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MASTER'S THESIS

Decoding in Picture-Naming Tasks: The Role and Function of Stroop Effect in Bilinguals

Dekodiranje u zadacima imenovanja slika: Uloga i funkcija Stroopovog efekta kod bilingvalnih govornika

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ABSTRACT

The present master's thesis entitled *Decoding in Picture-Naming Tasks: The Role and Function of Stroop Effect in Bilinguals* explores the influence of phonological similarities between distractor words and picture names in picture-naming tasks discussed in various experiments in the field of psycholinguistics. In 2007, Knupsky and Amerhein published the results of their experiment in which they wanted to explore the existence of phonological facilitation through translation in English-Spanish bilinguals. They concluded that through translation (TT) phonological facilitation was more consistent when the participants were asked to name pictures in their L2.

Fascinated by their work, I modified their experiment in order to examine the impact of phonological facilitation in picture-naming tests in Croatian–English bilinguals. The experiment consisted of three conditions depending on the type of phonological similarities between distractor words and picture-names: 'direct', 'through translation', and 'unrelated'. The 23 participants were asked to name three sets of pictures while disregarding distractor words. Each set of pictures consisted of four language combinations (L1-L1, L1-L2, L2-L2, L2-L1) depending on the language used to name the pictures and the language in which the distractor words were written. I used simple black-and-white drawings found on a free website called *clipart-library.com* to create 72 picture-word combinations. Distractor words were phonologically similar to picture names by at least the first two phonemes. In designing the experiment, synonyms and near-synonyms posed a great challenge since they often do not share the same first two phonemes (e.g. *desk* and *table*). Thus, for 'direct' and 'through translation' conditions, I had to find those pictures which can be easily named using only one word.

The three hypotheses in this paper proposed that the participants will need the least amount of time to name pictures in direct phonological facilitation condition (H1), that they will need more time to name those pictures where the phonological facilitation existed only through translation (H2), and that they will need the greatest amount of time to name pictures in phonologically unrelated condition (H3). The results of the conducted experiment supported all the three hypotheses. In short, to complete the task given, the participants on average needed 24.15 seconds in 'direct' condition, 27.2 seconds in 'through translation' condition, and 28.68 seconds in 'phonologically unrelated' condition.

One of the main limitations of the study was a small number of participants. If I were to conduct a similar study again, I would perhaps use a different time-tracking software. Furthermore, I believe the word length of picture-names should be approximately the same in each language combination and each condition. Therefore, for future research, I would suggest keeping in mind the length of the words used to name the pictures in the tasks. Also, it would be interesting to compare results of various groups of participants based on their age, education, professional life, foreign language acquisition age, etc.

KEY WORDS: Stroop effect, picture-naming task, decoding, translation, phonological facilitation

SAŽETAK

Ovaj završni diplomski rad pod naslovom *Dekodiranje u zadacima imenovanja slika: Uloga i funkcija Stroopovog efekta kod bilingvalnih govornika* se bavi istraživanjem utjecaja fonoloških sličnosti između riječi distraktora i naziva slika u zadacima imenovanja slika kojim se, kroz različite eksperimente, bavi psiholingvistika. Knupsky i Amerhein su 2007. godine objavili rezultate svog eksperimenta kojim su željeli istražiti postojanje fonološke facilitacije putem prevođenja kod bilingvalnih govornika koji govore engleski i španjolski jezik. Zaključili su da je fonološka facilitacija kroz prevođenje bila znatno dosljednija u slučaju kada su sudionici imenovali slike na stranom jeziku.

Fascinirana njihovim radom, odlučila sam prilagoditi njihov eksperiment kako bih istražila utjecaj fonološke facilitacije u zadatku imenovanja slika kod bilingvalnih govornika koji govore hrvatski i engleski jezik. Eksperiment se sastojao od tri uvjeta ovisno o vrsti fonološke sličnosti između riječi distraktora i imena slika: „uvjet direktne fonološke facilitacije“, „uvjet fonološke facilitacije putem prevođenja“, „uvjet bez fonološke facilitacije“. Od 23 sudionika se tražilo da imenuju tri skupa slika pri tome zanemarujući riječi distraktore. Svaki set slika se sastojao od četiri jezičke kombinacije (L1-L1, L1-L2, L2-L2, L2-L1) ovisno o jeziku koji je korišten za imenovanje slika i jeziku kojim su napisane riječi distraktori.

Kako bih izradila 72 kombinacije slika i riječi, koristila sam jednostavne crno-bijele crteže koje sam pronašla na web stranici pod nazivom *clipart-library.com*. Riječi distraktori su bile fonološki slične nazivima slika u minimalno prva dva fonema. Pri izradi eksperimenta, istoznačnice i bliskoznačnice su predstavljale veliki izazov s obzirom na to da uglavnom nemaju ista prva dva fonema (npr. *desk* i *table*). Prema tome, za uvjet direktne fonološke facilitacije i uvjet fonološke facilitacije putem prevođenja, bilo je potrebno pronaći one slike koje se lako mogu imenovati koristeći samo jednu riječ.

Na osnovu tri postavljene hipoteze, pretpostavilo se da će sudionici trebati najmanje vremena da imenuju slike u uvjetu direktne fonološke sličnosti (H1), kao i da će biti potrebno više vremena da se imenuju one slike u kojima je fonološka sličnost postojala samo kroz prevođenje (H2), te da će trebati najviše vremena da imenuju slike u uvjetu nepostojeće fonološke sličnosti (H3). Rezultati provedenog eksperimenta su potvrdile pretpostavke date u sve tri hipoteze. Naime, za izvršavanje zadatka sudionici su u prosjeku trebali 24,15 sekundi u uvjetu

direktne fonološke facilitacije, 27,2 sekunde u uvjetu fonološke facilitacije putem prevođenja, te 28,68 sekundi u uvjetu bez fonološke facilitacije.

Jedan od glavnih nedostataka ovog istraživanja je mali broj sudionika. Ukoliko bih ovaj eksperiment ponovo provodila, pokušala bih koristiti i neki drugi softver za praćenje vremena. Nadalje, smatram da bi imena slika trebala biti otprilike jednake dužine u svakoj jezičnoj kombinaciji i u svakom uvjetu. Prema tome, za buduća istraživanja predlažem da se uzme u obzir dužina riječi kojima se imenuju slike u zadacima. Također, bilo bi zanimljivo usporediti rezultate različitih grupa sudionika na temelju njihove dobi, obrazovanja, profesionalnog života, dobi usvajanja drugog stranog jezika itd.

KLJUČNE RIJEČI: Stroopov efekat, zadatak imenovanja slika, dekodiranje, prevođenje, fonološka facilitacija

1. INTRODUCTION

Psycholinguistics is said to be a hydra-like branch of linguistics (Aitchison, 2007, p. 2) due to its interest in exploring various aspects of the mind and cognitive processes that underlie our ability to produce, comprehend and acquire language. Even though this field of study is quite young, with its origin in 1946, it already gave answers to many questions that puzzled philosophers and scientists for centuries. However, one phenomenon, among others, continues to fascinate researchers for over half a century.

In 1935, a year before even the name for this new interdisciplinary field was coined, John Ridley Stroop described a phenomenon that entices many psychologists even today. The reason for scientists' longstanding and growing interest is that it "appears to tap into essential operations of awareness, thereby offering clues to fundamental cognitive processes" (Shalabi&Sameem, 2017). By definition "the Stroop effect", also known as "the Stroop interference", is the term that stands for the interference of the brain's reaction time when it has to process 'conflicting information' (McMahon, 2017). In his widely famous experiment, "the Stroop Color-Word test", John R. Stroop tested the processing delay that occurs when a color name (e.g. red) mismatches the color of ink (e.g. blue) which is used to write the color name. The effect can be seen in a subject's inability to process the semantic information as quickly as the syntactic information.

In other words, John Stroop found out that color naming is more difficult than word naming. The results of his study may indicate that the decoding of words is automatic. However, opinions about it are divided among scientists. Thus, this thesis calls for a more detailed researching of the decoding in reading. Furthermore, the Stroop effect is not restricted only to colors. Variants of Stoop tests showed that processing delays occur in all sorts of conflicting information. For example, the picture-naming test is often used to demonstrate an interference that arises while naming objects presented on a picture containing embedded words that mismatch the name of the object.

Nevertheless, the growing interest in the Stroop effect is not limited just to psychologists since its occurrence proves to be valuable in understanding the neural mechanism. Throughout the second half of the 20th century, many psycholinguists sought to understand the cognitive processes which underlie this phenomenon and thus they offered various explanations for the effect.

However, 50 years after its first description, they still struggle to produce and agree on one all-encompassing theory explaining how and why the interference occurs. On the contrary, the effect compelled psychologists to question all they knew about language comprehension and production. Therefore, in this thesis, I will describe and examine more closely the Stroop effect and the so far established theories explaining the processes behind this occurrence. Furthermore, the thesis will examine the role of bilingual phonological facilitation in the Stroop picture-naming test.

1.1. Structure of the Thesis

The present thesis (*Decoding in Picture-Naming Tasks: The Role and Function of Stroop Effect in Bilinguals)* presents the problem of decoding in reading relating the Stroop effect to bilingualism. In the *Literature Review* chapter, I introduce and explain the theory behind the Stroop effect and the variants of its tests. Moreover, the chapter provides a detailed explanation of the process of decoding in reading since the process of decoding words is one of the main aspects of many variants of Stroop tests. The last sub-headline in the second chapter deals with explaining bilingualism and the way the brain of a bilingual person processes words. The third chapter of the paper deals with the research methodology, the research problem, the participants and the research instrument. The fourth chapter presents the results of the research as well as the discussion and analysis of the data collected. The findings are then analyzed further and suggestions for future research proposed in the conclusion.

2. LITERATURE REVIEW

2.1. Decoding in Reading

Reading is one of the fundamental skills a person needs to acquire in the early ages of pre-school and elementary school education. The main cognitive process behind the ability to read is 'decoding'. Perfetti defined decoding in reading as the process in which printed letters and letter combinations are transformed or decoded into a phonetic code (Perfetti 1985 in: Aarnoutse, C. et al. 2001, p.62) whereby 'code' is a signal or a system of signals that stand for a certain idea, i.e. a signal that carries a certain meaning. Therefore, in the English language and any other language with the alphabetic writing system, "the code involves a system of mappings, or correspondences, between letters and sounds" (Juel and Beck, 2002, p.2). Juel and Beck (2002) state these systems of signals "become meaning-bearing units" only when a person is familiar with the assigned meaning of the signal. Therefore, decoding in reading can be explained as an ability to adequately connect the assigned meaning with its signals (Juel and Beck, 2002). Furthermore, the process of decoding implies an interconnected employment of several skills such as predicting, skimming, scanning and recognizing systems of signals(Unit 4: Reading skills, n.d.).

The two most important principles that initiate and operate with the process of decoding are the so-called process of *segmenting* and the process of *blending* as, in order to decode a text, a person first needs to segment the sounds in words and then to blend them together (What is Decoding in Reading?, n.d.). However, the process is not as simple and straightforward as it seems as numerous other skills and processes drive the process of decoding. As I have already mentioned above, *prediction* is one of the skills that necessarily need to be a part of the decoding process. In other words, in order to segment the sounds in a word, an individual first needs to scan the word and to make certain predictions, based on the previously acquired knowledge and experience, on the meaning of the word. For instance, Stanovich (1986) states that in order to identify written words, a person first needs to "utilize the alphabetic principle", i.e. to know the correlation between letters and phonemes (Stanovich 1986 in: Voeten, R, 2001, p.62). Therefore, decoding in reading in one way requires the ability to decode phonemes from the written letters and combinations of letters. For the development and practice of using the alphabetic principle, readers must develop their phonemic awareness that refers to the awareness that letters in words of alphabetic language systems also represent phonemes. Phonemic awareness, for that reason,

can be defined as “the ability to hear and manipulate the sounds in spoken words, and the understanding that spoken words and syllables are made up of sequences of speech sounds (Yopp, 1992)”. For example, the letter /t/ is pronounced as *tuh* since *tuh* is a phonemic representation of the letter /t/. However, more often than not letters in isolation are pronounced differently than when they come in words surrounded by other letters (What is Decoding in Reading? n.d.). For example, letter /t/ in the word *tea* is pronounced differently than in the word *this*. Therefore, readers must have not only a firmly established phonemic awareness but also graphemic awareness.

Graphemic awareness refers to the ability to connect phonemes with graphemes which in education is commonly called either letter-sound correspondence or grapheme-phoneme correspondence (Garforth, 2020). Therefore, children first learn to recognize the graphemes in a written word and to connect the graphemes to their appropriate phonemes. The next stage in the process of decoding is the blending of phonemes into words. Thus, by practicing and developing the phonemic and graphemic awareness, children acquire the ability to recognize and decode words very fast (Perfetti, 1985 in: Voeten, R, 2001, p.63).

The ability to decode phonemes from written graphemes at the beginning of primary school education can be a reliable indicator of a child’s cognitive and linguistic ability and a signal of possible learning disabilities. Some countries, e.g. Italy, require elementary school children to conduct a standardized test in the form of reading a list of words, non-words, or a text.

Sartori, Job, and Tressoldi developed the most commonly used tests for measuring the decoding ability in children (Moralini et al. 2015, p. 177). Through these standardized screening procedures, examiners are able to detect if a child has a linguistic impairment correlated to recognizing the sound-letter correspondence, the pronunciation of whole words or some phonemes, the reading speed, etc.

Aarnoutse et al. list two means by which the process of decoding can be measured. One way is to measure “the accuracy of pronouncing increasingly difficult words or pseudowords” by focusing on the accuracy of pronouncing increasingly difficult words and the other method is based on an individual’s efficiency, i.e. the rate in pronouncing increasingly difficult words or pseudowords (Aarnoutse et al., 2001, p.62).

Therefore, by focusing on the first aspect of measuring, researchers focus only on how accurately a person pronounces words regardless of the time he or she takes to perform the task. The second aspect puts focus on the rate, i.e. the "speed" at which a participant pronounces words. It is important to recognize that these two aspects of measuring the decoding process should not be taken as two complete and separate methods, but rather as two joined aspects of one method. For example, if a person is able to read a list of words accurately but he or she takes way too much time to perform the task, we cannot say that the person is a skilled reader. In other words, a "skilled decoder is - not only is able to spell written words (or non-words) accurately, but also does so rapidly and automatically" (Bowers & Wolf, 1993 in: Moralini et al. 2015, p. 177).

2.2. Phonological Recoding

The process of orthographical decoding is closely related to the phonological recoding. The phonological recoding is the term that stands for the ability to recognize and employ letter-sound correspondence "to retrieve the pronunciation of an unknown printed string or to spell words" (Alphabetic Principle: Concepts and Research, 2009). The decoding, i.e. the phonological recoding, is a three-step process. In other words, the phonological recoding is: "the ability to

- read from left to right, simple, unfamiliar regular words,
- generate the sounds for all letters,
- blend sounds into recognizable words." (Alphabetic Principle: Concepts and Research, 2009)

There are three types of phonological recoding based on the level of correspondence between written words and their pronunciation. Those are *regular word reading*, *irregular word reading*, and *advanced word analysis*. The first type, i.e. *regular word reading* refers to phonological recoding of the words with most straightforward correlation between sounds and letters in the word. For instance, a word *hat* consists of three letters, i.e. *h, a, t* and each letter in this word is pronounced using their most common sound. However, these letters are pronounced differently, in other words, depending on the letters and letter combinations that surround them, e.g. /a/ is pronounced differently in words *hat, hate,* and *heat.*

Therefore, phonological recording of the so-called regular words is the easiest for young learners to acquire. The process of developing reading skills for regular words goes through four stages. The first one requires sounding out of the words, i.e. the pronunciation of each sound in the word out loud. In the second stage, an individual is supposed to pronounce not only each sound in the word but also the whole word. The following stage is characterized by the ability to sound out the word using *inner speech*. This phase is also known as the sight word reading (Alphabetic Principle: Concepts and Research, 2009). Sight words are words that occur very frequently and are thus supposed to be read automatically without employing any decoding strategy. The last stage of reading regular words is automatic reading, i.e. reading without sounding out phonemes of the word either out loud or by means of inner speech. The following table is adopted from the University of Oregon ("Alphabetic Principle: Instruction", n.d.) and it illustrates regular word reading ordered in accordance with the complexity of letter-sound correspondence and word length.

Table 1 Regular word reading ("Alphabetic Principle: Instruction", n.d.)

Word Type	Reason for Relative Ease/Difficulty	Examples
VC and CVC words that begin with continuous sounds	words begin with a continuous sound	it, fan
VCC and CVCC words that begin with a continuous sound	words are longer and end with a consonant blend	lamp, ask
CVC words that begin with a stop sound	words begin with a stop sound	cup, tin
CVCC words that begin with a stop sound	words begin with a stop sound and end with a consonant blend	dust, hand
CCVC	words begin with a consonant blend	crib, blend, snap, flat
CCVCC, CCCVC, and CCCVCC	words are longer	clamp, spent, scrap, scrimp

The second type of phonological recoding is known as *irregular word reading* and it refers to the reading of words the pronunciation of which does not correspond to the written combinations of letters or the pronunciation of such combinations is rare. Therefore, irregular words most frequently need to be learned as sight words since no decoding strategy can be used in the process of reading. The importance of memorization of sight words depends on the depth of the alphabetic orthography of a speaker. Therefore, automatic reading of sight words is especially important for speakers of languages with deep orthography. Ram Frost explains orthographic depth in the following way:

> Orthographic depth is often regarded as a continuum, and in this view, languages may be aligned one next to the other where one language would be considered deeper than another but shallower than a third one (Frost, Katz, & Bentin, 1987 in: Frost, 2005, p. 278).

Therefore, languages with deep or opaque orthography are those in which the letter-sound correspondence is less consistent, i.e. the pronunciation of a letter may vary depending on the surrounding letters and combination of letters. Languages with deep orthography are, for example, French and English. Murray et al. (2018) illustrate deep orthography in the English language using the following examples:

> *cough, rough, though* and *through* all share the same spelling pattern, but [not all of them] rhyme; yet *though* rhymes with *know, cough* with *off*, etc. English vowels represent multiple phonemes (compare *a* in *cat, bacon, father, ball* and *again*), and English spellings feature many digraphs, silent letters and irregularities (Murray et al., 2018, p. 3).

Unlike languages with deep orthography, some languages are characterized by highly regular and consistent letter-sound correspondence. Those languages are said to have shallow or transparent orthography. For example, Croatian, Finnish and Greek have shallow orthographies.

The third type of phonological reading is the so-called *advanced word analysis*. It can be described as the phonological processing ability i.e. the ability to recognize and use the speech sounds, and "the awareness of letter sound correspondences in words" (Alphabetic Principle: Concepts and Research, 2009).

In order to reach the level of advanced word analysis, an individual needs to acquire a broad knowledge of possible word prefixes, suffixes and roots in a language in order to be able to know "how to use them to 'chunk' word parts within a larger word to gain access to meaning" (Ibid).The development of phonological recoding in terms of the advanced word analysis requires the so-called *word analysis instruction.* By being taught about the meanings and roles of word prefixes, suffixes and roots, students are able to understand new, additional and, possibly unfamiliar to them, meanings of words which they have already acquired. In other words, through *word analysis instruction* learners acquire "information and strategies that will help them gain access to the meaning of words" (Wexler, J. et al, 2008, p.194). For instance, teachers might instruct students to chunk the word *retyped* into meaningful parts to understand its meaning. Through morphemic analysis of the word *retyped* students my chunk the word into: prefix *re-* which bears the meaning *again,* root word *-type-* which carries the meaning "to write using a typewriter", and the suffix *–ed* which indicates that *typing* occurred in the past.

2.3. The Stroop Effect

Long before John R. Stroop published his dissertation on the topic of the Stroop effect, psychologists noticed that people find it easier to read words than to name objects and their properties (MacLeod, 2015). This belief was further reinforced by the growing interest in the phenomenon called "the Stroop effect" among various scientists since its first description in 1935. With the color-naming Stroop test, containing, for instance, the word "blue" written in red ink, John R. Stroop concluded that interference occurs only when naming a color while the color (e.g. red) and word content (e.g. blue) mismatch, but no processing delay occurs when reading the word (e.g. blue). The participants were supposed to disregard the meaning of the written words and to name the color of the used ink (see Picture 1). The studies showed that the participants make more mistakes and need more time to name colors if the color and word content are not congruent, as in the word "yellow" being written in green ink. Furthermore, the studies showed that no delay and no mistakes occurred if the participants were asked to simply read the written words and to disregard the color of the ink used for writing the words. It has been concluded that the processing delay is caused by conflicting information.

James McKeen Cattell explained this phenomenon by stating that “in the case of words and letters, the association between the idea and name has taken place so often that the process has become automatic, whereas in the case of colors and pictures we must by a voluntary effort choose the name (Cattell 1886, in MacLeod, 1991, p.163).”

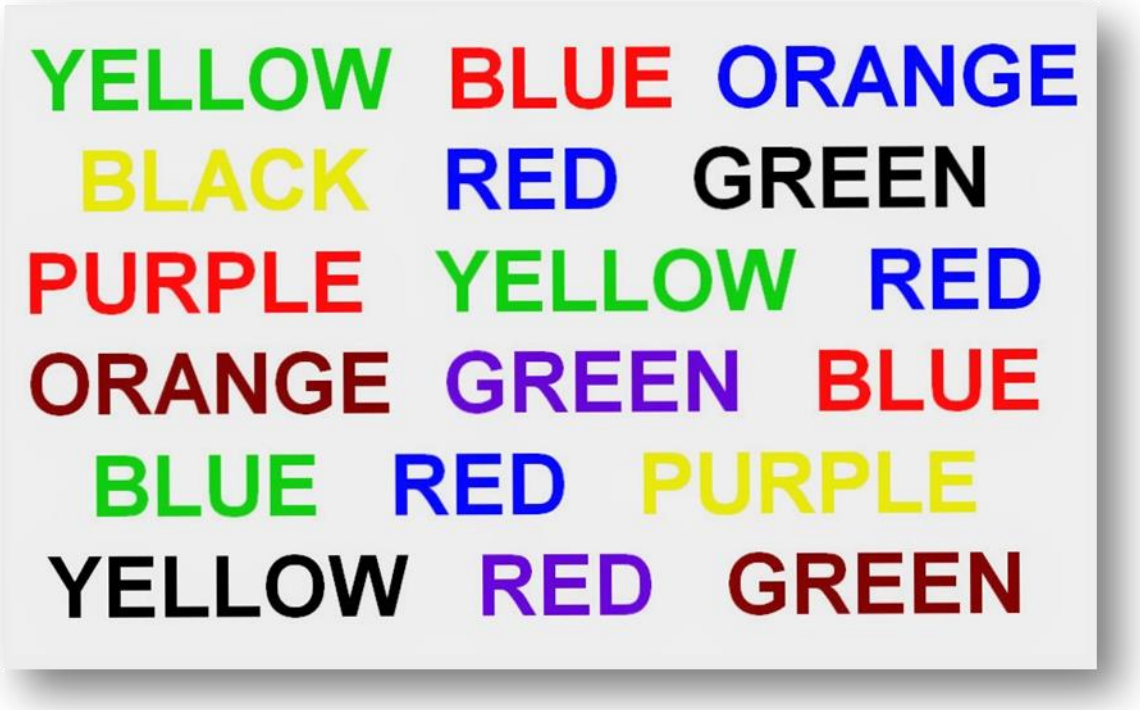

Illustration 1 Color-naming Stroop test (Cannot Unsee, 2018)

Besides color naming tests, John R. Stroop also created the so-called *picture naming tests*. In those tests, the participants were asked to name animals on the pictures and to ignore the mismatching word written on the pictures. For instance, if a card showed a picture of a zebra with the word “snake” over it, the participant was supposed to name the picture by saying “zebra” and to completely ignore the interference word – “snake” (see Picture 2). Once again, the participants found it easier to name animals on the pictures when the words written over them matched the pictures.

Therefore, picture-naming tests just like color-naming tests indicate that a delay in the processing will occur if a participant is presented with conflicting information.

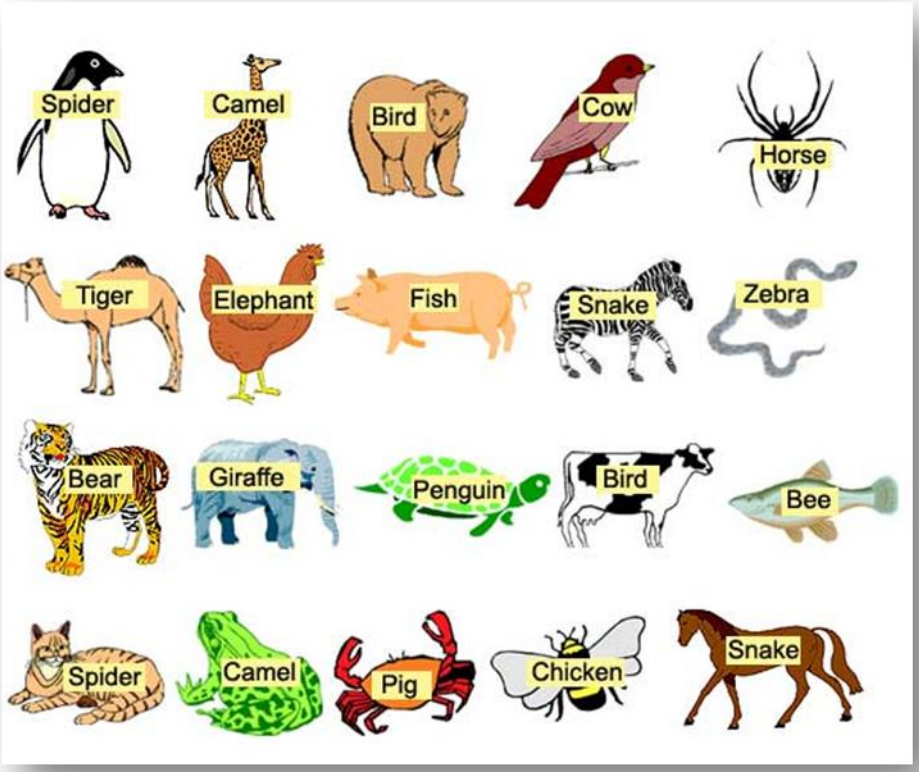

Illustration 2 Picture-naming Stroop test (Reynolds K., 2016, slide 12)

2.4. Sapir–Whorf Hypothesis

It has been assumed that the brain sorts information into different categories. For example, Thompson (1995) claims that even though we can discriminate a great number of colors, we divide the color spectrum into a small number of categories (~10), for instance, a few basic color terms are enough to describe all possible colors (Wiggett & Davies, 2008, p. 231).

This led linguists to question whether the language in which the words and colors are presented has any impact on a subject's processing of information. This goes hand in hand with the Sapir-Whorf hypothesis. Namely, in 1929 Sapir presented for the first time the idea that a person's mother tongue determines or at least has a certain impact on the way he or she perceives

the world. The strong version of this hypothesis, which claims that our native language controls our cognitive processes leading to a complete linguistic determinism, has been rejected long ago. However, the weak version of the Sapir-Whorf hypothesis, claiming that our mother tongue influences (but does not determine) our thoughts only to a certain extent, found many supporters. This can lead us to pose a question: "Is our perception of a color affected by the words for colors in our mother tongue?" In order to find an answer to this question, Kay and Kempton (1984) conducted an experiment testing whether English speaking subjects and Tarahurama speaking subjects differ in their perception of several different chips of colors: green, light blue (turquoise), dark blue in different shades. Both groups were asked to sort the chips based on the distance between colors. Since the Tarahurama language does not distinguish between blue and green, i.e. it has one word (*siyóname*) for both colors, its speakers' perception of the distance between colors was not influenced by their language. On the other hand, English-speaking subjects sorted the colors based on their categories in the English language, i.e. based on the words for those colors. Therefore, Kay and Kempton concluded that

> The presence of the blue-green lexical category boundary appears to cause speakers of English to exaggerate the subjective distances of colors close to this boundary. Tarahumara, which does not lexicalize the blue-green contrast, does not show this distorting effect (Kay & Kempton, 1984, p.72).

Therefore, our first or dominant language may influence our perception of colors, and thus our performance in the color naming Stroop test. In other words, if our mother tongue (L1) does not distinguish between e.g. blue and green, then the word "green" written in turquoise ink will not cause a processing delay since there is no conflicting information.

2.5. Phonetic Facilitation through Translation in Stroop Tests

In 2007, Amiee C. Knupsky and Paul C. Amrhein published their research work on the possibility of phonological facilitation in picture-naming Stroop tests for bilingual people. As already mentioned, picture-naming Stroop tests commonly consist of sets of pictures onto which some incongruent distractor words are written. The participants of Stroop picture-naming tests usually tend to make mistakes and delays in naming those pictures onto which mismatching words are written.

However, on the other hand, there is no interference on the ability to read the words and to ignore the pictures. This could mean that our brain processes syntactic information, i.e. words, faster than semantic information (e.g. naming pictures). Nevertheless, Knupsky and Amerhein hypothesized in their work that the phonological similarity between mismatching words and pictures could facilitate the picture-naming task. To be more precise, the participants of their experiment were asked to name pictures in either their L1 or L2, onto which the distractor words with phonological similarity to the name of the picture were written. The languages they used to carry out their experiment were Spanish and English. In their experiment, some distractors were phonologically related to the required name of the picture either through translation or though the same language. In this case, 'through translation' refers to a "subconscious" process of retrieving information about a lexical item in two languages. Namely, even though the participants are trying to disregard the written words, it is almost impossible to completely ignore them. To be more precise, when the participants are presented with conflicting information the processing delay occurs due to the participants' inability to completely disregard the distractor words. Information processing occurs on the "receptive channel" (eyes) through which we receive signals. In other words, after the visual input is received, the output (picture naming) is "produced" through the speech apparatus. At the same time, the processing delay or the lack of it is produced in the mental lexicon. A few theories have tried to explain this phenomenon.

Speed processing theory suggests that our brain can "process written words faster than we can process colors [or pictures]. Thus, it is difficult to identify the color [or a picture] once we've already read the word" (What the Stroop Effect Reveals about Our Minds | Lesley University, n.d.). Therefore, the reason why it is difficult to ignore distractor words in Stroop tests is the fact that brain processes syntactic information, i.e. words, faster than semantic information, i.e. colors, pictures etc. Thus, even though the participants are trying to ignore distractor words they will still notice them. This experiment explores whether we can subconsciously recall the translation of a word and whether that subconscious translation can help us to recall the name of a picture.

Phonetic facilitation through translation in Stroop tests can be best explained using the following example from Knupsky and Amerhein's experiment. In their experiment Knupsky and Amerhein asked the participants to name a picture of a leg, that is to say: "*leg"* in English while

having the word *milk* as the distractor word. This word can be translated into Spanish as *leche*. Therefore, the phonological facilitation though translation in this case would occur due to the phonological similarity of the first two phonemes of the lexical item represented by the picture (Eng. leg) and the distractor word but only when translated (Eng. milk → Sp. *leche*).Besides phonologically related distractors, they used a set of pictures with distractors that are completely phonologically unrelated to the name of the picture. In other words,

> Each target picture was paired with one visually presented word distractor that was either phonologically related (direct condition; FISH-fist), phonologically related through translation (through translation condition; LEG-milk-leche), or unrelated (BEAR-peach). (Knupsky &Amerhein, 2007, p.214)

Thus, Knupsky and Amerhein analyzed the participants' accuracy and speed in naming pictures and compared their results to test whether the phonological relatedness of pictures' names and distractor words, either in the same language or through the translation, can facilitate the picture-naming task. Through their experiment, they concluded that the phonological similarity of distractor words and picture names can be conducive to the accuracy and speed of picture-naming. Furthermore, their findings indicated that through translation (TT) phonological facilitation was more consistent when the participants were asked to name pictures in their L2. Before their work, the experiment conducted by Hermans (2004) also indicated that facilitation through translation in L2 picture naming tasks does exist.

3. DECODING IN PICTURE-NAMING TASKS: THE STROOP EFFECT IN BILINGUALS

Having presented the research conducted so far, it is possible to analyze how picture-naming tasks may affect language processing of bilinguals and decoding in reading, what is the role of conflicting information in picture-naming tasks which causes delays in language processing and how non-conflicting information in picture-naming tasks enhances language processing.

In order to verify and test the hypotheses presented above, this section of my thesis contains detailed descriptions of the research methodology, the research problem, goals and objectives, the research materials, participants of the research, etc.

3.1. Research Problem

Ever since John Ridley Stroop first described the phenomenon today known as *the Stroop effect* or *the Stroop interference* it has fascinated psycholinguists. Namely, the effect indicated that people tend to process syntactic information more quickly and accurately than semantic information. Many researchers attempted to explore and analyze possible correlations between the Stroop interference and other psycholinguistic phenomena. This resulted in variants of Stroop tests in which researchers tried to examine the existence of the processing delay in various conditions. For instance, some studies showed that there are strong indications that word recognition is automatic for skilled readers. In other words, the results of many Stroop effect studies have shown that linguistic skills, such as reading, after extensive practice, eventually become automatic. On the other hand, other studies, such as the one published in 1999 by Besner, D. and Stolz, J. A. under the title *Unconsciously controlled processing: The Stroop effect reconsidered,* showed strong indications that extensively practiced linguistic skills are not automatic. Besner and Stolz (1999) found out that no interference occurs in the *Stroop color-naming tests* when only one letter of the incongruent word is colored instead of the entire word. Besner, S. et al. (1997) explain the importance of the phenomenon by stating:

> This outcome flies in the face of any automaticity account in which specified processes cannot be prevented from being set in motion, but it is consistent with the venerable idea that the mental set is a powerful determinant of performance. (Besner, S. et al., 1997, p.221)

Furthermore, other studies showed that processing delays occur in all sorts of conflicting information. Thus, many researchers attempt to find out if there are any exceptions. Therefore, numerous studies in which the results of variants of the Stroop test are being published. For instance, Van der Elst et al. (2006) analyzed the influence of age, sex, and education on the Stroop test performance and concluded that "executive function, as measured by the Stroop test, declines with age and that the decline is more pronounced in people with a low level of education (Van der Elst et al., 2006, p.62)." Moreover, Sabourin, L. and Vinerte, S. attempted to examine and analyze the bilingual 'cognitive control' through the Stroop test, i.e. the possibility that bilinguals have a cognitive advantage over monolinguals while performing the Stroop tasks. In their paper *The Bilingual Advantage in the Stroop Task: Simultaneous vs. Early Bilinguals* published in 2014, Sabourin and Vinerte concluded that

> different patterns of facilitation and inhibition [while performing the Stroop tasks] suggest to us that even though both simultaneous and early bilinguals have acquired two languages from an early age, there are differences in underlying processing (Soburin, L. and Vinerte, S., 2014, p.354).

The cognitive processing of bilingual people while performing the Stroop tasks has intrigued many psycholinguists. Thus, researchers designed and conducted numerous Stroop-like tests in which they attempted to investigate, examine and analyze the impact of various conditions on the cognitive processing of bilinguals and multilinguals. For instance, in 2007 Knupsky and Amerhein published the results of their study on the *Phonological Facilitation through Translation in a Bilingual Picture-Naming Task*. Knupsky and Amerhein (2017) confirmed the existence of phonological facilitation in both direct and through translation conditions in a picture-naming Stroop test. As explained above, 'through translation' refers to a "subconscious" process of retrieving information about a lexical item in two languages, in this case the phonological components. When I decided to write this thesis, the first thing that came to my mind is that two mental lexicons are "overlapping". However, we cannot talk about overlapping of mental lexicons since they greatly differ from physical dictionaries. Thus, we can presume that the delays in processing or a lack of them in picture-naming tests occur due to an overlapping of phonological components of "bilingual mental lexicons", i.e. their nodes.

3.2. Research Goals and Objectives

The aim of the present thesis is to explore and analyze the influence of phonological similarities between distractor words and picture names on language production (speaking) and language processing of bilingual people. Furthermore, the aim was to examine and prove that the semantic, conceptual and phonological components in the mental lexicon of an individual are being activated during the picture-naming task.

Therefore, for the purpose of the present research, the following three hypotheses have been proposed:

H1: The participants will need the least amount of time to name pictures in direct phonological facilitation condition, i.e. when naming those pictures onto which there are distractor words attached that are phonologically similar to the picture names regardless of the language combination.

H2: In comparison to the task of naming pictures in direct phonological facilitation condition, the participants will require more time when naming those pictures onto which there are distractor words attached that are phonologically similar to the picture names only when they are translated regardless of the language combination.

H3: The participants will need the greatest amount of time to name pictures in phonologically unrelated condition, i.e. when naming those pictures onto which there are phonologically unrelated distractor words attached regardless of the language combination.

3.3. Research Methodology

This study was conducted in order to examine and analyze a possible existence and impact of phonological facilitation in picture-naming tests. Furthermore, the study was conducted to see if the phonological similarities through translation between a distractor word and a picture name are equally as efficient in enhancing the process of picture-naming as the phonological similarities in the direct condition. The participants of the research voluntarily

agreed to participate in the study. The data gathered in this survey will be kept confidential and participants' anonymity will be protected.

3.3.1. Research Instrument

The findings of Knupsky and Amerhein have fascinated me and prompted me to modify their experiment with another language combination in order to explore and analyze the existence and possible impact of phonological facilitation through three conditions: 'direct phonological facilitation', 'through translation phonological facilitation', and 'phonologically unrelated condition'. In each condition, there were four sets of picture-distractor combinations in accordance with four possible response language and distractor word language relations, i.e.

1) (E-E) English as a response language used to name pictures, and distractor words written in English,
2) (E-C) English as a response language used to name pictures, and distractor words written in Croatian,
3) (C-C) Croatian as a response language used to name pictures, and distractor words written in Croatian,
4) (C-E) Croatian as a response language used to name pictures, and distractor words written in English.

Therefore, the three conditions with four combinations of response language and distractor word language were used in the present research. Thus, the research instrument consisted of 12 possible variations of phonological conditions. To be more precise, three following condition-response language combinations were used.

- **Direct phonological facilitation**, i.e. phonological facilitation generated by the phonological similarity of the first two phonemes of a distractor word and a picture name (see Appendix pictures 3, 4, 5, and 6). The four language combinations were used in the direct phonological facilitation. For example, the participants were supposed to
    - name a picture by saying *lav* (L1) while having for the distractor the word *ladica* (L1); C-C – language relation
    - name a picture by saying *bunar* (L1) while having for the distractor the word *book* (L2); C-E – language relation

- name a picture of a *glass* (L2) while having for the distractor the word *globe* (L2); E-E – language relation
- name a picture of a *star* (L2) while having for the distractor the word *strijela* (L1); E-C – language relation

- **Phonological facilitation through translation**, i.e. phonological facilitation generated by the phonological similarity of the first two phonemes of a distractor word in one language and a picture name in another language (see Appendix pictures 7, 8, 9, and 10). For example, participants were supposed to
  - name a picture of *milk* (L2) while having for the distractor the word *zrcalo* (L1), which is phonologically related through translation to the picture name, i.e. *milk – mirror* (L2); E-C – language relation
  - name a picture by saying *konj* (L1) while there is the word *thread* (L2) as the distractor, which is phonologically related through translation to the picture name, i.e. *konj–konac;* C-E – language relation
  - name a picture by saying *stolica* (L1) while having for the distractor the word *korak* (L1) which can be translated to L2 as *step;* C-C– language relation
  - name a picture by saying *butterfly* (L2) while having for the distractor the word *pool* (L1), which can be translated to L1 as *bazen;* E-E – language relation
- **Unrelated conditions**, i.e. picture naming without any phonological similarities between the first two phonemes of a picture name and the accompanying distractor (see Appendix pictures 11, 12, 13, and 14). In other words, there was no phonological similarity between the first two phonemes of the distractor and the picture name either directly or through translation. For example, participants were supposed to
  - name a picture of a *pineapple* (L2) while having for the distractor the word *stol* (L1)*;* which can be translated as *table* or *desk* in L2; E-C – language relation
  - name a picture of a *guitar* (L2) while having for the distractor the word *tea* (L2)*;* which can be translated to L1 as *čaj;* E-E – language relation
  - name a picture by saying *kruna* (L1) while having for the distractor the word *zastava* (L1)*;* which can be translated as *flag* in L2; C-C – language relation
  - name a picture by saying *balerina* (L1) while having for the distractor the word *wall* (L2), which can be translated to L1 as *zid;* C-E – language relation.

In every combination, each picture-word set was semantically unrelated. Distractor words that were phonologically related to picture names contained at least the first two similar phonemes. In this study, 72 picture-word combinations were used, i.e. 24 picture-word sets for each condition.

3.4. Research Participants and Procedure

In this research, there were 23 participants whose ages range from 21 to 28 years old. The participants' L1 (mother tongue) is Croatian. The participants are advanced users of English and speak English fluently or on a daily basis. Furthermore, the participants voluntarily agreed to take part in the experiment and they will be referred to as Participant 1-23 as the data have been anonymized. The research presented in this paper was conducted during the month of April, 2019.

For the purpose of carrying out the research, 3 sets of 24 pictures with the accompanying distractor words were presented using PowerPoint slide show. To be more precise, three PowerPoint slide shows were made in accordance with the three conditions. Each condition contained four sections which began with a slide that indicated which language the participant was supposed to speak. In other words, three slide shows each containing four separate language-sections were used in this research. After naming pictures in one section of the slide show, the participants were taking a break for 10 seconds during which they were notified that they need to switch the language for the naming task in the next section. After finishing the picture-naming task for one condition, the participants were taking a break for 30 seconds and then they were presented with another set of slides.

In order to indicate which language the participants were supposed to use to name the pictures, there was a white slide onto which the instruction '*Speak English'* or '*Speak Croatian'* was written. The participants were informed that on each slide there would be a picture that they are supposed to name and a word that they are supposed to ignore. In order to ensure that each participant understood the task properly, I provided examples of such slides that were not used later on as a part of the experiment. The language used for picture names and distractor words was very simple and it consisted only of nouns.

Only one part of speech was used in order to exclude the possibility of confusion or of a variety of parts of speech having any impact on the time needed for picture-naming.

The participants were instructed to name pictures without delay and then to move onto the next slide, i.e. to move to another picture after having named the first one. The participants were informed that the goal was to correctly name as many pictures as they could. As the participants were naming pictures, I observed the process and used a stopwatch in order to track the time used for each condition.

3.5. Materials

For this study, 72 picture-word combinations were used. All pictures used in the experiment were simple black-and-white drawings found on a free clipart website called *clipart-library.com.* Each picture was accompanied by a semantically unrelated distractor word. Distractor words were either **phonologically related** (e.g. a picture of glass accompanied with a word *globe),* **phonologically related through translation** (e.g. a picture of leaf accompanied with a word *usne – eng*. lips), or were **phonologically unrelated** (e.g. a picture of pineapple accompanied with a word *stol – eng.*table/desk). Phonological relatedness was defined as "sharing of at least the first two phonemes between picture name and distractor (Knupsky&Amerhein, 2007, p.214)". Each distractor word was written in capitalized and bold letters in Times New Roman font, size 40. Distractor words were written using a *text box* tool in PowerPoint with opaque white background and with black 3/4pt full text box outline. In order to indicate the beginning of a new language section in one PowerPoint presentation, I used a white slide onto which "*Speak English*" or "*Speak Croatian*" was written in black and bold letters of Times New Roman font, size 54. The reason behind using larger font size for those slides is to make sure the participants are well aware which language they need to use and if they need to switch to another language in the next section. Semantically unrelated distractor words were placed over the pictures so that the pictures were still clearly visible and easily recognizable. All distractors were nouns (concrete and abstract) in order to avoid any possible interference or delay in the process of picture naming as a result of inconsistent usage of parts of speech.

Synonyms and near-synonyms posed additional challenge in designing the research materials. For instance, if a participant would name a picture by saying *desk* instead of *table* in

any but phonologically unrelated condition that would interfere with the results of the experiment. In order to avoid such issues, in 'direct phonological facilitation' and 'phonological facilitation through translation' conditions I focused on using those picture names which have no synonyms or their synonyms are less often used. For instance, in those two conditions I used pictures of *sun, dog, tooth, elephant, lion, socks, key, star, etc.*

On the other hand, in the third condition, i.e. in phonologically unrelated condition, I used even those picture names which have more frequently used synonyms, however, I paid attention to not have phonological relatedness between the picture name synonyms and the distractor word. For example, a picture of *pants* might be named as *pants, trousers,* or *jeans,* but the distractor word, i.e. *mjesec* (*Eng. moon*) is not phonologically related to any of those picture name synonyms.

3.6. Study Limitations

The main limitation of this study is that it included only 23 participants of similar age and educational background. Therefore, we have to bear in mind that the results might be different if the study included more participants of various backgrounds. Furthermore, the experiment was conducted using a smartphone stopwatch in order to track the time used for each condition. Therefore, more precise results would be obtained if the research was conducted using more complex time-tracking programs. The results might have been even more precise if the participants could focus only on naming pictures and not on switching the slides as well. Therefore, in future studies, it would be possible to include more researchers who would have different roles such as switching the slides, tracking the time, writing down the time, observing and monitoring the participants' responses, etc.

4. ANALYSIS OF THE RESEARCH RESULTS FOR THE THREE CONDITIONS

4.1. Discussion and Analysis of the Research Results for Direct Phonological Facilitation Condition

Analyzing the results of all participants for the test of direct phonological facilitation condition, we can conclude that the participant who needed the least time to complete the task needed 5.27seconds to name all the pictures in the first language combination, i.e. to name pictures in Croatian while having the distractors written in Croatian as well (Column 1). The participant who spent the most time to perform the task for the C-C language combination needed 6.92seconds. Therefore, we can use those two time stamps as the minimum and maximum time the participants needed to perform the task. The arithmetic mean for the amount of time used to perform this task in C-C language combination is 5.9seconds. If we divide that number by the number of pictures in the task that were named, which is 6, we get 0.983seconds as the average time needed to name one picture in this condition in the C-C language combination.

Table 2 Results of direct phonological facilitation condition per participant

LANGUAGE COMBINATION				
Participants	**C-C** **Column 1**	**C-E** **Column 2**	**E-C** **Column 3**	**E-E** **Column 4**
1.	5.61	5.78	6.11	6.09
2.	5.97	5.77	6.34	5.81
3.	6.04	6.1	6.45	6.71
4.	6.77	6.81	5.65	5.4
5.	5.27	5.34	6.96	6.95
6.	6.92	6.34	5.48	6.01
7.	6.23	6.78	5.03	5.14
8.	6.11	6.32	6.14	5.96
9.	5.23	5.87	6.12	6.05
10.	5.29	5.82	5.97	5.97

11.	5.83	5.66	6.23	6.12
12.	5.95	6.01	6.45	6.79
13.	5.3	5.7	6.23	6.44
14.	6.27	6.39	5.31	5.68
15.	5.82	5.99	6.23	6.41
16.	5.97	5.62	6.04	6.24
17.	6.31	6.58	5.33	5.62
18.	6.29	6.44	6.25	6.2
19.	5.48	5.32	5.94	6.35
20.	5.72	5.94	6.74	6.82
21.	5.49	5.53	5.82	6.16
22.	6.61	6.35	6.21	5.97
23.	5.38	5.77	6.88	6.96
Average time	**5,9**	**6,01**	**6,08**	**6,16**

If we look at the results presented in the Column 2 of this table, we can see that the participants spent approximately the same amount of time to complete the task in another language combination. To be precise, the participant who needed the least amount of time needed around 5.32 seconds to name the pictures in Croatian while having the distractor words in English. The maximum time spent on this task was 6.81 seconds. If we compare the average time spent on performing the task in these two language combinations, we can notice only a slight difference in the time needed. Namely, the task in C-C language combination was performed faster by only 0.11seconds. The arithmetic mean for the amount of time used to perform this task was 6.01seconds, while the average time spent to name one picture in this language combination was 1.001seconds.

Column 3 presents the results of the task performed using another language combination, i.e. the language combination in which the pictures were to be named in English while the distractor words were in Croatian. Here we can see a more noticeable difference. The participant who needed the least time to complete the task needed around 5.03seconds, which is actually less time than the minimum time used for completing the task in the previous two language

combinations. The participant who needed the most time was the one who spent 6.96 seconds on completing the picture-naming task. The arithmetic mean for the amount of time used to name all the pictures in the C-E language combination was 6.08 seconds. The participants on average spent 1.013 seconds to name one picture in this task.

Column 4 presents the amount of time the participants needed to name pictures in English while having distractor words in English as well. The participant who needed the least amount of time needed 5.14 seconds to complete the task. Just like in the previous column, the participant who needed the greatest amount of time took 6.96 seconds. Thus, the arithmetic mean for the time needed to complete the task in E-E language combination is 6.16 seconds, while the average time spent on naming one picture is 1.026 seconds.

Taking into consideration the results presented in Table 2, we can conclude that the minimum amount of time used to name a set of pictures in this condition was 5.03 seconds and the greatest amount of time needed was 6.96 seconds.

The arithmetic mean for each language combination in the direct phonological facilitation condition (Table 2) is 5.9 seconds for C-C, 6.01 seconds for C-E, 6.08 seconds for E-C, and 6.16 seconds for E-E language combination.

Therefore, the participants on average needed 6.03 seconds to name the pictures in one language combination and 24.15 seconds to complete the *direct phonological facilitation* test in all language combinations. This time will be used when comparing the arithmetic means for the time needed to complete the other two conditions in order to support or reject the hypotheses.

Comparing the arithmetic mean for the time spent on the task in each language combination, we can notice that there is an obvious correspondence of the results between the first and the second column and between the third and fourth column. Therefore, we can conclude that the task with language combinations in which the participants were required to name pictures in Croatian was easier since the participants needed less time to perform it.

One of the reasons why it might be easier for the participants to name pictures in Croatian could be because it is their L1. Since the participants are bilingual and speak the English language fluently, I supposed that there would be no noticeable differences in the time needed to

perform the task in different language combinations. Not only because the participants are fluent English speakers, but even more so because the language used to name the pictures consisted of high-frequency nouns the participants are familiar with. This might suggest that L1 nodes in the mental lexicon activate faster. This can indicate that the language used for the naming task plays an important role in this bilingual Stroop effect test. To support this idea, we also need to compare the arithmetic mean for time spent on the task in each language combination for the other two conditions, i.e. for the **phonological facilitation through translation condition** and **no phonological facilitation**.

However, it is important to notice that some participants needed more time to name the pictures in Croatian than in English. For example, participant 4 spent 6.77 seconds to complete the task in C-C language combination, 6.81seconds in C-E, 5.65seconds in E-C, and 5.4seconds in the E-E picture-naming task. There were eight participants who needed significantly less time while naming pictures in English in both E-C and E-E language combination than in Croatian. The reasons behind such unexpected results could be numerous. One possible reason why one third of the participants needed less time in English could be word length. English words from the corpus are shorter than their Croatian equivalents which could impact the time needed to pronounce the words while naming them. In other words, the pictures to be named in E-E and E-C tasks were somewhat shorter than in C-C and C-E. For instance, in E-E and E-C language combinations, the participants needed to name pictures by saying *stairs, bell, key, star, cat, gloves* etc. Those words are shorter than their translation equivalents provided, i.e. *stepenice, zvono, ključ, zvijezda, mačka, rukavice.* However, the participants were not required to name the same pictures in C-C and C-E to avoid word repetition. Still, the names of the pictures in C-C and C-E language combination were somewhat longer, e.g. *čarape, telefon, haljina, bunar, medvjed.* There were only two somewhat longer words to be named in English. Those are *banana* and *elephant.* Even though, the length of the majority of the words in all language combinations of the direct condition was around 5 letters, the abovementioned exceptions may have had some influence on the time needed for the picture-naming task.

Therefore, for future research, I would suggest keeping in mind the length of the words used to name the pictures in the tasks.

4.2. Discussion and Analysis of the Research Results for Phonological Facilitation Through Translation Condition

Table 3 presents the results of the *phonological facilitation through translation* test with separate columns dedicated to each of four language combinations. Analyzing the results of all participants for the first language combination (C-C), we can notice that the participant who needed the least amount of time named all the pictures in 5.39 seconds. The participant who needed the greatest amount of time to name the pictures took 7.31seconds to complete the task. Therefore, the arithmetic mean for the time needed to complete the task in C-C language combination was 6.65 seconds. On average, the participants spent 1.108 seconds to name one picture in this language combination.

Table 3 Results of phonological facilitation through translation condition per participant

LANGUAGE COMBINATION				
Participants	**C-C** **Column 1**	**C-E** **Column 2**	**E-C** **Column 3**	**E-E** **Column 4**
1.	5.91	5.67	6.51	6.7
2.	6.78	6.82	6.98	7.21
3.	5.39	5.42	6.73	6.59
4.	7.24	7.36	6.86	6.75
5.	6.34	6.8	7.01	7.41
6.	7.29	7.18	6.32	6.22
7.	7.2	7.31	6.49	6.58
8.	7.27	7.05	6.62	6.35
9.	6.23	6.31	7.43	7.2
10.	6.27	6.89	7.19	7.04
11.	6.83	6.88	7.13	7.31
12.	5.95	6.3	6.61	6.89
13.	6.14	6.59	6.87	6.92
14.	7.27	7.3	6.71	6.5
15.	6.82	7.01	7.27	7.14

16.	6.29	5.97	7.26	7.31
17.	7.31	7.29	6.5	6.72
18.	7.02	7.1	5.98	6.21
19.	6.98	7.31	7.27	7.4
20.	6.83	6.8	7.41	7.49
21.	5.92	6.21	6.9	7.01
22.	7.2	7.33	6.73	6.9
23.	6.82	6.9	7.2	7.31
Average time	**6.65**	**6.77**	**6.86**	**6.92**

Column 2 contains information about the time that the participants needed to complete picture-naming tasks for the pictures in Croatian while being presented with distractor words in English. The minimum time used to complete the task was 5.42 seconds, while the maximum time spent on the task was 7.33seconds. The arithmetic mean for the amount of time spent to perform the entire task in C-E language combination was 6.77 seconds. The average time spent to name one picture in this language combination was 1.12seconds. If we compare the arithmetic means for the time needed to complete the task in C-C language combination and C-E language combination, we can notice that there is a very slight difference. To be precise, the difference is only 0.12seconds.

In Column 3, we can see that the minimum time used to perform the task in E-C language combination was 5.78 seconds, which is 0.39 seconds more than in the C-C combination and 0.36 seconds in the C-E language combination. The maximum time spent to complete the task was 7.43 seconds. On average, the participants needed 1.143 seconds to name one picture and 6.86 seconds to complete the entire task in the E-C language combination. Therefore, the arithmetic mean for the time spent in this language combination is noticeably greater than in the C-C and C-E language combinations.

To be precise, to complete the test in this set, the participants on average needed more time as opposed to the first two language combinations, i.e. 0.09 seconds more than in C-E language combination and 0.21seconds in E-E.

The results of the test conducted in the E-E language combination are presented in Column 4. Here we can notice that, once again, the participants needed more time to name pictures in English. The participant who needed the least amount of time took 6.21 seconds to complete the task, while the participant who needed the most time took 7.49 seconds to name all the pictures. By calculating the arithmetic means for the time needed to complete the task in the E-E language combination, we can see that the participants needed 1.153 seconds to name one picture in this set and 6.92seconds to complete the entire task.

The least amount of time spent in this condition on naming a set of pictures was 5.39 seconds, while the greatest amount of time spent on naming a set was 7.49 seconds. The arithmetic mean for each language combination in the *phonological facilitation through translation* condition was 6.65 seconds for C-C, 6.77 seconds for C-E, 6.86 seconds for E-C, and 6.92 seconds for E-E. Therefore, the participants on average needed 6.8 seconds to name the pictures in one language combination and 27.2 seconds to complete the *phonological facilitation through translation* condition test in all language combinations. This time will be compared with the arithmetic means for the time spent to complete the other two conditions in order to support or reject the hypotheses.

If we compare the average time needed to complete the task in this condition in each language combination, we can conclude that the language combination for which the participants needed the least amount of time to complete was C-C (L1-L1), followed by C-E (L1-L2), then E-C (L2-L1) and at last E-E (L2-L2). Therefore, in this condition, the task of naming pictures in L1 while having distractor words written in L1 was the easiest for the participants. On the other hand, the task of naming pictures in L2 while having distractor words written in L2 was the most challenging. This supports the suggestion that items in mental lexicon L1 activate faster. However, one third of participants found naming pictures in L2 easier and thus needed less time to complete the task in the L2-L1 and L2-L2 language combinations.

4.3. Discussion and Analysis of the Research Results for Phonologically Unrelated Condition

Table 4 presents the results of the picture-naming test in phonologically unrelated condition with separate columns dedicated to each of four language combinations. The participant who

needed the least amount of time to complete the task in the C-C language combination needed 6.57seconds to complete the task. The maximum time spent to perform the task was 7.72seconds. Therefore, the average time spent on naming pictures in the C-C language combination of the phonologically unrelated condition is 7.06 seconds. If we divide that number by the number of pictures in the task that were named, which is 6, we get the average time needed to name one picture in this condition in the C-C language combination and that is 1.176 seconds.

Table 4 Results of phonologically unrelated condition per participant

LANGUAGE COMBINATION				
Participants	**C-C** **Column 1**	**C-E** **Column 2**	**E-C** **Column 3**	**E-E** **Column 4**
1.	6.61	6.58	7.41	7.56
2.	6.97	7.01	7.87	7.95
3.	6.88	6.87	7.25	7.36
4.	7.42	7.67	6.88	6.98
5.	6.7	6.58	7.44	7.32
6.	7.72	7.65	6.56	6.67
7.	7.54	7.41	6.8	6.91
8.	7.51	7.63	6.74	6.84
9.	6.81	6.72	7.27	7.38
10.	7.02	6.98	7.4	7.57
11.	6.83	6.77	7.65	7.79
12.	6.95	6.91	7.49	7.67
13.	6.59	6.62	7.42	7.8
14.	7.64	7.73	6.88	6.72
15.	6.82	6.9	7.23	7.63
16.	6.97	7.03	7.14	7.29
17.	7.54	7.74	6.71	6.91
18.	7.39	7.6	6.79	6.6
19.	6.98	7.13	7.53	7.74

20.	6.57	6.74	7.78	7.89
21.	6.58	6.78	7.31	7.23
22.	7.71	7.89	6.85	6.88
23.	6.8	6.81	7.34	7.56
Average time	**7.06**	**7.11**	**7.2**	**7.31**

In Column 2, we can see that the participant who needed the least amount of time to complete the task in the C-E language combination needed 6.58 seconds to name all the pictures, while the participant who needed the most time to complete the task took 7.89 seconds. Thus, the arithmetic mean for the amount of time spent to perform the task in this condition in C-E language combination was 7.11 seconds. Thus, on average, the participants spent 1.185 seconds to name one picture in the C-E language combination.

Column 3 contains the results of the conducted test in this condition in the E-C language combination. Once again, the participants took more time to name pictures in English than in their L1. The least time spent to complete the task was 6.56 seconds. The participant who took the longest to name the pictures spent 7.87 seconds to complete the task. On average, the participants needed 7.2 seconds to name all the pictures, and 1.2 seconds to name one picture in the E-C language combination in the set representing the phonologically unrelated condition.

Column 4 presents the time that the participants spent to complete the task in the E-E language combination. The minimum time spent to perform the test was 6.6 seconds, while the maximum time spent was 7.96 seconds. Therefore, the participants on average needed 7.31 seconds to name all the pictures and 1.21 seconds to name one picture in this language combination. Thus, the last column shows once again that the participants needed more time to name the pictures in English. This finding once again supports the suggestion that L1 mental lexicon nodes are more easily activated than for L2.

Therefore, the minimum amount of time spent on naming a set of pictures in this condition was 6.57 seconds while the greatest amount of time spent on a set was 7.96 seconds. The arithmetic mean for each language combination in the *phonologically unrelated* condition was 7.06 seconds for the C-C set, 7.11 seconds for the C-E set, 7.2 seconds for the E-C set, and 7.31seconds for the E-E set. Therefore, the participants on average needed 7.17seconds to name all the pictures in one language combination and 28.68 seconds to complete the entire task, i.e. to

name all the pictures in all four language combinations. This time will be also compared with the arithmetic means for the time spent to complete the other two conditions in order to support or reject the hypotheses.

4.4. Research Results - Conclusion

Table 5 presents the comparison of the average time the participants spent to complete each of the three conditions in all the four language combinations. The results in this table will be used to approve or reject the hypotheses that were set at the beginning of this study.

Table 5 Average time spent in all the conditions

	Direct phonological facilitation	**Phonological facilitation through translation**	**Phonological unrelatedness**	**Average time per language combination**
C-C	5.9	6.65	7.06	6.536
C-E	6.01	6.77	7.11	6.63
E-C	6.08	6.86	7.2	6.713
E-E	6.16	6.92	7.31	6.796
Average time per condition	24.15	27.2	28.68	26.675

The first hypothesis of my research predicted that regardless of the language combinations the participants will take the least amount of time while naming those pictures next to which there are distractor words that are phonologically similar to the lexical item the picture represented. Since the participants were informed that the goal of this test is to name the pictures as fast as they possibly could, i.e. without delay, we can say that the first hypothesis suggested that the **direct phonological facilitation** condition will be the easiest for the participants to perform regardless of the language combinations. If we compare the average time spent on the direct phonological condition with the other two conditions, we can see that the participants needed significantly less time to name pictures in this condition in each language combination.

To be more precise, the participants needed 24.15seconds on average to complete the task in all four language combinations when there was a direct phonological similarity between the lexical item the picture represented and distractor words. Therefore, while naming pictures, it took the participants 3.05 seconds less in the **direct phonological facilitation** condition than in the **phonological facilitation through translation** condition. Furthermore, it took the participants 4.53seconds less in this condition than in the phonologically unrelated condition. Thus, the first hypothesis of this research has been confirmed by the data collected in the conducted experiment.

The data presented in Table 5 also indicate that the majority of the participants needed less time to name the lexical items in Croatian rather than in English. To be more precise, the participants needed the least amount of time when they named the lexical items in Croatian while also having distractor words in Croatian. On the other hand, they took the most time while naming the lexical items in English especially when the distractor words were in English as well. The reason behind this could be in the structure of the mental lexicon, which opens new questions on lexical access for future research. These data may possibly indicate that it is easier to retrieve information from L1 mental lexicon nodes.

However, it is important to note that one third of the participants found it easier to name pictures in English rather than in their mother tongue. Possible reasons behind such exceptions could be numerous and related to bilingualism. One possible reason could be the fact that some lexical items to be activated in E-E and E-C language conditions were shorter than those in C-C and C-E language condition. For the reasons given above, I suggest that future studies that will be conducted regarding the existence of phonological facilitation in picture naming tasks should take into consideration the participants' professional life, foreign language usage frequency, and word length.

The second hypothesis proposed that the participants will need more time to name pictures when distractor words are phonologically similar through translation to the picture names rather than when there is a direct phonological correspondence between picture names and distractors. In order to examine the second hypothesis, we need to compare the average time spent on completing the picture naming task in the *phonological facilitation through translation*

condition with the time spent on the task in the *direct phonological facilitation condition*. In each language combination of the direct phonological facilitation condition, the participants needed less time to complete the task than in the *phonological facilitation through translation condition*. Namely, it took the participants 0.75seconds less time in C-C, 0.76 seconds less in C-E, 0.78 seconds less in E-C, and 0.76 seconds less time in E-E language combination in the direct condition when compared to the time needed to perform the task in *phonological facilitation through translation condition*. On average, the participants needed 24.15seconds to complete the entire task in the direct condition, and 27.2seconds to complete the task with the phonological facilitation through translation. Therefore, we can conclude that the conducted research supported the second hypothesis of this paper as, on average, it took the participants 3.05 seconds more to complete the task in this condition than in the direct phonological facilitation condition.

Once again, it took the participants less time to name the lexical items the pictures represented in their mother tongue/L1 than in English. Nevertheless, some participants needed less time to complete the task in those language combinations which required them to speak in English. However, the possibility of word length hindering the time needed to complete the picture naming task should be excluded since the length of the names of lexical items the pictures represented in each language combination in this condition was (more or less) the same.

The third hypothesis of this research proposed that the most time will be needed when naming those pictures next to which there are phonologically unrelated distractor words. The results in Tables 4 and 5 support this hypothesis. Namely, the participants took more time to perform the task in this condition than in the *phonological facilitation through translation* condition for each language combination. To be more precise, the participants needed 0.41seconds more in the C-C set, 0.34 seconds more in the C-E set, 0.34 seconds more in the E-C set, and 0.39 seconds more in the E-E set in this condition. By comparing and contrasting the average time needed to complete the task in each language combination of phonologically unrelated condition with the time needed to complete the task in the direct condition, we can notice that the task in phonologically unrelated condition took the most time to complete. To be precise, the participants spent more time completing the task in the phonologically unrelated condition in each language combination than in the direct condition. In other words, in phonologically unrelated condition, the participants needed 1.16 seconds more in the C-C set, 1.1

seconds more in the C-E set, 1.2 seconds more in the E-C set, and 1.5 seconds more in the E-E language combination than in the direct condition. On average, the participants needed 28.68 seconds to complete the entire task in phonologically unrelated condition, which is more processing than in the first condition, by 4.53 seconds, and more processing than in the second condition, by 1.48 seconds. Therefore, the third hypothesis of this study is supported by the collected data.

5. CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

Since it was first described by John Ridley Stroop, numerous experiments regarding the existence and effects of Stroop interference phenomenon have been conducted. Accordingly, results of the Stroop interference experiments led to various theories being proposed in relation to the process of decoding in reading, and the time at with which people recognize words and colors, the process of developing automaticity in reading, etc. One of the most popular theories that have intrigued psycholinguists is whether bilingualism can influence people's mental lexicon and cognitive processes. Sabourin, L. and Vinerte, S. have conducted research in order to examine through the Stroop effect tests whether bilinguals have an advantage in 'cognitive control' over monolinguals. Namely, some studies showed that bilinguals have more cognitive control and easier lexical access to the mental lexicon. However, Sabourin and Vinerte's study opposed those theories. Namely, their study as well as many others indicated that the bilinguals' performance in the Stroop effect tests highly depends on the type of bilingualism people have, e.g. sequential, simultaneous, early bilinguals, etc.

Furthermore, Knupsky and Amerhein were interested in finding whether phonological similarities between picture names and distractor words could facilitate and thus speed up the process of completing the Stoop picture-naming test. In their extensive study, Knupsky and Amerhein asked their bilingual participants to name pictures in three conditions: direct phonological facilitation condition, phonological facilitation through translation condition, and phonologically unrelated condition. The experiment which I designed and conducted in this paper was to a great degree methodologically based on the research they conducted. Therefore, I asked 23 participants to perform the picture-naming tasks trying to spend the least amount of time possible on completing the task in the three above-mentioned conditions. A stopwatch was used to track their time which was later on compared and contrasted with their results in each condition and language combination. The results of my study supported the findings of Knupsky and Amerhein. Namely, the results presented in this study indicated the existence of direct and through translation phonological facilitation in a picture-naming Stroop test. As the hypotheses of the present thesis have predicted, it took the participants the least amount of time in naming pictures when there was a direct phonological similarity between picture names and accompanying distractor words.

On the other hand, it took the participants the greatest amount of time while naming the lexical items that were accompanied by phonologically unrelated distractor words. The fact that the majority of the participants needed more time to name pictures in phonologically unrelated condition than in the other two conditions indicates that the existence of phonological facilitation triggered in the mental lexicon and one aim of the present thesis was to try and capture it.

The results of the experiment also indicate that lexical items in the L1 mental lexicon are easier to access and activate than those in L2 since the majority of the participants needed less time to name pictures in L1 in all conditions.

For further research, I suggest conducting the same picture-naming test on more groups depending on the frequency at which they use the English language in their everyday lives and the time and manner in which the foreign language is acquired so that their results could be compared. Therefore, the main goal of this thesis was to examine and analyze a possible influence of phonological facilitation in picture-naming Stroop tests in bilinguals. The results of the conducted experiment indicated that phonological similarities between distractor words and picture names facilitate the process of naming pictures. Furthermore, they showed that certain facilitation in the picture-naming test occurs even when the phonological similarities exist only through ‘translations’. Therefore, this thesis proved that phonological components in the mental lexicon of a bilingual individual can be activated during the picture-naming task.

GLOSSARY

Alphabetic principle – "the understanding that there are systematic and predictable relationships between written letters and spoken sounds (Reading Rockets: Alphabetic Principle, 2002)."

Cognitive control – also known as *the executive control*, and *executive functions* is "the ability to regulate one's cognition and actions on the basis of over-riding goals (APA Dictionary of Psychology, n.d.)." Three core executive functions "are inhibition [response inhibition (self-control—resisting temptations and resisting acting impulsively) and interference control (selective attention and cognitive inhibition)], working memory, and cognitive flexibility (including creatively thinking "outside the box," seeing anything from different perspectives, and quickly and flexibly adapting to changed circumstances). […] stress, lack of sleep, loneliness, or lack of exercise each impair EFs. That EFs are trainable and can be improved with practice is addressed, including diverse methods tried thus far. (Diamond, 2013)" It is well established that executive functioning declines during aging. (Isingrini et al., 2015)"

Decoding – "the process of using letter-sound correspondences to recognize words (University of Oregon: Alphabetic Principle: Concepts and Research, 2009)."

Graphemic awareness – the ability to "connect phonemes with graphemes which in education is commonly called either letter-sound correspondence or grapheme-phoneme correspondence (Garforth, 2020)."

Interference word – also known as *a distractor word,* is a part of picture-naming Stroop tests which has a purpose to distract the participant of the experiment while completing the task.

Mental lexicon – This term is very difficult to define, however, a generally accepted definition of it is that it is "a mental dictionary that contains information regarding a word's meaning, pronunciation, and syntactic characteristics (Levey, 2017)." There are several theories which attempt to explain what mental lexicon is and how an individual's mental lexicon develops and changes. According to graph theory, mental lexicon is like "a large network with nodes and connections. Directly connected words are usually referred to as neighbors. (Trautwein and Schroeder, 2018)." Also see *Erdeljac, V. (2009) Mentalni leksikon – modeli i činjenice. Zagreb: Ibis grafika.*

Phonemic awareness – “is the ability to identify and manipulate individual sounds (phonemes) in spoken words (Reading Rockets: Phonological and Phonemic Awareness, n.d.).”

Stroop effect - also known as *the Stroop interference* – “is a demonstration of the phenomenon that the brain's reaction time slows down when it has to deal with conflicting information. (McMahon, 2017)”

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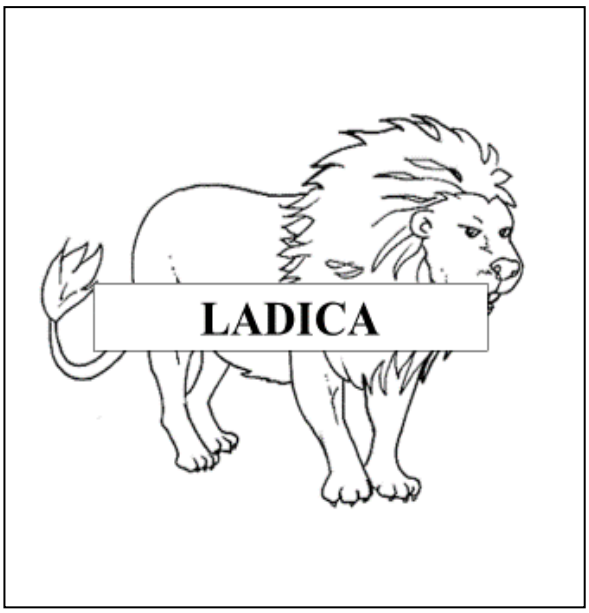
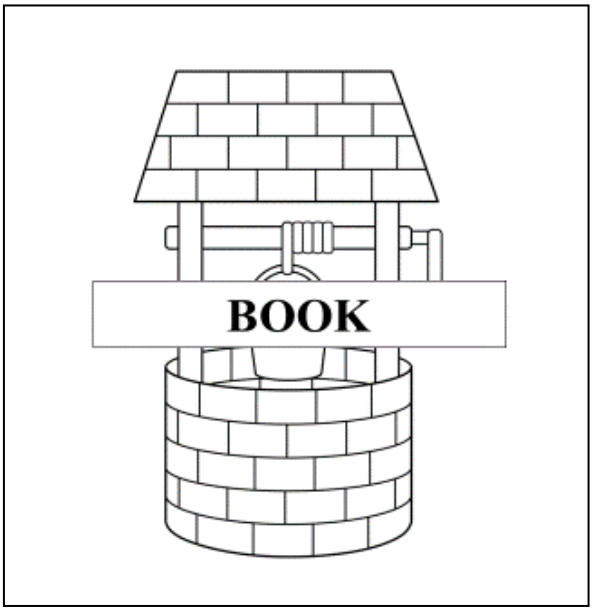
APPENDIX

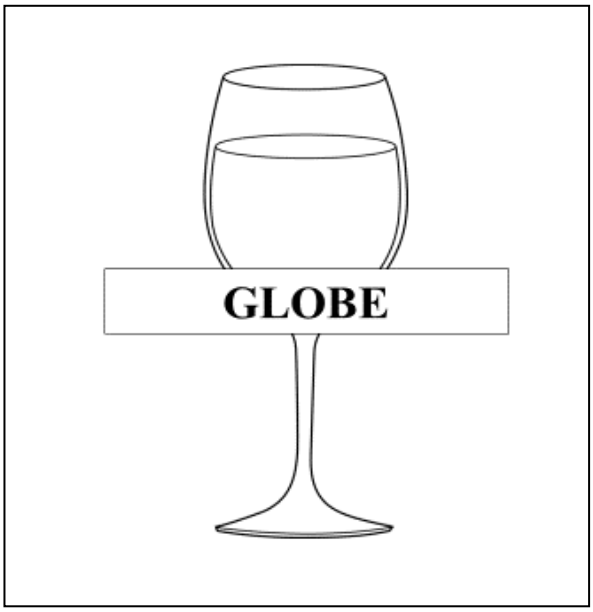
Corpus



Picture 3 – Direct condition; C-C



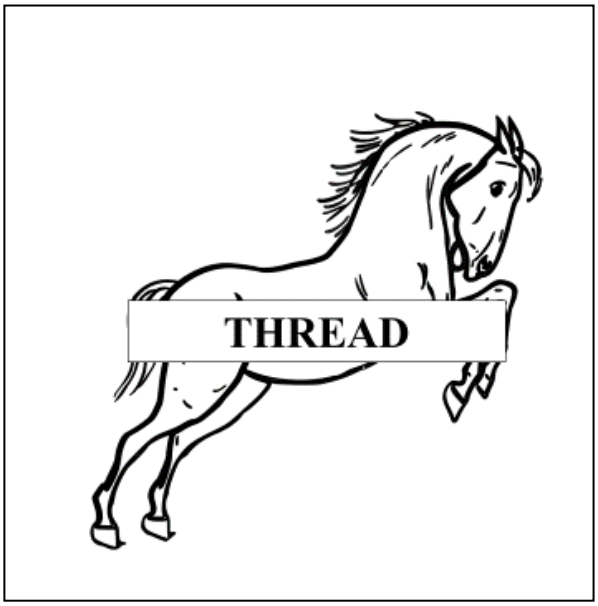
Picture 4 – Direct Condition; C-E



Picture 5 – Direct condition; E-E

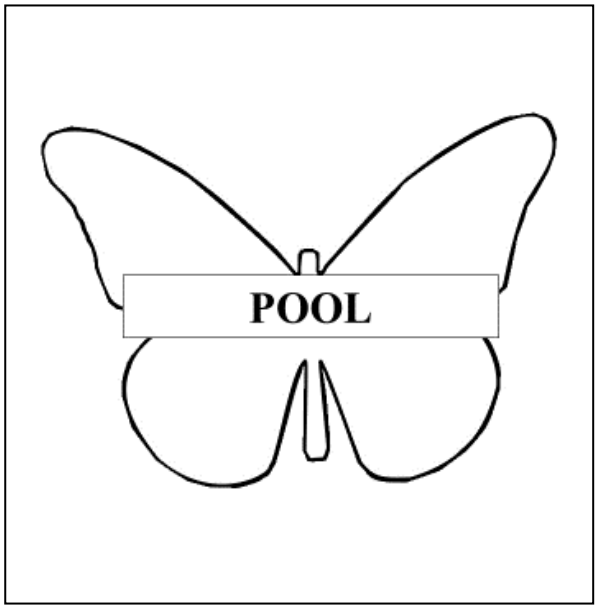
Picture 6 – Direct condition; E-C

Picture 7 – Through translation; E-C

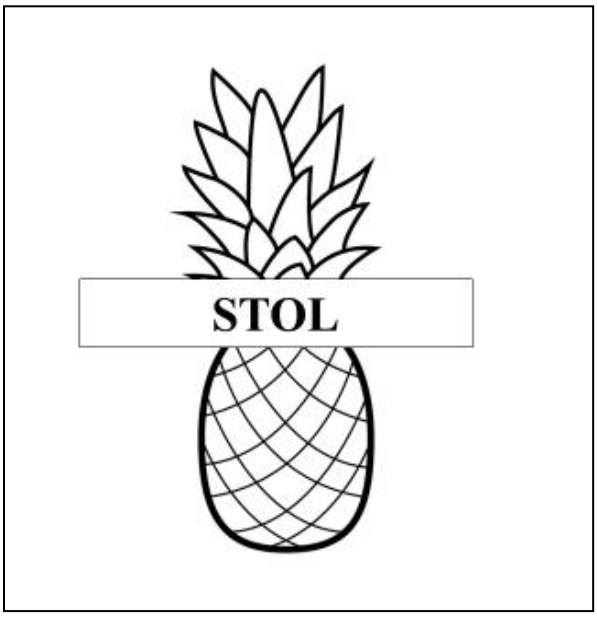


Picture 8 – Through translation; C-E

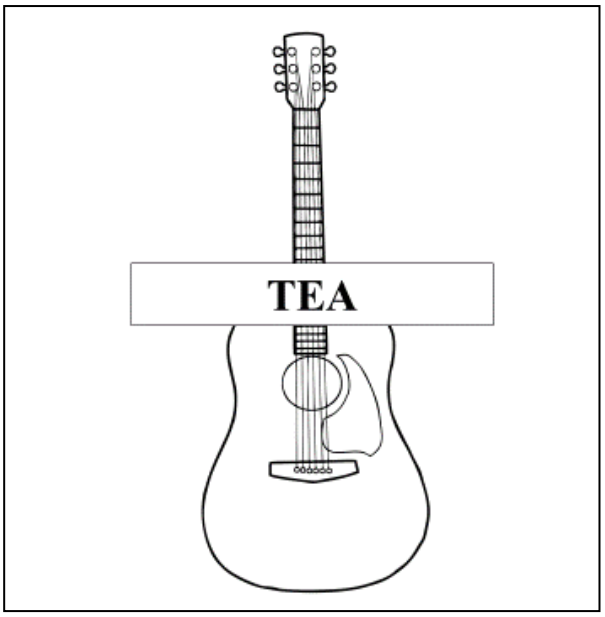
Picture 9 – Through translation; C-C



Picture 10 – Through translation; E-E

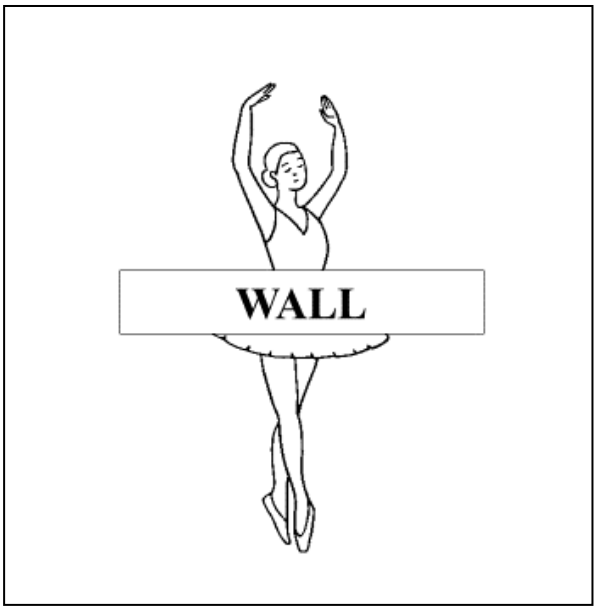


Picture 11 – Unrelated condition; E-C



Picture 12 – Unrelated condition; E-E

Picture 13 – Unrelated condition; C-C



Picture 14 – Unrelated condition; C-E