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BILINGUALISM AND DEVELOPMENT OF COGNITIVE FUNCTIONS IN HUNGARIAN CHILDREN IN ROMANIA

ABSTRACT OF THE DOCTORAL THESIS

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Abstract

Keywords: bilingualism, language competence, cognitive development, executive functions, bilingual spectrum, bilingual model, bilingual environment, cultural minority, attentional control, inhibitory control, working memory, short term memory

Introduction

The relationship between bilingualism and cognitive functions has been in the centre of attention for many decades now. The literature relating to bilingualism assumes that similar mechanisms drive the bilinguals' language selection as well as the approaches to conflict resolutions, both relating to the executive functions (Bialystok et al 2009). Executive functions are described as a set of skills that underlie cognitive processes responsible for planning and solving difficult tasks in a goal-oriented manner while inhibiting inappropriate or inadequate responses (Graham–Hughes 2002, Zelazo et al 2003, Tánczos et al 2014). It is believed that the constant selection of one language over another strengthens the executive function skills specifically responsible for these processes, such as switching, inhibition, attention and working memory, making them more efficient for a variety of different tasks, including problem solving. A great number of empirical studies have built their hypothesis on the premises that the executive function skills are enhanced in bilinguals, and therefore predicted that bilinguals would have an advantage over monolinguals in non-verbal tasks requiring these specific skills (e.g. Stroop task or Card Sorting). Indeed, over the years, many studies have shown a bilingual advantage for children in executive function domains, including the inhibitory and attentional controls (Martin-Rhee–Bialystok 2008; Carlson–Meltzoff 2008; Prior–MacWhinney 2010; Barac et al 2014; Grundy–Keyvani Chahi 2017; also see metaanalysis from Adesope et al 2010), however, in recent times, many have failed to demonstrate the same (Paap–Greenberg 2013; Dunabeitia et al 2014; Gathercole et al 2014). Thus the findings relating to bilingual advantage are controversial.

There are controversies also in the results of those studies that examined the potential effect of bilingualism specifically on working memory and short term memory. For instance, Morales and colleagues (2013) report bilingual advantage on the working memory in 5-7 year old bilinguals which they tested on tasks involving spans of visuo-spatial skills. Many others have shown similar bilingual advantage and not only on the working memory – which is considered part of the executive functions by many – but also on the short term memory (Engle

2002; Bialystok et al 2004; Linck et al 2014; Marini et al 2019). In a recent study, Marini and colleagues (2019) make an interesting consideration when proposing bilingual advantage on memory skills. The authors claim that the performance of the bilinguals in tasks targeting working memory and short term memory depend on the type of bilingualism (simultaneous or sequential). They believe that in simultaneous bilinguals, having been exposed to two languages from birth, the switching between languages becomes automatic after a time, resulting in the diminished use of the working memory, which, in turn, also reduces the possibility of its development. On the contrary, sequential bilinguals presumably need to monitor their languages attentively on a continuous basis in order to decide which of the two to use at a given time. Therefore, it is expected that this constant control enhances the development of both working memory and short term memory.

Besides the positive results, naturally there are others that could not show bilingual advantage neither on working memory (McVeigh 2019), nor on short term memory, or only partially (de Abreu 2011).

Seeing this controversy, the present study aspires to provide further evidence with respect to the bilingual experience and its possible cognitive benefits. Before proceeding to the methodology section, it is important to clarify that the study does not aim to compare bi- and monolinguals as most of the past research have done so. Instead, it aims to investigate the relationship between cognitive functions and bilingualism, especially in respect to bilingual advantage in executive functions skills in those children that have different degrees of bilingual competence.

Methodology

The research question is evaluated by assessing the performance of three groups of 10-year-old children attending schools in three different Transylvanian regions (Székelyudvarhely/ Odorheiul Secuiesc, Kolozsvár/Cluj-Napoca and Brassó/Braşov). All children (n=72) are Hungarian mother tongue speakers with differing levels of Romanian language knowledge. The degree of knowledge and competence in the languages is expected to vary based on the region of origin. A fourth group of children (n=25) from Kolozsvár – with Romanian mother tongue and no knowledge in Hungarian – is also part of the study and serves as a control group. The four groups together make up the 97 children who participated in the study.

Initially, a teacher questionnaire is used to evaluate the language competence of the groups and results confirm the predictions about the region of origin: the group from Székelyudvarhely (SZcs) being the least competent in Romanian, while the group from Brassó (Bcs) being the most equally advanced in both languages among the three Hungarian groups. A parent questionnaire is also used in order to gain insight into the socio-economic background and the socio-linguistic environment of the children. The information gathered from the questionnaire enables the study to control for possible confounding variables that may have an effect on children's cognitive development and, combined with the teacher questionnaire, it also helps in highlighting potential factors relating specifically to children's language development.

For instance, it is likely that having one parent with Hungarian mother tongue and the other with Romanian is a contributing factor to children's Romanian language development. (Results from teacher and parent questionnaires combined show that there is a significant difference between the highlighted factors: parents' mother tongue and school performances assessed by the teachers. The ones who have one Romanian parent score higher in the school performances in the Romanian language. KMcs: N=7 vs 12; mean 4,43 vs 3,00; standard deviation 1,134 vs 1,206; t-test: 2,587, p=0,022, Bcs: N=6 vs 12; mean 4,67 vs 3,75; standard deviation 0,516 vs 1,138; t-test: 2,348 p=0,032.)

At this point, it is important to emphasize that based on the children's Hungarian and Romanian language competencies, none of the groups can be considered highly balanced bilinguals while, at the same time, none can be considered monolingual either in the strictest sense of the word. It seems that the three experimental groups are mainly Hungarian dominant who also have some knowledge in the Romanian language, naturally some groups, or even individual children being more highly competent than some others. In the evaluation of our results against the results of previous studies this will have to be taken into consideration.

Tasks

The cognitive performance of the groups is assessed on 7 tasks, both verbal and non-verbal. The two verbal tasks (letter fluency and word association), involving word generations (both in Hungarian and Romanian for the three groups with Hungarian mother tongue), aim to determine the children's performance in language function domains (e.g. vocabulary, lexical access, developmental level of language competence). The five non-verbal tasks, including a listening span, a forward and a backward digit span, a numerical Stroop task and a Card Sort-

ing task, endeavour to explore a number of different cognitive functions. Through the listening span, which is a type of memory task, the study assesses whether the children's cognitive capacity is aligned to the expectations of their age. The other four evaluate different cognitive functions, mainly executive functions skills. The forward and backward digit span assesses short term and working memory, respectively. In the forward digit span the children need to repeat a series of numbers in the same order as they hear it from the examiner, while in the opposite or backward order in the backward digit span. The adapted version of the numerical Stroop task tests the inhibitory control of the executive functions. In this task, the children need to decide between two numbers which one has a higher value while at the same time need to ignore the irrelevant information regarding the size of the numbers. The Card Sorting task, being based on situational conflict resolution, is even more complex in the sense that it activates not only the inhibitory control but several other key components of the executive functions, including the attentional control, switching and working memory. Children need to sort a stack of cards with different colour and geometric form (red or blue, triangle or circle) into two or three boxes by a number of different criteria. Both the Stroop task and the Card Sorting has congruent and incongruent phases, and it is suggested that those children that have more developed executive functions perform not only faster but also make less errors, especially in the incongruent phases (Bialystok–Martin 2004; Carlson–Meltzoff 2008; Dunabeitia et al 2014; Gathercole et al 2014).

We use SPSS 20 and Microsoft Excel for statistical analyses. First, group averages are obtained, after which further analyses focus on potential differences. In order to evaluate the performances of the groups against each other, one-way ANOVA (analysis of variance) is employed. If the results of the ANOVA are statistically significant ($p < 0,05$), Tamhane post-hoc tests are used to evaluate the nature of the differences between the groups. Independent t-tests are run in those cases when only two groups's averages are compared.

In the study the dependent variables are made up by all the verbal and non-verbal tasks. The independent variable is the Hungarian and Romanian language knowledge and competence of the children. When analysing the results of the experimental tasks it is the existing differences between the groups that are important, and not the groups' performances.

Hypotheses

Based on findings from past research, the current study hypothesizes the followings:

- The positive effect of the bilingual competence on the cognitive functions manifests mainly when a high level of (second) language competence is built on an established (first, – mother tongue –) language.
- There will be differences among the groups in their performances in the cognitive tasks. Those that have a higher level of bilingual competence ("balanced" is the expression that previously has been used in the literature) will perform better.
- Bilingualism and cognitive functions correlate: the more equally highly advanced the competence in the two languages is, the more developed are the cognitive functions.

Results

Verbal Tasks: Letter Fluency and Word Association

The groups do not perform differently in relation to each other when compared in their dominant languages, except for SZcs. The results of SZcs in Hungarian are tendentially better in the letter fluency and significantly better in the word association with respect to all the other groups in all the associations except in *pâine/kenyér* 'bread' (***ház/casă*** **'house'** F(3)=10,990, p=0,001, ***kéz/mână*** **'hand'** F(3)=5,075, p=0,003, ***víz/apă*** **'water'** F(3)=4,506, p=0,005). The source of the advantage for SZcs in the word association might lie in a technique mainly applied by this group (i.e. associating more abstract terms to the respective calling words).

In the Romanian version of the two tests a significant difference is found between the groups in favour of the control group (KRcs) as it was expected but only in relation to the letter *b* (F(3)=17,832, p=0,001) and in all the associations except for *casă* 'house' (***mână*** **'hand'** F(3)=5,077, p=0,003, ***pâine*** **'bread'** F(3)=10,589, p=0,001, ***apă*** **'water'** F(3)=6,467, p=0,001), but no difference in the results among the three groups with Hungarian mother tongue.

Non-Verbal Tasks: Memory and Conflict Resolutions Tasks

Using the group averages as a mean for significance (see Table 1), the group most equally advanced in both languages (Bcs) performs tendentially better than all the other

groups (including the control group) in both of the memory tasks and significantly better than KMcs in the forward digit (F(3)=3,965, p=0,011).

Table 1: The compilation of the group averages and standard deviation in the four cognitive tasks

Tasks	Group averages (with standard deviation)			
	KRcs	SZcs	KMcs	Bcs
Forward digit	5,48 (1,194)	4,96 (0,720)	4,71 (0,717)	5,52 (1,030)
Backward digit	3,75 (0,676)	3,77 (0,765)	3,90 (0,625)	4,05 (1,146)
Numerical Stroop phase I.	49,17 (6,863)	48,33 (6,839)	47,25 (6,889)	49,19 (9,464)
Numerical Stroop phase II.	48,92 (7,366)	48,78 (8,224)	48,70 (6,530)	48,05 (8,517)
Card sorting phase I.	49,39 (9,741)	53,92 (10,127)	57,22 (7,409)	46,27 (8,498)
Card sorting phase II.	46,00 (10,34)	55,38 (13,888)	57,67 (9,762)	42,86 (8,002)
Card sorting phase III.	72,96 (23,679)	81,15 (21,952)	78,33 (14,426)	67,18 (12,764)

KRcs: Romanian group from Kolozsvár; SZcs: Hungarian group from Székelyudvarhely; Bcs: Hungarian group from Brassó; KMcs: Hungarian group from Kolozsvár

A more detailed analysis conducted specifically on the memory tasks (forward and backward digit), – where the frequency for scoring the highest common value was considered – shows that Bcs performs better not only in the forward digit, but potentially also in the backward digit span with respect to all the other groups, including the control group.

Table 1: The frequency of the highest scores in the forward and backward digit spans

Tasks	KRcs	SZcs	KMcs	Bcs
Forward digit ≥ 6	32%	15%	14%	57%
Backward digit ≥ 5	13%	12%	14%	35%

This suggests that relevant differences between the groups' performances can be masked when only group averages are used in the comparison (Grundy–Keyvani Chahi 2017; Marini et al 2019), therefore it is important to run in-depth analyses where possible.

Regarding the two conflict-based tasks (Stroop and Card Sorting), in the first two phases of the Card Sorting as well as in the three phases together the ANOVA shows significant differences between the groups in favour of Bcs who performs better than the other two Hungarian dominant groups (**congruent phase**: F(3)=5,767, p=0,001, **incongruent phase**: F(3)=9,196, p=0,001, **the three phases together:** F(3)=6,036, p=0,001) as well as tendentially better than KRcs. KRcs also performs significantly better than KMcs in the first two phases of the Card Sorting. There was no difference between the groups' performances in

the Stroop task (reaction time in the congruent and incongruent phases together: F(3)=0,084, p=0,969, and total number of errors in the two phases together: F(3)=1,275, p=0,288).

The differences in the results of the two tasks are consistent with the theory of a different inhibitory control behind the Stroop task and Card Sorting: univalent vs bivalent inhibition (the bivalent one being more congruent to the bilingual experience which is reported to enhance particularly the attentional control). While in the Stroop task there is only one relevant (univalent) option to choose from, namely the number with the higher value (the other option, the size of the number not being relevant), in the Card Sorting it is possible to choose from two or more relevant (multivalent) options the one that is the most appropriate for the given stimuli (Bunge et al 2002). The difference between these alternatives is that while the multivalent alternatives could mean two or more potentially conflicting options, the univalent alternative offers only one option, therefore the conflict here is reduced. Therefore in the Card Sorting perhaps because of the potentially conflicting options (the child needs to keep in mind all the relevant rules as well as all the alternative answers while at the same time needs to block the irrelevant ones in order to inhibit their potential effect) there is more need for the attentional control than in the Stroop task.

Summary of the results

Some of the emerging patterns in each of the group's performance are as follows:

- **Bcs** (most equally advanced in both languages) performs either not differently or, in some cases, significantly worse in the verbal tasks (in the Hungarian version of the tasks in comparison to SZcs while in the Romanian versions in comparison to KRcs) and significantly better or not differently in some of the non-verbal tasks in comparison to the other groups.
- **SZcs** (most advanced in Hungarian and least in Romanian) outperforms the other Hungarian groups in the Hungarian versions of the verbal tasks (especially in the word association task), but shows no difference or is significantly worse in non-verbal tasks in comparison to Bcs.
- **KMcs** (not highly advanced neither in Hungarian nor in Romanian) shows no difference or performs significantly worse in both verbal and non-verbal tasks in comparison to the other groups.
- **KRcs's** (control group with Romanian mother tongue) performance in Romanian in the verbal tasks compared to the groups with Hungarian mother tongue performing in

Hungarian shows no difference, except in comparison to SZcs the group performs significantly worse in the word association task; in the non-verbal tasks no difference in comparison to SZcs and Bcs (tendentially worse than Bcs and better than SZcs), however performs significantly better than KMcs in the first two phases of the Card Sorting task and tendentially better in the forward digit span task, but not differently in the backward digit span and Stroop task.

In summary, the memory and the attentional control seem to be the functions in which children who achieved a certain high level of competence in the second language besides having a strong mother tongue base benefit the most. However, a more detailed analysis (conducted on the memory tasks) leads to the realization that a possible advantage might extend more generally to the executive function domains including also the working memory (not only the inhibitory and attentional controls).

The question could also be raised whether factors such as income and parent education may have had an influence on the performance of the groups in the cognitive tasks. The results of correlation analyses suggest that, generally, these factors do not seem to play a role in the children's performances (only the forward digit span correlated with both of the parents' education: mother – Pearson's r 0,485, p=0,001, father – Pearson's r 0,530, p=0,001).

In the subsequent paragraphs the findings are discussed in the light of some previously existing bilingual theories and models (e.g. Cummins 1976, 1979b Threshold Theory and Developmental Interdependence Hypothesis, Baker's analogy of the TH 2001) as well as in the light of those developed in the current study (i.e. the additive and the integrative models of the bilingual spectrum).

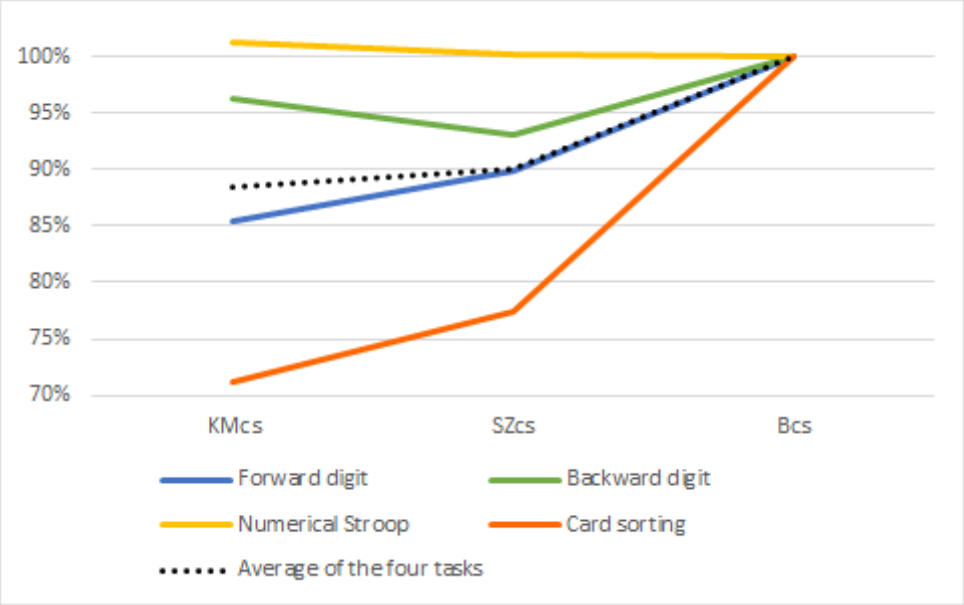
The Discussion of the Results in Light of Different Bilingual Models

Our results seem to be consistent with Cummins' Threshold Theory (1976) and Baker's (2001) "three-floor house" model of bilingualism which state that those highly advanced in both languages (second threshold) benefit the most in executive function domains (in the current study this corresponds to Bcs), followed by the ones that have an advanced dominant language base and some competence in another language too (middle floor: SZcs) and finally those that are less advanced in both of the languages (first threshold: KMcs).

If we examine the results of the four non-verbal cognitive tasks (see Figure 1), we see that the performances of the groups are not only in concordance with Cummins' theory and

the underlying illustrative models but also with our hypotheses. Bcs's performances across the cognitive tasks are consistently better than the other two groups', except in the Stroop task. SZcs outperforms KMcs in the Card Sorting (which tests the inhibitory and the attentional control of the executive functions) and in the forward digit span, but not in the other two tasks. Although the four tasks measure different cognitive functions, we calculated a tentative average which, even if just very slightly, also reflects the cognitive performances that are underlined by the bilingual theories.

Figure 1: The performance of the Hungarian groups in the four non-verbal cognitive tasks

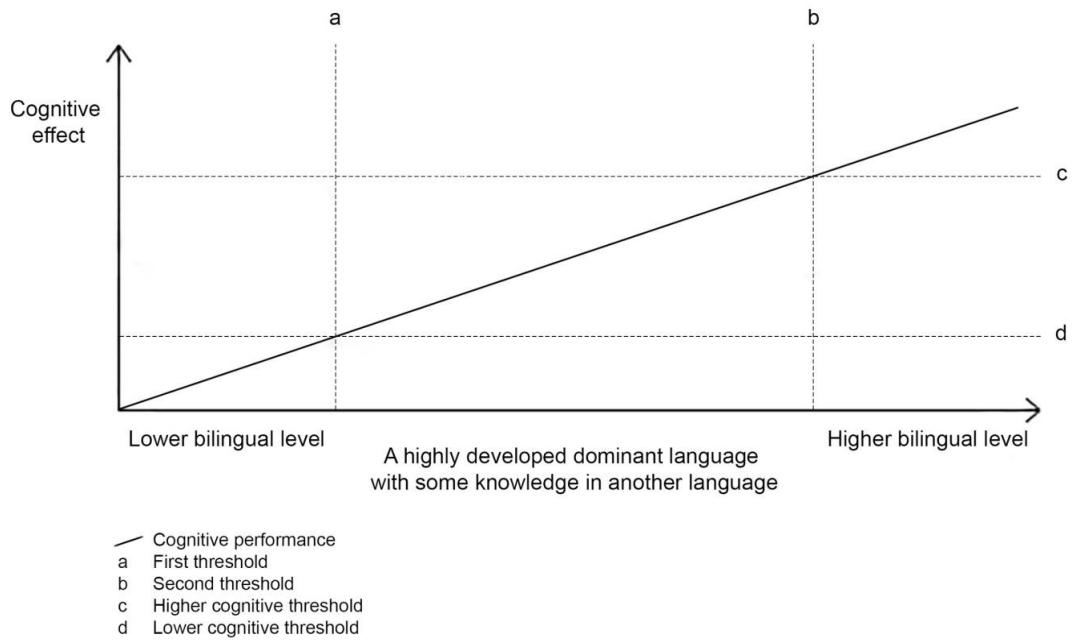


The Additive Model of the Bilingual Spectrum

With the aim to propose the groups along a bilingual spectrum we transpose Baker's "three-floor house" model horizontally and name it additive, based on the consideration that the positioning along the spectrum (from left to right) is the sum of all knowledge and competences in two languages, giving a higher weight to competences in the dominant language. This 'higher weight' means that children that are more advanced in the dominant language are positioned more towards the right side of the spectrum (and therefore closer to the higher associated executive function performances) than children with average competences in both languages.

On the model the cognitive performance is illustrated by a straight line that increases in a linear fashion: the closer the line is to the right side of the spectrum (where theoretically the highly advanced, more or less balanced bilingualism can be found) the better the cognitive performance.

The Additive Model of the Bilingual Spectrum



Furthermore, there are several thresholds on the spectrum. On the horizontal axis in order to pass through the first threshold a highly advanced competence in the dominant language is necessary (which is underlined by Cummins' Developmental Interdependence Hypothesis 1979b). To pass through the second threshold, besides having high competence in a dominant language, a highly advanced level of language competence in a second language is also crucial.

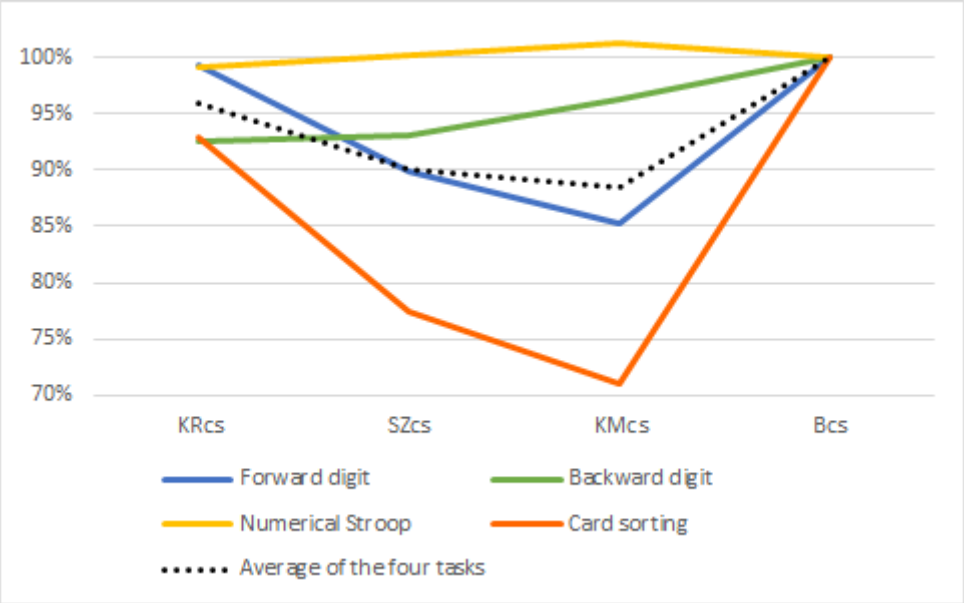
One of the main contributions of the additive model is that it enables the positioning of several groups with different levels of bilingual competence on a spectrum. It also helps in clarifying the expression "balanced bilinguals" that is often used in the literature and that could be, at least partially, at the origin of controversial reports regarding bilingual advantages in executive functions. The current study, instead of using this expression, refers to these children as ones that have highly advanced bilingual competence (usually a strong mother tongue base on which they built advanced competences in another language).

The bilingual spectrum can be approached from another perspective, one that is different from that described in the additive model, for example from the point of view of the complementary relation between languages and cultures that could draw the two languages and cultures (Hungarian and Romanian) in parallel with each other. A model built on this idea can

also be structured along a horizontal line which, this time, represents the spectrum of the sociolinguistic environment. For this, the groups' region of origin is used as a base to determine the extent to which the Hungarian and the Romanian languages are part of the environment. Taking this as a guideline, the group with the Romanian mother tongue (KRcs) takes up the part on the far left where the Romanian language represents the one highly developed dominant language (without any knowledge in the other language, in our case in Hungarian). This group is followed by SZcs, KMcs, then finally Bcs, this latter one on the far right of the spectrum.

Before presenting the model, first we present the results of the cognitive tasks organised by using this perspective:

Figure 2: The performance of the groups in the four non-verbal cognitive tasks



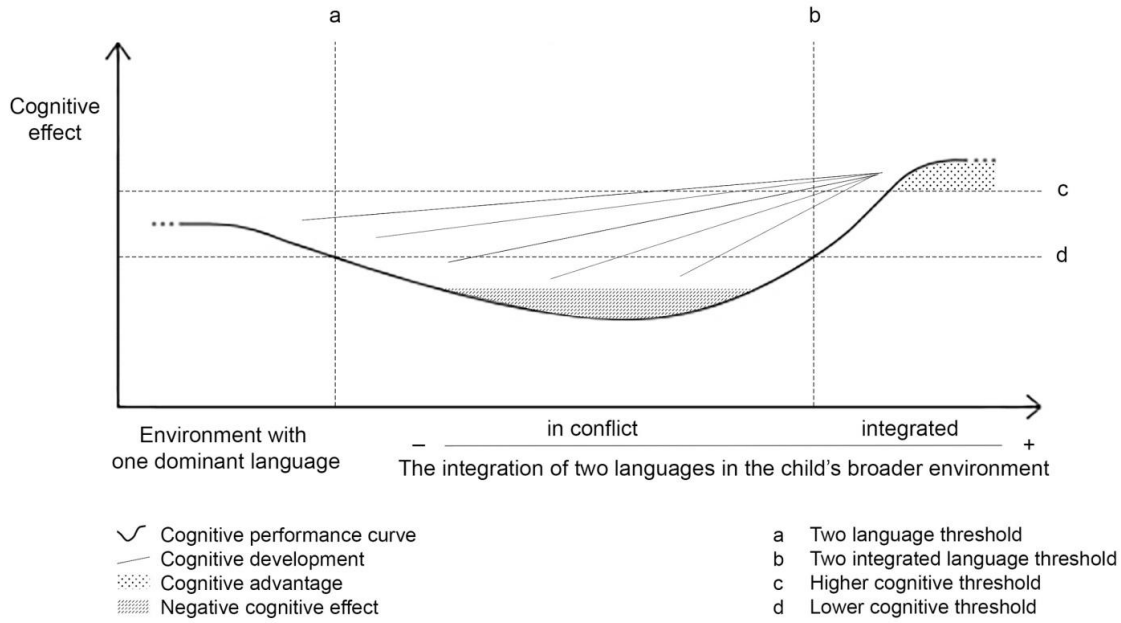
On the graph, like on the one above (Figure 1), the Bcs is the reference point. This group was chosen to be the reference group because it is the one that performs better than the other groups, sometimes tendentially, often significantly. Both from the illustration of the groups' results separately in the four cognitive tasks as well as together as the four tasks' average, we see that the curves denote a gradually decreasing direction from KRcs through SZcs until KMcs, and then suddenly start increasing to finish with Bcs. This curve is visible in the forward digit span (short term memory), and even more so in the Card Sorting (attentional control).

The Integrative Model of the Bilingual Spectrum

The innovation behind the model lies in its rationale which is not necessarily to illustrate the relationship between bilingualism and cognitive functions but rather to depict the sociolinguistic environment where it is either one language and culture or the integration of two languages and cultures that shape the child's cognitive development. The model aims to offer an alternative lense for the evaluation of the bilingualism experience and its possible cognitive benefits in children.

On the left side of the horizontal line there is an environment that is dominated by one language. Starting from the language threshold, besides the first (mother tongue) language the relevance of another gradually becomes more and more prominent as we approach the right side of the spectrum. From the two integrated language threshold onwards we find the linguistically and culturally integrated environment. Through this model we hypothesize that in lack of the appropriate integration of the languages, the gradual presence of the second one in the environment of the first might generate some conflicts. In a conflict situation the child might not have the opportunity to rely on a strong (mother tongue) language base while also feeling less inclination towards acquiring another (second) language which, ultimately, could even negatively affect the cognitive development. If, however, the environment creates conditions where the integration of two languages is possible, this could lead to cognitive benefits. A linear cognitive development can be witnessed when, even if not integrated, the two languages are not in conflict with each other.

The Integrative Model of the Bilingual Spectrum



As a summary, we can conclude that both models can be predictive of the child's cognitive performance in the light of the language knowledge levels and different degrees of competences. In the additive model a linear development is predicted based mainly on a high level of mother tongue language knowledge. According to this model, the higher the competence level in the two languages is, the bigger the positive effect on the attentional control component of the executive functions, thus the cognitive advantage depends on how highly advanced the bilingual competence is. In the integrative model the language competence is not considered to be the main aspect. Here, instead, another perspective is used: the environment of the child. We rendered the child's cognitive performance likely to be based on how well are the languages integrated in the environment. Here, the cognitive advantage is conditioned by the child's environment. The implications of the integrative model can be seen particularly with regards to cultural minority groups. The linguistic and cultural diversity within the environment might represent a great value and preserving such variety might lead to results beyond expectations.

Conclusions and perspectives of the study

Since many inferences can be made regarding the possible effects of bilingualism on the executive function components, an in-depth evaluation of the children's language competence would have been important. However, during data collection, the amount of time we

had at the schools for interacting with children was limited and therefore we decided to focus more on the cognitive tasks. We considered the teacher questionnaires to be sufficient in providing guidelines especially since the children's regions of origin already suggested the differences between the groups's language competences. Indeed, the questionnaires tended to confirm such differences. However, when discussing the bilingualism effect stemming from language competence, it would be important to base this on standard values. A more standard value would aid in better determining the specific levels or sections of the bilingual spectrum, at the same time enabling a more in-depth discourse about the relationship between language development and cognitive functions. Standard values would not only allow better comparisons among children, but also could help the replicability of the study.

The study can be regarded as a first step in the mapping of the relationship between cognitive functions and bilingual competence of Hungarian children with differing degrees of Romanian knowledge. In future, we recommend the repetition of the study using a bigger sample which could enable more in-depth evaluations with regards to the investigated variables. A separate group made up of only simultaneous bilinguals could aid us to understand better the performance of those children whose languages have already become somewhat automatic. In the current sample there have been some children from Kolozsvár and Brassó who acquired the Hungarian and Romanian languages simultaneously, however, their numbers is too few to be able to conclude anything significant from their results.

This study contributes to the literature by extending previous research to different linguistic groups and cultures (children with differing levels of Hungarian and Romanian competences). With this it makes wider generalizations possible.

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