Filozofická fakulta Univerzity Palackého

Ability to switch in linguistic and non-linguistic tasks: Interpreters vs. Non-interpreters

(diplomová práce)

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V Olomouci dne 1.5. 2019 **Bc. Markéta Levá**

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Abstract

The overall topic of this thesis is bilingual processing in advanced EFL learners (Czech EFL bilinguals). Participants with a high level of L2 proficiency were pre-selected based on their English language skills. The experiment included a picture-naming task during which the participants named objects in simple pictures either in English or Czech depending on an external cue. Reaction times on language switch trials and non-switch trials were compared to determine, whether there is a difference between in how fast the bilinguals start naming the picture on switch and non-switch trials and how many mistakes they will make. We also wanted to examine, whether it takes longer to switch into L1 than into L2 as found in previous research. What is more, we focused on whether the bilinguals who are trained in language switching are faster than untrained bilinguals on the switch trials and whether they will show smaller differences between switch and non-switch trials.

The research conducted in this thesis, found that it took the participants significantly longer to name the picture, if the picture was in switch position, switching to the minority language than when it was in the stay position in the minority language. We also found that trained bilinguals do not name the pictures in switch positions significantly faster than untrained bilinguals in our experiment. Furthermore, we found neither cognate facilitation effect nor cognate inhibition, the cognates in our experiments were named with the same speed as the corresponding non-cognates.

Key words

Bilingualism, Cognitive control, Inhibitory control, Language switching, Lexical selection, Picture-naming task, Switching studies

Anotace

Tématem této diplomové práce je bilingvní lexikální výběr u českých bilingvních studentů angličtiny. Cílem této diplomové práce je zjistit, zdali budou studenti překladatelství a tlumočení, u kterých se přepokládá, že jsou v přepínání jazyků cvičení, lepší než studenti filologie. Účastníci byli vybráni dle jejich jazykové úrovně. Experiment zahrnuje pojmenovávání obrázků, kdy účastníci pojmenovávají obrázky buď v angličtině nebo v češtině, podle vnějšího podnětu. Měřili jsme reakční časy těch slov, jež se vyskytovala v tzv. switch pozici (když se měnil jazyk) a jejich kontrolních protějšcích, abychom zjistili, zdali se budou časy, ve kterých bilingvní účastníci našeho výzkumu pojmenují dané obrázky ve switch pozicích a jejich kontrolní protějšky lišit. Dále nás zajímalo, kolik chyb při přepínání z jednoho do druhého jazyka studenti udělají. Dále jsme se soustředili na to, jestli bude přepínání do dominantního jazyka pomalejší než do jazyka nedominantního. Také jsme zkoumali tzv. „cognate facilitation effect“ tj. rychlejší pojmenovávání slov podobného původu a zdali budou studenti tlumočení lepší i v nelingvistických úkonech.

V našem experimentu jsme zjistili, že trvalo významně déle pojmenovat obrázek, když se nacházel v přepínací pozici do menšinového jazyka, než když se nacházel v menšinovém jazyce. Studenti, u kterých se předpokládalo, že budou v pojmenovávání obrázků v tzv. switch pozici rychlejší, nebyli významně rychlejší než ti, u kterých jsme předpokládali, že nejsou trénovaní. Slova podobného původu byla v našem experimentu pojmenována stejně rychle, jako k nim patřící kontrolní slova.

Klíčová slova

Bilingvismus, Inhibice, Kognitivní funkce, Lexikální selekce, Pojmenovávání obrázků, Přepínání jazyků, Přepínací studie

Obsah

1 Introduction

Bilinguals are said to be operating on a language continuum going from one monolingual setting to another (Grosjean 1997). They are also able to differentiate and switch between their two languages (in our case between Czech and English) without major effort and mostly without mistakes, besides slips of the tongue or some minor mistakes. It has been found in many studies that when switching from one to another language, the bilinguals experience the switch cost which is defined as a reaction time delay when switching from one language to another. Interestingly, the switch cost is greater when switching from L2 to L1 or in other words from the non-dominant language to the dominant one (Olson 2016). One of the explanations for why the bilinguals are able to communicate in one language, while both of the languages are activated is the Inhibitory Control Model as proposed by Green (1998). The inhibitory control model proposes that if both the languages are active at the same time and both of them are competing for selection, there has to be some process or processes by which the lexical item in the correct language is selected. Green (1998) claims that we use the same mechanisms as in everyday activities, and that the lexical item in the non-target language has to be supressed or in other words inhibited.

This thesis examines late Czech-English bilinguals and their ability to switch in their two languages using both linguistic and non-linguistic switch task. The main aim is to determine whether there is a difference in the naming latencies on switch trials and non-switch trials, and if it is, whether it will take longer to name the pictures when switching into the more dominant language than when switching into the non-dominant one. Furthermore, we would like to investigate whether the students of translation and interpreting, who are expected to be trained in language switching, prove to show greater ability to switch languages compared to philology students at the same level of language proficiency. Since previous research have shown that there is an influence of frequent exercise of cognitive function on switching ability, we also employed non-linguistic switch task, to determine whether there is a relation between language switching and non-linguistic switching. What is more, it is claimed, that the cognate status influences the speed with which the bilinguals are able to name the pictures, thus we incorporated cognates and the corresponding non-cognate controls into our experiment to investigate this claim.

First, we summarize how the lexical access works in monolingual and bilingual speech production, then we focus on the Inhibitory Control model as proposed by Green (1998), and we review the current research done in bilingualism and switching studies.

Second, the methodology of data collection is described, and we provide a discussion on given results. The participants in our experiments are both students of interpreting and English philology, having high language proficiency, signalling bilingualism. To assess our subjects' proficiency, we used the vocabulary size test. We chose the students of interpreting, anticipating their previous experience with language-switching and philology students, who lack this experience, in order to discover, whether the previous experience makes a significant difference. We used picture naming task during which the subjects have to name the objects in simple pictures either in English or Czech depending on an external cue to measure our subjects' reaction time.

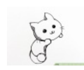
Further on we also use non-linguistic task to determine their reaction time and their ability to switch also in non-linguistic task. Reaction times are compared in order to detect whether the switch and non-switch trials are different in speed of naming the picture and mistakes they make. Then we attempt at testing the Olson's (2016) findings of slower switching into L1 than into L2. We also measure the naming latencies of cognates and non-cognate controls, to test the cognate facilitation effect. Next the results are described and discussed.

2 Literature review

2.1 Bilingual mind and two separate but interconnected languages

Being a bilingual may bring many advantages ranging from the ability to communicate more or less equally fluently in two (or more) languages to benefits connected with enhancement of cognitive abilities (Colzato et al. 2008). Psycholinguistic research of bilingualism has many dimensions. One important question that has been driving research on bilingual speech is the question how is it possible that bilinguals are able to separate their two languages in online production. Connected to that are questions about processes involved during the selection of only one language to produce an utterance. In the following paragraphs we aim to describe monolingual and bilingual production.

2.1.1 Monolingual speech production

Both of the languages in the bilingual mind are said to be working on the background, being both separate but also active during the speech production.
Focusing on the monolingual speech production, even when a speaker is purely monolingual, production of speech is a complex process that involves a number of steps. This process is often analysed for producing single words, like one would do in naming objects in pictures. La Heijl (2005) claims that during the lexical selection, both monolingual and bilingual speakers are challenged by similar problems (289). For example, in order to say out loud the word "CAT" when a monolingual speaker of English is prompted by a picture such as . First, the speaker visually processes the image, then the relevant concepts, based on the pre-verbal message, which is complex and contains all the information that is essential to make the right choice (to produce the word "CAT") are activated in the conceptual systems. As a result of the activation of the concepts, the visual object, the "CAT" is identified and the information about the object becomes available. At this point, more than one concept is activated due to the competing stimuli in the speaker's environment or due to the overlap of the meaning in the preverbal message ("CAT" shares the concept of a domesticated

four-legged animal with the concept of a “DOG”) and thus, the concept of the “DOG” can also be activated. The activation spreads not only through the representational concept but also to the lexical system, activating the lexical nodes. The next process that takes place is the concept selection, in which the target word “CAT” has to be selected while the other concepts are competing for selection. There is a set of activated candidates for selection and the lexical selection is made based on the level of activation. As a result, the concept of the “CAT” achieves the highest level of activation and therefore is selected for production. Then, the concept is matched with sub-lexical and the phonological levels and finally, the desired word is articulated.

2.1.2 Bilingual speech production

For a speaker bilingual for example in English and Czech, the process is much more complex. The complexity of the problem is summarized by Klaus (2018): “unlike in monolingual speech production, speakers do not only have to select a to-be-expressed concept and assign it to the appropriate lexical-semantic and phonological attributes, they also have to select the currently appropriate language” (867). Numerous studies show that bilinguals’ languages are activated even at times when only one language is spoken (e.g., Abutalebi and Green, 2007; Blumenfeld, 2014; Costa et al., 2000; Costa and Sansesteban, 2004, 2006; Filippi, 2013; Green, 1998; Kroll et al., 2006). The activation of the lexical items is claimed to language non-specific, and therefore both of the languages get to be activated (Costa, 2005) and the speaker always has to select the appropriate one.

As already mentioned above, one of the advantages of bilingualism is that bilinguals do not confuse their languages. If both languages are activated simultaneously and the speaker has very little time to select the appropriate one, one would expect to encounter mistakes and unintentional language switching caused by the competition of the two languages in a single mind. However, it is not often the case. Highly proficient bilinguals are able to separate the two languages effectively, not letting them to interfere and rarely making a mistake such as producing a word in the other language as the person is using (Olson 2013). The question that arises is what process enables the bilinguals to switch from one language to another, without causing disruptions in conversation and if both of the languages are activated, how does one language come to be selected/spoken. There are two competing theories to be mentioned.

One, as Costa (2005) mentions is language-specific or selective, which means that the selection of the intended language is made at the conceptual level and that the lexical nodes are not further activated, and thus the following process is the same as in monolingual speech. If we take our example with the “CAT”, following the language-specific theory, only the lexical nodes in the chosen language would be considered and activated (“CAT” and “DOG”) and those in lexical nodes in the non-desired language (“KOČKA”, “PES”) would not be activated and therefore only the lexical nodes of “CAT” and “DOG” would be competing for selection which would be the same process as in the monolingual production.

Another theory claims that the lexical selection is language-nonspecific or non-selective, and it proposes that both the languages are activated at the same time at the lexical level. According to this theory, both lexical nodes of “CAT” and “DOG” and “KOČKA” and “PES” would be activated and competing for selection. There are two approaches trying to explain the process of selection of the appropriate lexical node in the appropriate language when both the languages are activated (Costa, 2005).

One, concerning the levels of activation, which means that the intended language receives greater level of activation than the non-intended one and therefore it is chosen. Another approach is that there is an inhibitory control that supresses the activation of the irrelevant language and so it lowers the activation of the lexical item irrelevant to the task. In this thesis we focus on the latter approach, called the Inhibitory Control Model (IC) which was proposed by Green (1998). In the following chapter we aim to describe the cognitive control and the executive function in general, specify its location and further on to elaborate on Green’s IC model. Of course, bilinguals not only have to separate the two languages on lexical level, but also syntactic, phonological, phonetic etc. all of which are in competition for selection.

As far as the activation of the phonological segments is concerned, the question that arises is whether the phonological segments are also activated in both languages as the activation spreads, or not. There are also two theories to be discussed. First, the discrete model of production, which claims that the phonological segments of the non-selected language do not become activated and the bilingual activation ends with the lexical nodes, which compete for selection and at the lexical level, where the selection is made, and therefore only the phonological segments that belong to the selected language are activated. Taking this approach, after the lexical selection, the process of phonological encoding should be the same as in monolingual production.

Another theory, which is called the cascaded model, supposes that the activation spreads to the phonological level in the same way as it does in the lexical level and so if we take our example with the lexical node "CAT", taking this approach, the phonetic properties of both "CAT", "KOČKA", "CAT" and "DOG" would be proportionally activated, even if they are not selected . This theory was supported besides others by a study by Peterson and Savoy (1998), who used picture-based Stroop task, in which the subjects had to name the pictures they were presented distracting them with the preceding picture, which was either phonologically related, near-synonym of the word or phonologically related to a semantically related word or semantically unrelated. They discovered, that the subjects' naming latencies were faster when the distractors were pictures that were phonologically related to the target word (Peterson and Savoy, 1998). This result according to them supported the theory, that the lexical nodes, which are not selected are also activated on phonological level. Nevertheless, their results were questioned by for example Costa et al. (2000) who believed, that the facilitation effect that was shown in the study by Peterson and Savoy (1998) applied only to a small portion of language; the near-synonyms and therefore, it might not be considered as an evidence towards the cascaded model.

Costa et al. (2000) tested both of the theories using cognates and non-cognates. According to the cascaded model, the cognates (defined as words, having the same or similar orthographic and phonetic forms in both languages) would be named faster because of their phonological similarity in both languages than non-cognates, which do not have any similarity across the two languages. Whereas according to the discrete model the cognates and the non-cognates would be named with the same speed, because only the phonological properties of the selected lexical node in one language would be activated. They indeed found that cognates were named faster in their research than corresponding non-cognate controls.

Although bilinguals do not often make mistakes of speaking the "wrong" language when they talk, careful psycholinguistic measurements show that there are inter-lingual effects evident in speech production of bilinguals, that is bilingual speech processing is different from monolingual speech processing. When performing picture-naming tasks, bilinguals show slower naming latencies than monolinguals which is caused by the fact that bilinguals name a specific word less frequently during their life time than monolinguals because of the two languages. Unlike bilinguals, monolinguals use only one language and therefore they produce the lexical item more frequently than bilinguals who have their production frequency split into two languages, one of which might be more dominant and therefore the frequency of the naming is never equal (Abutalebi and Green, 2007). The frequency with which a certain word is produced influences the speed with which the speakers are able to name the picture. The study of cognates by Costa et al. (2000) supported this claim in the way that there is a cognate facilitation effect when naming cognates, which means that cognates are named faster than corresponding non-cognates. For further specification, cognates will be defined here as words, having similar or the same orthographic and phonetic representation in both languages ('*football*' and '*fotbal*'). The cognates, sharing some properties in both of the languages are not only increasing the frequency of the production of the word, which increases the speed with which they are named, but they also increase the speed supporting the cascaded model of activation. Further on, bilinguals experience much more often the tip-of the tongue state (which does not apply to proper names or cognates), which supports the theory of the language-non-specific selection.

2.2 Green's model Inhibition Control Model of lexical access

This section discusses the issue of language control during production of speech by bilinguals. It is limited to the stage of retrieving words from memory, i.e. to lexical access.

Bilinguals mostly need to express themselves only in one language, but all the words in their mind are linked with two lexical nodes, each of which is in another language. This fact leads to a question; what is the process of lexical selection and how is the correct language selected? As mentioned in the previous chapter, there are two competing theories that address this issue. One is the selective view, in which the lexical selection is language specific and the other, on which we will focus in this thesis, is the non-selective view of lexical access represented by Green's inhibitory control model.

As Norman and Shallice (1986) proposed, there are mechanisms controlling our behaviour. These mechanisms influence the activation of certain schemas (such as pouring water or warming it), that we make use of in our everyday activities. Green (1998) uses these mechanisms that we normally use as an explanation for bilingual language production. These mechanisms, according to Green (1998) enable the bilingual speaker to produce a word in the target language, without making mistake.

First, Green (1998) claims that, during speech production, the bilingual speaker has to set a goal (to articulate a word in a specific language), which is similar to performing non-verbal actions (68). Green assumes that there is a language-independent conceptualiser which "builds conceptual representations (based on information in long-term memory), driven by a goal to achieve some effect through language" (1998). This goal (i.e. the communicative intention, to produce a word in a specific language, simple to fulfil the task) is mediated by the supervisory attentional system (SAS) together with components of the language system, i.e. the lexico-semantic system and a set of language task schemas (Green, 1998). The SAS can be viewed as a controller that supervises the construction and modification of schemas and their performance in a certain task. Green (1998) claims that "language task schemas (e.g. word production schemas or translation schemas) compete to control output from the lexico-semantic system" (69). The schemas are defined by Green (1998) as "mental devices or networks that individuals may construct or adapt on the spot in order to achieve a specific task" (69).

For the word to be selected and further articulated, the target language has to specified in order to be successfully transmitted by the SAS to the task schemas. It also requires conceptual information to be transmitted to the lexico-semantic system from the "conceptualiser" (Green 1998, 69). As the schema becomes automatized, it can be further adjusted to achieve a new goal. During the language production, the outputs from the lexico-semantic system are regulated by regulating the levels of activation and by inhibiting outputs from the system. The activation is finished either when the goal is achieved, the goal is changed by the SAS or is inhibited by another schema. The SAS plays the role in reaching the goal in the way that it changes the activation levels.

After performing a specific task (such as production of a word to name an object) it will be stored in memory and a certain schema for such task can be retrieved and adapted from memory and the schemas will bring an automatic response. However, when a person is confronted with a new task, the old schemas will be insufficient, and the automatic control will not perform its task, the supervisory attentional system (SAS) will modulate the contention scheduling (Green 1998).

To explain the way the lexical selection in IC model works more closely with respect to lexical selection, recall the widely accepted Levelt's model of speech production in which every lexical concept is connected to the system of lemmas, which carry a syntactic information by which they are used in sentences (Levelt et al., 1999). If a lemma is selected, the particular word form is activated. A bilingual mind has to choose between the two languages, to produce the desired word in the desired language. In non-selective models of lexical access, the relevant lemmas in both languages are contacted by the conceptual representation, which is part of the intention to produce a specific word in a specific language. In Green's lexical access model "lemmas are specified in terms of a language tag and that tag specification is also part of the conceptual representation" (1998,71). Thus, there is a tag of L1 or L2 for every lemma and the activation of lemma depends on how the tag is specified. The Inhibitory Control Model argues that the lemmas with the tag, which is not desired to the task are inhibited, so that only the lemma with the tag relevant to the task is chosen to be produced. In sum, the IC model proposes that lemmas in both languages which are linked to the active concepts are activated and subsequently the lemmas which are labelled with tags incorrect to the goal of speaking in a given language, are supressed or in other words, inhibited.

The process of inhibition begins when the "lemmas linked to active concepts have been activated" (Green 1998, 71). As mentioned in the second chapter, the lemmas in one language may share some similarities with a concept in the other language and thus both lemmas receive some levels of activation. Further, as mentioned above, the conceptual system activates the lexical nodes in both languages and the IC model is said to work on the lexical level, thus the inappropriate lexical nodes are supressed on the lexical level. The inhibition is claimed to be reactive, which means that it reacts to the level of the activation of the lexical nodes, in other words, the inhibition process starts after the activation of both lexical nodes in both languages. The inhibition also reacts to the level of activation of a certain lexical node, thus the more the lexical nodes in the non-target language are activated, the greater the inhibition will be (and further on the greater the inhibition has to be, the longer it would take for a speaker to produce the target word in a certain language). Furthermore, there is also said to be an interference between the lexical nodes of the suppressed language and the target language, even though they are supressed.

As far as the activation of the sub-lexical level is concerned, the IC model assumes, that phonological properties are available only to the selected lexical node and thus it goes against the cascaded model of phonetic activation, being contradicted for example by Costa et al. (2000). Costa et al. (2005) however, accounts for both the possibility of cascaded model of activation and the IC model, by proposing that 'by the time inhibition reaches the nonresponse lexical nodes, the target's translation has already spread some activation to the nodes representing its phonological properties' (322).

To conclude, when a bilingual is faced with the language switching task, he will have to change the language schema for the task. It is widely argued that switching from one language to another and the other way around will result in switch cost (Costa 2000; Filippi, 2014; Olson, 2016). Which means that it will take longer to switch from one language to another. The fact that the switch cost will appear, might be the outcome of the fact that the previously activated language schemas will have to be inhibited and overcome by the new schemas. It is assumed that both of the languages are activated at the same time and thus they are competing for selection, the selection of the lemma labelled with the goal-appropriate tag will have to take place. Further on, the inhibition of the lemma with the goal-non-appropriate tag will have to be inhibited.

Based on the theory of Inhibitory Control, we expect to find longer naming latencies for switch trials than for the non-switch trials, as shown by previous research.

2.2.1 Inhibition as a process

We have so far discussed the lexical selection of bilinguals, stating that we are concentrating on the theory of inhibition, however, we have not considered the inhibition itself, as a process yet. Below we aim to describe the inhibition as a process.

According to Harnishfeger (1995) "inhibition is … a basic cognitive suppression that contributes to task performance by keeping task-irrelevant information from entering and being maintained in working memory" (178). In other words, inhibition is a process that lets us supress a certain stimulus in order to concentrate on another, more important one. We inhibit or supress the stimuli that is not relevant to the task we are aiming at completing at the moment. Harnishfeger (1995) further mentions that "if processing efficiency is conceptualized as speed of activation, such as in semantic network, then inhibition can be conceptualized as a process that blocks the spread of activation, keeping attention focused sharply on the task at hand" (178). Thus, inhibition is said to block the semantic activation of a certain lexical node during bilingual speech production as the two languages are competing for selection in the bilingual mind. Inhibition can be either behavioural or cognitive, this diploma thesis considers cognitive inhibition.

The inhibitory processes as well as the executive functions reside in the prefrontal cortex. The executive functions have several subdomains including; problem-solving, abstract thinking, organisation, verbal fluency, inhibition, initiation, mental flexibility, anticipation, creativity, metacognition, introspection, working memory and many others. Time arrangement of behaviour, language and thinking is also located in the prefrontal cortex. The prefrontal cortex is also called the brain executive and the organ of creativity. The executive function is a multi-operative system which is ensured by prefrontal areas of the brain and their reciprocal cortical and subcortical circuit.

The key components of cognitive control and executive functions are working memory, inhibition, and cognitive flexibility, which make us able to remember information and work with it, to supress impulse behaviour and use our self-regulation and to be able to react to changing situations (Davidson, 2006, 2037).

Cognitive control is not located in one separate region of the brain, rather it is a complex function that works by the interaction of separable systems (Gruber & Groshke, 2004). Many studies using functional neuroimaging provide an evidence that cognitive control is integrated into separable neural systems (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999; Carter, et al., 1998; Petrides, Alivisatos, Meyer, & Evans, 1993). Further on, basal ganglia and their multiple parallel excitatory and inhibitory cortical connections play an essential role in cognitive control and information processing (Graybiel, 1997; Middleton & Strick, 2000). As Abutalebi and Green (2008) mention, the *Figure 1* is a model of the areas that play role in cognitive control.

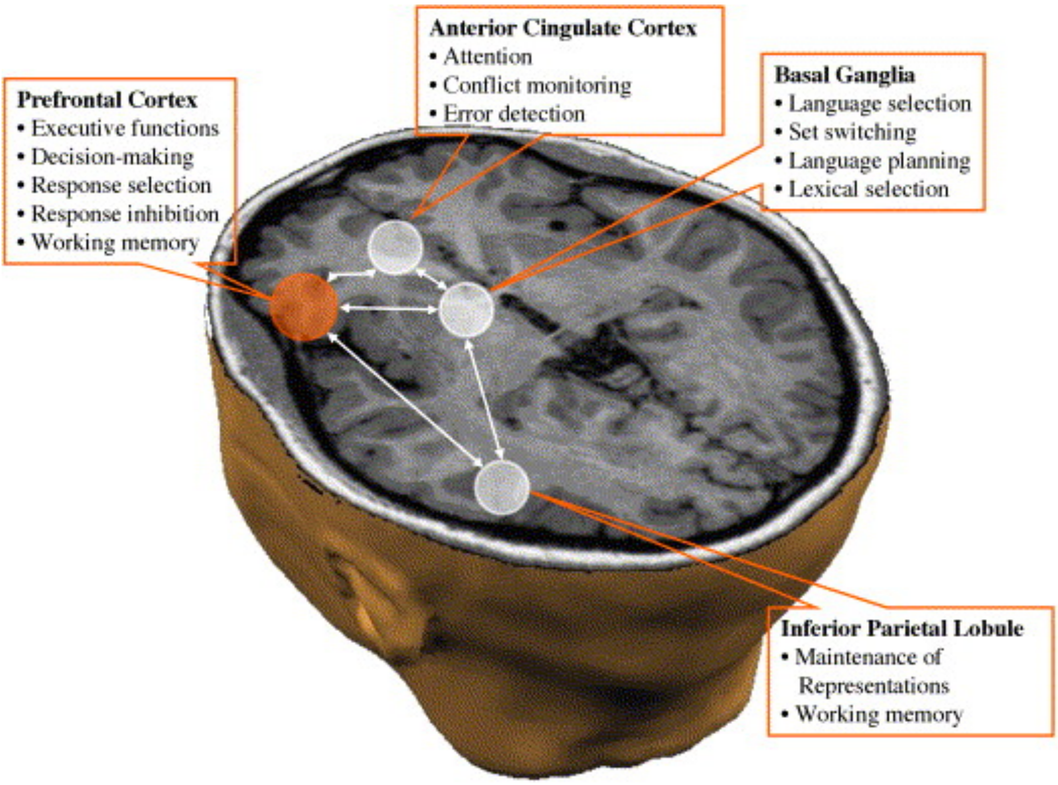


Figure 1 (see Abutalebi and Green, 2007)

As visible from the *Figure 1*, the Prefrontal cortex is claimed to be responsible for the executive functions, decision-making, response selection, response inhibition and working memory. The basal ganglia deal with the language selection, set switching, language planning and lexical selection whereas the inferior parietal lobule is where the maintenance of representations and working memory are located.

As mentioned above, the cognitive control is located in the prefrontal cortex, which plays an important role in sensory, motor and associative neocortical systems (Abutalebi and Green 2007). There are several cognitive controls located in the prefrontal cortex, all of which are located in different areas of the prefrontal cortex and perform a different function.

The cognitive control can be either strategic or automatic. The strategic retrieval needs the person to be consciously attempting and intentionally planning to retrieve a specific information (for example a word), thus it is self-governed and specified by the assessment of the intended goal. Whereas the automatic retrieval, which does not need the inferior prefrontal cortex to be activated, is as it is called automatic, thus it does not require the intention of the person (Abutalebi and Green 2007). Abutalebi and Green (2007) claim, that retrieval of words in L2 in which the person is not in high proficiency is a process which is controlled, and thus it involves the activation of the prefrontal cortex, whereas when the person is highly proficient in his L2, the process might be automatic and thus the prefrontal cortex might not be involved in it or it will be less activated, except for translation.

The Anterior cingulate cortex (ACC) is where the centre for attention, conflict-monitoring and error detection is located. Cabeza & Nyberg (1997) proved that anterior cingulate cortex (ACC) is active in the tasks which engage selective attention, working memory, language generation and controlled information processing. Anterior cingulate cortex is further claimed to be modulating the cognitive control. The activation of ACC is said to be in relation to response conflict, which is the 'simultaneous co-activation of incompatible responses' (Abutalebi and Green 2007, 250). The response conflict could be explained when there is a picture naming task and a person sees a picture of a parrot and he cannot say both parrot and 'papoušek' at the same time. Current research shows that ACC deals with the response conflict and in case of a need for greater control it sends signal to the prefrontal cortex, which 'implements control via top-down modulation of posterior cortex or the basal ganglia' (Abutalebi and Green 2007, 250).

2.2.2 Simultaneous activation; evidence from neurolinguistic studies

Abutalebi and Green (2007) proposed a single network hypothesis for processing languages which is based on convergence. They propose, that a person uses the same computational devices in his L1 as in his L2, thus monolinguals and bilinguals will use the same control circuits. Further on, they claim, that the principles one uses in his native languages will be the same in his L2, even if the second language was learned relatively late. Convergence further on implies that the neural region in all the levels (lexical, syntactic, phonological) will be activated in the same way as in L1. The convergence predicts that as one acquires his L2 on a certain level of proficiency, the processing of L2 will converge with the processing of the L1, however it will not be the same. What is more, Abutalebi and Green (2007) argue that since the two languages have different syntactic and phonological patterns, the speaker's brain will adapt and thus the processing of his own L1 will be different to the monolinguals. So, the Czech-English bilingual speaker will process Czech differently than Czech monolingual speaker and she will also process English differently than the English monolingual.

The process of acquisition of a language involves competition for neural representation, consequently, when acquiring new vocabulary, the brain structures will have the need to adapt, so that the specific regions representing vocabulary will have to enlarge its storing space to represent relevant information or it will have to reorganize in order to be able to represent the relevant new information (Abutalebi and Green 2007). "So, we should expect either a broad structural effect such as an expansion of the relevant neural region (i.e., increasing the number of units for coding input and output) or an increase in functional capacity by other means such as increasing the connectivity among the units or by increasing their density in a given region" (Abutalebi and Green 2007, 254). Mechelli et al. 2004 found out that the inferior parietal cortex showed increased density of the grey matter density in bilinguals in comparison to monolinguals which confirms the convergence hypothesis. One factor influencing the convergence is the language proficiency, people with low proficiency in their L2 will spend more time in naming a picture because of the weaker connection between the lemma and the word as Kroll& Steward (1994) and Snodgras (1993) found out.

Going back to what we have already mentioned above, the hypothesis was that the low proficient L2 speaker will have to inhibit the more dominant and more proficient L1 when speaking in L2, and thus the prefrontal cortex will be activated, signalling the controlled not the automatic processing of L2. As the speaker of the L2 becomes more accustomed to the L2, and gains more practise, the interference will be less frequent, and the inhibition will demand less effort and the competition resolving when switching from one language to another will become more automatic. However, as Rodriguez- Fornells et al. (2002) found out, bilinguals still need to inhibit the language irrelevant to the task, nevertheless they proved to show the activation of the left anterior prefrontal region, whereas the monolinguals did not (they tested the ability of the subject to identify a word as a Spanish word or a pseudo word). As mentioned above, the more automatic the control is, the less the prefrontal cortex is activated. What is more, as speaker gets used to the task performed, it becomes automatic and it will show lower activation of the prefrontal cortex rather than changes in the neural representation of the lexical item. This phenomenon is called the "left prefrontal effect" and it is confirmed that the effect decreases as the proficiency grows (Kan, Kable, Van Scoyoc, Chatterjee and Thompson-Schill, 2006).

Hernandez et al. (2001) found out that the left dorsolateral prefrontal cortex activation was greater when the subjects (early Spanish-English bilinguals) did the switch trials, rather than non-switch. "Such an increase is consistent with the requirement to switch between language goals (i.e., to handle goal competition). In the sense that currently active lexical concepts in the current language activate the language goal to name in the current language, any effects of lexical competition between-languages are indirect" (Abutalebi and Green 2007, 260). Thus, even though the inhibition or the control mechanism may become automatic as the language proficiency grows, it is still present and not only attributable to low-proficient speakers.

2.2.3 Evidence for inhibitory control from picture-naming switch studies

There are several studies supporting the Green's IC model, including behavioural study of Meuter and Allport (1999), who explored whether there will be a switch cost (which is defined as a longer naming latency in when the subject switch from one language to another) when the late bilinguals are faced with the language switching task. They asked bilinguals of different languages to name nine numbers presented in lists. They were supposed to name the numbers in a language according to the colour of the frame presented, concentrating on the naming latencies (the time counted from the presentation of the digit or in other studies a picture until the onset of voicing). They discovered, that their subjects were faster in non-switch trials than in switch trials, discovering the switch cost, supporting Green's (1998) model of Inhibitory Control. Meuter and Allport's (1999) results also showed that there is an asymmetry in switch cost, which means that it took their participants longer to switch from their less dominant language (L2) to their dominant language than the other way around. They also found that the asymmetrical switch cost correlated with the level of proficiency in L2. This fact might lead into thinking that the degree of inhibition increases with the degree of proficiency, which means that the switch cost from L1 to L2 in bilinguals proficient in their L2 will require greater inhibition and thus will cause greater switch cost than for less proficient L2 bilinguals switching from their L1 to L2. However, this claim was not supported by Meuter and Allport's (1999) results. They showed, that in fact, the increase in proficiency leads to the reduction of switch cost in both directions. Overall, they found an asymmetrical switch cost (which means that there was greater switch cost when the participants were switching from their L2 to L1) for both less proficient bilinguals and for more proficient bilinguals, but the switch cost for more proficient bilinguals was smaller than for the less proficient. Several other studies (Chen and Leung, 1989; Christoffels et al. 2006, Olson 2013) supported the results of Meuter and Allport (1999).

The language proficiency, or language dominance was also studied by Poulisse and Bongaerts (1994) who researched unintentional language switches and they found that the subjects having lower proficiency in their L2 produced more mistakes when they selected the word from the non-target language and ended up producing it in the other language, Poulisse and Bongaerts (1994) found that these mistakes are especially intrusions of L1 into the L2. As Kroll et al. (2008) pointed out, the inter-lingual effects might influence speech production not only in one's native language but also in the second language.

In order to further test the direction of the switch cost, and the language dominance factor, Costa and Sansteban (2004) tested Spanish learners of Catalan and Korean learners of Spanish by presenting them with picture naming task in which they had to switch between their first and more dominant language and their second language. They tested both low-proficient bilinguals and high-proficient bilinguals. In testing the low-proficient bilinguals, they discovered an asymmetrical switching cost, which replicated the findings in study by Meuter and Allport (1999).

In another part of the experiment Costa and Sansteban (2004) tested highly proficient bilinguals and they found the same switching time from L1 to L2 as from L2 to L1, however they also found that the participants were slower in naming the words in L1 than in L2. They suggested that the difference in the switching is caused by the difference in dominance in between the two languages, showing that the balanced bilinguals had symmetrical switching cost.

The symmetrical switch cost for balanced bilinguals was further on studied by Verhoef, Roelofs, and Chwilla (2009), who manipulated the preparation time and found asymmetrical switch cost for highly proficient bilinguals in short intervals and symmetrical switch cost in long intervals. Gollan and Ferreira (2009) also found asymmetrical switch cost in voluntary switches.

Olson (2016) wanted to examine the direction of switch cost by manipulating the language context and his result supported those of the previous research; he found asymmetrical switch cost that is caused by the language dominance. He used cued picture-naming task with variable contexts and modes. He confirmed the thought that the language dominance causes the switch cost and also found an influence made by language context.

He presented the participants with three contexts; predominantly English (95% English, 5% Spanish), predominantly Spanish (95% Spanish and 5% English) and balanced bilingual context (50% English, 50% Spanish). He discovered that L1 dominant participant showed to have asymmetrical switch cost in the monolingual context in a way that it took them longer to switch from their non-dominant language to the dominant one, whereas in the bilingual context, they showed to have a symmetrical switch cost. He also concentrated on mistakes produced during the experiment and concluded that in the monolingual context there were more error switch cost in the dominant language than in the non-dominant one, whereas in the bilingual context the error rate was roughly the same for both languages.

Klaus et al. (2018) focused on the activation of the phonological form of L1 during the L2 production. They asked their participants to name a picture in their native language while presenting them with a distractor in a form of sound in their second language. The distractor was either the translation of the word in the picture or it was an unrelated word. They found that it took longer the participants to name the object when the distractor was related to the object than when it wasn't which according to them suggest that the activation of the non-desired language (L2) was spread even to the phonological level.

Most of the studies concerning the inhibition model used picture-naming switching task (Broersma et al., 2016; Costa and Sansteban, 2004; Costa and Sansteban, 2006; Kroll et al. 2006). Amengual (2011) who was concerned with the phonological activation of the lemmas in both languages used reading task. All the studies pay attention to the language proficiency and language dominance (Costa and Sansteban,2004; Chen and Leung, 1989; Christoffels et al. 2007; Meuter and Allport, 1999; Olson 2013) as they are the factors influencing the language inhibition. Most of the studies concerning the switch cost used the setting as 30% switch trials and 70% non-switch trials (Costa and Sansteban,2004; Costa et al., 2006; Meuter and Allport, 1999). There are also some studies, manipulating some of the conditions, Olson (2016) for example manipulated the language context. Other studies (Costa et al., 2000; Hoshino and Kroll, 2008; Christoffels et al. 2007) manipulated the cognate status, which is also one of our concerns and thus it will be discussed in the following chapter.

To conclude, previous research showed that there is an asymmetrical switch cost when switching to the more dominant language for unbalanced bilinguals, thus based on what we have found in previous studies and assuming, that our participants are unbalanced bilinguals, we hypothesise, that it will take them longer to switch from English (L2) to Czech (L1) due to the greater activation of the dominant language and thus the need of greater inhibition to overcome the lexical competition.

2.2.3.1 Cognate facilitation studies

One of the aims of this diploma thesis is to examine, what happens, if the bilinguals are faced with a cognate in picture naming task (for the purpose of this diploma thesis, cognates are defined as the lexical items, which share similar meaning and orthographic, and phonological form in both languages). Most of the current research (Broersma et al., 2016; Costa et al., 2000, Hoshino and Kroll, 2008, Christoffels et al. 2007) show, that cognates are named faster, pointing to cognate facilitation effect. The cognate facilitation effect is defined as shorter naming latencies for cognates than for non-cognates. However, there is also an opposite effect, which was revealed by Filippi et al. (2014), who found that cognates in their research were named slower, and they called this effect cognate inhibition.

The cognate facilitation effect is mostly explained by the fact, that cognates share some specificities of the word form and thus when it comes to the activation of the word form in both languages, the fact that the word forms overlap to a certain degree leads to greater levels of activation and thus for faster lexical choice (Broersma et al., 2016). The opposite effect, cognate inhibition, may be explained by the increased level of the lexical competition at lemma level (Filippi.et al., 2014).

As Broersma et al. (2016) pointed out, there are many studies which are concerned with the cognate facilitation effect with respect to the speech processing, however there are relatively few studies which focus on cognate facilitation effect with respect to speech production. As mentioned above, in several picture-naming experiments the naming latencies for cognates were shorter than for non-cognates (Costa et al., 2000, Hoshino and Kroll, 2008, Christoffels et al. 2007; Verhoef et. al, 2009). On the other hand, Filippi et al. (2014) found a cognate inhibition effect in their experiment in which they asked late Italian-English bilinguals to read words from a computer screen in one or the other language based on the colour of the cue, this finding as Filippi et al. (2014) mention may indicate lexical competition between the lemmas of the cognates. There are several factors that can influence the language inhibition, including language proficiency, language dominance or practise in switching. Costa et al.

(2000) who tested Catalan-Spanish bilinguals using picture naming showed that the cognate facilitation effect is greater in the non-dominant language than in the dominant one. Costa et al. (2000) followed the study by Peterson and Savoy (1998), which is mentioned in the previous chapter and which tested the theory of cascaded model by asking the participants to name pictures while being distracted by the preceding picture which was either phonologically related, near-synonym of the target word or phonologically related word to a semantically related word or completely semantically unrelated. Peterson and Savoy (1998) found that the subjects were faster to name the picture when the distractor was phonologically related than when it was not related at all, supporting the cascaded model of activation.

Further, Broersma et al. (2016) used highly proficient early Welsh-English bilinguals and presented them with mixed picture naming task using 50% of one language and 50% of the other in one trial including 18 cognates and phonologically matched non-cognate controls. Their hypothesis was that there will be a cognate facilitation effect. They found that there was a cognate facilitation effect when the participants were Welsh-dominant and equally dominant, whereas when they were English-dominant they showed cognate inhibition which leads to the thought that language dominance affects the direction of the cognate effect.

The fact that language proficiency influences the production of cognates as well, in a way that the facilitation effect is greater for lower-proficient speakers than for speakers whose proficiency is high was also proposed by Van Hell and Dijkstra (2002) who studied Dutch trilinguals, who were native speakers of Dutch, having English as their L2 and French as their L3. They found that it took the participants, who were highly proficient in English and had low-proficiency in French shorter to associate a word when it was a Dutch cognate with English, than if it was not a cognate, however, there was no difference in response time for cognates with French and non-cognates.

Another factor influencing the cognate facilitation effect was studied by Hoshino and Kroll (2006) who tested whether there will be a cognate facilitation effect if their participants' languages do not share the script. They asked their Spanish-

English and Japanese-English participants to name the pictures they were presented in their L2 (English) and they found a cognate facilitation effect in Japanese-English bilinguals which suggests the phonological activation of the non-target language.

Based on the reviewed research, we hypothesise that our late bilingual speakers of Czech and English will show cognate facilitation effect, enhancing the speed of the naming of cognates.

2.3 Inhibitory control and other cognitive tasks

There are several factors which are said to be influencing the inhibitory control, among which are age, language proficiency and language dominance, and practise. The research done in exploring the language proficiency and language dominance was discussed in the previous chapter. In this chapter, we would like to discuss the factor of age and the factor of practise in language switching on cognitive control.

As discussed in previous chapters, it is generally assumed that bilinguals must use some sort of specific control mechanisms for their speech production (as well as for speech perception), however these mechanisms also involve general cognitive processes (Abutalebi and Green 2007). Thus, during speech production, both language control mechanism and general cognitive control mechanisms are active. As mentioned above, Green (1998) proposed the model of Inhibitory control (IC) which can be held accountable for the control which bilinguals use when switching back and forth in their two languages. This control can be likened to the control of action, since language is communicative action (Abutalebi and Green 2007).

Abutalebi and Green (2007) further proposed and gave an evidence to; "neural representation of a second language and that language production in bilinguals is a dynamic process involving cortical and subcortical structures that make use of inhibition to resolve lexical competition and to select the intended language" (242). Several recent studies (Olson 2013, Olson 2016, Klaus et al. 2017) provide evidence that bilinguals take advantage of a cognitive control to help them to supress the activity of the language which is not used in a certain situation.

Bialystok et al. (2004) and Bialystok et al. (2006) confirmed that the process of selection of the lexical node is similar to the selection of the competing cues in non-verbal task. Thus, bilingualism is claimed to improve cognition and brain processes that influence language cognition (Kroll et al., 2014) and furthermore as bilinguals use cognitive control mechanisms much more often than monolinguals, they were found to outperform the monolinguals in non-linguistic tasks testing the cognitive controls such as in Stroop task or Simon task (e.g. Bialystok and Klein, 2004, Costa et al., 2008, Costa et al., 2009). Bilinguals show to be able to respond faster than monolinguals even in non-linguistic tasks, pointing out that the fact, that bilinguals have two constantly competing languages in one mind, leads to the enhancement of cognitive control in general. Garbin et al. (2010) mention; "the impact of bilingualism on the executive control system has been observed across the life span, being more apparent at ages at which this system is either not fully developed (young children) or already decaying (old adults)" (1272).

Age is one of the factors influencing the executive functions and inhibition because the prefrontal cortex is developing along with the age of a person. As well as inhibition, the executive functions fully develop in the adulthood. Using a Simon task, we can detect the inhibitory control, which shows that the information which is not relevant to the task (in this case the location of the stimulus) has to be inhibited in order to achieve the goal. Older adults are said to have greater Simon effect (longer naming latencies for incongruent trials than for congruent trials) than younger adults, Bialystok et al. (2004) wanted to examine, whether the greater Simon effect is in any way influenced or reduced in bilinguals. They found that older bilinguals outperform monolinguals in Simon task, where they showed smaller Simon effect than monolinguals who were of the same age. These findings indicate that there is an effect of bilingualism on executive function explained by the fact that a person has two languages which keep competing for selection, even if one is using only one of the languages, which leads to enhancement of his ability in switching in non-linguistic tasks.

Garbin et al. (2010), who also focused on the effect of bilingualism on cognitive control, studied highly proficient bilinguals who were used to language switching on a daily basis and they proposed that the fact that the people are used to language switching and to supressing one of the competing languages will have an effect on brain networks involved in the general cognitive control system.

The study aimed at answering the question whether bilingualism has an impact on the brain areas used in language switching. They tested both bilinguals and monolinguals in non-linguistic task. The tests revealed that bilinguals had lower switch cost than monolinguals as shown also in previous research (Costa et al.

2008). Bilinguals also showed to have greater activation of the left IFG, which is the part of the brain responsible for the inhibition of the language, which is irrelevant to the task, and correcting the errors. This result could be attributed to their "better ability to establish the appropriate response set to each stimulus, a strategy that would facilitate performance in conflict tasks" (Garbin et al. 2010, 1277). The results confirmed the thought that bilinguals and monolinguals differ in the development of cerebral networks connected with the control of executive functions. They also found that there is in fact a connection between the general brain networks and the language control.

The idea of practise as an enhancement of executive functions in was also supported by Abutalebi and Green (2007) who claim that "exercise and practise of specific skills (e.g. simultaneous translation) will also impact on how linguistic information is represented and connected" (Abutalebi and Green 2007, 246). They further believe that the neural regions in which the control which we use during code switching is located can be exercised and thus improved.

On the contrary, Colzato et al. (2008) who tested bilinguals and monolinguals in the stop task to determine whether they are better inhibitors than monolinguals found no significant difference between monolinguals and bilinguals. Colzato et al. (2008) wanted to determine if bilinguals are better at the inhibition of return than monolinguals. They also dealt with the active and reactive inhibition, the active inhibition "would reflect processes carried out with the main purpose of excluding particular information from processing, and reactive inhibition which may be a side effect of faciliatory processes in a capacity-limited system" (310). They found that bilinguals do not differ from monolinguals in a stop test which showed contradictory evidence to the thought that bilinguals are better at active inhibition. Colzato et al. (2008) pointed out that the differences in performance of the bilinguals and monolinguals seem to reflect side effects of selecting stimulus events for action rather than differences in some general inhibitory mechanism. Based on their experiments, Colzato et al. (2008) claim that the advantages that bilinguals have in cognitive tasks is not due to the exercise of their inhibition mechanism. They also argue that bilingualism helps the people to select goal-relevant information from competing and supress goal-irrelevant information more effectively. They gave an explanation for it, stating that "(T)this improvement may be achieved by the stronger maintenance of goals in working memory, so they can provide more and stronger support for goal-related cognitive representations" (Colzato 2008, 310).

Contradictory to Colzato et al. (2008) but based on the results of Abutalebi and Green (2007) and others, we hypothesise that our participants trained in language switching will show smaller naming latencies for switch trials and non-switch trials than the untrained participants.

2.4 Non-linguistic measures of inhibitory control

The mechanism, that permits bilinguals to switch from one language to another without making mistakes, or in other words, their ability to supress the one inappropriate linguistic representation of the intended word to be produced of the two simultaneously activated linguistic representations is said to be language non-specific. It is a mechanism that people employ in cognitive conflict (Hilchey et. al, 2011). In the previous chapter, we mentioned that it is widely assumed that by frequent exercising the executive control, bilinguals are better than monolinguals at non-linguistic tasks in which they have to supress the inappropriate stimuli.

To determine whether the exercise of the executive function by frequent switching back and forth in the languages influences the executive function employed in non-linguistic tasks as well, we decided to assign either Simon task or Flanker task. In the paragraphs below, we explore both of the tasks and their usage in previous research concerned with bilingualism. We will choose the one that fits our experiment the best. One of our research questions is whether the group of subjects who will have smaller naming latencies on switch trials, will also have smaller naming latencies in the non-linguistic task as well. Our hypothesis is that the subjects who switch back and forth between their two languages more frequently will be better not only at picture-naming task (linguistic) but also in the non-linguistic task, since they will have greater experience with such inhibition and since as mentioned before, the speed of inhibition is enhanced by frequent practise of switching.

Simon task, Flanker task and Stroop task or their variations are widely used in determining whether there is a bilingual advantage concerning faster reaction times (RTs) in inhibition of an incongruent stimuli. In the paragraphs below, we aim to explain how Simon task and Flanker task work and to summarize their usage in various studies. The bilinguals were also found to outperform monolinguals in Stroop task (Bialystok et al., 2008) however, the Stroop task is language driven, and thus the result is not relevant to the research of non-linguistic ability of the bilinguals. For this reason, we decided to eliminate Stroop task because it is not non-linguistic task to measure the bilingual advantage in supressing the inappropriate stimuli.

2.4.1 Simon Task

The Simon task was named after J.R Simon who developed this type of test and who was also the inventor of Simon effect. The Simon test is a stimulus-response compatibility test, which means that it tests whether the fact that the target and the stimulus are matched make the subjects respond faster. The Simon effect predicts, that the reaction time will be faster, if the target and the stimulus match. In other words, the Simon task measures the reaction time of the subjects' response to the stimulus and their ability to inhibit the inappropriate stimulus. The Simon task is a two-alternative forced choice test, which means that the subjects are presented with two choices, most likely colours (red and green) each of which is associated with a certain hand and a side (either left or right). There are two trials, the congruent one, in which the target colour is in the original location (let's say red is on the left) and the incongruent one, in which the colour (green) is placed on the opposite side (right) and thus the subjects has to use their hand and inhibit the need to push the left button. Originally Simon and Rudell (1967) used the audio version of the test, playing the words LEFT or RIGHT into the subjects' right or left ear and asking them to push left or right button according to the word they hear. They found that if the subjects were played the word RIGHT to the right ear, their reaction time was faster than if the stimulus was not matched with the target. They further on conducted another experiment to prove that the "phenomenon was not caused by a simple isomorphic association between ear stimulated and ipsilateral hand" (Simon 1969, 174) and he proved it by making the subjects use only one hand. Simon claims that it is a "natural tendency to react toward the source of stimulation" (1969, 175).

The Simon effect predicts that the subjects will have slower reaction times in the incongruent trials than in the congruent ones, caused by the extended time spent on inhibiting the inappropriate stimuli. The Simon effect also predicts that not only are the reactions faster, but the subjects also make less mistakes if the stimulus and the target are matched. In the present research, we would like to examine whether the participants who are faster in naming pictures in switch positions are also faster in inhibiting the inappropriate stimulus in the Simon task.

In the paragraphs below, we aim to summarize the studies concerning bilingualism which used the Simon task and their results.

Bialystok (2001) proved that the fact that a person is bilingual and has the two languages in a single mind has an effect on executive functions and that it enhances the executive function in children. In following study Bialystok et al. (2004) and Bialystok et al. (2006) wanted to determine whether the executive function is also more effective with middle-aged adults and older adults and thus whether it persists through ageing. They predicted to find a reduced Simon effect for bilinguals and to prove that exercising executive control leads to faster reaction times and that it persists through the process of ageing. They further on predicted that there should be smaller decrease in reaction time for the incongruent stimuli for the group of older bilinguals than for the group of older monolinguals. In their previous research, Bialystok and Martin Rhee (2008) examined bilingual children and found an advantage in the response time in bilingual children compared to monolingual when "the demands on the inhibitory controls were high" (Bialystok & Rhee 2008, 81). They compared it with the same subjects' performance in Stroop task and found out that bilingual children are better at interference inhibition than in response inhibition as they did not outperform the monolinguals.

They also showed that older bilinguals prove to make less mistakes in Simon task than older monolinguals. In the first experiment they discovered, that both the monolinguals and the bilinguals had increased their reaction time in the incongruent stimuli and thus they showed that there is no delay of the decline of inhibitory effect in adult bilinguals. However, in the second experiment they assessed more trials for the Simon task, and they discovered that bilinguals do show smaller decline in executive function than monolinguals and they showed smaller Simon effect than monolinguals of the same age. They further on proved that over the three experiments, the monolinguals improved and showed smaller reaction times which the bilingual group has been showing from the beginning. Linck, Schwieter and Sunderman (2013) tested trilingual young adults and found a correlation between faster switching from one language to another and a smaller Simon effect. On the other hand, Blumenfeld and Marian (2014) examined whether the fact that one is a bilingual has a greater influence on the Stroop test (stimulus-stimulus) inhibition than on the Simon test (stimulus-response) inhibition. The bilinguals showed greater advantage in performing the Stroop task than in performing the Simon task. The monolinguals proved to show the same performance in both tests. Bialystok et al. (2004) and Costa et al. (2009) also found that bilinguals are better at Simon task both on congruent and also on incongruent trials. Research (Bialystok 2006, 2009; Bialystok & Craik, 2010; Costa et al., 2009) suggest that the advantage that bilinguals have in non-linguistic task over the monolinguals might be related to second-language learning and the exercise of the executive function, as mentioned in the previous chapter.

2.4.2 Flanker Task

The Flanker task was developed by Eriksen and Eriksen in the 1970s and therefore it is also referred to as Eriksen Flanker Task. It is similar to Simon task or Stroop task in the employment of inhibition of the incongruent stimuli. In Flanker task, however, the participants are asked to determine the side to which the central arrow is pointing. It contains congruent trials in which the central arrow is pointing the same direction as the other arrows, in the incongruent trials, the central arrow (the target one) is pointing a different direction than the other arrows around it. It has been used by studies by e.g. Carlson & Meltzoff, 2008; Costa et al., 2009; Costa, Hernández, & Sebastián- Gallés, 2008. The difference in the reaction times between the incongruent and the congruent trials is referred to as Flanker effect which is more or less the same as Simon effect. Costa et al. (2008) used combination of Flanker task and cue reaction time task and Costa et al. (2009) used also a variation of Flanker task, in both studies they found out that there is global advantage of bilinguals over monolinguals in flanker task, both on congruent and incongruent trials. Luk et al. (2010) used combined flanker interference task and no-go task and also found the overall RT advantage for bilinguals. Simon task and Flanker task are similar, but overall the Flanker task is used less frequently in an unchanged version in studies concerning bilingualism than Simon task and therefore we decided to use Simon task instead of Flanker task.

2.4.3 Research questions

The overall aim of this thesis is to determine, whether there will be a difference between naming latencies on switch trials and stay trials, supporting the Inhibitory control model (Green, 1998). Further, we would like to test Olson's (2016) findings of asymmetrical switch cost, which showed that naming latencies are longer when switching into more dominant language than when switching into less dominant one. We also want to explore the influence of cognates on naming latencies and we want to test the hypothesis, that frequent exercise of language switching leads to better performance in both linguistic and non-linguistic switch task. What is more, we focus on the ability to switch in linguistic and non-linguistic task of students of interpreting, who are believed to be frequently exercising the language switching, and students of English philology, who are not trained in language switching. With respect to this, we state our research questions below:

1. Are switch and non-switch trials different in how fast the bilinguals start naming the picture and in how many mistakes they make?
2. If there is a difference between switching into one's L1 and one's L2? Is switching into L1 slower (Olson 2013) or is switching into L2 slower?
3. Will bilinguals trained in language switching (students of translation and interpreting) be faster than untrained bilinguals (students of philology) on the switch trials? Will they show smaller differences between switch and non-switch trials?

4. Will there be a cognate facilitation effect, i.e. will cognates accelerate the speed of the switch?
5. Will the interpreters perform better on the non-linguistic switching task?
6. Will the performance on linguistic switching be aligned with the performance in the non-linguistic switching?

3 Methodology

3.1 Language use and self-assessment of code-switching questionnaire

All the participants completed the language questionnaire (see Appendices). The aim of the language questionnaire was to determine how the participants acquired English and whether any of them learned the language in naturalistic way in childhood and how often they use each of the languages. To evaluate how often they switch in between languages we also administered the self-assessment of code-switching to distinguish in between the different switching habits the participants might have. The questionnaire also focused on participants' language dominance. The results of the questionnaire will be discussed in the detailed participants' profile below. All the questionnaires were submitted electronically by google questionnaire.

3.2 Vocabulary size test

Since we wanted the participants to be as proficient in English as possible, we administered the vocabulary-size test LexTALE (Lemhöfer & Broersma, 2012), which is available online at http://www.lextale.com/.

3.3 Participants

There were twenty-seven Czech-English bilinguals (6 males and 21 females) participating in the research. All the participants were students of Palacký University, all of them were students of either English philology or translation. All the participants were volunteers. All of them had some phonetic background in form of a university course. All the participants were either bachelor study programme students or master study programme students. All of them have passed at least C1 exam which is a part of both of the study programmes. The mean age of the participants was 21.9 years (ranging from 20 to 27). Majority of the participants were ranged from 23 to 25.

One participant was excluded because she was not able to name majority of the pictures in both languages. They were all late bilinguals, who learned English at school. All the participants reported to have no hearing or speech problem, they also reported to have normal or corrected to normal vision.

Since one of our research questions concentrates on the difference between philology students and students of translation and interpretation, there were 18 students of philology and 8 students of translating. However, one student of interpreting was excluded from the interpreting group and included in the philology group since she was first year master student of interpreting with no previous experience with interpreting. Thus, there were 19 students of philology and 7 students of interpreting.

3.3.1 Detailed participants' profile

Nine out of the nineteen participants who were students of philology reported that they have participated in an interpreting seminar. Three out of the twenty-six participants have reported that they have lived in an English-speaking country. Their period of residence ranged from 2 months to 2 years. None of the participants were raised in an English-speaking environment. The mean of the age of acquisition of English was 8.2 years (ranging from 5 to 11 years). Four out of the twenty-six participants reported that they attended high school with extended language instructions. Eighteen out of the twenty-six participants reported that they feel more confident in Czech than in English. Only one of the participants reported that he did not learn any other foreign language beside English.

Eighteen out of the twenty-six participants reported that they teach English, and all of those agreed that when they teach, they switch from English to Czech. Their mean self-rating on how often they switch during their teaching was 4.7 on a scale from 1 (never) to 9 (always).

The participants' mean self-rating on how much they currently use English outside classroom was 5.5 on 1 to 9 scale (1 = not much, 9= very much). Their mean self-rating on how much they translate from English to Czech was 4.8 on 1 to 9 scale (1= none, 9= on daily basis), however their mean self-rating on how much time they spend interpreting was 2.9 (on the same scale). Only one participant reported to be translating on daily basis.

Their mean self-rating on how often they experience not being able to remember a word in Czech when speaking in English (in case of an instant translation) was 5.9 on scale 1 (never) to 9 (always) whereas their mean rating on how often they experience the same thing in English was 5.1.

Thirty percent of the participants reported that they are likely to use a word in English when they are speaking in Czech and cannot recall the word in Czech. Whereas only 7.7% of the participants reported that they are likely to produce a word in Czech when they are speaking English and cannot recall a word in English.

The mean rating of self-assessment of how often the participants switch to English consciously was 5.7 on scale 1 (never aware of switching) to 9 (always aware of switching). Most of the participants (88.5%) reported that they switch between languages most often when they are speaking with schoolmates or speaking with friends (84.6%). Further, 26.9% of the participants consider using English words and phrases when speaking Czech to be perfectly normal with the mean rating 5.8 on scale from 1 (I really hate when people do it) to 9 (I think it's perfectly normal. Whereas, only 11.5% of the participants think that using Czech words and phrases when speaking English is perfectly normal, having the mean rating 5.3 on scale (I really hate when people do it) to 9 (I think it's perfectly normal.

The mean rating for how comfortable they feel when they switch between English and Czech was 7.4 on scale from 1 (not comfortable at all) to 9 (perfectly comfortable).

3.4 Picture-naming task

For our experiment focused on the switch-cost, we used the picture-naming task. In this task, the participants were presented with visual images of target words to be named in either English or Czech. They were supposed to name the object in the picture in a certain language according to the colour of the frame and the background of the picture. If the frame and background was red, they were supposed to name the picture in English, if it was blue, the target language was Czech. We did two experiments, Czech-biased and English-biased. The Czech-biased experiment contained 75% of the pictures to be named in Czech and 25% of the pictures to be named in English, whereas the English-biased experiment contained 75% of pictures to be named in English and 25% of the pictures to be named in Czech. The participants' responses were recorded. The analysis concentrated on reaction times, which were taken from the moment of the first sight of the target picture, which was represented by a beep sound to the moment the participant named the picture. The mistakes the participants produced were also taken into consideration.

3.5 Stimuli

The stimuli for the picture-naming task were all black and white drawings of unambiguous objects (for complete list of stimuli see Appendices). To investigate the cognate facilitation effect, we chose 20 English – Czech cognates and a corresponding number of non-cognate controls. The cognates and the non-cognate controls were matched by frequency across the two languages. The data about the relative frequency of both the cognate and non-cognate stimuli were taken from the Czech National Corpus using the ORAL v1 and the BNC spoken demographic corpus. We chose to use the data from the spoken corpus to reflect the current use of the language. We excluded the spoken context-governed part of the BNC since the Czech National Corpus does not include broadcasting data and the speech that is planned. For exclusion of the context-govern part of the spoken BNC we used Sketch Engine. Both the cognates and the non-cognate controls were matched in frequency across both languages (e.g. Czech *magnet* and English *magnet* both having frequency around 3 instances per million (i.p.m) and the non-cognate controls (e.g. *velbloud* and *camel* which both have i.p.m. around 3 i.p.m. as well). They were also matched in syllables and were either monosyllabic, disyllabic or tri-syllabic. Some of the words were excluded due to the multiple meaning in English but not in Czech (e.g. *bank*) which made the frequency of their occurrence higher. All the cognates and the non-cognates were nouns and we also aimed at matching the stimuli in both languages with respect to the phonological structure, the word stress and the number of syllables. All words having stress somewhere else than on the first syllable were excluded (e.g. *shampoo* and *šampon*) in order to be as similar across the languages as possible.

To analyse the impact of the language context, we used two conditions for our experiment. Each of the contexts were presented to the participants in a separate session and at least a week apart from each other.

In each experiment, there were 10 switch trials from the dominant language of the experiment into the other language and 10 switch trials from the other language back to the dominant language. All the words in switch positions were paired with non-switch controls. The switch words were matched in frequency with the non-switch words within one language but not across the languages. The words, that appeared in switch position and the corresponding stay position always had two syllables. Within the 10 switch position words, 5 of them began with *k* because of another experiment which we shared the data with, and which concentrated on the VOT of the stimuli starting with *k*. The other 5 words in switch position began with a various consonants other than /k/.

The words in switch positions in both experiments were the same. There were also 90 fillers in the dominant language and 30 fillers in the non-dominant one, the fillers were also the same for both experiments, changing in the appropriate language.

3.6 Linguistic experiment

3.6.1 English-biased picture naming task

There were 75% of the pictures to be named in English which means there were 150 words in English and 25% of the pictures to be named in Czech, which means 50 words in Czech. Within the 150 words to be named in English, there were 20 cognates (English in English dominant test, Czech in Czech dominant test) and 20 non-cognate controls in corresponding language. In order not to be influenced by the switch trials, both cognates and non-cognate controls could not appear in the switch positions or in the position immediately after the switch.

There were also 10 words in switch position switching back to English and 10 words in stay position in English. The rest of the 75% of the pictures (90 words) to be named in English were fillers.

Within the 25% of the pictures to be named in Czech (50 words), 10 of the words were in switch position into Czech and 10 were their corresponding stay-controls, and there were also 30 words which were fillers. The switch control tokens were not preceded by the switch. After each switch there were at least 2 stay trials and maximum of 6 stay trials.

3.6.2 Czech-biased picture naming task

The Czech-dominant test mirrored the English-dominant one. The words in switch-positions and corresponding stay positions were the same in both tests. The fillers and the cognates were the same but in the other language.

3.7 Non-linguistic task

To determine whether the participants who perform better in the linguistic code-switching task will perform also better in the non-linguistic task we administered the Simon task which is available online:

https://scienceofbehaviorchange.org/measures/simon-task/.

The participants were presented the Simon task either on their first or their second session. All the participants were asked to use only one finger and to return the finger to red label places below the "down" arrow on the keyboard, in order to acquire as accurate results as possible.

3.8 Procedure

Participants were tested individually in a soundproof room with the experimenter present. They were seated in front of a laptop monitor and a microphone. First, they were presented a presentation containing all the details of their task in order to familiarize them with the task. Then, they were presented with a training set of pictures. They were asked to name the pictures spontaneously in the corresponding language, according to the colour of the screen and the flag. If the colour was red with the flag of the United Kingdom of Great Britain, they were asked to name the picture in English, whereas when the screen was blue with the Czech flag, they were supposed to name the picture in Czech. The practise block consisted of 20 trials. They were asked to use only one word which is always a noun and they were advised not to use articles. The instructions in English-biased experiment were given in English and in the Czech-biased experiment in Czech. The participants were also asked to name the pictures as fast as possible. The practise block was followed by the experimental block consisting of 200 trials. In order to minimise tiredness, there were 3 pauses within the experimental block, each of which was after 50 trials. The experimental session lasted approximately 45 minutes.

The pictures were presented on the computer screen one at a time. Each trial began with the fixation cross, presented in the middle of the screen for 500ms, then the beep sound was played and then the picture was presented. The picture (487x441 pixels) was displayed for 3000ms in the middle of the screen, independently of whether the participant named it or not. Then there was a blank screen for 700ms and then the next trial started. The procedure was inspired by the experiment design in Olson (2016).

The participant's answers were recorded using Handy 4next Zoom recorder. The pictures-naming task was presented in Praat (version 6.0.46., Broersma and Weenick 2019).

3.9 Data processing

The onset of voicing of each of the response was labelled first automatically by Praat (version 6.0.46., Broersma and Weenick 2019) and then adjusted manually to obtain as accurate results as possible. The naming latencies were taken from the end of the beep sound to the onset of voicing of the response. The responses were labelled with the appropriate label (cognate, non-cognate control, switch, non-switch control) and we also noted whether the response word was correct, or it was named using another word or another language or whether it was missed. We analysed only the naming latencies of the target words (cognates, non-cognate controls, switch to majority language, switch to the minority language, non-switch controls) the responses which either did not match the intended name or were produced in different language were excluded from the analysis. The filler words were not analysed.

4 Results

4.1 Simon Task

The *Figure 2* summarizes the mean reaction times (RTs) for the congruent and the incongruent trials in the Simon task. Four participants showed unexpected results, i.e. mean response time was shorter on the incongruent trials and one participant could be considered as an outlier, since she showed much greater RT than the other participants (for the mean response times of incongruent and congruent trials of individual participants check Appendices).

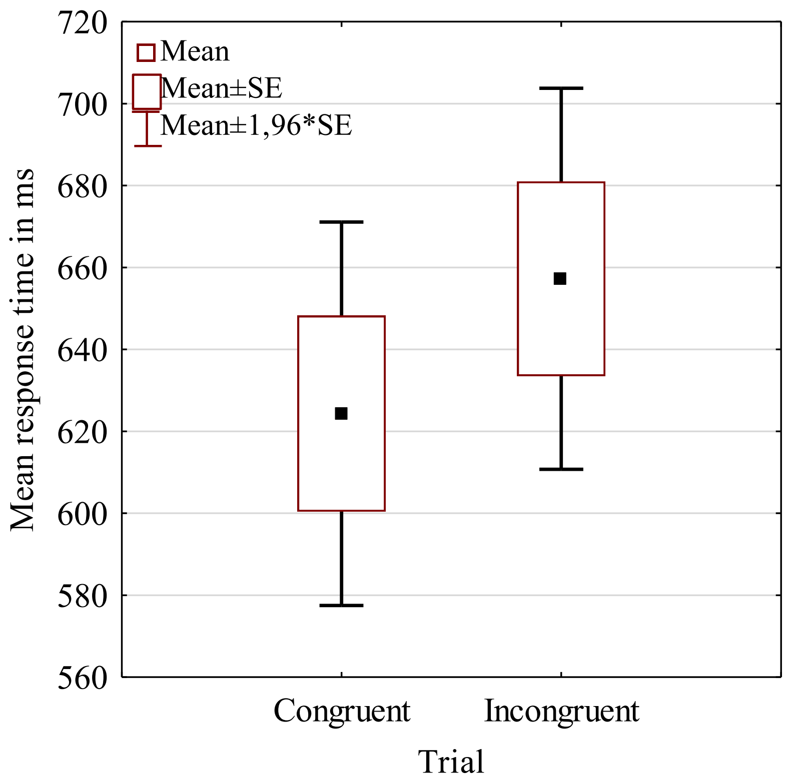


Figure 2. Mean reaction times in ms in incongruent and congruent trials.

As visible from *Figure 2*, the participants were faster in the congruent trials than in the incongruent trials. To determine whether the difference between RTs of congruent and incongruent trials is significant we conducted t-test for dependent samples. As visible from *Table 1*, the difference between RTs in congruent and incongruent trials was significant, $t(26) = -5.47$, $p = .000018$. As expected, this result supported the widely studied Simon effect, which shows that it takes the participants longer to respond when the target stimulus is incongruent than when it is congruent.

trial	T-test for Dependent Samples Mean RT (ms)	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
Congruent	624.30	121.8						
Incongruent	657.25	120.97	26	-5.4693	25	0.000018	-45.76	-20.13

Table 1. T-test for congruent and incongruent RTs difference. t(26) = -5.469, p< 0.001

4.2 Picture naming switch task

4.2.1 Mistakes

In the English-biased experiment the participants were able to name the pictures correctly in 93.1% of the target trials (we did not keep a record of the mistakes in filler words), and in 99.6% of the target trials, the participants used the correct language in the English-biased experiment. Whereas in the Czech-biased experiment, 99.5% of the target trials were named in the correct language and 92.3 % of the target trials were named correctly, using the desired word. The mistakes made in both of the experiment are visible in *Table 2* and *Table 3*. Most mistakes made because of a usage of different word than we expected the participants to use.

Condition	Mistakes in English-biased experiment Another word used	Another language used	Missed word
Czech switch	5	7	3
Czech stay	18	0	2
English switch	9	4	16
English stay	15	0	9

Table 2. Mistakes made by participants in English-biased experiment.

Condition	Mistakes in Czech-biased experiment		
	Another word used	Another language used	Missed word
English switch	16	1	12
English stay	21	0	9
Czech switch	7	3	1
Czech stay	8	3	1

Table 3. Mistakes made by participants in Czech-biased experiment.

4.2.2 Switch vs. non-switch trials

4.2.2.1 English-biased experiment

First, we compared the switch trials into Czech and non-switch trials in Czech. We expected that the switch trials will be slower than the non-switch trials. As visible from *Figure 3*, in the English-biased experiment the non-switch trials in Czech were faster (M=1.38s, SD= .2858) than the switch trials into Czech (M=1.52s, SD= .2917). Further on, the mean RTs for all the conditions in English-biased experiment are summarized in *Figure 4*. Within this experiment, we also compared the naming latencies of switching to the minority language and switching to the majority language, however it is important to note, that the words in switch positions were not compared with each other with respect to the frequency of occurrence.

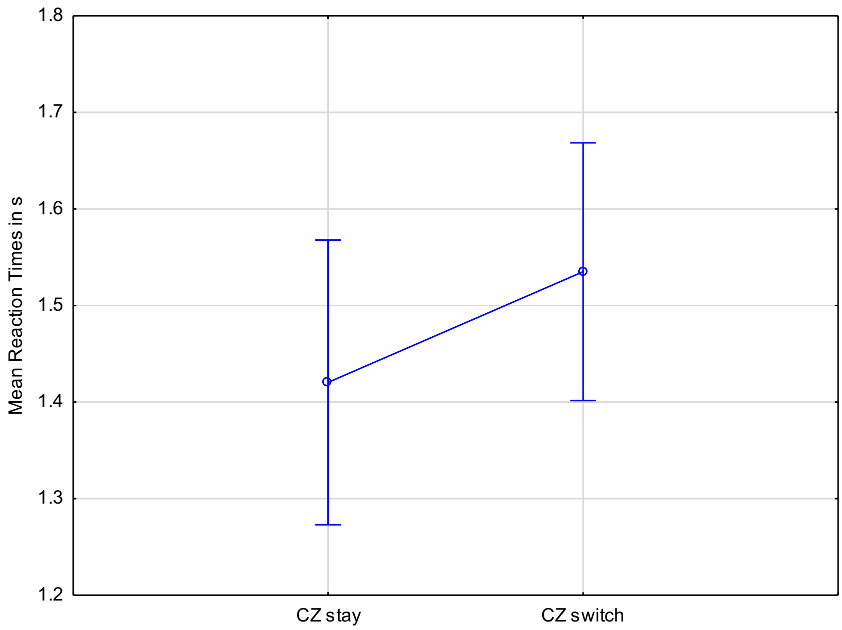


Figure 3. Mean reaction times for Czech stay controls and Czech switch in English-biased experiment. F(1.15)=11.017, p= *.00467*

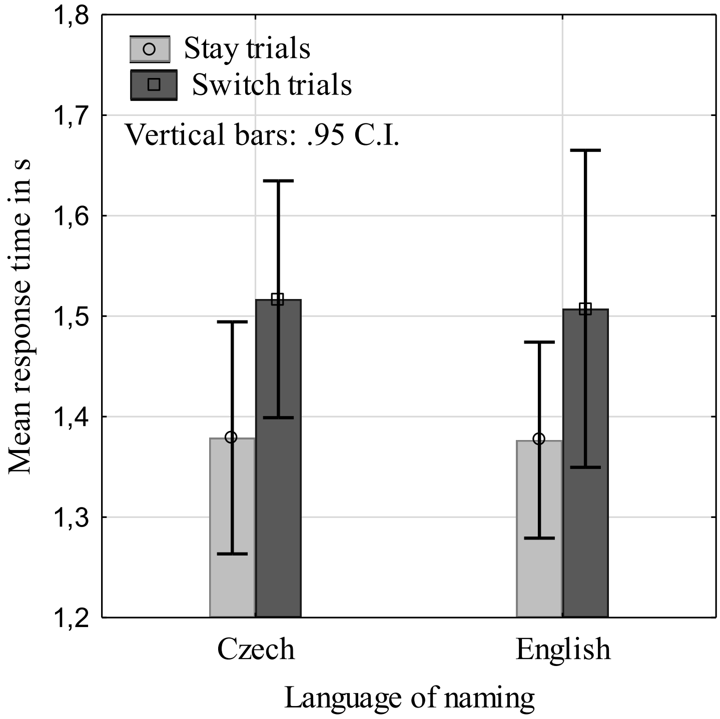


Figure 4. Mean reaction times for English stay trials, English switch trials, Czech stay trials and Czech switch trials in English-biased experiment.

Four paired sample t-tests were conducted on data from the English-biased experiment to test the hypotheses about the impact of language switching on the speed of naming of the target words using Bonferroni adjusted alpha levels of .01 per test (.05/5).

As visible in *Table 4*, the group results for all speakers indicated that the mean response time was significantly longer for switch trials into L1/minority language (M= 1.52s, SD= .29) than for naming the words in L1 after previous L1 word was named (M=1.38s, SD .29) $t(25)= -4.342$, $p= 0.0002$.

	T-test for Dependent Samples– English-biased experiment							
Trial	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I +95%
Stay	1.379	0.29						
Switch	1.516	0.291	26	-4.342	25	0.00025	-0.203	-0.073

Table 4. English-biased experiment. T-test for stay trials in the minority language (Czech) and switch trials to the minority language (Czech). t(25) = -4.342, p< 0.01.

For switching back into the main language, the difference between switching from Czech into English (M= 1.51s, SD= .39) and staying in English (M= 1.38s, SD= .24) was not significant at the Bonferroni-corrected alpha level, *t*(25)=-2.312, *p*= .0292 (see *Table 5*).

Trial	T-test for Dependent Samples – English-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
Stay	1.377	0.242						
Switch	1.507	0.391	26	-2.312	25	0.029	-0.247	-0.014

Table 5. English-biased experiment. T-test for stay trials in the majority language (English) and switch trials to the majority language (English). t(25) = -2.312, p< 0.01

As visible from *Table 6* we further compared the difference between stay trials in the majority language (M= 1.38s, SD= .24) and in the minority language (M=1.38s, SD= .29) in the English-biased experiment and there was no difference in between, *t*(25)= -.057, *p*= .9543.

Trial	T-test for Dependent Samples – English-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
English stay	1.377	0.241						
Czech stay	1.379	0.286	26	-0.057	25	0.9543	-0.08355	-0.0789

Table 6. English-biased experiment. T-test for stay trials in the majority language (English) and stay trials in the minority language (Czech).t(25) = -0.057*, p< 0.01.*

As you can see in *Table 7*, there was also no difference between switching into English (M= 1.51s, SD= .39) and switching into Czech (M=1.52s, SD= .29), *t*(25)=.189, *p*= .189. However, as mentioned above, these target words were not matched in frequency.

Trial	T-test for Dependent Samples – English-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
Czech switch	1.517	0.292						
English switch	1.507	0.391	26	0.189	25	0.1891	-0.0942	-0.1133

*Table 7. English-biased experiment. T-test for switch trials into the minority language (Czech) and switch trials into the majority language (English). t(25) =*0.189*, p< 0.01.*

4.2.2.2 Czech-biased experiment

In the Czech-biased experiment (see *Figure 5* for mean reaction times), we did four paired sample t-test using Bonferroni adjusted alpha levels of .01 per test (.05/5) to determine whether there is a difference between the reaction times of switch trials and stay trials.

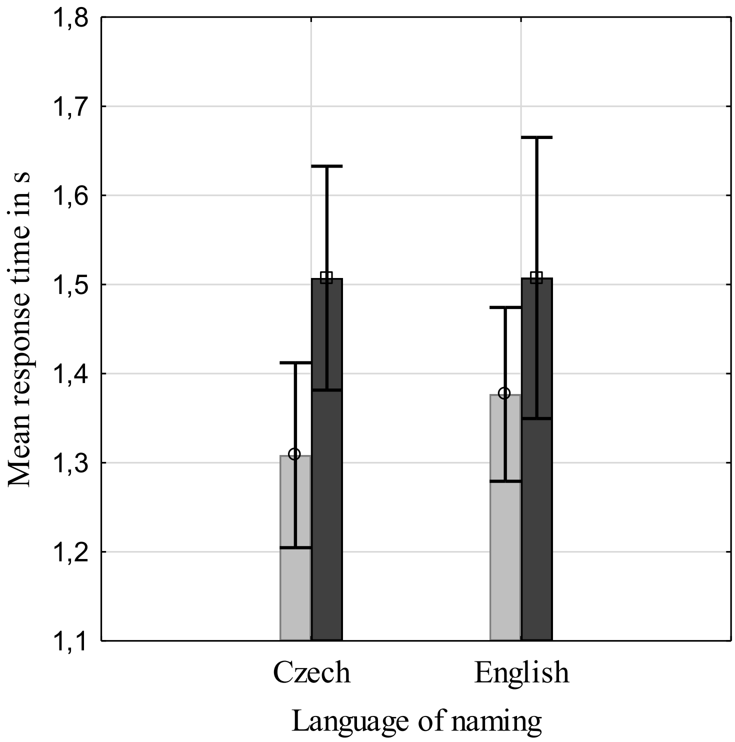


Figure 5. Mean RTs of Czech stay trials, Czech switch trials, English stay trials and English switch trials in Czech-biased experiment.

The group results for all speakers indicated that the mean response time was longer for switches into English (M=1.48s, SD= .28) than for naming words in

English after a previous English word was named (M=1.31s, SD= .026). This result was significant at Bonferroni-corrected alpha level, *t*(25)=-6.584, *p*= .000001 (*Table 8*).

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
Stay	1.309	0.257						
Switch	1.481	0.281	26	-6.584	25	0.000001	-0.226	-0.119

Table 8. Czech-biased experiment. T-test for stay trials and switch trials into the minority language (English). t(25) = -6.584*, p< 0.01.*

As you can see from *Table 9*, the stay trials in the majority language (M=1.44s, SD= .24) were not named significantly faster than the switch trials in the majority language (M=1.51s, SD= .31) at the Bonferroni-adjusted alpha level, *t*(25)=-2.262, *p*= .0325).

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
Stay	1.437	0.236						
Switch	1.507	0.311	26	-2.262	25	0.0325	-0.134	-0.007

Table 9. Czech-biased experiment. T-test for stay trials and switch trials into the majority language (Czech). t(25) = -2.262*, p< 0.01.*

The RTs of stay trials in English (M=1.31s, SD= .26) were significantly faster at Bonferroni corrected alpha level, *t*(25)= -3.696, *p*= .00108, than the RTs of stay trials in Czech (M=1.44s, SD= .24), see *Table 10*. However, it is important to note, that the target words in stay positions were not matched in frequency with each other.

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
English stay	1.309	0.257						
Czech stay	1.437	0.236	26	-3.696	25	0.00108	-0.1998	-0.0568

Table 10. Czech-biased experiment. T-test for stay trials in the minority language (English) and stay trials in the majority language (Czech). t(25) = -3.696*, p< 0.01.*

We found no difference between switching into the minority language (M= 1.48s s, SD= .28) and switching back to the majority language (M=1.51s, SD= .31), *t*(25)=*-0.613, p*=.5449 (*Table 11)*.

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
English switch	1.481	0.281						
Czech switch	1.507	0.311	26	-0.613	25	0.544949	-0.115	-0.062

Table 11. Czech-biased experiment. T-test for switch trials into the minority language (English) and switch trials into the majority language (Czech). t(25) = -0.613*, p< 0.01.*

4.2.2.3 Switching task and language proficiency

We also wanted to determine, whether there is a correlation between how well the participants did in linguistic switching task and their language proficiency, as measured by LexTale (Lemhöfer & Broersma, 2012). We found no significant correlation in either Czech-biased or English-biased experiment, as visible from *Table 12* and *Table 13*.

Variable	Correlations Marked correlations are significant at p< .0500 N=26			
	English switch	English stay	Czech switch	Czech stay
LexTale	-0.221	-0.209	-0.127	-0.116

Table 12. Correlation between Lextale and English-biased experiment – English switch trial, English stay trial, Czech switch trial, Czech stay trial.

Variable	Correlations Marked correlations are significant at p< .0500 N=26			
	English switch	English stay	Czech switch	Czech stay
LexTale	0.302	0.291	0.289	0.086

Table 13. Correlation between Lextale and Czech-biased experiment – English switch trial, English stay trial, Czech switch trial, Czech stay trial.

4.2.3 Cognates vs. Controls

The research question number 6 asked whether there would be a cognate facilitation effect, accelerating the speed of naming cognates or whether there will be cognate inhibition, which means that there will be cognate cost. As in previous studies by e.g. Costa et al., 2000, Hoshino and Kroll, 2008, Christoffels et al. 2007, we expected that there will be a cognate facilitation effect, however, using three dependent t-tests with the Bonferroni-corrected alpha level, we found that in the English-biased experiment, there was not a significant difference between naming cognates (M=1.46s , SD=.27) and naming non-cognate control words (M=1.49s , SD= .28), $t(25)=-1.080$, $p=.2902$ (*Table 14*).

Trial	T-test for Dependent Samples – English-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
cognate	1.458	0.269						
control	1.487	0.283	26	-1.080	25	0.2902	-0.0855	-0.0266

Table 14. English-biased experiment. T-test for cognates and controls. t(25) = -1.080*, p< 0.01.*

The difference in naming latencies of cognates (M=1.34s, SD= .23) and their non-cognate counterparts (M=1.37s, SD= .19) in the Czech-biased experiment was also not significant at Bonferroni-adjusted alpha level, $t(25)=-1.202$, $p= .2405$ (*Table 15*).

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
cognate	1.343	0.227						
control	1.370	0.185	26	-1.202	25	0.24050	-0.073434	-0.019299

Table 15. Czech-biased experiment. T-test for cognates and controls. t(25) = -1.202*, p< 0.01.*

We also conducted t-test for dependent samples, using Bonferroni-corrected alpha level 0.01, to discover whether there is a difference between languages in terms of how fast the speakers name cognates and we found that the participants tended to name cognates slightly faster in the Czech-biased (M=1.34s, SD= .2269) than in the English-biased experiment (M=1.46s, SD= .2688), however this difference was not significant either, *t*(25)=1.717, *p*= .09828 (*Table 16*).

Trial	T-test for Dependent Samples – Czech-biased experiment							
	Mean	Std.Dv.	N	t	df	p	C.I. -95%	C.I. +95%
English cognate	1.458	0.269						
Czech cognate	1.343	0.227	26	1.717	25	0.09828	-0.0228	-0.25195

Table 16. T-test for naming cognates in English-biased experiment and Czech-biased experiment. t(25) = 1.717, p< 0.01.

Mean RTs are visible in *Figure 6*, and we also conducted repeated measures ANOVA to find the difference between naming latencies of cognates and controls in English and in Czech which be visible from *Figure 7*. There was no significant difference between naming cognates and controls in either Czech or English, F(1.25)=.00503, *p*=.94401.

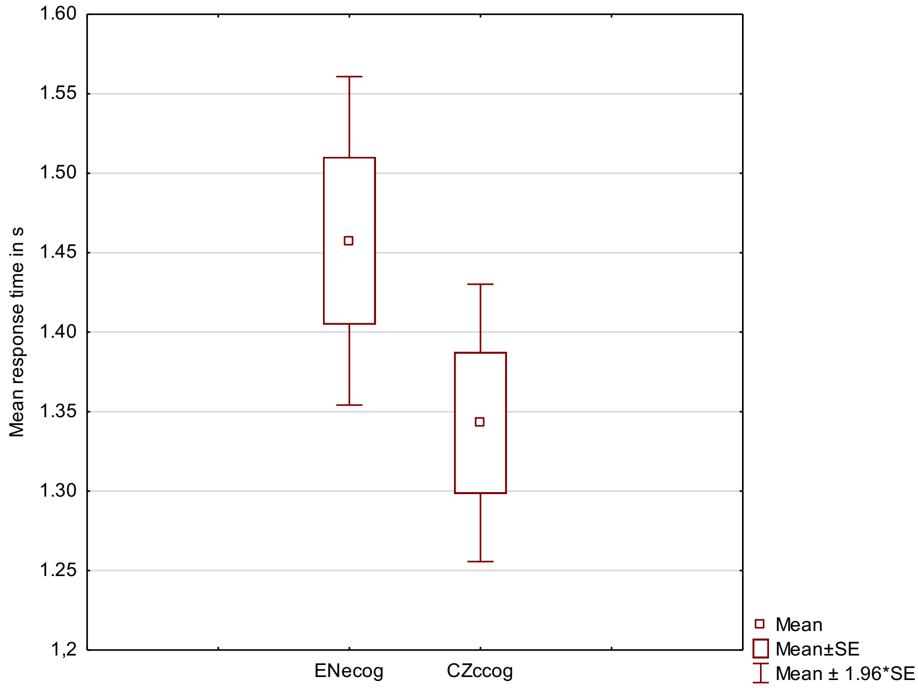


Figure 6. Mean RTs of Cognates in English-biased experiment and Czech-biased experiment.

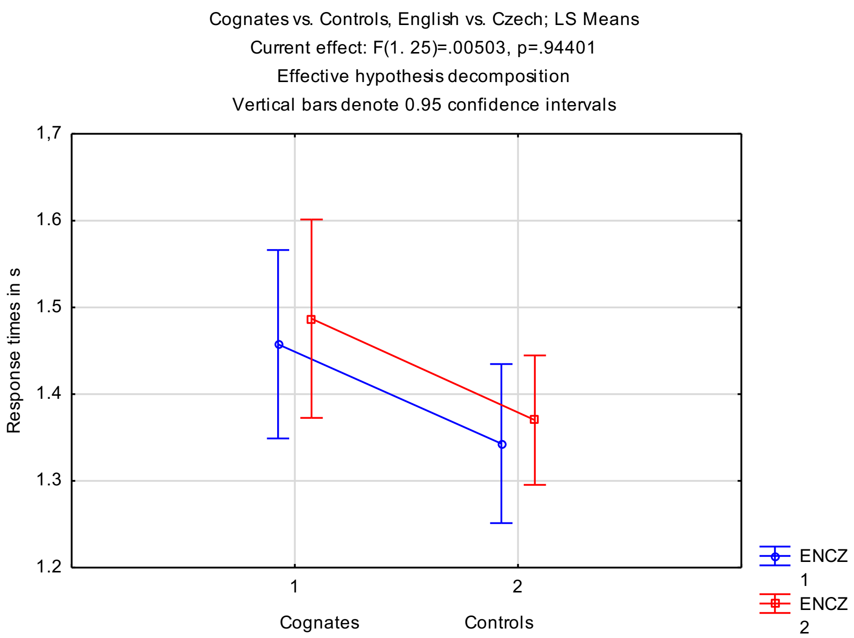


Figure 7. Comparison of mean RTs of cognates and controls in English and Czech. F(1.25)=.00503, p=.94401.

We further conducted repeated measures ANOVA to detect the difference between reaction times of cognates and controls in Czech-biased experiment and English-biased experiment, which are visible in *Figure 8*. This difference was also not significant, F(1.25)= .00503, *p*=.94401.

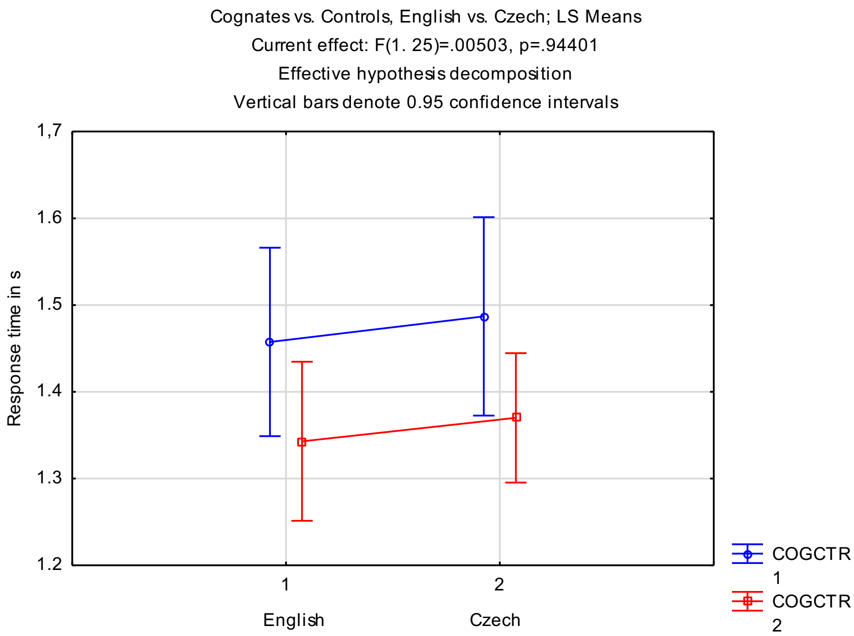


Figure 8. Comparison of mean RTs of Cognates and Controls in Czech and English. F(1.25)=.00503, p= .94401.

4.2.4 Philology students vs. Translation students

Our research question number 3 asked, whether there will be a difference between bilinguals who are trained in language switching (translation and interpreting students) and untrained bilinguals (philology students) with respect to the speed of switch trials.

Unfortunately, only 7 translation students volunteered to participate in our study. For the analysis they were paired with those philology students, who had the most similar results on the LexTale (Lemhöfer & Broersma, 2012) test. First, we conducted t-test for two independent samples, to discover, whether the translation students are better in incongruent and congruent trials in the non-linguistic experiment. We found that there is not a significant difference between the two groups $t(15)= -.22$, $p= .83$, as visible from *Table 17.*

Group	t-test for dependent samples							
	Mean INC-CON	*Std.dv.*	*N*	*t*	*df*	*p*	F-ratio Variances	p variances
Philology	32.77	*26.77*	*10*					
Translation	36.55	*43.18*	*7*	*-0.223*	*15*	*0.83*	2.601	0.191

Table 17. T-test for the mean difference in incongruent and congruent with respect to students of philology and translation. t(15)= -.223, p< 0.05.

Conducting repeated measures ANOVA, we also found that the students of translation were as expected faster in both English-biased experiment, F(2.14)=1.5454, *p*=.2475 (*Figure 9*) and Czech-biased experiment, F(2.14)=.73056, *p*=.49913 (*Figure 10*), in both switch and non-switch trials, however the difference was only small and thus not significant.

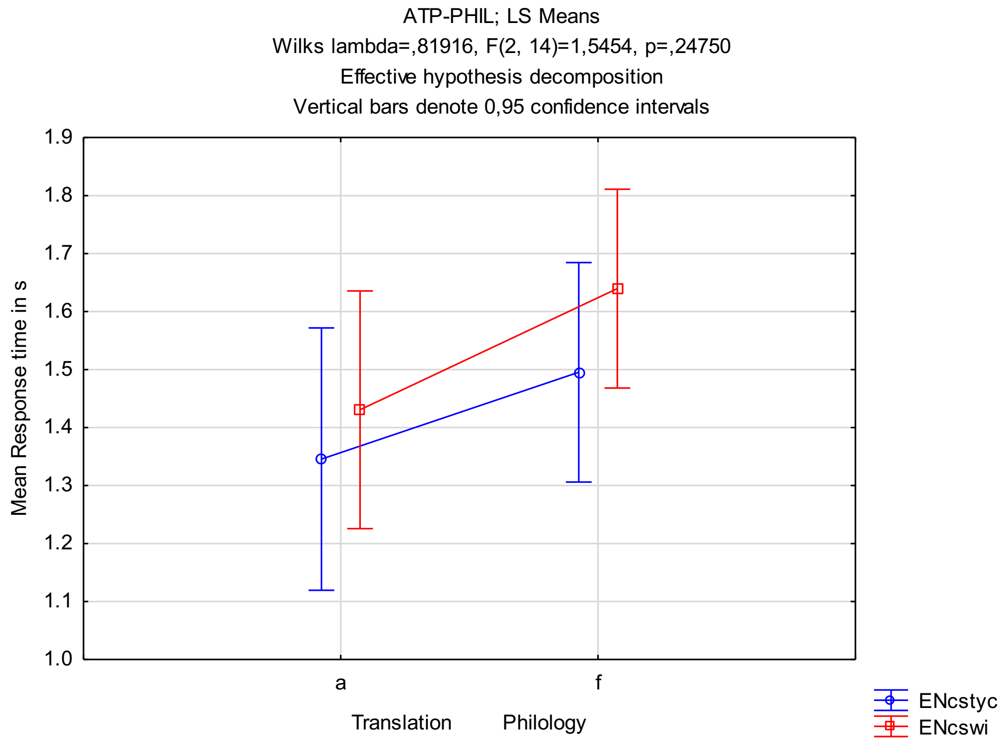


Figure 9. Comparison of mean RTs of Czech stay trials and Czech switch trials in English-biased experiment and Translation and philology students. F(2.14)=1.5454, p= .24750.

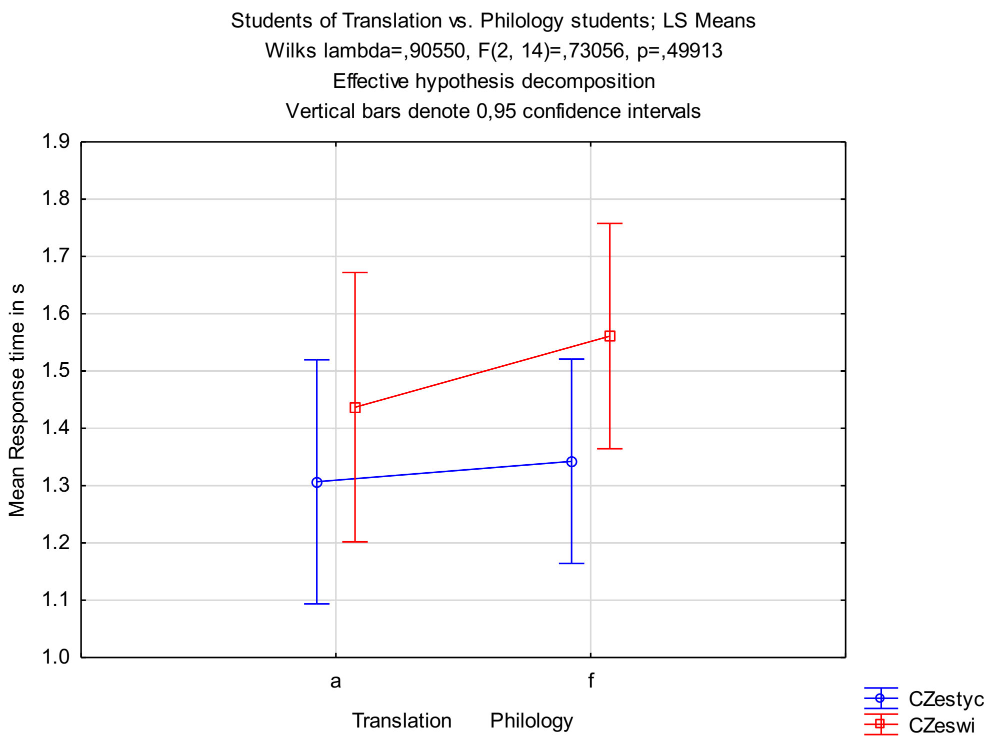


Figure 9. Comparison of mean RTs of English stay trials and English switch trials in Czech-biased experiment and Translation and philology students. F(2.14)= .73056, p= .49913.

4.2.5 Non-linguistic vs. Linguistic experiment

Our research question number 6 was whether the performance on linguistic switching will be aligned with the performance in the non-linguistic switching. Since there were four participants that showed the opposite effect in Simon task (they were faster in incongruent trials than in congruent trials) and there was one participant that significantly exceeded all others, we decided to exclude those 5 participants from this analysis.

In the Czech-biased experiment (see *Table 18*), we discovered a significant correlation between the non-linguistic switch task both the switch into the majority language (r=.59, p< .0500), and the switch into minority language (r=.50, p< .0500), further on, there was also a significant correlation between the non-linguistic switch task and stay trials in both majority (r=.66, p< .0500) and minority languages (r= .48, p< .0500). Whereas in English-biased experiment, there was not significant correlation between the non-linguistic switching task and neither of the conditions (see *Table 19*).

Variable	Correlations Marked correlations are significant at p< .0500 N=21			
	English switch	English stay	Czech switch	Czech stay
INC-CON	0.508	0.481	0.599	0.661

Table 18. Correlation between Incongruent-congruent trials in Simon task and Czech-biased experiment – English switch trial, English stay trial, Czech switch trial, Czech stay trial.

Variable	Correlations Marked correlations are significant at p< .0500 N=21			
	Czech switch	Czech stay	English switch	English stay
INC-CON	0.050	0.199	0.017	0.026

Table 19. Correlation between incongruent-congruent trials in Simon task and English-biased experiment-Czech switch and stay trials, English switch and stay trials.

5 Discussion

Our first research question was whether there will be a difference between switch and stay trials with respect to naming latencies. We hypothesized, that the switch trials will take longer to name than the corresponding stay trials. As expected, the naming latencies for switch trials were indeed longer than for the non-switch trials, however the difference was significant only when the participants were switching from majority language to minority language. This result supports the model of inhibitory control proposed by Green (1998), which claims the lexical nodes in both of the languages in the bilingual mind become activated during the lexical selection and thus there is so called switch cost, which is defined as longer naming latency for switch trials than for the stay trials. The bilinguals are said to have to overcome the activation and it results in longer time for the production of the desired word in the desired language. We also found that the participants made more mistakes in the stay positions than in the switch positions, however we most of these mistakes were due to the inability of the participants to name the pictures as we needed them, not due to the switch or non-switch position.

We further analysed the naming latencies for switch trials and stay trials from the majority language to the minority language which means that in the English-biased experiment, we analysed the switch and stay trials from English to Czech and in the Czech-biased experiment we analysed the switch trials into English and non-switch trials in English. We found that it took the participants significantly longer to name the word, if they were switching to the minority language than if they stayed in the minority language in both English-biased and Czech-biased experiment.

On the contrary, we discovered no significant difference between switch trials back to majority language and stay trials in the majority language in both experiments. Surprisingly, it did not matter whether they were switching from their L1 or into their L1. This result might indicate an influence of language context. The whole experiment was recorded using the majority language, thus it might have influenced the speed with which the participants named the items in the minority language in a way that it was more difficult for them to recall the target word in the minority language, however when they switched, they named the word in the stay position faster, as they got adjusted to the language they were in. What is more, we compared the naming latencies of stay trials in both majority and minority languages in both experiments and we found that the stay trials in English, in Czech-biased experiment were significantly faster than the stay trials in Czech in the same experiment. Thus, once the participants switched into the language, they were fast to name the picture. However, in the English-biased experiment, we found almost no difference between the stay trials in both languages. We also compared the naming latencies of switch trials in both languages in both experiments and we also found no significant difference. It is important to note, that both the switch trials and the stay trials were not matched in frequency of occurrence in between each other, thus the reason for the significantly faster naming of stay trials in English than stay trials in Czech in the Czech-biased experiment, may be influenced by the relative frequency of the target words in these positions.

Second, based on the previous research (Costa & Sansteban, 2004; Costa et al., 2006; Meuter and Allport, 1999; Olson, 2016)) we hypothesised that there will greater switch cost when switching from the less dominant language (L2) to the more dominant one (L1), which is in our case from English to Czech. This asymmetrical switch cost was attributed to the fact, that the more dominant language receives greater activation and thus it takes longer time to inhibit such activation, resulting in switch cost.

Surprisingly, in both of the experiments, we found no significant difference between switching into L2 and staying in the L2 and switching into L1 and staying in the L1. It did not matter whether the participants were switching from their dominant language to the non-dominant one or the other way around. The only thing that mattered was as mentioned above the language context; they were significantly slower at switch trials than in stay trials when switching from majority language. This result might be viewed as contradictory to the different degrees of inhibition for the dominant and non-dominant language. One explanation for the symmetrical cost found in our experiment may be the degree of language dominance and language proficiency. As Costa & Sansteban (2004) found, balanced bilinguals did not show asymmetrical switch cost when switching from their L2 to their L1, whereas imbalanced bilinguals showed asymmetrical switch cost. However, our result may not be attributed to the language dominance, since our participants are late bilinguals, who acquired their second language in school setting, and they are in their L1 setting permanently, thus they are expected to be imbalanced bilinguals. Another explanation for symmetrical switch cost can be high language proficiency, however we found no significant correlation between the participants' results in the LexTale and their ability to react fast to switch trials, thus it cannot be inscribed to the language dominance and proficiency either.

Third, based on claim by Abutalebi and Green (2007), we hypothesised that the bilinguals trained in language switching will be faster on switch trials than the bilinguals that are not trained. We found that bilinguals trained in language switching were only slightly faster in the non-linguistic experiment than the bilinguals who were not trained in language switching, but the difference was not significant, thus they were not significantly better at non-linguistic switch task. Similarly, they were only slightly faster on both switch trials and stay trials than the bilinguals who were not trained in language switching. We would not claim that this result is contradictory to the thought of Abutalebi and Green (2007), who assume that frequent exercising in executive function leads to smaller switch costs, since the number of participants was relatively small.

We also asked, whether there will be an alignment of the speed of switch trials and the performance in non-linguistic task, and we found that the better the participants performed in Simon task, the better they performed in the linguistic switching task in Czech-biased experiment, which was true was all conditions, not only the switch conditions. Interestingly this was true only for the Czech biased experiment, and not for the English biased experiment.

Next, we hypothesised that there will be cognate facilitation effect as in numerous studies (Costa & Caramazza, 2000; Christoffels et al., 2007; Hoshino and Kroll, 2008), which means that cognates will be named faster than corresponding non-cognate controls. However, we discovered that there is no difference between naming latencies of cognates and non-cognate controls in both languages, showing that the cognate status does not affect the naming latency. This result may reflect the fact, that in Czech, the cognates do not compete at lexical level in any different way than non-cognates and that they receive the same amount of activation at lexical level and thus they are not considered to be different from non-cognates.

6 Conclusion

The main aim of this thesis was to explore the way the bilinguals' mind works when producing a word in one or the other language. Bilinguals are said to able to speak only in one language, while both of their languages are activated at the same time. Nevertheless, they hardly ever make mistake while speaking in one or the other language, how is this possible?

One explanation of such bilingual production was proposed by Green (1998), who claimed that the simultaneous activation and competition of two lexical items each of which belongs to a different language is solved by inhibition. The lexical item, which is irrelevant to the task is supressed, or in other words, inhibited. What is more, it is widely claimed that bilinguals outperform monolinguals in non-linguistic switch task, indicating that frequent exercise in cognitive control leads to faster reactions at switch trials (Abutalebi and Green, 2007).

We conducted 3 experiments, to test the inhibitory control model as proposed by Green (1998), and the fact that frequent exercise enhances the cognitive control, using both linguistic and non-linguistic switching task. We also incorporated a set of cognates in order to determine, whether there will be a cognate facilitation effect or not.

In our experiment we tested late bilinguals of Czech and English and we found a significant switch cost, only when switching to the minority language, independent of whether it was the participants' L1 or L2. This result may indicate the influence of language context, because we found no significant switch cost when the participants were switching to the majority language, again independent of whether it was their L1 or L2.

Our result further did not duplicate the results of previous studies (Costa & Sansteban, 2004; Costa et al., 2006; Meuter and Allport, 1999; Olson, 2016) which showed that there was an asymmetrical switch cost, when speakers were switching to their L1. Our result showed that even though there was a switch cost for all the switch trials when compared to the stay trials, only the switch cost from majority language to the minority language was significant.

As far as the cognate facilitation effect is concerned, the cognate status did not influence the naming latencies of cognates, showing almost same naming latency, thus we suggested, that cognates might not compete on the lexical level in any different way than non-cognates.

Another aim of this diploma thesis was to discover, whether frequent exercise of executive function in students of translation and interpreting leads to better performance in both linguistic and non-linguistic switch task. However, we found no significant difference between bilinguals trained in language switching and bilingual who were not trained. We attributed this result to the low number of participants from translation and interpreting study programme.

7 Resumé

Je známo, že bilingvní lidé jsou schopni fungovat v jednom jazyce, i když jsou oba jejich jazyky aktivní, aniž by se jim jejich dva jazyky navzájem pletly. Existuje několik teorií o tom, proč jsou bilingvní lidé schopni rozlišovat své dva jazyky, aniž by dělali chyby. Jednou z těchto teorií je teorie kognitivní inhibice, kterou navrhl Green (1998). Tato teorie tvrdí, že aby mohl bilingvní člověk říci slovo v jednom jazyce, když jsou oba jazyky aktivní a oba soutěží o to, aby byly vybrány, musí být to dané slovo v nežádoucím jazyce potlačeno neboli inhibováno.

Tato diplomová práce zkoumá schopnost pozdních Česko-Anglických bilingvních studentů přepínat jak v jazykových úkonech, tak v úkonech nejazykových. Předchozí výzkumy ukázaly, že trvá déle přepnout z nedominantního jazyka do dominantního než naopak. Tento jev je vysvětlen vetší aktivací dominantního jazyka, a tak větší inhibicí daného jazyka, která vede k delšímu času výsledného pojmenování obrázku. Bilingvní lidé jsou také lepší než lidé monolingvní v nelingvistických úkonech, jako je například tzv. Simon task, což vede k teorii, že časté cvičení exekutivních funkcí vede k lepším výkonům v přepínání nejen mezi jazyky. Dále je známo, že slova podobného původu mají vliv na rychlost pojmenovávání obrázků, buď ji výrazně zrychlují, nebo zpomalují.

V našem výzkumu jsme zjistili, že našim subjektům trvalo významně déle pojmenovat obrázek, když přepínali do menšinového jazyka, než když ho pojmenovávali v menšinovém jazyce, což nás vede k myšlence vlivu jazykového kontextu na přepínání mezi jazyky. Na rozdíl od ostatních studií jsme nenašli významný rozdíl mezi přepínáním do mateřského, nebo dominantního jazyka a přepínáním do jazyka nedominantního. Dále jsme se soustředili na rychlost pojmenovávání slov podobného původu, a na rozdíl od ostatních studií jsme však nenašli žádný vliv slov podobného původu na rychlost pojmenování obrázků. Dále jsme také nenašli významný rozdíl mezi studenty překladatelství, u kterých se předpokládá, že jsou v přepínání mezi svými dvěma jazyky cvičení, a studentů filologie, u kterých se předpokládá, že v tom cvičení nejsou. Tento výsledek jsme přisoudili tomu, že se našeho výzkumu účastnilo poměrně malé množství studentů překladatelství.

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9 Apendices

Language Questionnaire (distributed by email via google forms)

Available online:

https://docs.google.com/forms/d/e/1FAIpQLSc3f7ufTz0qowrurmceI9Cqa787tR7l7VnOkHKkj1wBwfR0lQ/viewform

1. Name
2. Age
3. I am/was
   a. student of philology
   b. student of interpreting

4. Have you ever lived in an English-speaking country?
   YES NO
5. If **YES** how long and when was it?
6. Were you raised in an English-speaking environment (is your mum/dad a native speaker of Enghlish)?
   YES NO
7. How old were you when you started learning English?
8. At which grade were you?
9. Did you attend grammar school with extended language instruction (e.g. Anglická sekce gymnasium Hejčín)?
   YES NO
10. If you are a philology student, have you ever taken a seminar in interpreting?
    YES NO
11. Please mark on scale how much you currently use English to communicate outside school?
    1 = not much 9 = very much
12. In which of your languages do you feel more confident?
    English Czech
13. How much time apart from school do you spend **INTERPRETING** from English to Czech and vice-versa?
    1= none 9= on daily basis
14. How much time apart from school do you spend **TRANSLATING** from English to Czech and vice-versa?
15. Do you teach English?
    YES NO

16. If you teach, how many hours (60 min) a week do you teach?

17. If you **teach**, do you use English the whole class or do you switch to Czech?

I use only English

I switch

18. If you switch, how often do you switch during the class?

1 = never 9= always

19. Have you ever experienced not being able to remember a word in Czech when you were speaking in English (e.g. when you need the Czech word – for translation)?

1= never 9 = always

20. Have you ever experienced not being able to remember a word in English when you were speaking in Czech (e.g. when you need the English word – for translation)?

1= never 9 = always

21. When you're speaking in Czech and you cannot recall a word, are you likely to use a word in English?

1= definitely NO 9= definitely YES

22. When you're speaking in English and you cannot recall a word, do you tend to produce it immediately in Czech?

1= definitely NO 9= definitely YES

23. When you switch from Czech into English or the other way around, do you do it consciously?

1 = I am never aware of switching 9 = I always switch consciously

24. In which of these situations do you usually switch between your languages? (you can choose more than one answer)

Anytime when:

a. Speaking with schoolmates
b. Speaking with teachers
c. Speaking with friends
d. Speaking with family members
e. Speaking with foreigners
f. In other situations (specify):

25. What do you think about someone who uses English words and phrases when speaking to you in Czech?

1 = I really hate when people do it 9= I think it's perfectly normal

26. What do you think about someone who uses Czech words and phrases when speaking to you in English?

1 = I really hate when people do it 9= I think it's perfectly normal

27. How comfortable do you feel when you go between English and Czech in conversation?

1= not comfortable at all 9 = perfectly comfortable

Stimuli

English switch	English stay	Czech switch	Czech stay
feather	pencil	ježek	náplast
lighthouse	cherries	hasič	hrozny
tent	fist	česnek	mísa
statue	bucket	vlak	vlk
beach	lips	houby	dýně
king	key	kuře	kufr
cup	cat	kabát	kachna
cow	cap	kostka	košík
coffin	candle	komín	kočár
corn	kite	konev	kohout

COGNATES	CONTROLS
granande – granát	lipstick – rtěnka
crab – krab	worm – červ
nose – nos	cake -dort
cacus-kaktus	turkey – krocan
juice -džus	bull – byk
doctor – doktor	window – okno
garage – garaž	rabbit – kralik
helmet – helma	arrows – šipky
mouse – myš	ghost -duch
magnet – magnet	camel – velbloud
pirate – pirát	lemon – citron
robot – robot	scissors – nůžky
roses -ruže	ladder – žebřik
stadium – stadion	spoon – lžice
tiger – tygr	scarf – šala
zebra – zebra	penguin – tučňak
dominoes – domino	lollipop – lizatko
banana- banan	envelope – obalka
crocodile – krokodyl	pineapple – ananas
giraffe – žirafa	rainbow – duha

Participants' mean difference between incongruent and congruent trials in Simon task

Inicials	INC-CON
AK	43,26
BT	-4,46
BE	51,46
DP	22,74
DK	38,02
HH	-0,82
JB	31,64

KM	17,56
KT	23,98
KR	63,00
KK	-31,80
MR	44,08
MJ	68,86
MK	60,84
MA	-7,86
PV	62,48
PL	25,82
ŘA	8,54
SŠ	70,26
SB	123,12
ŠT	-0,84
UA	21,32
VN	6,48
VA	32,52
VM	53,98
ZM	13,84
ZP	13,86