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Connection between Bilingualism and Executive Functions in Hungarian-Serbian Bilinguals

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Abstract

Many studies have reported advantages in executive control for bilingual children and also adults**.** Previous results has shown that bilinguals show significant difference when they should focus on the differences between the form and the meaning, as well as in non-verbal problems when they have to ignore the incongruent information, so bilinguals are able to quickly notice any changes in their environment and they can quickly adapt to these changes. The present study examined 80 adults, who were Hungarian monolinguals and Hungarian-Serbian bilinguals, performing a Go-Nogo task, Wisconsin Card Sorting task, Number Stroop task and Simon task from the PEBL Psychological Test Battery 2.0. Bilinguals outperformed monolinguals on these tasks, confirming previous results for a bilingual advantage in executive functions. The results show that the advanced executive functions in childhood caused by bilingualism will give advanced executive functions in adulthood, which will provide an improved solution and execution in everyday life.

Keywords: bilingualism; executive functions; PEBL Psychological Test Battery 2.0.

1. Introduction

Regarding the whole population of the world, bilingualism, nowadays, becoming the norm rather than exception.

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More than 50% of humanity is able to communicate in writing or speaking on two or more languages [1]. Consequently, bilingualism could have different types, which could overlap each other, so a bilingual person can be classified into more types at the same time. We distinguish between early and late bilingualism according to the time of learning. Early bilinguals can be simultaneous bilinguals, when the learning of the two languages starts simultaneously at the same time, and sequential bilinguals, when the person learns the mother language first and later another language. We can differentiate balanced (the same competence of both languages) and dominant (one language is more dominant) bilingualism; according to the level of language knowledge there is proficient (high level knowledge of both languages) and partial (the level of one language is lower) bilingualism. The method of language learning separate natural (the person learns the second language between natural circumstances, without any difficulty), voluntary (voluntary efforts for learning the second language) and involuntary (centrally imposed, learning takes place within the institutional framework) bilinguals and socio-cultural attitudes discriminate additive (the social value of the native language is high, bilingualism has a positive effect on cognitive development) subtractive (the native language devalued) bilingualism [2].

1.1. Critical period of second language acquisition (SLA)

There are many different concepts about the beginning of learning a second language. According to [3], it is the beginning of active bilingualism (cut-off: 10 years), [4] claim that we can talk about beginning, when the person deepens himself or herself in the second language (cut-off: 6 years). In the opinion of [5] the starting point is the beginning of the use of the second language (cut-off: 3 years), [6] believe that it is the time when a person finds himself or herself in permanent bilingual environment (cut-off: 6 years), while according to [7] it is the beginning of using the second language smoothly (cut-off: 7 years). These differences strongly affect the outcome of the examinations and can explain the controversy present among the test results.

The classic critical period hypothesis can be linked to [8]. According to this hypothesis, the development of verbal abilities is determined by childhood brain plasticity and hemisphere specialization [9]. During adolescence the child loses the ability to learn a language automatically on a native level [10]. Lenneberg emphasises the learning between the age of 3 and 12, thus the learning of a second language has to begin before adolescence. It is because after adolescence the right hemisphere in not able anymore to replace the controlling function of the left hemisphere in verbal functioning [11]. Authors in [12] have similar opinion: the brain is more capable of language learning in childhood, while the author in [13] claims that due to the early learning of the second language the person gains more advantages, which could be related to the development of EF.

1.2. Executive functions (EF) in bilinguals

Different studies found that bilingualism creates increased EF and it manifests itself mainly in inhibition, during the repression of interference, when the person has to choose from the two simultaneously activated stimuli (language) the relevant and ignore the other [14]. With EF we gain conscious and behavioral control for achieving a distant goal [15] [16]. Within EF we distinguish between stimulus inhibition, when we choose the important stimulus from the stimuli around us and simultaneously inhibit the other; selective attention, with which we choose the relevant stimulus; task switching, the ability of detaching from the irrelevant task set and

switching over to the more relevant set; cognitive flexibility, the ability of rapidly adapting to unusual/unexpected situations and decision making; when we decide which one is the best to choose from the possible behaviors in the given situation [17]. These processes are crucial in controlling other cognitive functions [18].

Why do bilinguals have some advantages in EF? Because both languages of bilinguals are constantly active, they need to manage their attention to the actually used language and inhibit the other. This cognitive mechanism, namely the inhibition system, controls attention to the two activated language and selects which one is needed [19, 20]. Even bilingual children have better EF, especially in terms of inhibition [21, 22, 23]. Bilinguals may have advanced cognitive flexibility, because they acquire more experiences in code-switching between two languages and this helps them in situations or this kind of cognitive task to abandon a rule/behavior and try another, which is more corresponding to the task. So bilinguals' EF is focused on the selection of one language and the inhibition of the other at the same time, moreover they can change between languages if it is necessary for the successful communication [24, 25]. In a bilingual context, authors in [26] says, that a continuous monitoring of which language to use for each communication is active. Some researchers think that instead of inhibition, monitoring will give a bilingual advantage, although, inhibition is also included in this process too; when someone switch across stimuli/ information/ rule/ behaviour, the irrelevant information must be inhibited. In a bilingual context the speaker continuously has to be aware of the language the interlocutor uses, has to inhibit the interference between languages and has to be prepared for language switching in every moment, so more aspects of EF are involved. These views assume that bilingualism enhances executive control and also some studies show these advantages in selective attention, inhibition [27] and task-switching [28], tasks that involve task-irrelevant information like the flanker task [29, 30, 31], the Simon task [32], Stroop task [33, 22], etc. These changes could be found also in brain structures involved in EF. Results show that bilinguals have greater grey matter density in frontal lobes [34], left inferior parietal lobule [35], the anterior cingulate cortex [36], and putamen [37]. These areas are part of the EF and because of these changes in the brain bilinguals have a cognitive advantage.

However there are researchers who doubt whether bilingualism has any effect on EF, e.g. authors in [38], who claim that there are no convincing evidences related [38], but they ignore the adaptive control hypothesis by [39]. This theory states that the cognitive demand for verbal control increases among bilinguals, therefore a more advanced cognitive control develops, which affects every other non-verbal area [39]. Authors in [40] agree with this theory, because when we talk about bilingualism we should consider specific issues, like the interactional context of bilinguals' conversational changes and how long the bilingual speak two languages actively [40]. In bilingual context a bilingual speaker continuously has to be aware of the language the partner uses, has to inhibit the interference between languages and has to be prepared for language switching in every moment. In this case, control becomes adaptive and creates a successful communication situation [39]. Authors in [40] claims that according to this hypothesis, among balance bilinguals a better verbal control arises due to the bilingual context, which helps to create adaptive cognitive control, while among bilinguals deprived from this bilingual context the adaptive control is less developed [40]. Hereafter this study will also concentrate on these aspects and the critical period of SLA.

The aim of this research was to examine the bilingual advantage in EF tasks between young adult monolinguals and bilinguals. The study used tasks measuring more aspects of EF (inhibition, monitoring, task-switching, selective attention, decision making) which have been used in the literature. The hypothesis is that if there is a bilingual advantage, bilinguals should outperform monolinguals on these tasks mostly in inhibition, but also in other EF components.

2. Materials and Method

2.1. Participants

80 college students, aged 20-29, participated in the study (M=21.85; SD=2.18), with average IQ and high socioeconomic status. Hungarian is the mother language of all the participants in the study. They were divided into two groups, Hungarian-Serbian early simultaneous bilinguals (they had started to learn second – Serbian - language before the end of the critical period of SLA: M=3.47 years; SD=0.81) and the Hungarian monolingual control group, who also had learned a second language but had started it later (M=13.35 years; SD=2.11), so were exposed to their non-Hungarian language from birth and acquired two languages during childhood. In addition there was another important difference between the two groups, in daily language use. Bilinguals use both their languages more often (M=31.37%; SD=12.42) than monolinguals (M=4.32; SD=5.56).

2.2. Questionnaires, tests

Language knowledge, language learning and language use were examined by a questionnaire with questions which were taken over from the Language Experience and Proficiency Questionnaire (LEAP-Q), created by the Northwestern Bilingualism and Psycholinguistics Research Laboratory [41]. The questionnaire revealed how many languages the individual speak, which one is the mother language, when had the individual started to learn the languages and which languages the individual uses in daily situations and in what percentage.

For measuring EF **PEBL Psychological Test Battery** was used, which contains most of the standard computer-administered psychological experiments of interest to neuropsychological, cognitive, clinical communities. The current version of the battery is designed to work with PEBL version 2.0 and was released in 2016 [42]. In this study Go-Nogo task, Wisconsin Card Sorting Test (WCST), Number Stroop and Simon task were used.

2.2.1. Go-Nogo task

In Go-Nogo task the subject has to give a motor response (pushing the right button), when a signal stimulus appears on the center of the screen after a fixation point (letter ‘P’), but has to avoid motor response when a different signal stimulus appears (letter ‘R’). With the frequency of occurrence of the two types of errors – motor response when it is not relevant and absence of response when it should have happened - inhibition, reaction time and selective attention can be measured. We can determine them with the summarization of correct and incorrect responses in the complete test, then in the two specific blocks (Go and Nogo blocks), while being aware of the reaction time of responding (how quick was the motor response) [42].

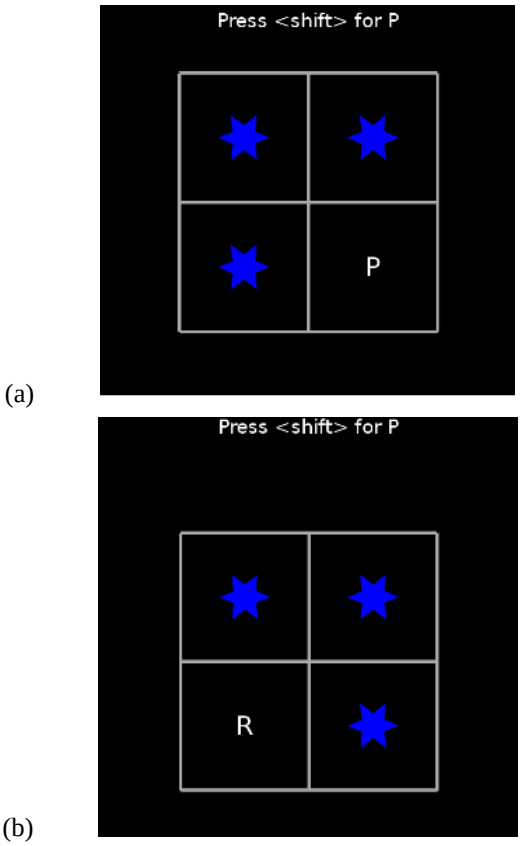


Figure 1: Go-Nogo task 'Go' block (a); Go-Nogo task 'Nogo' block (b)

2.2.2. Wisconsin Cars Sorting Task

In WCST the participant has to sort cards showing simple figures, concluding the actual viewpoints of sorting from the feedbacks of the experimenter ('correct' or 'incorrect'). The cards have to be sorted by the shape, color or number of objects on them. The experimenter changes the aspect of sorting at fixed intervals without indicating it. The participant then needs to abandon the rule that became incorrect and find the new, correct rule. This test is mostly used to measure strategy and problem solving, decision making, inhibition, working memory [42].

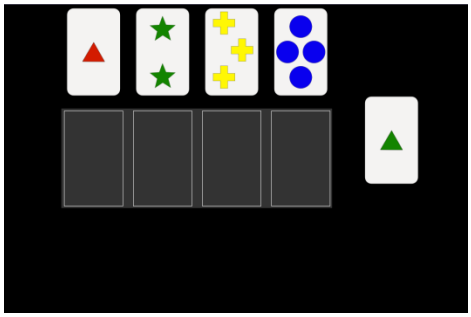
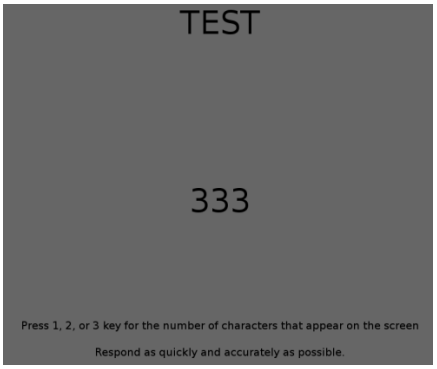


Figure 2: WCST

2.2.3. Number Stroop

Number Stroop task and other variants of it are used to measure inhibition and selective attention. In the Classic Stroop task the individual has to identify the color in which the names of the colors were printed, but in the Number Stroop task the participant has to tell how many numbers appears on the screen. The participant has to inhibit the response deriving from the automatic value of the number, when the number of the marks and the value of the number do not coincide. The test provides the total numbers of errors and the number of incongruent errors (when the character quantity and meaning differ, e.g.: 222) and random errors, while also measuring reaction time [42].

(a)



(b)

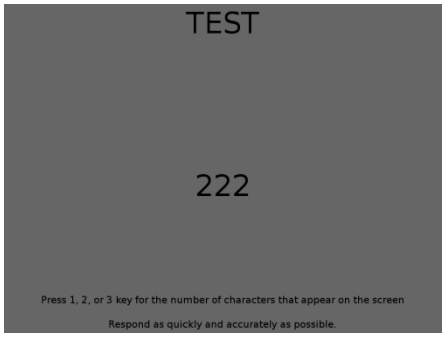


Figure 3: Number Stroop task congruent information (a); Number Stroop task incongruent information (b)

2.2.4. Simon task

Simon task is used for examining selective attention and inhibition. The task includes spatial and color dimensions. At the beginning of the test a red circle appears on the left side of a monitor and a blue circle on the right side of it. The participant should press the left Shift button if the red circle appears and the right Shift button if the blue one does. Only one circle appears on the screen at once. The task is complex, because the person has to inhibit the spatial pattern appearing at the beginning of the test (blue on the right side, red on the left side) and has to inhibit the motor response related to the momentarily absent color. With this task we can

measure inhibition, visual processing, selective attention and reaction time [42].

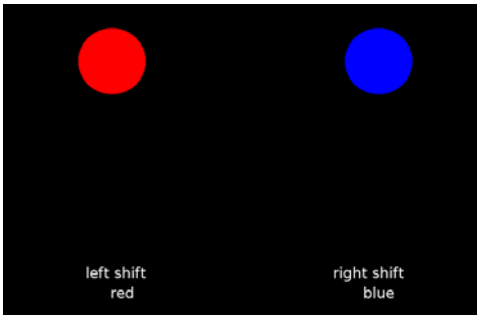


Figure 4: Simon task beginning screen

3. Results

3.1. Differences between groups

Data were analyzed with one-way ANOVA. The results of the Go-NoGo task revealed significant difference between groups in favor of bilinguals, for they provided more correct responses ($F(1,78)=39.202$; $p=0.00$), while making less errors ($F(1,78)=33.450$; $p=0.00$). If we examine it separately in the two different blocks the same result will emerge. The correct results provided in Go block are more numerous among bilinguals ($F(1,78)=13.152$; $p=0.00$), while errors occur less frequently ($F(1,78)=12.915$; $p=0.00$). It is also recognizable in Nogo block: more correct responses ($F(1,78)=48,783$; $p=0.00$) and less errors ($F(1,78)=49.005$; $p=0.00$) occurred. There is no difference in the speed of responding ($F(1,78)=0.05$; $p=0.82$).

ANOVA shows significant differences in the WCST, bilinguals found the sorting rule faster ($F(1,78)=236.334$; $p=0.00$) and less incorrect response appeared ($F(1,78)= 236.334$; $p=0.00$). Perseverative errors occurred less frequently in bilingual group ($F(1,78)=22.664$; $p=0.00$) which means, bilinguals realized the new rule to follow in a given task more quickly, task-switching was more rapid, thus inhibition of the former rule was more rapid too. The non-perseverative errors occurred also less frequently ($F(1,78)=85.425$; $p=0.00$), which means that bilinguals kept their attention focused more easily and effectively and that they did not get lost in the task. There is observable advantage in conceptualization ($F(1,78)=142.801$; $p=0.00$), for they can give meaning to stimuli more easily, thus they can react to them rapidly.

Errors in the Number Stroop occurred less frequently among bilinguals than monolinguals ($F(1,78)=13.474$; $p=0.00$). That was the case when focusing on incongruent errors ($F(1,78)=6.012$; $p=0.01$) and random errors ($F(1,78)=13.551$; $p=0.00$). In this task there was not any difference in reaction time observable, neither in congruent ($F(1,78)=0.04$; $p=0.84$), nor in incongruent ($F(1,78)=0.105$; $p=0.74$) or neutral situations ($F(1,78)=0.05$; $p=0.82$).

In Simon task we found difference in correct responses ($F(1,78)=91.146$; $p=0.00$) and in errors ($F(1,78)=91.146$; $p=0.00$), but not in reaction time ($F(1,78)=14.364$; $p=0.83$).

3.2. Correlational relationship

Pearson Correlation analysis showed that the earlier an individual had started to learn a second language (bilingual group) the better were their results in the tests, thus there is positive correlation between the beginning of language learning and more effective executive functions (p=0,00).

Moreover, there is also a positive correlation between daily language use and test results (p=0,00), which means that the more regularly an individual uses both languages in everyday life the more probably the cognitive differences will appear in favor of bilingualism. It is clear that the beginning of language learning is very important, but it is also necessary to use the languages regularly, thus for the cognitive benefits it is not enough to learn two languages, they have to be used as well.

4. Discussion

Early simultaneous bilinguals had significantly better results in EF tests than monolinguals. In terms of EF, the better results are due to the more effective selection of important stimuli from the environment and the simultaneous inhibition of other – less important – stimuli [20]. Conceptualization is better, that is to say they can understand stimuli more easily. They can detach from the irrelevant task-set more quickly and can adapt to the more - in terms of the given task - relevant set more swiftly [26]. This procedure strongly related to the ability of selection and inhibition, for without these abilities task-switching could not occur, because to find a better, more appropriate solution we first have to inhibit the former one [24]. Successful task-switching implies that perseveration will barely occur, that is to say they realize easier what solution to use and what rule to follow in order to achieve their goal and they do not repeat the irrelevant rule again and again regardless of the new task. This ability will lead to cognitive flexibility, which means the ability of rapid adaptation to unusual and unexpected circumstances [25].

The role of bilingualism is reflected in the fact that the early language switching situation helps the development of EF. From the beginning of the language sensitive period, early bilinguals hear two kind of verbal information and this will become the normal verbal medium for them, thus they need to inhibit one language continuously, they need to decide which language is suitable in a given situation, which language is understood by the interlocutor and they might need to switch from one language to the other in order to maintain the appropriate communication and the correct transfer of information [14]. In such circumstances, a bilingual person is able to realize that the interlocutor is in a different mental state, for s/he uses a different language, so the bilingual will have to transform the behavior in order to maintain successful communication. Bilinguals often find themselves in situations where different verbal codes appear, so, to ensure that the interaction will be successful, they have to adapt to that situation rapidly [14].

In a bilingual environment one always should be ready to choose the language the communication partner uses. It is necessary to be alert of which language one uses and to be able to change the verbal code, if needed. Even a two years old bilingual child is able to realize this confronting situation, that is to say that a 2-3 years old

bilingual child can adapt to the language knowledge of the communication partner and can realize the difference in their mental states, which means the different verbal code. Therefore, bilinguals are better in solving problems related to different perspectives [14].

5. Conclusion

The aim of this study was to examine the effects of bilingualism on cognitive (executive) control. It appears that early bilinguals have better EF than monolinguals due to the daily use of the two languages and the early bilingual environment. Considering all these examinations, the claim that bilingualism will cause different cognitive disadvantages in life is mostly outdated, as it is clear that the two languages do not encumber the mind. The learning of the second language in the language sensitive period will secure more effective solutions and executions in terms of numerous cognitive functions, which abilities will remain active in adulthood.

6. Recommendations

As the study says, early bilingualism does not have inherent negative effects in many cognitive functions. Regarding the results, it has been proven that Hungarian-Serbian bilinguals are more effective in terms of EF, which is observable even at an early stage of bilingual education. However, the results provided in this study require further and more precise examinations about bilingualism (other language groups/other bilinguals from different countries) to be able to form a holistic view.

However, these finding about early bilingual exposure may encourage educational institutions and parents not to fear using a second language, because the early age of first bilingual language exposure directly and seriously impacts a person's cognitive development.

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References

[1] Butler, G.Y. "Bilingualism /Multilingualism and Second-Language Acquisition," in The Handbook of Bilingualism and Multilingualism, 2nd ed., T.K. Bhatia, W.C. Ritchie, Eds. Chichester, UK: Wiley-Blackwell Publishing. 2013, pp. 109-136.

[2] L. Göncz, A vajdasági magyarság kétnyelvűsége, Nyelvpszichológiai vonatkozások. Szabadka: MTT Könyvtár 8, 2004, pp. 1-307.

[3] G. Luk,, E. De Sa, E. Bialystok. "Is there a relation between onset age of bilingualism and enhancement of cognitive control?" Bilingualism: Language and Cognition, vol. 14, (4), pp. 588-595,

Oct. 2011.

[4] L. Tao, A. Marzecová, M. Taft, D. Asanowicz, Z. Wodniecka. "The efficiency of attentional networks in early and late bilinguals: the role of age of acquisition." Frontiers in Psychology, vol. 2, pp. 123-132, Jun. 2011.

[5] L.L. Kapa, J. Colombo. "Attentional control in early and later bilingual children." Cognitive Development, vol. 28,. (3), pp. 233-246, Jul. 2013.

[6] V. Kalia, M.P. Wilbourn, K. Ghio. "Better early or late? Examining the influence of age of exposure and language proficiency on executive function in early and late bilinguals." Journal of Cognitive Psychology, vol. 26, (7), pp. 699-713, Sep. 2014.

[7] S.D. Pelham, L. Abrams. "Cognitive advantages and disadvantages in early and late bilinguals." Journal of Experimental Psychology: Learning, Memory, and Cognition, vol. 40, (2), pp. 313-325, Mar. 2014.

[8] E.H. Lenneberg. Biological Foundations of Language. New York: Wiley, 1967, pp. 1-167.

[9] Cs. Pléh. "A nyelv biológiai alapjai. Bátor elméletek és józan építkezés." Magyar Tudomány, vol. 8, (172), pp. 901-906, 2011.

[10] G. Kovács. (2014). "Idegennyelv-elsajátítás." in Pszicholingvisztika, vol. 1. Cs. Pléh, Á. Lukács, Eds. Budapest: Akadémiai Kiadó, 2014, pp. 593-674.

[11] J.S. Johnson, E.L. Newport. "Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language." Cognitive Psychology, vol. 21, pp. 60-99, Jan. 1989.

[12] E. Bialystok, K. Hakuta. "Confounded age: Linguistic and cognitive factors in age differences for second language acquisition." in Second Language Acquisition and the Critical Period Hypothesis, D. Birdsong, Ed. Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers, 1999, pp. 161-173.

[13] L. Wei. "Conceptual and Methodological Issues in Bilingualism and Multilingualism Research." in The Handbook of Bilingualism and Multilingualism, 2nd ed., T.K. Bhatia, W.C. Ritchie, Eds. Chichester, UK: Wiley-Blackwell Publishing. 2013, pp. 26-53.

[14] S. Kousaie, C. Sheppard, M. Lemieux, L. Monetta, V. Taler. "Executive function and bilingualism in young and older adults." Frontiers in Behavioral Neuroscience, vol. 8, pp. 250-260, July. 2014.

[15] A. Miyake, N.P. Friedman. „The nature and organization of individual differences in executive

functions: Four general conclusions." Current Directions in Psychological Science, vol. 21, pp. 8–14, Feb. 2012.

[16] A. Miyake, N.P. Friedman, M.J. Emerson, A.H. Witzki, A. Howerter, T.D. Wager. „The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: a latent variable analysis." Cognitive Psychology, vol. 41, (1), pp. 49-100, Aug. 2000.

[17] D.T. Stuss, M.P. Alexander. "Executive functions and the frontal lobes: A conceptual review." Psychology Research, vol. 63, pp. 289–298, Mar. 2000.

[18] E.K. Miller, J.D. Cohen. "An integrative theory of prefrontal cortex function." Annual Review of Neuroscience, vol. 24, pp. 167–202, Mar. 2001.

[19] G.J. Poarch, E. Bialystok. "Bilingualism as a model for multitasking." Developmental Review, vol. 35, pp. 113-124, Mar. 2015.

[20] E. Bialystok. "How does experience change cognition? Evaluating the evidence." British Journal of Psychology, vol. 102, pp. 303–305, Aug. 2011.

[21] E. Bialystok. (2001). Bilingualism in development: Language, literacy and cognition. New York: Cambridge University Press, 2001, pp. 281.

[22] E. Bialystok, F.I.M. Craik, G. Luk. "Lexical access in bilinguals: Effects of vocabulary size and executive control." Journal of Neurolinguistics, vol. 21, pp. 522–538, Nov. 2008.

[23] E. Mezzacappa. "Alerting, orienting, and executive attention: developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children." Child Development, vol. 75, pp. 1373–1386, Sep-Oct. 2004.

[24] E. Bialystok. "Cognitive complexity and attentional control in the bilingual mind." Child Development, vol. 70, pp. 636–644, May-Jun. 1999.

[25] E. Bialystok, F.I.M. Craik, G. Luk. "Bilingualism: Consequences for mind and brain." Trends in Cognitive Sciences, vol. 16, (4), pp. 240-250, Apr. 2012.

[26] A. Costa, M. Hernández, J. Costa-Faidella, N. Sebastián-Gallés. "On the bilingual advantage in conflict processing: Now you see it, now you don't." Cognition, vol. 113, (2), pp. 135–149, Nov. 2009.

[27] E. Bialystok, M.M. Martin. "Attention and inhibition in bilingual children: evidence from the dimensional change card sort task." Developmental Science, vol. 7, pp. 325– 339, Jun. 2004.

[28] M. Hernández, C.D. Martin, F. Barceló, A. Costa. "Where is the bilingual advantage in task-switching?" Journal of Memory and Language, vol. 69, (3), pp. 257–276, Oct. 2013.

[29] A. Marzecová, D. Asanowicz, L. Krivá, Z. Wodniecka. “The effects of bilingualism on efficiency and lateralization of attentional networks.” Bilingualism: Language and Cognition, vol. 6, pp. 608–623, July. 2013.

[30] S.M. Carlson, A.N. Meltzoff. “Bilingual experience and executive functioning in young children.” Developmental Science, vol. 11, pp. 282–298, Mar. 2008.

[31] K. Emmorey, G. Luk, J.E. Pyers, E. Bialystok. “The source of enhanced cognitive control in bilinguals: Evidence from bimodal bilinguals.” Psychological Science, vol. 19, pp. 1201–1206, Dec. 2008.

[32] E. Bialystok, F.I.M. Craik, R. Klein, M. Viswanathan. “Bilingualism, aging and cognitive control: evidence from the Simon task.” Psychological Aging, vol. 19, pp. 290-303, Jun. 2004.

[33] H.K. Blumenfeld, V. Marian. “Cognitive control in bilinguals: Advantages in Stimulus–Stimulus inhibition.” Bilingualism: Language and Cognition, vol. 17, pp. 610-629, Jul. 2014.

[34] G. Luk, E. Bialystok, F.I.M. Craik, C. Grady. “Lifelong Bilingualism Maintains White Matter Integrity in Older Adults.” Journal of Neuroscience, vol. 31, (46), pp. 16808-16813, Nov. 2011.

[35] A. Mechelli, J.T. Crinion, U. Noppeney, J. O’Doherty, J. Ashburner, R.S. Frackowiack et al. “Structural plasticity in the bilingual brain.” Nature, vol. 431, 757, Oct. 2004.

[36] B.T. Gold, C. Kim, N.F. Johnson, R.J. Kriscio, C.D. Smith. “Lifelong bilingualism maintains neural efficiency for cognitive control in aging.” Journal of Neuroscience, vol. 33, pp. 387–396, Jan. 2013.

[37] J. Abutalebi, P.A.D. Rosa, A.K. Castro Gonzaga, R. Keim, A. Costa, D. Perani. “The role of the left putamen in multilingual language production.” Brain & Language, vol. 125, pp. 307–315, Jun. 2012.

[38] K.R. Paap, H.A. Johnson, O. Sawi. “Should the search for bilingual advantages in executive functioning continue?” Cortex, vol. 74, pp. 305-14, Jan. 2016.

[39] D.W. Green, J. Abutalebi, “Language control in bilinguals: The adaptive control hypothesis”. Journal of Cognitive Psychology, vol. 25, (5), pp. 515-530, May. 2013.

[40] H. Yang, A. Hartanto, S. Yang. “The importance of bilingual experience in assessing bilingual advantages in executive functions.” Cortex, vol. 75, pp. 237-240, Dec. 2015.

[41] V. Marian, H.K. Blumenfeld, M. Kaushanskaya. “The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals.” Journal of Speech, Language, and Hearing Research, vol. 50, pp. 940-967, Aug. 2007.

[42] S.T. Mueller, B.J. Piper. “The Psychology Experiment Building Language (PEBL) and PEBL Test Battery.” Journal of Neuroscience Methods, vol. 222, pp. 250-259, Oct. 2014.