Studies in Second Language Learning and Teaching
Department of English Studies, Faculty of Pedagogy and Fine Arts, Adam Mickiewicz University, Kalisz
SSLLT 8 (4). 2018. 755-774
http://dx.doi.org/10.14746/ssllt.2018.8.4.3
http://pressto.amu.edu.pl/index.php/ssllt

Automaticity of lexical access and executive control in Croatian-German bilinguals and second language learners

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Abstract

The aim of this study was to explore automaticity of lexical access and executive functions of language learners and bilinguals while considering their language automaticity. Three groups of youths aged 14 to 18 were tested: Croatian-German early bilinguals, Croatian high school students who participated in a German immersion programme at school and Croatian high school students of German as a foreign language. The participants were tested on a modified version of the Stroop test (i.e., a Stroop-like test). It presented pictures of an animal or an object with names of an animal or an object written over the picture. The names were written in Croatian or German and were either congruent or incongruent. Lexical access was slower for the bilinguals in both Croatian and German, which suggests that they used more of their cognitive resources because both of their languages were highly active, and more executive control was required to complete the task.

Keywords: automaticity; lexical access; executive control; bilingualism; second language learning

1. Introduction

Lexical access is the process in which we access the mental lexicon in order to retrieve information about words (Dijkstra, 2005), and word identification is based on lexical access through phonological and written inputs. Over the last few decades, a large body of empirical research has been devoted to the study of bilingual word identification. The models that were developed were mostly based on monolingual word identification models, with, however, the necessity of adding features which are present in bilingual language processing. In addition, the advantages of bilingualism are widely discussed in terms of academic achievements or cognitive flexibility (Bialystok, Craik, & Luk, 2008; Costa, Hernandez, Costa-Faidella, & Sebastian-Galles, 2009; for a review, see Bialystok, Craik, Green, & Gollan, 2009). However, bilingualism seems to produce subtle difficulties in accessing each language and even proficient bilingual speakers actually perform worse than monolingual speakers in language production tasks and lexical access tasks in L1 and L2. Even bilinguals who are highly proficient in both languages and who acquired both languages at an early age perform worse in picture naming tasks in their L2, and more surprisingly in their L1, when compared with monolingual speakers (Ivanova & Costa, 2008). When bilingual speakers need to produce examples of words that belong to a certain semantic category (e.g., fruit) they are slower in retrieving words and they produce fewer examples than monolingual speakers (Roselli et al., 2002; see Bialystok et al., 2009 for a review). Additionally, bilingual speakers report more tip-of-the-tongue states (Gollan & Silverberg, 2001), even when they are tested only in their L1. However, when they are required to put picture names into categories such as human-made or natural objects, they are equally successful as monolingual speakers (Gollan, Montoya, Fennema-Notestine, & Morris, 2005), which suggests that differences do not occur at the semantic level.

The cause of these difficulties is debated: While some claim that they are caused by the constant need for monitoring (cognitive control), others view the divided exposure (weaker links) as the main factor that explains the difficulties. Therefore, in order to differentiate between these two accounts of bilingual processing, we examine the results from a Croatian-German Stroop-like task, carried out by three groups of Croatian-German speakers assumed to differ in automaticity of lexical access (skilled bilinguals, immersion students and students of German as foreign language). Automaticity in lexical access is studied with the Stroop task in which a word in Croatian or German is written over the picture in two experimental conditions (word congruent with the picture or not). The prolonged reaction times are measured in the incongruent conditions due to the students' need to inhibit the automatic retrieval of the word represented by

the picture. The pattern of the results in two languages and three student groups will be interpreted in relation to the two approaches.

Given this rationale for the study, the article will start with the literature review, which elaborates on the bilingual disadvantage found in language production tasks and automaticity in language processing, two topics that we try to integrate in our research in order to answer the questions of how much proficiency and exposure is enough for bilinguals to achieve automaticity of lexical access and whether the participants who achieved automaticity in both languages experience difficulties in bilingual language mode due to this dual automatic language processing. While examining automaticity we wanted to determine whether partial immersion in school could provide sufficient exposure for language students to achieve automaticity of lexical access. We expect these answers to our questions to be able to give us a new perspective in our attempts to differentiate between the two approaches (cognitive control and weaker links) in the context of bilingual disadvantages. This review and the statement of our aims are followed by the section on participants, a more detailed task description in the materials and procedure sections, and finally the results and discussion sections containing statistical analysis of the results and their interpretation. We end the article with the conclusion and propositions for further research.

2. Literature review

Models of bilingual word recognition refer to the questions of whether the word form is stored in a shared lexicon or in two different lexicons. Empirical research evidence implicates that the former proposition is probably valid (Francis, 2005). Furthermore, it has been proposed that task demands influence whether lexical access is language selective or non-selective. Generally, two viewpoints are usually contrasted in theoretical approaches: language selective access in independent lexicons and language non-selective access in a shared lexicon (Dijkstra & Van Heuven, 2002). Another important question in bilingual word recognition is whether skilled bilinguals are able to attenuate the influence of one of their languages, to what degree they can do that and which factors influence this process. Though we are far from a complete model of bilingual word recognition, progress has been made in the form of computational models. The following computational models are the current models of bilingual word recognition: bilingual interactive activation model (BIA; Dijkstra & Van Heuven, 1998), inhibitory control model (Green, 1986, 1998), language mode framework (Grosjean, 1997, 2001) and BIA+ model (Dijkstra & Van Heuven, 2002). All of these current models support the viewpoint of language non-selective access in an integrated

lexicon. However, Costa and Caramazza (1999) challenged the assumption of non-selective access and proposed the hypothesis of language-specific selection (Costa, Colomé, & Caramazza, 2000; Costa, Miozzo, & Caramazza, 1999; Finkbeiner, Gollan, & Caramazza, 2006). In this study we will make reference to two of these models: inhibitory control model and language mode framework via the executive control approach to bilingual disadvantages, and to the previously mentioned hypothesis via the *weaker links* approach.

2.1. Bilingual disadvantage in language production tasks

According to Costa, Sadat, and Martin (2013), bilingual disadvantages in lexical access and word production can be explained in two ways: They can be seen as the consequence of the fact that bilingual speakers need to constantly control the two languages, that is, the consequence of higher demands placed on executive control in bilingual speakers (Green, 1998). The other explanation is the weaker links hypothesis, also known as the frequency-lag hypothesis (Gollan, Slattery, Van Assche, Duyck, & Rayner, 2011), which is based on frequency effect (Gollan, Montoya, Cera, & Sandoval, 2008). The name of the weaker links hypothesis comes from assumed weaker links between semantic and phonological representations of words. According to the weaker links hypothesis, bilingual speakers use each of their languages less frequently compared to monolingual speakers using their language, and this means that the frequency of use of lexical representations in both languages is lower in bilingual speakers. When a word is used less frequently, the response latencies in retrieving the word are longer (Jescheniak & Levelt, 1994), so bilingual speakers are consequently slower in lexical access than monolingual speakers.

According to the executive control approach, language production of bilingual speakers is under the influence of language control mechanisms activated during language production (Green, 1998). As opposed to monolinguals, who activate only one language, bilinguals show different levels of activation of both of their languages. As Grosjean (2008, p. 38) points out, "the state of activation of the bilinguals' languages and language processing mechanisms, at a given point in time, has been called the language mode." Bilinguals can be in the monolingual language mode when they deactivate one language (but never completely) and in the bilingual language mode when both languages are active. Furthermore, there can be various levels of activation for both languages, ranging from slightly to fully active. In order to avoid interference between languages, especially when both languages are highly active, bilingual speakers need to use some kind of language control, and this additional processing influences lexical access, which becomes slower in bilingual speakers.

Along with cross-language interference and a need for language control in bilingual language production suggested by the executive control approach, numerous studies and review articles (Bialystok et al., 2009; Bialystok et al., 2008; Bialystok, Craik, & Luk, 2012; Costa et al., 2009; Costa & Sebastián-Gallés, 2014; Kroll & Bialystok, 2013) suggested a bilingual advantage in non-verbal executive control tasks. The idea is that due to constant need for language control, bilinguals actually exercise their executive control. For example, Costa et al. (2009) reported faster bilingual overall response times in the flanker task.[1] They conducted two experiments in which bilingual and monolingual participants performed the task in two different versions of the experiment. In the first experiment, which was a low-monitoring version, the participants responded to mainly congruent or mainly incongruent trials, and in the second experiment congruent and incongruent conditions were randomly distributed in a mixed condition, which was a high-monitoring task. The bilingual advantage was only present in the high-monitoring experiment. According to the authors, this may be an effect of a better monitoring system which is highly active in high-monitoring demands of the task. Better performance may be the result of the bilingual need to monitor and control the appropriate language in everyday communication, which serves as a practice for the monitoring system. However, an opposed view proposed by Paap and Greenberg (2013) suggests that the bilingual advantage is actually a result of a publication bias which favours positive results over negative and null results (de Bruin, Treccani, & Della Sala, 2015). Paap, Johnson, and Sawi (2015) refer to other possible causes for the bilingual advantage, such as Type 1 error and confounds in demographic factors, and they reinforce their view by stating that many authors have not been able to replicate the findings from the seminal studies.

2.2. Automaticity in language processing

Research in automaticity in lexical access has shown differences between the first and the second language. Lexical access in the first language is fast, the language is processed with little or no conscious control, and once it is initiated it cannot be stopped (Segalowitz, 2013). On the other hand, lexical access in the second language is usually not automatic, especially in the early phases of language learning, whereas later phases include a higher degree of automaticity defined as ballistic, fast and effortless processing (Segalowitz & Hulstijn, 2005). When we are acquiring a new skill, automaticity is the result of long and continuous practice (Schneider, Dumais, & Schiffrin, 1984) and it is important in fluency

[1] Eriksen flanker task is a non-verbal executive control task which is based on the suppression of unwanted responses (Eriksen & Eriksen, 1974).

development in the second language (Segalowitz, 2010). Tzelgov, Henik, Sneg, and Baruch (1996) examined automaticity in dominant bilinguals of Hebrew and English. The participants performed a modified Stroop test[2] which contained words in Hebrew and English and the incongruent condition had the orthography of the other language. The participants demonstrated a strong interference effect for incongruent L1 words written in L2 orthography and L1 phonology, but not for L2 words written in L1 orthography and L2 phonology. The results suggest that once the phonology in L1 is activated, linguistic processing cannot be stopped, which is not the case with L2. Favreau and Segalowitz (1983) conducted a study with two groups of bilingual speakers, both fluent in English and French with equally high language proficiency. The groups differed in the relative speed of first- versus second-language reading. Bilingual speakers with equal reading rate demonstrated ballistic language processing in both of their languages, and those with slower optimal reading rates in the second language showed ballistic language processing only in their first language. These results suggest that the automaticity of language processing is related not only to high proficiency and fluency, but that there are also differences in automaticity in various groups of fluent language speakers. There is a need to further explore which level of proficiency in the second language is sufficient in order to achieve automaticity in the weaker language and whether different approaches to language learning, such as bilingual immersion programs and traditional methods of language learning provide enough language input and interaction in order to achieve automaticity in lexical access in the weaker language.

3. The present study

The first aim of this study is to explore the differences in automaticity in the weaker language among three groups of participants. Our hypothesis (Table 1 includes a summary of the study hypotheses, dependent variables, expected group differences and the relation of the hypotheses to the two approaches) is that all the groups should demonstrate language automaticity in their first language, that is, there should be a significant Stroop effect, which is observed as the difference between congruent and incongruent stimuli in all three groups of participants in the Croatian language. Furthermore, we propose that in a language which is not our native tongue, the lack of inhibition of the incongruent stimuli is actually a sign of the lack of second language automaticity. Therefore, in the German language the difference in reaction times between the congruent and incongruent conditions

[2] Stroop task is a verbal executive control task which is based on interference in the reaction time, e.g., it requires the participant to name the colour of the word while ignoring the word itself (Stroop, 1935).

should be large only for the bilingual participants who acquired both languages early and use them regularly in everyday communication, that is, who are equally proficient and fluent in both languages. In other words, in this group language behaviour in German should resemble language behaviour in Croatian.

Table 1 Hypotheses, dependent variables, expected group differences and the relation of the hypotheses to the executive functions approach and weaker links approach

Hypothesis	Dependent variable	Group differences	In accordance with the approach
All the groups should demonstrate automaticity in lexical access in their first language	RT difference between congruent and incongruent stimuli in Croatian	Significant RT difference between congruent and incongruent stimuli in Croatian in all three groups	Both approaches
Only bilinguals should demonstrate automaticity in lexical access in their second language	RT difference between congruent and incongruent stimuli in German	Significant RT difference between congruent and incongruent stimuli in German only in bilingual group	Both approaches
Only in bilinguals strong activation of both languages requires high monitoring and control	Total RT	Total RT slower in bilinguals, faster in immersion students and the fastest in German language students	Executive functions approach
Bilingual speakers have weaker connections than native speakers even in their first language	RT for Croatian stimuli	RT for Croatian stimuli should be slower for bilinguals than the other two groups	Weaker links approach
Native speakers who are not bilinguals do not differ in automaticity of lexical access	RT for Croatian stimuli	RT for Croatian stimuli should not differ significantly between immersion students and German language students	Weaker links approach
Bilingual speakers show more automaticity in lexical access in their second language than non-native language learners	RT for German congruent stimuli	RT for German congruent stimuli should be faster for bilinguals than for the other two groups	Weaker links approach

Note. RT = reaction time.

The second aim is to see whether the differences in language processing among the three groups could help choose between the executive functions approach and the weaker links hypothesis, that is, to see whether the pattern of the results fits one approach better than the other. In accordance with the executive control model (Green, 1998) and different levels of activation that could be achieved in bilingual speakers (Grosjean, 2008), our hypothesis is that there will be a difference in overall reaction time in the Croatian language and German language among the three groups. We propose that for bilinguals, whose both languages are very strong, the mere presence of both languages in the task is enough to put

them into a state where high monitoring and control is required, and that for less proficient bilinguals, less monitoring and control is required since the second language is not as strongly activated. The bilingual speakers, who are highly proficient in Croatian and German and have the highest level of the German language activation among our participants along with a strong activation of the Croatian language, are faced with higher demands on their control and monitoring processes. For them the performance of the task requires more cognitive resources in order to successfully monitor and avoid the interference of the unwanted language. Therefore, the reaction time in both languages should be slower in bilingual speakers, faster in immersion students and the fastest in German language students.

On the other hand, the weaker links hypothesis proposes that bilingual speakers have weaker connections in both languages due to reduced language use of each language. According to this approach, that is, if we exclude the possibility that bilingual participants need to use more executive control because of cross-language interference, the pattern of results should indicate that bilinguals are slower in lexical access in Croatian, but immersion students should be equally fast in lexical access in their first language (Croatian) as German language students since both groups are native speakers of Croatian. In addition, bilinguals should be faster in the congruent condition in the German language than the other two groups of participants since the other two groups are not native speakers of German.

3.1. Participants

The participants were high school students aged 14 to 18 from Zagreb and Velika Gorica, Croatia. The students were divided into three groups: Croatian German bilingual group (N = 29), Croatian native speakers who were enrolled in a German immersion programme at school (N = 34) and Croatian native speakers who learned German as a foreign language at school (N = 31). All the participants gave their informed consent to participate in the study and their rights were protected according to the University of Zagreb ethics code and the ethics code for research with children. The most significant differences between bilingual students and the other two groups were the age of acquisition (AoA), the context in which they acquired/learned German, the amount of time they lived or were educated in German speaking countries and the amount of German language use in everyday situations. Bilingual speakers acquired both their languages in everyday communication with their parents, relatives and friends and spent a long period of time in a German speaking area. At the time when the study was conducted, all three groups were attending German language classes as part of their education in Croatia. All the bilingual participants were exposed to the German language before adolescence (the average age of exposure to German M = 1.47, SD = 1.98; Croatian M =

1.02, *SD* = 2.87). Bilingual participants continually used both Croatian and German at school and at home. At home they spoke both Croatian and German with their parents, siblings and/or relatives. Their estimated proficiency was C1/C2 according to *The Common European Framework of Reference for Languages (CEFR)*. Other participants did not use German at home and their exposure to the language was limited to language lessons at school and television programmes in German. Immersion students attended a partial immersion program in high school. They had been attending the immersion program for 2-4 years. They attended on average 12 lessons in German per week where they were taught in German and interacted in German during the lesson. This part of the program was taught by native speakers and German language teachers. Subjects taught in German were: German language lessons, history, physics, chemistry, sociology, ethics, logic and philosophy. The students estimated proficiency was B2 according to CEFR. Prior to attending the immersion programme in high school, these students started their formal German language education in elementary school in the fourth grade (aged 10), while being first exposed to German at an earlier age (age of first exposure to German on television and/or in kindergarten *M* = 4.63, *SD* = 3.06). Foreign language learners who learned German almost exclusively during language lessons began their German language learning in elementary school in the fourth grade and continued in high school (three German language lessons per week on average). The age of first exposure to German was *M* = 6.62, *SD* = 3.01. The students' estimated proficiency was B1 according to CEFR. The results of the self-evaluation questionnaire with language use data and demographic characteristics are shown in Tables 2 and 3.

Table 2 Means and standard deviations of the participants' language characteristics

	Bilinguals *N* = 29 (18 females)	Immersion students *N* = 34 (19 females)	Language students *N* = 31 (19 females)	Test	*p*
Percentage of Croatian use currently	65.28 (14.74)	64.06 (13.32)	69.03 (14.48)	F (2,91) = 1.069	>.05
Percentage of German use currently	24.41^{a} (10.85)	19.15^{a} (8.52)	8.58^{b} (5.87)	F (2,91) = 26.661	.000
Age of first exposure to Croatian (yrs)	1.02^{a} (2.87)	.10^{b} (.00)	.10^{b} (.00)	F (2,91) = 3.347	.04
Age of first exposure to German (yrs)	1.47^{a} (1.98)	4.63^{b} (3.06)	6.62^{c} (3.01)	F (2,91) = 26.471	.000
Years of education in Croatia	6.59^{a} (3.55)	10.41^{b} (1.48)	10.77^{b} (.99)	F (2,91) = 32.295	.000
Years of education in a German speaking country	6.59^{a} (3.64)	0^{b} (0)	0^{b} (0)	F (2,91) = 106.672	.000
Croatian language use with family	Since early childhood	Since early childhood	Since early childhood		
German language use with family (in yrs)	12.48 (5.30)	No	No		
Years of watching TV in Croatian	9.17^{a} (6.37)	14.38^{b} (2.71)	13.52^{b} (4.07)	F (2,91) = 11.499	.000
Years of watching TV in German	12.79^{a} (3.94)	9.00^{b} (5.25)	6.77^{b} (5.76)	F (2,91) = 10.742	.000
Years living in Croatia	7.3^{a} (4.41)	16.18^{b} (.94)	16.19^{b} (2.55)	F (2,91) = 93.564	.000
Years living in a German speaking country	9.07^{a} (3.71)	.03^{b} (.17)	.16^{b} (.64)	F (2,91) = 184.289	.000
Self rated Croatian proficiency (1-7)	6.38^{a} (.78)	7^{b} (0)	7^{b} (0)	F (2,91) = 20.889	.000
Self rated German proficiency (1-7)	6.62^{a} (.62)	5.09^{b} (1.16)	4.84^{b} (1.00)		
CEFR Croatian	C1/C2	C2	C2	F (2,91) = 29.553	.000
CEFR German	C1/C2	B2	B1		

Note. The means in the same row with the same letters do not differ significantly and with different letters differ significantly from each other. Standard deviations are shown in brackets.
CEFR is the abbreviation for *the Common European Framework of Reference for Languages*.

Table 3 Means and standard deviations of the bilingual participants' language characteristics

	Croatian *M* (*SD*)	German *M* (*SD*)	*t* test	*p*
Percentage of language use currently	65.28 (14.74)	24.41 (10.85)	8.960	.000
Age of first exposure (yrs)	1.02 (2.87)	1.47 (1.98)	-.632	>.05
Years of education in Croatia/German speaking country	6.59 (3.55)	6.59 (3.64)	.00	>.05
Language use with family (in yrs)	14.86 (3.82)	12.48 (5.30)	1.80	>.05
Years of watching TV in Croatian/German	9.17 (6.37)	12.79 (3.94)	-3.711	.001
Years living in Croatia/German speaking country	7.3 (4.41)	9.07 (3.71)	-1.190	>.05
Self rated Croatian/German proficiency (1-7)	6.38 (.78)	6.62 (.62)	-1.367	>.05

The main differences between the three groups of participants are the context of language acquisition/learning and the frequency of language use. Psycholinguistic research suggests that there are differences in the memory systems and depth of language processing between speakers who acquire a language in a natural setting and those who learn it as a foreign language (Paradis, 2009). As foreign language learners we mostly use our explicit memory, for example, for memorization, which is slower than implicit memory, which requires no conscious awareness. In a real-life context every situation is personalized and it requires a fast response with deeper processing involved, which leads to stronger and more automatic recall. In contrast, language learning in the formal language class setting involves shallow processing and more metalinguistic awareness (Paradis, 2009). Recently a number of researchers (Ferré, Sánchez-Casas, & Guasch, 2006; Kroll, van Hell, Tokowicz, & Green, 2010) have pointed out that there is a limit to direct access to L2 semantics even for highly proficient bilinguals and it is connected to the type of exposure to L2, that is, whether they were exposed to L2 in daily life and whether they acquired it early in life or as an adult. As opposed to early bilinguals who acquire both of their languages simultaneously, late bilinguals acquire their L2 with reduced neuroplasticity and their L1 had already become entrenched by the time they started learning their L2. Consequently L2 competes with L1 or parasitically relates to L1 (Hernandez, Li, & MacWhinney, 2005). According to the *competition and entrenchment model* of Hernandez et al. (2005), late bilinguals differ in several aspects which influence their proficiency and, in our opinion, also their automaticity in second language: How deeply their L1 was entrenched when they started acquiring their L2, how much brain plasticity was available and how much dedication they put into acquiring metacognitive strategies like rehearsal, imagery and recoding. Factors that could influence whether someone becomes a more and less proficient late bilingual would be the use of metacognitive strategies and L2 exposure. This increased exposure and strategy use would increase the ability of a proficient late English-Spanish bilingual to think of *manzana* independently of the word *apple*, thus enhancing automaticity.

Having this in mind, we included three groups of participants: bilinguals who acquired both languages early in a naturalistic setting, still use the languages outside the classroom and differ in the age of first exposure to L2 and in the quantity of exposure to L2 from the other two groups (early exposure, high proficiency); immersion students who were exposed to classical teaching methods and also to a more naturalistic setting of immersion experience at school and who also used more metacognitive strategies than foreign language learners and were more proficient (late exposure, high proficiency); and foreign language students who learned their second language almost exclusively in their language lessons (late exposure, lower proficiency). Thus, examining these three groups we can compare them with regard to proficiency and exposure.

3.2. Materials and procedures

The participants performed a modified Stroop task on a laptop. The task was displayed on a 15-inch laptop screen using E-prime 2 stimulus presentation program (Schneider, Eschman, & Zuccolotto, 2002). The modified Stroop task was based on a picture word interference paradigm described in Roelofs and Lamers (2007). However, this task required the participants to name the word, while in our task the participants gave their answers by pressing a button. The participants were shown black and white pictures of an animal or an object with the name of the same animal or object written over the picture in capital letters (congruent condition) or a name of an object written over a picture of an animal and a name of an animal written over a picture of an object (incongruent condition). The stimuli (20 animals and 20 objects) were chosen among a larger set of stimuli based on familiarity of the words in German at B1 level of language knowledge, which is the level of the least proficient group (see Appendix for a full list of the stimuli). The instructions were to press X on the keyboard if they see a picture of an animal on the screen and to press M if they see a picture of an object, regardless of the text written over the picture. Before every picture there was a fixation cross on the screen for 250 ms to orient the participant's gaze and after that a blank screen for 100 ms. The stimuli (picture-word combinations) were shown in the middle of the screen for 300 ms. The participants were given 1800 ms to press the correct button before a new stimulus was shown. The reaction times were measured from the onset of the stimuli, as usual in this sort of research. The stimuli consisted of 20 different animal and 20 different object pictures with congruent or incongruent names in Croatian or German (altogether 160 different stimuli). Every participant was randomly shown 100 stimuli. Half of the stimuli were congruent and another half incongruent; also, a half were in Croatian and the other half in German. The names of animals and objects were matched in frequency and syllable length in Croatian and German.

Before performing the task, the participants were given a short trial task that was not included in the analysis and its purpose was to familiarize them with the demands of the task. Example task stimuli are offered in Figure 1.

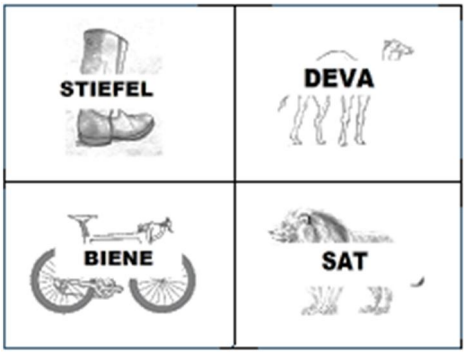

Figure 1 Example of the task stimuli (congruent and incongruent stimuli in Croatian and German)

4. Results and discussion

The descriptive statistics for all the reaction times (RTs) are included in Table 4. Mixed model ANOVA with *language group* as between-subjects factor, *congruency* (congruent, incongruent) and *language of the stimulus* (German, Croatian) as within-subjects factors was used for the statistical analysis of the data. Only the correct responses were included in the reaction time analysis and all the reactions that were shorter than 150 ms or longer than 1500 ms were excluded from further analysis. The analysis has shown a significant main effect of *congruency* ($F(1, 91) = 37.447$, $p = .000$): The participants responded faster to congruent stimuli than to incongruent ones. The main effect of *language* was not significant ($F < 1$), which means that there was no difference in reaction times in Croatian and German. Furthermore, the interactions between *language* and *language group* and between *congruency* and *language group* were not significant (both $F < 1$), which means that the groups' overall RTs in each language did not differ with regard to language and the groups did not differ in RTs with respect to the congruency of the picture and the word written over it. The interaction between *language* and *congruency* was significant ($F(1, 91) = 4.566$, $p = .035$). The participants showed the Stroop effect in Croatian, but not in German. The interaction between *language*, *congruency* and *language group* was not significant ($F(2, 91) = 1.246$, $p > .05$). However, the main effect of *language group* was significant ($F(2, 91) = 3.432$, $p = .037$). Based on Bonferroni post hoc analysis, there was a significant difference between bilingual speakers and foreign language learners in overall RTs. Bilingual speakers responded significantly slower than foreign language learners ($p = .033$). Immersion programme students did not differ significantly either from

bilingual speakers ($p > .05$) or foreign language learners ($p > .05$). The results for Croatian stimuli are shown in Figure 2 while the results for German stimuli are shown in Figure 3 for all three groups of participants. There were no significant differences between the groups with regard to accuracy analysis.

Table 4 Mean reaction times (in milliseconds) and standard deviations (in parentheses) by language group in the Stroop task

Language group	Croatian		German	
	Congruent	Incongruent	Congruent	Incongruent
Bilingual students	495.89 (48.22)	507.13 (54.61)	497.03 (50.57)	508.21 (56.43)
Immersion students	477.11 (43.38)	489.95 (45.72)	483.05 (44.29)	483.55 (43.66)
Foreign language students	465.93 (40.55)	481.14 (42.40)	468.60 (37.39)	475.63 (40.63)

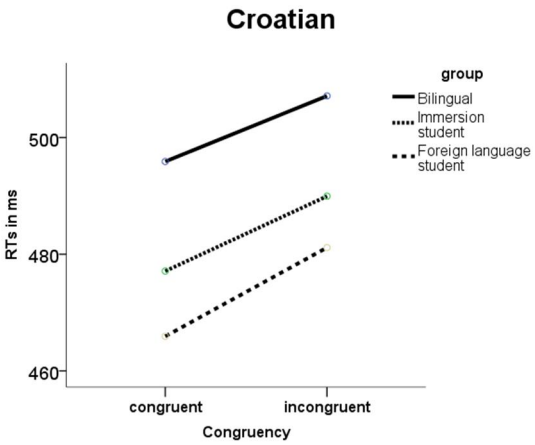

Figure 2 Results of the Stroop-like task for Croatian stimuli

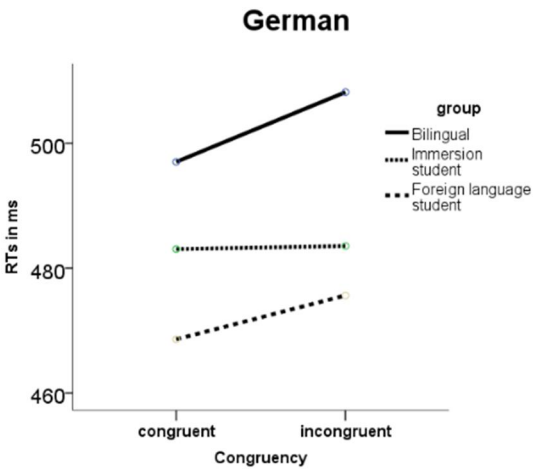

Figure 3 Results of the Stroop-like task for German stimuli

Our study revealed some interesting results regarding automaticity and language processing in bilinguals and language learners. First, the participants showed a Stroop (or Stroop-like) effect only in Croatian, and not in the German language. The inhibition required for the Stroop-like task (to inhibit the linguistic information and response to the picture) is taken as a measure of the automaticity of language: The more inhibition is required, the more automated the language is. The word representations in an automatized language are automatically activated once we see the words and we cannot suppress them. In other words, we take inhibition, an executive function, as a measure of automaticity, our construct. Obviously, it is easier to suppress a word in a language which is not our mother tongue, just as it is more difficult for us and takes more time to read in a language which is not our native language, especially if we are not fluent in it.

This absence of automaticity was expected in German language learners and, to some extent, German immersion students, given that the participants in these two groups were native speakers of Croatian and that they might not have been sufficiently exposed to German. Literature (Tzelgov et al., 1996; Segalowitz, 2013) suggests that automaticity in dominant bilinguals should be expected only in the first language. However, we expected to find the Stroop effect in both languages in the bilingual group since some research (Favreau & Segalowitz, 1983; Segalowitz, 2013; Segalowitz & Hulstijn, 2005) has shown that once ballistic language processing is started in balanced bilinguals it cannot be stopped. Even though we can see the Stroop effect in bilinguals also in German (Figure 3), it was not significant in the statistical analysis. The bilingual speakers estimated their proficiency in Croatian and German as high (Croatian $M = 6.38$, $SD = .78$, German $M = 6.62$, $SD = .62$, $t = -1.367$, $p > .05$) and they speak German on a daily basis at home and at school; however, they have lived in Croatia on average for the last six and a half years and they speak Croatian significantly more than German ($M = 65.28$, $SD = 14.74$; $M = 24.41$, $SD = 10.85$, $t = 8.960$, $p = .000$). It might be possible that the attrition processes in the German language had already begun, which could be the reason why we found automaticity only in the stronger language, that is, Croatian, and why processing in the weaker language was less automatic. These results are consistent with the findings by Favreau and Segalowitz (1983), who reported that fluent bilinguals with high second language proficiency who have slower optimal reading rates in the second language demonstrate less automatic lexical access in the second language. It seems that achieving automaticity in a language which is less used is very difficult regardless of the various contexts of the second language usage, early exposure in L2, fluency and high proficiency in L2. Subsequently, our results suggest that a partial bilingual immersion environment does not provide enough language input and interaction in order to achieve automaticity in the weaker language.

Secondly, bilingual speakers tended to be overall slower than language learners. This effect is consistent with the findings by Gollan et al. (2005) and Ivanova and Costa (2008), who found slower bilingual performance in language production tasks, even in their first language. This is consistent with the executive control approach (Green, 1998) since it predicts slower performance on language-related tasks due to the constant need of bilingual speakers to monitor and control the activation of both languages. Faster performance for German language learners was significant for both languages and it reflects the processing speed in the given circumstances where both languages are highly active, but executive control and monitoring is highly needed only for one language which is automated. The overall RTs of immersion students of German follow this trend, since their performance is slower than the performance of language students and faster than the one of bilingual students. Even though their performance was not significantly different from either group in the post hoc analysis, it consistently follows this trend in both languages. We believe that these results are not consistent with the weaker links hypothesis, which Gollan et al. (2005) used in the interpretation of the slower performance of bilinguals compared to monolinguals in a picture naming task. This hypothesis would yield different expectations based only on word frequencies, that is, according to it there should be no difference in performance between immersion students and foreign language students in their native tongue due to the fact that the word frequencies are controlled for in the experiment and that the exposure to German differs only in the exposure to German at school, while both groups have little exposure to German in everyday life. Furthermore, the weaker links hypothesis would yield a prediction that the bilinguals should be faster than immersion students and language learners in the congruent condition in German, since this condition should be facilitated by their more frequent usage of German words. However, this was not corroborated by our data.

5. Conclusion

In this study, a modified Stroop task was used to investigate automatic processes related to word retrieval in Croatian-German bilinguals, immersion students, and classical German language learners. The results follow the pattern that was consistent with the executive control approach to bilingual processing. It seems that the bilingual group that has the strongest second language among our three groups experiences the most difficulties in lexical access because of this strong dual language activation. However, the group effect was somewhat diminished by the fact that the bilingual students had already spent more than six years on average in Croatia and the attrition processes in this group had started. We suggest

this was the reason we have not found automaticity in the second language in the bilingual group. Therefore, future work will have to put more focus on bilingual speakers in a bilingual environment. As for language learning, the program of partial immersion (i.e., attending some courses in the second language) does not provide enough language input to achieve automaticity in L2, although it has obvious educational value. We propose that it would be useful to explore programs with full immersion in the weaker language.

Acknowledgements

We would like to thank Kees de Bot and two anonymous reviewers for their helpful comments and suggestions on previous versions of this article.

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APPENDIX

Stimuli for the modified Stroop task

Stimuli (category of everyday objects) for the Stroop task in Croatian and German with their English translations

German word	Croatian word	English translation
Tisch	stol	table
Tasche	torba	handbag
Kissen	jastuk	pillow
Stiefel	čizma	boot
Mütze	kapa	cap
Mantel	kaput	coat
Hose	hlače	trousers
Schal	šal	scarf
Geldtasche	novčanik	wallet
Gardine	zavjesa	curtain
Uhr	sat	clock
Fenster	prozor	window
Haus	kuća	house
Fahrrad	bicikl	bicycle
Teller	tanjur	plate
Regenschirm	kišobran	umbrella
Löffel	žlica	spoon
Jacke	jakna	jacket
Kühlschrank	frižider	fridge
Flasche	boca	bottle

Stimuli (category of animals) for the Stroop task in Croatian and German with their English translations

German word	Croatian word	English translation
Hund	pas	dog
Katze	mačka	cat
Pferd	konj	horse
Maus	miš	mouse
Ratte	štakor	rat
Vogel	ptica	bird
Biene	pčela	bee
Wolf	vuk	wolf
Schaf	ovca	sheep
Schlange	zmija	snake
Kamel	deva	camel
Fisch	riba	fish
Löwe	lav	lion
Tiger	tigar	tiger
Schwein	svinja	pig
Frosch	žaba	frog
Spinne	pauk	spider
Giraffe	žirafa	giraffe
Fliege	muha	fly
Tintenfisch	hobotnica	octopus