8.19 | tleská [claps] |
| červ [worm] | 7.62 | slina [saliva] | 7.49 | mlátí [bangs (smth)] |
| komár [mosquito] | 6.89 | sekera [axe] | 6.92 | praská [bursts] |
| dinosaur [dinosaur] | 5.64 | vidlička [fork] | 5.76 | nalévá [fills in] |
| klaun [clown] | 4.21 | skica [sketch] | 4.26 | potápí [sinks] |
| jaguár [jaguar] | 3.53 | podkova [horseshoe] | 3.58 | zamyká [locks] |
| tučňák [penguin] | 3.42 | zátka [cork] | 3.30 | shazuje [throws down] |
| klokan [kangaroo] | 3.23 | myčka [dishwasher] | 3.27 | potírá [smears] |
| beran [ram] | 2.98 | léčka [trap] | 2.99 | holí [shaves] |
| krocán [turkey] | 2.58 | pružina [spring] | 2.56 | svěšuje [hangs] |
| šváb [cockroach] | 2.44 | harfa [harp] | 2.30 | sviští [whistles] |
| šnek [snail] | 2.28 | zástěrka [apron] | 2.15 | prská [spits] |
| lachtan [seal] | 1.57 | baletka [ballerina] | 1.62 | boxuje [boxes] |
| pelikán [pelican] | 1.44 | astra [aster] | 1.05 | drmolí [jabbers] |
| lemur [lemur] | 1.42 | osika [aspen] | 1.13 | hmatá [gropes] |

References

- Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R*. Cambridge University Press.
- Baayen, R. H. (2011). *languageR: Data sets and functions with "Analyzing Linguistic Data: A practical introduction to statistics"*. R package version 1.4. Available at <http://cran.r-project.org/web/packages/languageR/index.html>. Accessed on April, 29, 2013.
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of memory and language*, 59(4), 390-412.
- Bates, D. (2012). *Linear mixed model implementation in lme4*. Ms., University of Wisconsin.
- Bates, D., Maechler, M., & Bolker, B. (2012). *lme4: Linear mixed-effects models using S4 classes*. R package version 0.999999-0. Available at <http://cran.r-project.org/web/packages/lme4/index.html>. Accessed on April, 29, 2013.
- Bordag, D., & Pechmann, T. (2009). Externality, internality, and (in) dispensability of grammatical features in speech production: Evidence from Czech declension and conjugation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35(2), 446.
- Caramazza, A. (1997). How many levels of processing are there in lexical access?. *Cognitive neuropsychology*, 14(1), 177-208.
- Caramazza, A., & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: evidence from the tip-of-the-tongue phenomenon. *Cognition*, 64(3), 309-343.
- Caramazza, A., & Miozzo, M. (1998). More is not always better: A response to Roelofs, Meyer, and Levelt. *Cognition*, 69(2), 231-241.
- Costa, A., Alario, F. X., & Caramazza, A. (2005). On the categorical nature of the semantic interference effect in the picture-word interference paradigm. *Psychonomic Bulletin & Review*, 12(1), 125-131.
- Czech National Corpus - SYN2010. Institute of the Czech National Corpus, Praha 2010. Accessible at WWW: <<http://www.korpus.cz>>.
- Dell, G. S. (1986). A spreading activation theory of retrieval in language production. *Psychological Review*, 93, 283-321.
- Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, 35(1), 116-124.

- Garnham, A., Shillcock, R. C., Brown, G. D., Mill, A. I., & Cutler, A. (1981). Slips of the tongue in the London-Lund corpus of spontaneous conversation. *Linguistics*, 19(7-8), 805-818.
- Glaser, W. R., & Glaser, M. O. (1989). Context effects in stroop-like word and picture processing. *Journal of Experimental Psychology: General*, 118(1), 13.
- Indefrey, P., & Levelt, W. J. M. (2000). The neural correlates of language production. In M. Gazzaniga (Ed.), *The new cognitive neurosciences*. Cambridge, MA: MIT Press
- Indefrey, P., & Levelt, W. J. (2004). The spatial and temporal signatures of word production components. *Cognition*, 92(1), 101-144.
- Janssen, D. P., Roelofs, A., & Levelt, W. J. (2002). Inflectional frames in language production. *Language and Cognitive Processes*, 17(3), 209-236.
- Jescheniak, J. D., & Levelt, W. J. (1994). Word frequency effects in speech production: Retrieval of syntactic information and of phonological form. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20(4), 824.
- La Heij, W. (1988). Components of Stroop-like interference in picture naming. *Memory & Cognition*, 16(5), 400-410.
- Levelt, W. J. (1989). *Speaking: From intention to articulation*. MIT press.
- Levelt, W. J. (1999). Models of word production. *Trends in cognitive sciences*, 3(6), 223-232.
- Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22, 1-75.
- Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. *Memory & Cognition*, 7(6), 485-495.
- Lupker, S. J. (1982). The role of phonetic and orthographic similarity in picture-word interference. *Canadian Journal of Psychology/Revue canadienne de psychologie*, 36(3), 349.
- MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological bulletin*, 109(2), 163.
- Mahon, B. Z., Costa, A., Peterson, R., Vargas, K. A., & Caramazza, A. (2007). Lexical selection is not by competition: a reinterpretation of semantic interference and facilitation effects in the picture-word interference paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33(3), 503.
- Meyer, A. S., Roelofs, A., & Levelt, W. J. (2003). Word length effects in object naming: The role of a response criterion. *Journal of Memory and Language*, 48(1), 131-147.

- Miller, G. A. (1996). *The science of words*. New York: Scientific American Library.
- Miozzo, M., & Caramazza, A. (2003). When more is less: a counterintuitive effect of distractor frequency in the picture-word interference paradigm. *Journal of Experimental Psychology: General*, 132(2), 228.
- Oldfield, R. C., & Wingfield, A. (1965). Response latencies in naming objects. *Quarterly Journal of Experimental Psychology*, 17(4), 273-281.
- Pechmann, T., & Zerbst, D. (2002). The activation of word class information during speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28(1), 233.
- R Core Team (2013). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.
- Rayner, K., & Springer, C. J. (1986). Graphemic and semantic similarity effects in the picture—word interference task. *British Journal of Psychology*, 77(2), 207-222.
- Roelofs, A., Meyer, A. S., & Levelt, W. J. (1998). A case for the lemma/lexeme distinction in models of speaking: Comment on Caramazza and Miozzo (1997). *Cognition*, 69(2), 219-230.
- Rosinski, R. R. (1977). Picture-word interference is semantically based. *Child Development*, 643-647.
- Schiller, N. O., & Caramazza, A. (2002). The selection of grammatical features in word production: The case of plural nouns in German. *Brain and Language*, 81(1), 342-357.
- Schiller, N. O., & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. *Journal of Memory and Language*, 48(1), 169-194.
- Shapiro, K., Shelton, J., & Caramazza, A. (2000). Grammatical class in lexical production and morphological processing: Evidence from a case of fluent aphasia. *Cognitive Neuropsychology*, 17(8), 665-682.
- Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of experimental psychology: Human learning and memory*, 6(2), 174.
- Szekely, A., Jacobsen, T., D'Amico, S., Devescovi, A., Andonova, E., Herron, D., Lu, C.C., Pechmann, T., Pleh, C., Wicha, N., Federmeier, K., Gerdjikova, I., Gutierrez, G., Hung, D., Hsu, J., Iyer, G., Kohnert, K., Mehotcheva, T., Orozco-Figueroa, A., Tzeng, A., Tzeng, O., Arevalo, A., Vargha, A., Butler, A.C., Buffington, R., & Bates, E. (2004). A new on-line resource for psycholinguistic studies. *Journal of memory and language*, 51(2), 247-250.

Vigliocco, G., Vinson, D. P., & Siri, S. (2005). Semantic similarity and grammatical class in naming actions. *Cognition*, 94(3), B91-B100.