Executive Functions in Bilingual Children: Is there a role for Language Balance?

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Abstract

As part of the ongoing debate regarding possible bilingual advantages in executive functions, the current study compared bilingual Russian-Hebrew speaking children from two age groups (preschool and sixth grade) with their monolingual Hebrew speaking peers, matched on socio-cultural background. Bilingual children's vocabulary knowledge in both languages was measured objectively as an index of proficiency, and children were classified as balanced or unbalanced bilinguals. Participants performed a flanker task, measuring both inhibitory ability and cognitive flexibility. The bilingual preschoolers were not advantaged over monolinguals, possibly as a result of proficiency profiles. The sixth grade bilinguals showed some advantages over monolinguals in inhibition, but these were limited to the balanced bilinguals, who were able to achieve and maintain comparable levels of proficiency in their two languages. These findings suggest that only the demands posed by balanced bilingualism and strong competition between the two languages, might lead to EF advantages, specifically in inhibition.

Bilingual children master the use of two languages at the same time that their cognitive system develops. Executive functions are the cognitive abilities that allow people to manage the complexities of daily life, including the ability to focus attention, ignore distractions, and shift flexibly between changing demands in the environment. There is growing research interest on the possible connection between bilingualism and executive functions (EF).

A substantial body of research supports the notion that bilingualism may confer EF advantages for children and adults (Kapa & Colombo, 2013; Pelham & Abrams, 2014; for a review see Kroll & Bialystok, 2013), but conflicting data reporting no evidence for bilingual advantages is also growing (Antón et al., 2014; Duňabeitia et al., 2014; Gathercole et al., 2014; Paap & Greenberg, 2013). The current study reports new findings in this domain, while focusing on an issue that has received less attention in the literature, namely the degree of balance between bilinguals' languages. Further, we investigated two age groups, pre-schoolers and sixth graders, who speak the same language combination, Russian and Hebrew, using a task that taps both inhibition and shifting abilities. Monolingual and bilinguals were well matched on background socio-economic factors. Thus, the study provides a comprehensive contribution to the current knowledge.

Executive functions are complex cognitive processes that serve to maintain goal directed behavior. They involve selective attention and inhibitory control in order to suppress automatic responses in situations where these may be maladaptive (Bialystok 1999; Diamond, 2013). Executive function processes play an important role in everyday functions such as developing strategies for handling different situations, cognitive flexibility, perseverance and the ability to shift from one activity to another. Various definitions and taxonomies of EF have been put forth (Barkley, 1997; Jurado & Rosselli, 2007; Miyake & Friedman, 2012), but there are three main widely accepted components of EF: inhibition, updating (working memory) and shifting (cognitive flexibility) (Diamond, 2013; Miyake & Friedman, 2012).

These components are of high relevance for managing several languages in one's mind. Research has shown that when one language is in use, the other one is activated as well, and bilinguals need to use inhibition in order to suppress the competing language and to choose the intended language (Green, 1998; Kroll, Bobb, Misra & Guo, 2008). Thus, when a bilingual speaker plans an utterance, words and grammatical structures are activated in both languages, and ultimately the language of production is determined by control mechanisms, that inhibit activated representations in the non-target language. Similarly, when a bilingual encounters spoken or written linguistic input for comprehension, the lexicons of both languages might become activated, and again competition must be resolved, allowing the system to converge on the intended word in the relevant language. Contrary to the subjective feeling of many proficient bilinguals, there is abundant empirical evidence that the bilingual language system is fundamentally non-selective for language, (Christoffels, Firk & Schiller, 2007; Rodriguez-Fornells et al., 2002; Shook & Marian, 2012).

Thus, to the degree that bilinguals rely on the domain general component of inhibition to manage competition between their two languages, then such additional use might lead to improved inhibitory control abilities, even outside the language domain. In the current study we examine the hypothesis that bilinguals who are more balanced in their proficiency across the languages they speak have achieved greater proficiency at managing such language competition and interference, which may then lead to improve inhibitory control abilities, when compared either to less balanced bilinguals or to monolinguals.

In addition to managing language competition, children and adult bilinguals also engage in flexible language switching, depending on circumstance and interlocutors (Gollan & Ferriera, 2009; Hervais-Adelman, Moser-Mercer & Golestani, 2011; Meuter & Allport, 1999). As with managing language competition, such flexible language use likely relies, at least to some degree, on the domain general executive function of shifting (Prior & Gollan, 2011; 2013). The degree of language switching a specific bilingual engages in is influenced by various factors, including sociolinguistic norms of the language community, topic of discussion and proficiency in the two languages (Gollan & Ferreira, 2009; Green & Wei, 2014). Again, following the same logic outlined above, if bilinguals, by virtue of engaging in language switching, rely to a greater degree than monolinguals on domain general shifting, this again might lead to improved performance in this domain (Prior & MacWhinney, 2010).

Thus, we can see that the EF components of inhibition and shifting are in constant use by bilinguals to support fluent language use, which leads to the proposal that bilingual language experience might benefit executive functions more generally, even outside the domain of language (Kroll & Bialystok, 2013; Prior & Gollan, 2011). Such bilingual advantages have been investigated in children of various ages, young adults and older adults, and in the domains of inhibition and of shifting. For the sake of brevity, the remainder of the introduction will focus mainly on findings regarding bilingual children, the population investigated in the current study.

Inhibition

As noted above, the data on bilingual children's advantage on EF tasks over their monolingual peers is inconsistent and even controversial. Most of the research on bilingual advantages in children has focused on inhibition. Bialystok (1999) compared Chinese-English bilinguals to monolingual English speakers, from two different age groups. The younger group included children between the ages of 3.2-4.9 years, and the older group included children between the ages of 5-6.3 years. The task in this study was the Dimensional Change Card Sort (DCCS; Fry, Zelazo, & Palfai, 1995). This test puts two different rules into conflict. The child has to sort the same deck of cards by two different dimensions, first by color and then by shape, with the order counterbalanced across children. When the child is instructed to switch the sorting rule, he has to inhibit the tendency to act according to the previously relevant dimension. The results in this study showed a significant advantage for bilinguals over monolinguals, in both age groups.

In a series of studies, Martin-Rhee and Bialystok (2008) again reported a clear and significant advantage for bilingual preschoolers, who spoke English and an additional language, mean age of 4.5 years, over monolingual peers. The advantage appeared in inhibitory control tasks which require children to ignore an interfering distractor and remain focused on the target stimulus, or to overcome a pre-potent behavioral preference to act differently. These findings add to previous ones, by identifying specific aspects of inhibition that might be enhanced by bilingualism.

Bialystok and Viswanathan (2009) also reported clear advantages of bilinguals over monolinguals in more than one dimension of executive control, using an adaptation of the anti-saccade task, where in critical conditions participants need to ignore a spatially salient cue and direct their gaze in the opposite direction. Ninety 8-year olds participated in the study, from three groups: monolinguals in Canada, bilinguals in Canada, and bilinguals in India (bilinguals spoke English and an additional language). The bilingual children were faster than monolinguals in conditions based on inhibitory control and cognitive flexibility, though there was no significant difference between groups in response suppression or on a control condition that did not involve executive control. Interestingly, in spite of cultural and socioeconomic differences, both bilingual groups showed advantages in EF measures over the monolingual group.

Another study supporting the positive effect of bilingualism on EF, and specifically on its component of inhibitory control, was reported by Poarch and Van Hell (2012). They examined inhibitory control processes in three groups of bilinguals and trilinguals versus second language learners and monolinguals who differed in language learning background. German 5- to 8-year-old second-language learners of English, German– English bilinguals, German–English–Language X trilinguals, and 6- to 8-year-old German monolinguals performed the Simon task and the Attentional Networks Task (ANT). Bilinguals and trilinguals showed enhanced conflict resolution over monolinguals and over the group of second language learners. This research corroborates previous findings (e.g. Bialystok &

Viswanathan, 2009, described above) that suggests that the enhanced EF of bilinguals might be ascribed to the continuous inhibitory control processes necessary to resolve competition between two (or possibly more) languages.

Carlson and Meltzof (2008) also found a significant advantage for early bilingual Spanish-English preschoolers over monolinguals immersed in a bilingual environment (English-Japanese) and monolingual peers in tasks that call for managing conflicting attentional demands. However, these effects were significant only after background differences between the groups in SES were controlled for.

Finally, and of specific relevance to the present study, Bialystok & Barac (2012) examined 2nd and 3rd grade bilingual children immersed in a bilingual education setting, and reported that inhibition ability as measured in a flanker task was positively related with degree of balance between the two languages and by length of time spent in the immersion program (see also Tse & Altarriba, 2014). The current study also utilizes a flanker paradigm, and compares balanced and unbalanced bilinguals.

However, several studies examining the possibility of bilingual advantages in children have not found significant difference. Thus, Morton and Harper (2007) recruited bilingual (English-French speakers) and monolingual (English speakers) 6-7 year old children, from identical cultural and socioeconomic (SES) backgrounds. After controlling for differences in SES and cultural background, they found no advantages for bilinguals over monolinguals in a Simon task, in contrast to previous studies.

Two recent large scale studies have also failed to find differences. Duňabeitia et al. (2014) compared a large sample of monolingual Spanish and bilingual Spanish-Basque speaking school children, ages 8-13, using a classic and a numeric Stroop task. They found no difference between the two language groups in their inhibitory control abilities in either of the tasks. Antón et al., (2014) also compared monolingual Spanish and bilingual Spanish-Basque children ages 7.5-11.5 on the ANT task, and found no differences between the groups in any measures of performance. Similarly, Gathercole et al. (2014) examined young children and adolescents in Wales, with a wide age range from 2-16 years of age. They compared bilingual speakers of English and Welsh with monolingual English speakers, and did not find evidence for any systematic differences between the groups in a Simon task.

Hilchey and Klein (2011) reviewed the empirical data from the literature on nonlinguistic interference tasks in order to assess the validity of the proposed bilingual inhibitory control advantage, across different age groups. They concluded that bilinguals do enjoy an executive processing advantage that is likely observable on a variety of cognitive assessment tools but that is most often not apparent on experimental tasks of nonlinguistic inhibitory control processes. The authors state that there are neurocognitive differences between bilinguals and monolinguals, but claim that it is yet poorly understood how these differences translate into behavioral difference and whether these differences reflect bilingual advantages (Hilchey & Klein, 2011). In a more recent review (Hilchey, Klein, & St. Aubin, 2015) the authors again report conflicting findings regarding bilingual advantages in executive function in children. Thus, the question has not yet received a definitive answer in the extant literature.

Shifting

Although the shifting abilities of bilingual children compared to monolinguals have received less attention in the literature, here again there are conflicting findings. Thus, several studies have documented advantages for bilingual children over monolinguals in the domain of shifting and cognitive flexibility. Bialystok (2010) examined 6-year-old monolingual English speakers and bilinguals that speak English and another language at home, using the Trail Making task (parts A and B), which requires task shifting, planning, working memory, attention, and inhibition. In part A, the child needs to draw a continuous line through numbers (1-25) in a sequential order. In part B, the child is instructed to alternative between numbers and letters, also in a sequential order (1-A-2-B-3-C….). The results showed that the bilingual children were faster and more accurate than the monolinguals in both parts.

Barac and Bialystok (2012) also investigated the abilities of monolingual and bilingual 6 year old children to flexibly shift between domains using a task switching paradigm. Participants were either monolingual English speakers, or bilingual speakers of Chinese-English, French-English or Spanish-English. All three bilingual groups outperformed the monolinguals in that they had reduced costs for performance in a mixed task block relative to a simple consistent-task block.

In contrast, the study described above by Gathercole et al. (2014) also included a measure of shifting or flexibility, namely a card sorting task. In contrast to the above results, the authors did not find any differences between bilinguals and monolinguals in this task, in young children, adolescents or older adults (age range from 3 to 90 years of age).

Therefore, it seems that for both domains of executive function, there are inconsistencies in the literature regarding the effect of bilingualism on performance.

Balance and proficiency

Executive control of bilinguals can vary across different bilingual populations depending on age, environmental factors (SES, family, culture), intelligence and language proficiency, patterns of language use, distance between languages, sensitivity of the EF tests and more (Valian, 2015; Baum & Titone, 2014). Thus, it may not be surprising that bilingualism has been associated with enhanced EF in some studies but not others (Kaushanskaya & Prior, 2015). One critical component in this respect might be the degree of bilingualism, or balance between the languages of bilinguals.

General language proficiency is one of the factors that might have a direct influence on both bilingualism and EF. Individual differences in language experience (both bilingual and monolingual) might affect EF development. There are few studies that address the factor of general language proficiency and EF. In one study, Okanda, Moriguchi, & Itakura (2010) examined the relationship between second language experience and cognitive shifting in young children, aged 3-5.5. One monolingual group was matched to the bilingual group on verbal ability and the other group was matched by chronological age but had higher verbal ability. The results showed that the groups of children who were bilingual and monolingual with higher verbal ability performed the task significantly better than matched monolingual children. This finding supports the idea that language experiences may affect cognitive set shifting in young children.

In an earlier study by Bialystok and Majumder (1998) somewhat older 8 year old balanced bilinguals showed better performance on non-linguistic tasks requiring EF than both unbalanced and monolingual groups. These results indicate that differing degrees of bilingualism might arguably have different effects on cognitive abilities. In a relevant study examining the shifting abilities of adults, Prior and Gollan (2011) showed that balanced bilinguals were advantaged over unbalanced bilinguals and monolinguals in measures of task- and language-switching, but contrasting findings were reported in a recent study that also compared more and less proficient balanced and unbalanced bilinguals in a range of EF tasks (Rosselli, Ardila, Lalwani & Vélez-Uribe, 2015). The study described above by Poarch and van Hell (2012) also found that EF advantages were limited to higher-proficiency and more balanced bilingual children, but did not extend to second language learners (see also Carlson & Metlzof, 2008).

Results supporting the proposal that more balanced bilingualism could lead to more efficient EF processes return to the proposal expounded above. Specifically, individuals who have well-matched proficiency in their two language systems have arguably had more successful experience in using inhibitory mechanisms for managing language interference. In addition, balanced bilinguals are likely to switch between languages more often, again leading to greater use of flexible shifting abilities. If indeed this is the case, then more balanced bilinguals should exhibit more efficient EF when compared to less balanced bilinguals and monolinguals. This is the central question examined in the current study, which has only been examined in several previous studies.

In sum, the current literature shows a complex pattern of sometimes conflicting results. Whereas some studies have demonstrated advantages of bilingual children over monolingual peers in various aspects of EF, other studies do not find evidence supporting such advantages. Current discussions identify various explanations for these discrepancies, including participant matching, sensitivity of tasks and language proficiency and use (Valian, 2015), or even a publication bias (de Bruin, Treccani & Della Salla, 2015; but see Bialystok, Kroll, Green, MacWhinney & Craik, 2015 for a reponse). The present study addresses some of these issues, as described below.

The present study

The present study aimed to provide additional empirical evidence to the debate around possible bilingual advantages in EF. Specifically, we simultaneously investigated the two main components of EF previously associated with bilingualism – inhibition and cognitive flexibility. To this end, we selected a well-established experimental paradigm that allows tapping both processes of inhibition and processes of cognitive flexibility within the same task. Besides further exploring the influence of bilingualism on EF, we examined whether bilingual EF performance is influenced by balance between languages (or degree of bilingualism). Thus, we carefully quantified the relative proficiency of our participants in their two languages, to investigate whether the degree of balance achieved might be a contributing factor to putative executive function advantages.

We also controlled for other factors that might have confounded some of the previous research in this domain. All of the participants in the current study came from middle socio-economic background, which allowed us to control for possible background influence. The participants came from the same cultural background, and all bilingual groups spoke the same two languages – Hebrew and Russian. The languages of the research belong to different families and are represented by different scripts. Hebrew is a Semitic language while Russian is a Slavic language and there is minimal overlap between them (Schwartz, Kozminsky, & Leikin, 2009). This makes the linguistic knowledge more different and the written systems more distant from each other; therefore EF resources might be involved to a higher extent in allowing proficient bilingual performance. Thus, we tested a population only rarely examined in the context of bilingual advantage studies (Mor, Yitzhaki-Amsalem, & Prior, 2014), namely, bilingual speakers of Hebrew and Russian, to broaden the diversity of populations examined in this context.

Another goal of the study was to directly compare two age groups on well matched tasks. We included both preschoolers and advanced elementary school students (11 years old). Whereas the younger age group has received a fair amount of research attention in this domain, fewer studies have examined the EF abilities of older monolingual and bilingual children (though three recent studies have now included this age group Anton et al., 2014; Dunabeitia et al., 2014; Gathercole et al., 2014). Inclusion of this age group might shed new light on the developmental trajectory of EF among bilinguals compared to monolinguals. Previous research has shown that EF skills are the latest to develop in the entire attention network, and their stabilization lasts until late teens and even adulthood (Diamond, 2013). At the age of eleven both the development of the EF and of the language domain reach certain stability, therefore it is interesting to examine whether there are any differences in EF between groups at this age.

To summarize, there were two main research questions addressed in the current study. First, can we find evidence for a bilingual advantage in the executive functions of inhibition and shifting compared to monolinguals in the study population? The second research question was focused on the possible role of language balance and L1/L2 proficiency in bilingual EF abilities?

Experiment 1 – Pre-school children

Method

Participants

The population investigated in the present study was second generation immigrants from the former Soviet Union in Israel. This immigrant community is the largest sub-cultural community in Israel. It comprises approximately 20% of the country's total Jewish population and is characterized by high levels of education and a well-organized Russian-Hebrew speaking socio-cultural milieu (Horowitz, Shamai, & Ilatov, 2008). The first generation of this immigrant group is characterized, overall, by relatively rapid and successful acquisition of Hebrew compared to other waves of immigration (Olshtain & Kotik, 2000).

Another distinctive characteristic of these Russian-Hebrew speaking immigrants is appreciation of their culture of origin, which leads to high levels of heritage language (Russian) maintenance, as well as promoting its acquisition by their children, including those who were born in Israel (Kopeliovich, 2011). To this end a group of immigrant teachers established the Union of Immigrant Teachers - Igum – in 1992. This organization focuses, among other things, on the foundation of Russian-Hebrew speaking bilingual preschools in Israel. It is noteworthy that even though the Igum bilingual preschools are private institutions, they function under the supervision of the Israeli Ministry of Education. Teachers use the same curriculum as in the Hebrew-speaking monolingual preschools, adapted to their pedagogical approaches and needs.

Some of the bilingual children in the current study were recruited from two bilingual preschools included in the Igum network - "Radost" ("Happiness") and "Solnyshko" ("Sun"), located in northern Israel. Both preschools were established in adjacent neighborhoods approximately 10 years ago and have a similar pedagogical and language policy (First Language First model), which is applied throughout the Igum network.

A total of 60 Russian-Hebrew bilingual and Hebrew monolingual children, 4-5 years old from four pre-schools participated in the study. Two of the pre-schools were Russian-Hebrew bilingual pre-schools that aim to promote L1 (Russian) maintenance and L2 (Hebrew) acquisition. Up to age 3 children are exposed to Russian (L1) with accordance to the "first language first" approach. From age 3 to 4 there was intensive immersion in Hebrew conducted by native Hebrew speaking teachers. Thus, Hebrew is used for most of the classroom time (60-70%). The other two pre-schools were monolingual and provided exposure only to Hebrew. Bilingual children (n=40) were recruited from both education settings and monolingual children (n=20) were recruited from the monolingual pre-school. All children in the study were from middle class families and their parents had a relatively high educational level (see Table 1 for participant characteristics).

Parents of all participants gave informed consent for their child's participation. After the degree of bilingualism and socioeconomic level for every child were determined (see the Tasks section), the bilingual participants were classified as being either balanced or un-balanced bilinguals. Bilingual children were considered balanced if they had comparable levels of performance on the Hebrew and Russian vocabulary tests, whereas unbalanced children had wider disparities between Russian and Hebrew vocabulary.

Of the original participants, 3 bilingual children and 2 monolingual children were excluded because they failed to complete all experimental tasks. Three additional children initially recruited as bilinguals were excluded because of minimal vocabulary knowledge in either Russian or Hebrew. Finally, 2 bilingual children and 2 monolingual children were excluded in order to match groups on parental education and age. The remaining participants were divided into three groups: balanced bilinguals (n=16), unbalanced bilinguals (n=16) and Hebrew-speaking monolinguals (n=16).

Table 1. Social, linguistic and cognitive characteristics of the participants (n=48)

	Monolinguals *n*=16 *M (SD)*	Unbalanced Bilinguals *n*=16 *M (SD)*	Balanced Bilinguals *n*=16 *M (SD)*
Age (months)	58.6 (3.7)	56.4 (2.3)	57.6 (2.7)
Maternal Education (years)	14.9 (1.3)	14.7 (0.8)	14.5 (1.1)
Receptive Vocabulary (number correct)	H: 44 [a] (8.2)	H: 28.1[b] (11.8) R: 53.4 [a] (17.1)	H: 33.4[b] (9.2) R: 37.5 [b] (6.6)
Expressive Vocabulary (number correct)	H:36.6 [a] (7.0)	H: 12.4[b] (13.6) R: 20.1 (10.3)	H:21.8 [b] (9.9) R: 15.8 (9.2)
Raven (standard score)	102.6 (12.5)	97.8 (6.3)	96.1 (5.9)

H – Hebrew R – Russian

Means in the same row with different superscript letters differ from each other significantly at p<.01.

Tasks

General ability

Raven's Colored Matrices (Raven, Raven, & Court, 1976). In this test, the participant has to match one of six graphic patterns with a visual array. The 36 items are presented in three sets of 12, in increasing order of difficulty within each set. Each correct response is given 1 point. The maximum score is 36.

Vocabulary measures

Two vocabulary tests were carried out in order to provide a measure of the receptive and expressive vocabulary knowledge of the children. Bilingual children's vocabulary was assessed in both languages.

Receptive vocabulary - Peabody Picture Vocabulary Test (PPVT; Dunn, 1965) (Nevo, 1979, Hebrew version; after Dunn, 1965). Adapted versions in Hebrew (Nevo, 1979) and in Russian (Schwartz, 2006) were used to assess receptive vocabulary. The test required children to indicate which of the four pictures matched a spoken word. Children were given 1 point for each correct trial, and the test was stopped after six sequential incorrect responses. The full test includes 110 items.

Expressive vocabulary was measured using a test based on the principles of the MacArthur Communicative Development Inventory (Fenson et al., 1991), and conformed to Hebrew and Russian (Schwartz, Leikin, Shaul, Fuhrman-Engel, & Skarbovsky, 2007). The test included 10 semantic categories (animals, transportation, electrical devices, musical instruments, clothes, toys, furniture, fruit and vegetables, body parts and cooking utensils), which contained a total of 34 items. These items were graded by a pre-school teacher and speech therapists according to their frequency of use by pre-school children, aged 3 to 4 years. The children were asked to name the pictures. Each picture was scored in the following way: 2 points for the correct answer, 1 point for an answer from the same semantic category (e.g., coat instead of shirt), 0 points for an incorrect answer. The maximum score was 68. Internal consistencies for the Hebrew and Russian versions (alpha cronbach) were .92 and .90, respectively.

Language balance

In order to distinguish between balanced and unbalanced bilinguals (Luk & Bialystok, 2013; Barac & Bialystok, 2012), we calculated the number of correct answers in the vocabulary tasks in both languages, and then subtracted the performance in Russian from the performance in Hebrew, for expressive and receptive vocabulary separately. These gaps were then averaged, and the absolute value of this average served as the measure of balance, on which we conducted a median split. Children designated as balanced bilinguals had gaps in performance below 13.5 (mean=7.6, SD=4.1, range 0-13.5), and children designated as unbalanced bilinguals had performance gaps of 16.5 points or more (mean=26.6, SD=8.4, range 16.5-45.5). Note that children could show higher performance in either Hebrew or Russian.

Executive functions measure

Flanker fish task (Schonert-Reichl et al., 2015). In this task, the participant has to focus on one stimulus and ignore distracting stimuli. The stimuli were presented in three different blocks (two single blocks and a mixed block). In each block, the participant has to hold one rule in mind and to act accordingly. In the first single block (with blue fish), participants were instructed to attend to and respond based on the direction of the centered target and ignore peripheral flankers (18 trials). In the second single block (with pink fish), participants were instructed to attend and to respond based on the peripheral targets and ignore the centered distracter (18 trails). Both single task blocks contained congruent trials (the target and the distracters pointing in the same direction) and incongruent trials (the target and distracters pointing in opposite directions), as well as neutral trials (a single fish with no flankers) (see Figure 1). However, neutral trials were not included in any of the analyses, because they differed visually from both the congruent and incongruent trials – only a single fish was included in the display.

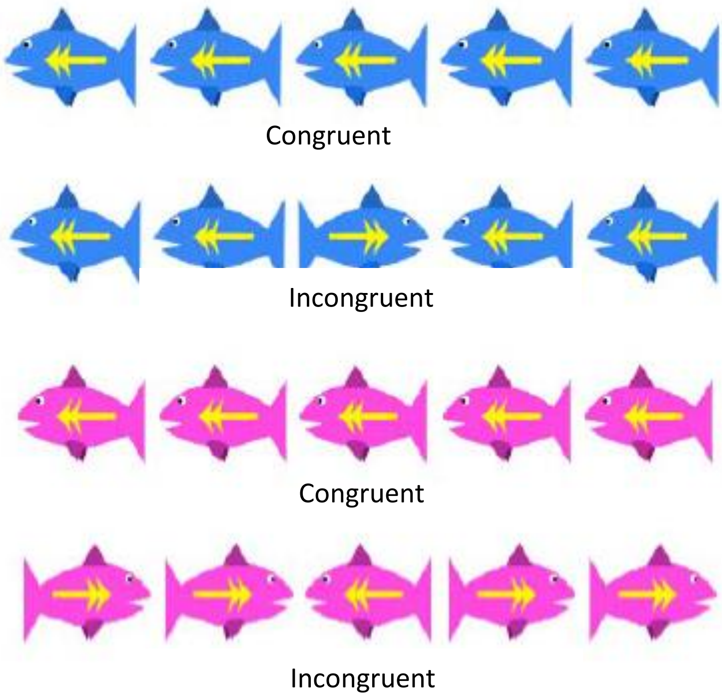

Figure 1. The flanker fish task.

The third mixed block included both blue target displays (focus on central target) and pink target displays (focus on peripheral targets) such that the participant has to hold both of the rules in mind and to act respectively on each trial. Mixed blocks, therefore, included both repeat trials (instantiating the same rule as in the previous trial) and switch trials (when there was a rule change, for example, from a blue display to a pink display). There were two mixed blocks, each including 20 trials, equally distributed among switch and repeat trials. The mixed blocks were followed by two additional single blocks, one blue and one pink (18 trials each), in order to control for practice effects.

The task was displayed on a laptop computer with earphones attached, on a 14' computer screen, in the form of a computer game. Five fish appeared on a screen in a row (one in the center and two on each side), with an arrow inside pointing in the same direction as the fish. The direction of the central fish (of both the fish and the arrow) could either be congruent with the four flanker fish or different from them. Participants were instructed to press a button according to the direction of the central fish if the stimuli were blue or according to the direction of the flanker fish if the stimuli were pink. Each correct or incorrect answer was followed by auditory feedback, expressing joy or disappointment, so the participants could know whether their response was correct. Accuracy and reaction time (RT) were recorded. Each block was preceded by 4 practice trials, which were repeated if the participant did not complete them successfully. There was no time limit for responding.

Dimensional Change Card Sort Task (DCCS; Zelazo, Reznick, & Pinon, 1995). This test puts two different rules into conflict. Stimuli include 8x8cm cards which displayed a picture of a red or blue flower or car (10 cards for each image). Children were first instructed to sort cards according to one dimension (either color or shape, counterbalanced across participants) and then instructed to sort according to the other dimension. Accuracy on the post-switch sort was an indication of cognitive flexibility abilities, as it required children to overcome the tendency to continue sorting according to the previously relevant dimension.

Procedure

Each child was assessed individually in a quiet room at the school. To avoid fatigue, every test session lasted no more than 20 minutes. The children were seen in three sessions. In the first session, we administered the receptive vocabulary test, and the DCCS task. In the second session, we administered the expressive vocabulary test and Flanker Fish task. In the third session we administered the Raven's Colored Matrices (Raven, Raven, & Court, 1976).

The Hebrew tasks were administered by a native Hebrew-speaker, and the Russian tasks by a native Russian-speaker. The instructions for each testing session were always given in the language being tested, and before performing each task children received several examples, to ensure the task was understood. The research assistants were Master's degree students.

Results

Participant characteristics are presented in Table 1. A one-way ANOVA showed significant differences between groups in Hebrew receptive vocabulary, $F(2,43)=10.4$, $p<.001$, and post-hoc bonferroni comparisons showed that both bilingual groups had lower scores than monolinguals (unbalanced bilinguals $p=.01$, balanced bilinguals $p<.001$) but did not differ from each other. There was also a significant main effect of group in Hebrew expressive vocabulary, $F(2,43)=20.3$, $p<.001$, and again both bilingual groups had significantly lower scores than monolinguals (both $p<.001$), and unbalanced bilinguals had marginally lower scores than balanced bilinguals ($p=.053$). As for Russian vocabulary, unbalanced bilinguals had larger receptive vocabulary scores than balanced bilinguals, $F(1,30)=11.5$, $p=.002$, but the groups did not differ in expressive vocabulary ($p=.23$). Finally, one-way ANOVAs showed no significant differences across the three groups in age, ($p=.12$), Raven score ($p=.24$), or maternal education level ($p=.2$).

Several considerations guided our analysis of children's performance on the Flanker Fish task. First, as stated in the task description, neutral trials from the single task blocks were not included in the analyses, because they difference visually from congruent and incongruent trials. Second, because of the relatively small number of trials (dictated by children's limited capacity for engaging in a longer task), we could not include all factors in the analysis of the mixed blocks (central/peripheral and congruent/incongruent in addition to repeat/switch), as that would have resulted in a very small number of trials per condition. We therefore decided to analyze the inhibition effects and the shifting effects separately, as detailed below.

Inhibition

Inhibitory abilities were examined by comparing performance in congruent and incongruent trials from the two single task blocks (central target and peripheral target). We analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with trial type (congruent, incongruent) as a within participant factor and group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor (Table 2).

The main effect of congruency was significant (in RT: $F(1,45)=43.5$, $p<.001$, $\eta^2=.49$; in Acc: $F(1,45)=70.2$, $p<.001$, $\eta^2=.61$), as all participants were faster and more accurate when responding to congruent than to incongruent trials. The main effect of language group was significant for reaction times, $F(2,45)=5.4$, $p=.008$, $\eta^2=.19$, and post-hoc bonferroni comparison showed that monolingual children were significantly faster than unbalanced bilinguals (p=.006), but that the balanced bilingual children did not differ significantly from monolinguals (p=.14) or unbalanced bilinguals (p=.67). The main effect of language group was not significant in accuracy (F<1), demonstrating that all participant groups were equally accurate. The two-way interaction was not significant (in RT: $F(2,45)=1.54$, $p=.22$; in Acc: F<1), as the three participant groups incurred similar costs when responding to incongruent versus congruent trials.

Inhibitory ability was also examined by investigating children's ability to inhibit a previously relevant rule (central target) and respond according to a newly instantiated rule (peripheral target), by comparing performance in the two simple blocks. Thus, we analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with target type (central, peripheral) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. The main effect of target type was not significant in accuracy, $F(1,45)=1.00$ $p=.32$, but was significant in RTs, $F(1,45)=5.7$, $p=.021$, $\eta^2=.11$, because participants were faster in responding to peripheral targets than to central targets. We believe this is the case because in fact in the peripheral target condition there were 4 targets and one distractor, whereas as in the central target conditions there was one target and 4 distractors. The main effect of language group was not significant in accuracy ($F<1$) but was significant in RTs, $F(2,45)=5.4$, $p<.008$, $\eta^2=.19$, with monolingual children performing faster overall. In this analysis, the two-way interaction was marginal in the analysis of RTs, $F(2,45)=2.9$, $p=.063$, $\eta^2=.12$ and was not significant in accuracy, $F(2,45)=1.6$, $p=.21$. Despite the marginally significant interaction, examination of Table 2 shows that whereas balanced bilinguals and monolinguals showed similar slowing in response time when comparing the central to the peripheral target (With discrepancies of 230 and 225 ms, respectively), unbalanced bilinguals were especially slower in responding to central than peripheral targets (a discrepancy of 1009 ms).

Shifting

Children's facility in mental shifting was examined by comparing performance in the single task blocks (central and peripheral target) with their performance in the mixed task blocks. Thus, we analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with block type (single, mixed) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor (Table 2).

The main effect of block type was significant (in RT: $F(1,45)=14.9$, $p<.001$, $\eta^2=.25$; in Acc: $F(1,45)=23.4$, $p<.001$, $\eta^2=.34$), because all participants were faster and more accurate in single task than in mixed task blocks. The main effect of language group was not significant (p=.18 for RT and p=.61 for Accuracy), and the two way interaction was not significant (p=.32 for RT and p=.21 for accuracy).

Finally, as an additional measure of shifting, we compared performance on repeat and switch trials within the mixed blocks. Thus, we conducted a two-way repeated measures ANOVA with trial type (repeat, switch) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. The only a significant effect was a main effect of trial type in RT, $F(1,45)=10.95$, $p=.002$, $\eta^2=.19$ because median responses were faster in repeat trials than in switch trials. All remaining effects and interactions were not significant (all *p*s>.16).

Table 2. Median RT (SD) and accuracy (SD) of responses in the Flanker Fish task, by block, target location and congruency

		Single Task Blocks					
		Central Target		Peripheral Target		Mixed Blocks	
Groups		Congruent	Incongruent	Congruent	Incongruent	Repeat	Switch
Monolingual	RT	1708 (724)	2390 (1452)	1465 (475)	2183 (903)	1947 (843)	2281 (1085)
	Acc	92% (14)	77% (27)	84% (17)	65% (26)	82% (17)	85% (15)
Balanced	RT	2213 (868)	2846 (891)	1883 (450)	2710 (683)	2092 (435)	2234 (681)
Bilingual	Acc	91% (15)	73% (18)	94% (10)	79% (16)	87% (10)	83% (14)
Unbalanced	RT	2335 (1012)	4209 (2625)	1888 (382)	2637 (1023)	2230 (703)	2483 (570)
Bilingual	Acc	91% (15)	72% (25)	89% (15)	73% (22)	81% (17)	78% (19)

DCCS task: In order to examine the effect of changing the sorting dimension, we compared performance of children from the three language groups on pre-shift and post-shift sorting accuracy (number of errors) and total RT, by language group. None of the effects in the accuracy analysis were significant, namely participants from all three groups were equally accurate in sorting the cards according to the first and the second rule (all p’s>.3). In the analysis of total RT, only the main effect of language group was significant, $F(2,44)=4.56$,

$p<.05$, $\eta^2=.17$. Post-hoc tests showed that monolinguals were significantly faster than unbalanced bilinguals (p<.05), and the balanced bilinguals did not differ significantly from either group (both p>.16). Due to the ceiling effect in accuracy, we believe that the DCCS task was quite easy for the children in the current study, and perhaps not sensitive enough to reveal meaningful group differences (see Table 3).

Table 3. Errors and total RT (in seconds) for pre- and post-shift sorting in the DCCS, by language group.

	Monolinguals		Balanced Bilinguals		Unbalanced bilinguals	
	RT	Errors%	RT	Errors%	RT	Errors%
Pre-Shift	51 (17.7)	1 (2.7)	66 (19.3)	1 (2)	77 (25.7)	2.7 (7.9)
Post-Shift	50 (15.7)	.6 (1.7)	63 (26.9)	4.7 (7.6)	68 (26.8)	2.7 (9.0)

Experiment 2 – Sixth Graders

Method

Participants

Ninety five 6th grade students from five elementary schools in the north of Israel participated, 52 *bilinguals* (Russian as L1 and Hebrew as L2) and 43 *monolinguals* (Hebrew L1) (Table 4). The schools were characterized by a similar middle socio-economic (SE) index. Based on classroom teacher reports and existing diagnostics, only children without learning disabilities participated in the study. Monolingual children studied English as a part of their school program, but they were considered monolinguals because they were still in the very early stages of second language acquisition. All children had started studying English in the 4th grade (two years prior to the time of study). At the time of study they were still acquiring basic decoding and reading skills, and had very limited vocabularies.

Similarly to the participants in the Experiment 1, the bilingual children were from families of Russian immigrants, who spoke Russian as their first language and had immigrated to Israel before second grade. According to parental reports, bilingual children in the current study had been exposed to Hebrew for 4-10 years. Russian was their home language although Hebrew was the primary language used outside of the home. Parents gave informed consent to their children's participation in the study. Additionally, parents of bilingual children completed questionnaires and reported the date of arrival in Israel and ratings of language dominance at home. The Russian–Hebrew speaking parental reports regarding language practice at home and in the immediate environment described the following: communication between children and grandparents occurred in Russian, communication between parents and children was mostly in Russian, between siblings communication was mainly in Hebrew for older siblings and in Russian for younger siblings and between friends was mostly in Hebrew but with Russian-speaking friends was sometimes in Russian (these reports were also corroborated by a child-filled questionnaire, see Table 5 below).

Of the original sample, 1 monolingual child was eliminated due to incompletion of the computerized EF task. Four children initially categorized as bilinguals were also eliminated – 2 due to very limited knowledge of Russian, and 2 due to incompletion of the computerized EF task. Thus, the final sample included 42 monolingual and 48 bilingual children.

Similar to the procedure described for the pre-school children, language balance was determined by vocabulary tests in Russian and Hebrew (Table 4). We calculated the number of correct answers in the vocabulary tasks in both languages, and then subtracted the performance in Russian from the performance in Hebrew. The absolute value of the gap served as the measure of balance, on which we conducted a median split. Children with difference of less than 10 points ($p \leq 10$) were considered *balanced* bilinguals, and children with difference of more than 10 points ($p \geq 10$) were considered *unbalanced.* This division resulted in two subgroups: 21 balanced bilinguals with similar oral vocabularies in the two languages (Difference score mean=5.5, SD=3.3, range 1.7-10), and 25 unbalanced bilinguals with larger discrepancies between the vocabularies of the two languages (Difference score mean=25.1, SD=12.5, range 11.6-68). The unbalanced bilinguals were partly Hebrew dominant, but mostly Russian dominant. Two children were not categorized as either balanced or unbalanced, because they had not completed the vocabulary task in one of the languages.

Table 4. Sixth grade participant characteristics.

	Monolinguals *n=42* *M (SD)*	Unbalanced Bilinguals *n*=25 *M (SD)*	Balanced Bilinguals *n*=21 *M (SD)*
Age (years)	10.6 (0.5)	10.6 (0.6)	10.8 (0.5)
Maternal Education (years)	14.4 (4.6)	15.3 (2.8)	14.8 (2.7)
Receptive Vocabulary (number correct)	H: 75.6[a] (9.4)	H: 64.9 [b] (14.3) R: 75.8 (21.7)	H: 75.6 [a] (9.9) R: 76.8 (9.0)
Raven (% correct)	69.9(12.1)	65 (17.3)	74.7 (10.6

H – Hebrew R – Russian

Means in the same row with different superscript letters differ from each other significantly at p<.01.

Design and Procedure

All participants completed the following tests in two sessions. The first session included vocabulary and literacy tests[1] in both languages and a non-verbal general ability test and lasted about half an hour for monolinguals and up to one hour for bilinguals. The second session included a computerized EF test and lasted about 15 minutes. Most of the tasks were presented in Hebrew, except for vocabulary and literacy tasks in Russian that were presented by a Russian native speaker. The tasks were administered individually, in the same order to all participants, in a quiet room at the school.

Peabody Picture Vocabulary Test (PPVT; Dunn, 1965). Adapted in Russian (Schwartz, 2006) and in Hebrew (Nevo, 1979) was used to test receptive vocabulary

[1] The literacy measures were collected as part of a wider study, and are not further analyzed here

knowledge. The test assesses the child's ability to match pictures to spoken words by pointing to them. The child was requested to choose one of four pictures that illustrated the word spoken by the experimenter on each item. The difficulty of the items increased and the test ended when six consecutive errors were made. There were a total of 110 pictures for each language.

The expressive vocabulary test that was used in Experiment 1 with the younger children is not appropriate for the older children tested in this experiment. We were unable to find appropriately matched tests of expressive vocabulary across the two languages, and so decided to rely only on expressive vocabulary for this age group. We did, however, supplement this measure with a child-filled questionnaire (in Hebrew), regarding language practice at home. The questionnaire helped to evaluate the amount of oral language usage at home and in immediate environment in both languages (see Table 5). The questionnaire included questions regarding the languages that children use in different situations.

Table 5: Child language use self-report, in percent of the sample

Question	**Russian**	**Hebrew**	**Both languages**
Which languages do your parents speak to each other?	92	-	8
Which languages does your mother speak to you?	60	4	36
Which languages does your father speak to you?	72	-	28
Which languages do you speak to your mother?	44	21	35
Which languages do you speak to your father?	56	22	22
Which languages do your grandparents speak to you?	100	-	-
Which languages do you speak to your grandparents?	98	2	-
Which languages do you speak with your siblings?	26	43	31
Which languages do you speak to your friends?	-	81	19
Which language do you know best?	12	81	7
What is your favorite language?	36	33	31

General ability test. As in Experiment 1, we used the *Raven's Colored Matrices* (Raven, Raven, & Court, 1976,) to measure non-verbal abilities. In this task, participants matched one of six graphic patterns to a visual array. There was a total of 60 items, in 5 sets of 12 items each.

Executive Function test. Participants performed a variant of the Flanker Fish task (Schonert-Reichl et al., 2015) similar to that described in Experiment 1. However, given the older age of the children the experimental blocks included a slightly larger number of trials. As a reminder, there were three experimental blocks: single task blocks (central target with peripheral distractors, peripheral targets with central distractor), and a mixed block. The single blocks included congruent (identical target and flankers), incongruent (different target and flankers) and neutral (no flankers) trials. The mixed blocks included only congruent and incongruent trials. As described above, neutral trials were not further analyzed.

Two single task blocks were presented at the beginning of the experiment (24 trials in each), followed by two mixed-task blocks (48 trials), followed by two additional single task blocks (24 trials each). As described above, each mixed block included 23 repeat trials and 23 switch trials. In all experimental blocks, children were instructed to respond as quickly and accurately as possible. For this age group, the target remained on the screen until a response was given or for a maximum of 5 seconds.

Results

Participant characteristics are presented in Table 4. ANOVAs were conducted in order to determine whether there were any group differences. A one-way ANOVA showed significant differences between groups in Hebrew receptive vocabulary, $F(2,85)=6.5$, $p=.002$, and post-hoc bonferroni comparisons showed that unbalanced bilinguals had lower scores than monolinguals ($p=.006$) and balanced bilinguals ($p=.009$) who did not differ from each other ($p=1$). The two bilingual groups did not differ from each other in Russian vocabulary knowledge ($F<1$). There were no significant group differences in age, $F(2,85)=1.06$, $p=.35$, or in maternal education F(2,45)=<1. However, a one-way ANOVA conducted on the Raven's scores showed a significant difference among the groups, $F(2,88)=3.9$, $p=.023$. Post-hoc comparisons revealed that unbalanced bilinguals had lower scores than balanced bilinguals ($p=.024$), but did not significantly differ from monolinguals ($p=.13$) No other group differences were significant.

The analysis of performance on the Flanker Fish Task was guided by the same principles outlined above in Experiment 1. Results are presented in Table 6.

Inhibition

Similarly to Experiment 1, inhibitory abilities were examined by comparing performance in congruent and incongruent trials from the two single task blocks (central target and peripheral target). We analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with trial type (congruent, incongruent) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor (see Table 6 for RTs and accuracy rates).

As expected, the main effect of congruency was significant (in RT: $F(1,85)=39.2$, $p<.001$, $\eta^2=.32$; in Acc: $F(1,85)=39.6$, $p<.001$, $\eta^2=.32$), as all participants were faster and more accurate when responding to congruent than to incongruent trials. The main effect of language group was marginally significant for RTs, $F(2,85)=2.5$, $p=.085$, $\eta^2=.06$. Planned comparisons showed that balanced bilingual children were significantly faster in responding than monolinguals ($p<.05$), but that the unbalanced bilingual children did not differ significantly from either group (both $p>.5$). The main effect of language group was not significant in accuracy ($p=.27$), demonstrating that all participant groups were equally accurate. The two-way interaction was not significant in the full analyses (in RT: $F(2,85)=2.16$, $p=.12$; in Acc: $F(2,85)=1.99$, $p=.14$). However, due to our specific theoretical interest in possible differences between balanced bilinguals and monolinguals, and in order to be able to compare our findings to previous studies that compared mainly these two types of participants, we conducted a planned comparison between balanced bilingual and monolingual children. This analysis showed a just-significant two-way interaction between group and congruency, $F(1,61)=4.0$, $p=.05$, $\eta^2=.06$, because balanced bilinguals showed smaller differences between congruent and incongruent trials than did monolinguals.

Inhibitory ability was also examined by investigating children's ability to inhibit a previously relevant rule (central target) and respond according to a newly instantiated rule (peripheral target) by comparing the two single task blocks. Thus, we analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with target type (central, peripheral) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. The main effect of target type was significant (in RT: $F(1,85)=25.3$, $p<.001$, $\eta^2=.23$; in Acc: $F(1,85)=5.2$ $p=.025$, $\eta^2=.06$), because participants were faster and more accurate in responding to central targets than to peripheral targets. This is in contrast with the pattern reported above for the younger children, and we attribute this finding to the older children's improved ability at focusing and orienting attention. The main effect of language group was not significant in the accuracy analysis ($p=.24$), or in the RT analysis ($p=.098$). For the same reason described above, we also conducted planned comparisons directly comparing the performance of the balanced bilingual children with that of the monolingual children, and found that the balanced bilinguals responded significantly faster than monolinguals ($p=.027$). The two-way interaction was not significant (both $p>.24$).

Shifting

Children's facility in mental shifting was examined by comparing performance in the single task blocks (central and peripheral target) with their performance in the mixed task blocks. Thus, we analyzed median RTs to correct trials, and accuracy rates as dependent variables, using a two-way repeated measures ANOVA with block type (single, mixed) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. The main effect of block type was significant (in

RT: $F(1,85)=320.6$, $p<.001$, $\eta^2=.79$; in Acc: $F(1,85)=80.0$, $p<.001$, $\eta^2=.49$), because all participants were faster and more accurate in single task than in mixed task blocks. The main effect of language group was not significant ($p>.26$ for RT and Accuracy), and the two way interaction was not significant ($F<1$ for RT and accuracy).

Finally, as an additional measure of shifting, we compared performance on repeat and switch trials within the mixed blocks. Thus, we conducted a two-way repeated measures ANOVA with trial type (repeat, switch) as a within participant factor and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. The only significant effect was a main effect of trial type in accuracy, $F(1,85)=23.3$, $p<.001$, $\eta^2=.22$, because responses were more accurate in repeat trials than in switch trials. All remaining effects and interactions were not significant (all *p'*s>.34).

Because participants in this experiment were older than in Experiment 1, and completed a larger number of trials (both in single task blocks and most importantly in mixed blocks), we were able to conduct an additional analysis, including the factors of both trial type and target type. Thus, we conducted a 3-way ANOVA with trial type (repeat, switch), target type (congruent, incongruent) as within participant variables, and language group (monolingual, unbalanced bilingual, balanced bilingual) as a between participant factor. There was a significant two-way interaction between trial type and target type (in RT: $F(1,85)=10.0$, $p=.002$, $\eta^2=.11$; in Acc: $F(1,85)=17.0$, $p<.001$, $\eta^2=.17$) because switching effects were significant for incongruent targets, but not for congruent targets. The effect of language group and all other interactions were not significant (all *p*'s>.15).

Table 6. Median RT (SD) and accuracy (SD) of responses in the Flanker Fish task, by block, target location and congruency

	Single Task Blocks					
Groups	Central Target		Peripheral Target		Mixed Blocks	
	Congruent	Incongruent	Congruent	Incongruent	Repeat	Switch
Monolingual	560 (95)	592 (112)	609 (154)	780 (306)	1005 (250)	1037 (339)
	99% (2)	97% (4)	98% (3)	93% (10)	91% (9)	87% (12)
Balanced	516 (94)	531 (83)	536 (98)	603 (154)	956 (264)	966 (191)
Bilingual	98% (4)	99% (3)	100% (0)	96% (6)	92% (6)	87% (10)
Unbalanced	550 (107)	570 (113)	591 (149)	743 (275)	954 (194)	1000 (251)
Bilingual	99% (2)	96% (4)	99% (2)	94% (7)	93% (6)	86% (12)

Discussion

The current study was designed to examine possible differences in executive functions between monolingual Hebrew speaking and bilingual Russian-Hebrew speaking children, in two age groups. The current study differs from previous research in several aspects. First, participants in the current study belonged to a large Russian speaking minority living in Israel, a population that has only been examined in one previous study in the context of possible bilingual advantages (Mor et al., 2014). Additionally, in the current study, SES was well matched between language groups, based on reports of parental education level. The issue of SES has been raised as a possible confound to findings of differential performance between monolinguals and bilinguals (Valian, 2015), and there have previously been some concerns regarding economic measures of SES for immigrant populations (Morton & Harper, 2008; Prior & Gollan, 2011). Therefore, we preferred educational attainment as a more sensitive indicator.

Importantly, in both age groups, children's vocabulary knowledge in both Hebrew and Russian was measured as an index of proficiency. Based on these data, children were classified as being balanced bilinguals, with comparable proficiency in the two languages, or as being unbalanced bilinguals, with higher proficiency in one language over the other. This measurement and classification allowed us to probe the possible importance of bilingual profiles to executive function performance.

Finally, the task implemented in the current study allowed us to derive independent measures of inhibitory control and of flexibility, or shifting abilities. These aspects of executive function have mostly been investigated independently in previous research, and one contribution of the current study is a joint examination of both aspects of the complex mechanism termed executive function.

The results reveal a complex pattern of performance across the language and age groups examined. The inhibitory abilities in pre-school children were examined in the two single task blocks – with central targets and peripheral targets. In both these blocks, monolingual children were faster to respond than unbalanced bilingual children but balanced bilingual children did not differ from either group. However, monolingual and bilingual children had similar congruency effects, e.g., showed less efficient performance on trials where the display included interfering information. In addition, all participants responded more slowly to centrally presented targets than to peripheral targets (which were more informative). Again, there were no statistically significant differences between the language groups. The examination of shifting abilities revealed similar patterns overall. All participants showed similar decreases in performance in the mixed blocks, and on switch trials. However, monolingual children did not maintain their RT advantage in the mixed blocks, as there were no significant differences in performance. Finally, there were no group differences in the DCCS task, which also measures cognitive flexibility.

Thus, bilingual pre-schoolers in the current sample did not present advantages over monolinguals, and in the case of overall speed, monolinguals outperformed bilinguals in the single task blocks. One possible explanation is that the unbalanced bilinguals in the current study were mostly in the early stages of acquiring an L2, and thus could also be described as emerging bilinguals, who still have only very limited knowledge of the L2. Even the more balanced bilinguals had not been exposed to both languages from birth, but rather through schooling experience, and indeed had lower expressive vocabularies than the Hebrew speaking monolinguals. It is therefore possible that under these circumstances, longer exposure and stronger proficiency need to develop in order for EF advantages to emerge, if at all (c.f. Barac & Bialystok, 2012). In addition, executive functions are undergoing intensive development in the target preschool age and there is large variability at this age, even among monolingual populations (Diamond, 2013; Shaul & Schwartz, 2014). On the background of such large variability it might be more difficult to identify group differences in this age group.

Our failure to identify advantages for the preschool children is somewhat surprising, given previous reports in the literature of bilingual advantages in this group (Barac & Bialystok, 2012; Martin-Rhee & Bialystok, 2008), though some recent studies have also found equivalent performance for bilinguals and monolinguals (e.g., Anton et al., 2014; Bialystok, Barac, Blaye, & Poulin-Dubois, 2011 in the ANT task; Dunabeitia et al., 2014; Gathercole et al., 2014). In light of the relatively small scope of the current study, it is possible that the task was not sensitive enough in the younger age group, or alternatively, that the study might be underpowered (Paap & Greenberg, 2013). On the other hand, language proficiency and balance were carefully measured, and groups were well matched on background measures and SES. Thus, the current results join a growing number of recent studies with bilinguals of various ages that do not replicate previous findings of a bilingual advantage in different aspects of EF (Anton et al., 2014; Dunabeitia et al., 2014; Gathercole et al., 2014; Goldman, Negen, & Sarnecka, 2014).

The results of Experiment 2, with sixth grade children, were somewhat different, in that an advantage for bilingual children over monolinguals did emerge in certain aspects of EF. In the single task blocks, from which the measures of inhibition were generated, balanced bilinguals were overall faster than monolinguals, and also had marginally smaller conflict or congruency effects. The performance of unbalanced bilinguals mostly fell between that of the two other groups, but generally did not differ significantly from either. In contrast, when examining the mixed task blocks, there were no significant group differences, although numerically, balanced bilinguals still had shorter RTs than monolinguals.

Thus, the pattern of results observed in the older children was more supportive of some bilingual advantage, though it was limited to measures of inhibition and not shifting. Interestingly, when the advantage emerged it was limited to balanced bilinguals, and was not apparent in comparisons of unbalanced bilinguals and monolinguals. Balanced bilinguals in the sixth grade were overall faster than monolinguals in responding to central targets and peripheral targets. This pattern of overall RT advantages has been previously reported in the literature, and ascribed to possible advantages in monitoring (for a review, see Hilchey & Klein, 2011). In addition, balanced bilinguals had marginally smaller conflict effects, namely smaller discrepancies between congruent and incongruent trials. This finding indicates more efficient inhibitory control in bilinguals, again a pattern evident in previous research (Bialystok & Viswanathan, 2009). However, there were no significant group differences in measures of shifting abilities. Namely, all participants were equally fast in performing the mixed blocks, and did not differ significantly in mixing or switching costs.

Thus, the findings from the older, sixth grade children, are aligned with some previous studies reporting advantages for bilinguals over monolinguals (Bialystok & Barac, 2012; Bialystok & Majumdar, 1998), but at the same time suggest that such an advantage might not be very robust and does not extend to all aspects of EF (c.f. Gathercole et al., 2014). Further, the current results demonstrate that there could be significant differences between balanced and unbalanced bilinguals in the performance of executive function tasks. For example, recently Tse and Altarriba (2014) reported that the ratio between L2 and L1 proficiency in a sample of Chinese-English bilingual children was predictive of overall speed as well as conflict effects, but not of cognitive flexibility – a pattern similar to the one observed in the current study.

Thus, the results observed with the older children in the current study showed that only the balanced bilinguals, who were able to achieve and maintain comparable levels of proficiency in their two languages, exhibited superior EF performance when compared with monolinguals. These bilinguals were advantaged in inhibitory control, but not significantly in cognitive flexibility, which have rarely been assessed concurrently. These findings might suggest that only the demands posed by relatively balanced bilingualism, in which strong competition exists between the two languages, might lead to advantages in some aspects of executive function. Thus, a careful examination of bilingual language profiles in future research might help elucidate current mixed findings.

In conclusion, the pattern of results emerging from the current study adds important data points to the ongoing investigation of the possible relationship between bilingualism and executive function, but does not unequivocally support either side of this debate. No bilingual advantages were found for the younger children, and some advantages of balanced bilinguals over monolinguals were found for the older children. Thus, the central contribution of the current study is in highlighting the importance of different bilingual profiles in such research, as advocated by others as well (Kaushanskaya & Prior, 2015; Luk & Bialystok, 2013). In the older group, only balanced bilinguals showed EF advantages when compared to monolinguals. In the younger group, unbalanced bilinguals on average had lower performance than both other groups, most likely due to their limited time in learning the L2, and limited proficiency in the language. Such considerations should continue to inform ongoing research, and help in elucidating the complex set of relations between bilingual profile and cognitive functioning overall.

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