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ВЛИЯНИЕ ДВУЯЗЫЧИЯ НА РАЗЛИЧНЫЕ ТИПЫ КРЕАТИВНОСТИ В РАННЕМ ДЕТСТВЕ
THE EFFECT OF BILINGUALISM ON VARIOUS TYPES OF CREATIVITY IN EARLY CHILDHOOD

Аннотация: в серии экспериментов приняли участие 75 детей билингвов (русский/иврит) и монолингвов (иврит), в возрасте от 3.5 до 6 лет, посещающие ивритоязычные детские сады. У детей билингвов проверялось знание обоих языков. В нескольких экспериментах сопоставлялось выполнение детьми тестов на креативность в решении проблем различного типа. Рассматривались лингвистическая, ситуативная, фигуративная и математическая креативность. Результаты исследования показали, что уже на ранних этапах овладения вторым языком (возраст 3,5-4,5) билингвизм положительно влияет на развитие креативности в решении проблем. Развитие креативности, однако, происходит неравномерно. В некоторых видах креативности (например, при решении ситуативных проблем) различия между билингвами и монолингвами с возрастом исчезают, в других же областях (например, в математической креативности) различия, напротив, нарастают. В работе рассматриваются так же теоретические вопросы, связанные с когнитивными механизмами креативности и механизмом влияния билингвизма на дивергентное и конвергентное мышление.
Abstract: a total of 75 monolingual (Hebrew) and bilingual (Russian/Hebrew) children aged from 3,5 to 6 years, participated in the study. In several experiments children performance on the tests for creativity in the solving of different types of problems were examined. The problems were of linguistic, situational, figurative and mathematical type and corresponding types of creativity were studied. The results showed that already at early stages of mastering in the second language (age 3,5-4,5) bilingualism positively influences development of creativity in the solving of different types of problems. This ability, however, develops unevenly. In some types of creativity (for example, in situational problems) distinctions between bilinguals and monolinguals disappear the age increase. On the contrary, in other areas (for example, in mathematical creativity) distinctions enlarge. In the study the theoretical issues related to cognitive mechanisms of creativity are discussed as well as the mechanism of influence of bilingualism on divergent and convergent thinking.
Ключевые слова: двуязычие, раннее детство, общая и математическая креативность.
Keywords: bilingualism, early childhood, general and mathematical creativity.

Introduction. The present study has been prompted by the limited but somewhat contradictory findings about the influence of bilingualism on the development of high-order cognitive functions, one of which is creativity [Bialystok 2009; Simonton 2008]. The study examines the effect of early, mostly balanced bilingualism on the development of linguistic creativity and creativity in solving non-mathematical and mathematical problems.

The oretical background. Bilingualism and cognitive development. There is no evidence that bilingualism affects intelligence, but there is abundant, albeit controversial, evidence that it affects the development of various specific cognitive abilities and processes, including different forms of creativity [Bialystok 2005; Ricciardelli 1992; Simonton 2008].

Several studies have demonstrated a significant influence of bilingualism on cognitive development [Bialystok, 2005]. The advantages of bilingualism have been reported across a variety of domains, including creativity (expressed in divergent thinking) [Ricciardelly 1992; Simonton 2008], problem-solving [Adesope, Lavin, Thompson, Ungerleider 2010], and perceptual disembedding [Bialystok 2005]. It has also been found that the performance of

balanced bilingual students, in particular, is better than that of their monolingual peers on tests assessing general creativity and flexibility [Torrance 1974; Simonton 2008] as well as on tasks assessing concept-formation [Bialystok 2005].

Research by Bialystok [2005] has pointed to an advantage among bilingual children in developing control processes and in processing complex stimuli in tasks that require executive processing for conflict resolution, including switching and updating, even when no inhibition appears to be involved. Bilingual children display better performance and earlier success on executive function tasks. Furthermore, research has demonstrated earlier development of the executive function in bilingual children (as early as age 3) than in monolingual children (ages 4–5).

The quality and manner of the influence of bilingualism on cognitive abilities, however, has not been sufficiently studied because of the interference of a variety of factors such as the social-economic status of bilingual vs. monolingual groups, the language of testing (i.e., first, second, dominant, well-acquired, and so on), the specific tests being used, the given cognitive domain (general vs. specific), various specific abilities of the students, and different definitions of creativity [Bialystok 2005; Gonzalez 2006; Hommel et al. 2011; Simonton 2008]. Most research in the field has focused primarily on language creativity and on school-age children, adolescents, and adults, whereas the abilities of younger bilingual children in the area of creativity have been studied inadequately.

What is creativity? Despite numerous attempts to define creativity, there has been no agreement on the subject. When we talk about creativity it is not clear whether we refer to people's abilities or inclinations, their behavior or activity, or to the result of some human activity [Hommel et al. 2011]. For example, creativity is usually considered to be a mental process involving the generation of new ideas or new connections between existing ideas or concepts (see Simonton, 2000 for a review). Creativity can also be manifested in the production of creative outcomes that are both *original* and *useful* [Leikin 2009; Simonton 2008]. An alternative and more common conception of creativity suggests that it is simply the act of making something new and different from what others are making (cf. "relative creativity," [Leikin 2009]).

In the present study we investigate linguistic creativity as manifested by semantic retrieval ability and creativity in solving situational (everyday or general) and mathematical problems. For this purpose we use Leikin's [2009] model for the evaluation of mathematical creativity based on solving Multiple Solution Tasks (MSTs), assignments that explicitly require the solver to approach a mathematical problem in different ways. This model is based on a definition of creativity by Torrance [1974], who suggests four mutually related components: fluency, flexibility, novelty, and elaboration. In this case**,** *fluency* relates to the continuity of ideas and use of basic and universal knowledge; *flexibility* is associated with changing ideas, approaching a problem in various ways, and producing a variety of solutions; *novelty* (or originality) is characterized by a unique way of thinking and by unique products of a mental or artistic activity; and *elaboration* relates to the ability to describe, illuminate, and generalize ideas.

Bilingualism and creativity. Studies of the relationships between bilingualism and creativity have dealt mostly with creativity in the area of language or figurative creativity [Lasagabaster 2000; Kharkhurin, 2010; Simonton, 2008). Despite their limited scope, the findings of previous studies are somewhat contradictory. The literature [Adesope et al. 2010, Ricciardelly 1992; Simonton 2008] generally supports the hypothesis about the existence of positive correlations between bilingualism and creativity. For example, it was found (Simonton, 2008) that bilinguals scored higher than monolinguals on verbal originality and flexibility and on figural originality and fluency. Note, however, that recently Kharkhurin [2010] found significant differences between nonverbal and verbal creativity in a bilingual context. Bilingualism was shown to have a positive effect on nonverbal creative behavior, but monolinguals were found to be better than bilinguals on verbal creativity measures. These data at least partly contradict the results of Cummings's studies (2000). Note, however, that there were prominent differences not only between the findings of Cummins (2000) and Kharkhurin [2010], but also differences in the experimental design of these studies, as well as participants' age, languages, and cultural background. At the

same time, language proficiency, age, and culture appear to be important for the issue being considered here.

To date, little research effort has been invested in the investigation of the relationship between bilingualism and bilingual development on one hand, and creative thinking or creativity in problem solving on the other. Moreover, there are few studies on preschool children in this respect [Leikin 2012; Ricciardelly 1992]. Finally, a review of the research literature in the field did not reveal any studies that compare linguistic and general creativity with mathematical creativity in young children.

Research goals and hypotheses. The first aim of the present study is to check whether early bilingualism affects the development of creativity. This aim leads to the following hypothesis: if bilingualism has a positive effect on creative ability, bilingual children will demonstrate greater creativity in solving problems, both non-mathematical and mathematical, than will monolingual children.

The second aim of the study is to examine the possible effects of bilingualism on creativity in non-mathematical and mathematical problem-solving of bilingual preschoolers compared with monolingual participants. Based on the research data on creative behavior in different cognitive fields (e.g., language and non-language creativity) and on our previous findings [Leikin, 2012], we hypothesize that there is no unequivocal correlation between different types of creativity.

Method

Participants

Thirty one children (mean age = 71.9 months, SD=3.6) were selected from two kindergartens in the north of Israel. The children were divided into two groups (Table 1):

1. Bilingual (Russian/Hebrew-speaking) children from Russian-Jewish immigrant families (henceforth the bilinguals, n=15);
2. Monolingual (Hebrew-speaking) children from the same Hebrew-speaking monolingual kindergartens as the bilingual group (henceforth the monolinguals, n=16).

Table 1. Means and standard deviations of background measures for monolingual and bilingual participants

Measure	Monolingual group n=15	Bilingual group n=16	*F*
Gender (male/female)	5/10	8/8	.850
Age (in months)	72.9 (3.8)	70.9 (3.2)	2.571
Mother's age	35.8	34.9	.261
Mother's education in years	15.3 (2.3)	14.6 (1.8)	4.333*
Father's age	39.2 (8.2)	36.9 (5.3)	.886
Father's education in years	12.6 (1.2)	12.6 (2.8)	.001

* p=.046

The two kindergartens were located in similar neighborhoods with an average socio-economic level. The kindergarten teachers in the two target programs used the same curriculum provided by the Israeli Ministry of Education. The typical everyday curriculum included the following activities: discussion sessions (e.g., holidays and seasons), read-aloud sessions (asking questions about a story, discussion, and vocabulary enrichment), sports, and art sessions. All activities were conducted in Hebrew.

The classification of children as monolingual or bilingual was based on a detailed questionnaire that collected information about the native language of the child's parents, the language spoken at home by the parents, and the language spoken by family members and preschool caretakers. The questionnaire also recorded the general impressions of Russian/Hebrew bilingual and Hebrew-speaking monolingual raters based on a conversation with the children. The native Russian-speaking bilinguals were Israeli-born children of Russian-Jewish immigrants from the former USSR. Russian was the dominant language in the homes of all the children. At the same time the children have already acquired Hebrew at a level that was almost equivalent to that of

their monolingual peers. According to the general impressions of three Russian/Hebrew-speaking raters (α=.893) and according to data obtained from family questionnaires, the children knew Russian sufficiently well to understand movies, TV shows, and books read to them by adults in Russian, and were able to converse and express their thoughts in Russian at a level comparable to Hebrew. At the same time, three native Hebrew-speaking raters characterized the children's linguistic competence in Hebrew as almost similar to that of Hebrew-speaking coevals (α=.921).

There were no significant differences between the two groups of participants in mean age, gender, and the parents' educational level, except for the mothers' education (see Table 1 for details).

Measures

Working Memory Test

Twenty eight Hebrew sentences to be completed by the missing (last) word were presented to children aurally. The sentences were presented in eight groups. In the first two groups there were two sentences in each group; in the second two groups there were three sentences; and so on. After completing all the sentences in a group participants were asked to repeat the words they had found (two, three, four, or five) in the right order.

Creative thinking tests

I. *Pictorial Multiple Solution (PMS) Task*

The black-and-white picture describes a problem as an everyday situation. In the picture, a small childlike kitten, easily associated as a coeval of the young participants in the study, wants to reach its cap on a high shelf but is unable to do so. There are various objects in the picture that could be used to help the kitten reach its cap: a chair, a stool, a bedside table, and a stick.

Participants were asked to suggest as many solutions as they could to the problem presented in the picture. Each answer was scored for fluency, flexibility, originality, and creativity using Leikin's (2009) model and scoring scheme for the evaluation of creativity.

The *fluency* score was obtained by counting the number of solutions that the participant offered. To evaluate *flexibility*, groups of solutions were established in such a way that two solutions belonged to separate groups if they employed solution strategies based on different principles, properties, or methods for problem-solving. For example, "get a stick," "jump up," and "call mom" are decisions belonging to different groups, whereas "climb on the chair," "climb on the table," and "climb on a ladder" belong to the same group. The children received a score of 10 for the first appropriate solution (Flx_1) (e.g., "climb on the chair") and for a solution (Flx_i) belonging to a group other than Flx_1 (e.g., "call mom" or "stand on tiptoes"). The children received a score of 1 for a solution (Flx_i) belonging to one of the previously used groups and having a clear but minor distinction (e.g., "climb on a ladder" vs. "to climb on the chair"). Finally, the children received a score of 0.1 for a solution that was almost identical to a previous one (e.g., "climb on the stool" vs. "get on the chair"). A participant's total *flexibility* score on a problem was the sum of the flexibility scores of the solutions in the participant's individual solution space.

The *originality* (Ori) score was also calculated based on a preliminary classification of solutions. In this case, however, all the answers of all the participants in the experiment were analyzed together and each solution received a corresponding individual score: Ori = 10 when a given solution was suggested by fewer than 15% of all participants, Ori = 1 when a given solution was suggested by more than 15% but fewer than 40% of participants, and Ori = 0.1 when a given solution was suggested by more than 40% of participants. A participant's total *originality* score on a problem was the sum of originality scores of all the solutions in the expert solution space (in this case, all the solutions of all the participants).

The *creativity* score was calculated by multiplying the flexibility score of each solution by its originality score, then summing up the results of the creativity scores obtained for all the solutions to a particular problem by the participant (for details, see Leikin, 2009). The Leikin's (2009) scoring scheme does not include fluency scores because of the high correlation between fluency and flexibility scores. In this case, the flexibility measure was found to be more accurate than the fluency measure, and it was revealed that the final creativity scores did not depend

significantly on whether or not the resulting formula for creativity scoring included fluency scores (Leikin, 2009).

II. Creating Equal Number (CEN) Task (borrowed from Tsamir, Tirosh, Tabach, & Levenson, 2009).

In the present study we used a slightly modified CEN task. Unlike in the original test (Leikin, 2012; Tsamir et al., 2009), in the present test the children operated 10 bottle caps instead of 8 in order to provide for a greater variety of solutions in problem solving. Following the instructions of Tsamir et al. (2009) for this task, "a child sat with an adult at a table in a quiet corner of the kindergarten. The child was presented with two distinct sets of bottle caps: three bottle caps were placed on one side of the table and five [seven in the present study] bottle caps were placed on the other side. No spare bottle caps were present. All bottle caps had the same shape, size, and color. The child was asked: 'Can you make it so that there will be an equal number of bottle caps on each side of the table?' After the child rearranged the bottle caps, the interviewer returned the bottle caps to their original arrangement (three in one set, five [seven] in the other), and asked the child, 'Is there another way of making the number of bottle caps on each side equal?' The rearrangement of the bottle caps (3 and 7) and the related question were repeated until the child signaled that he or she was done" (Tsamir et al., 2009, p. 6).

Fluency, flexibility, originality, and creativity scores were calculated in the same way as in the previous test. In this case, however, we considered not only the children's solutions (outcomes) but also the ways in which the problem was solved.

According to Tsamir et al. (2009), the CEN task can have five (six in the present study) different solutions (outcomes): 5-5, i.e., five caps in each set, 4-4, 3-3, 2-2, 1-1, and 0-0. Additionally, the authors described several methods that may be used to solve the task. Some are one-step methods: (a) removing all the elements from both sets, leading to an outcome of 0-0; (b) taking only from the larger set, which in the given task meant taking four elements from the set of seven, producing a solution of 3-3; (c) shifting from one set to the other, which in our case led to a solution of 5-5; (d) taking from both sets a number of elements to obtain the same number of caps in each set, leading to solutions of 1-1 or 2-2. A two-step method (e) involved collecting all the caps and re-dividing them to create two new sets from scratch. This method could result in any of the five above-mentioned solutions. Finally, another two-step method (f) involved removing three elements from the lager set with a partial addition of 1 element to the smaller group. This method produced a result of 4-4.

For data analysis, the above-mentioned classification based on Tsamir et al. (2009) was adapted to Leikin's (2009) model, so that the first appearance of any solution (i.e., the first-time use of a method) received a score of 10 on flexibility, and all others (e.g., outcomes of 4-4, 3-3, 2-2, and 1-1 after the outcome of 5-5) in which the same method of solving the problem was applied, received a score of 0.1. An exception was made for an outcome of 0-0, which was considered to be rare and especially interesting. Thus, on the originality measure, all outcomes, produced by any method, received a score that depended on the percentage of children who used that solution.

Verbal (Semantic) Fluency Test (Spreen & Strauss, 1998)

In this test children were asked to say as many words as possible belonging to three semantic categories ("animals," "food," and "what should be taken on a picnic?") in 60 seconds. Only words that were appropriate from a semantic point of view were considered to be correct answers. Because we treated this classic test not only as a test of language competence (language ability) but also of verbal creativity, the children's performance was measured by scores of *fluency, flexibility, originality, and creativity*. These scores were calculated in the same way as in the PMS Task. In this case, for flexibility measurement such words as "cow," "horse," and "goat" were classified as belonging to one category, and "cat," "dog," and "hamster" to another. The first word in a category received a score of 10 on flexibility, and all other words a score of 0.1. Rare words belonging to the same category (e.g., camel) received a score of 1 point.

Results

Background measures

Table 1 presents the children's background data. A series of one-way analyses of variance (ANOVA) were conducted to evaluate the differences between the two groups of participants on

the background measures. Table 1 shows that the groups did not differ significantly in gender, age, and years of father's education. The only marginal difference was in the years of mother's education.

Experimental measures

Both groups of participants performed all the experimental tasks in Hebrew without any difficulties.

Working Memory Test

The performance of monolingual and bilingual children on the Working Memory test is shown in Table 2. Both groups experienced the same difficulties in reproducing the correct word order although they were relatively successful in repeating the correct words. The bilingual children remembered significantly more correct words than their monolingual peers. This test was carried out in Hebrew (L2 for bilingual Russian/Hebrew speakers). The same, largely unexpected effect was shown in the Verbal Fluency test.

Verbal (Semantic) Fluency Test

The results of this test are shown in Table 2 (Fluency: Animals, Fluency: Food, and Fluency: Picnic). The children's performance was generally task-dependent. No significant differences were found on the Fluency: Animals task but there were prominent differences between the two groups, in favor of the bilingual children, on the two other fluency tasks. In the Fluency: Food task significant differences were found both on the flexibility and the originality measures, but not in the number of retrieved words (fluency), whereas in the Fluency: Picnic task the differences between two groups were significant in fluency and flexibility but not in originality. In all three fluency tasks extremely high standard deviations were found on the originality measure and consequently on the creativity measure. This effect was present in both groups.

Table 2. Children's performance on the Working Memory and Verbal Fluency tests (*M* and *SD*)

	Measure	Monolingual group n=15	Bilingual group n=16	*F*
Working Memory test	Correct words	11.3 (2.4)	22.9 (2.5)	169.318***
	Correct sequences	.4 (.5)	.4 (.6)	.033
	Total	11.7 (2.6)	23.3 (2.6)	159.616***
Fluency: Animals	Fluency	8.7 (3.1)	8.9 (4.1)	.024
	Flexibility	27.9 (6.5)	28.8 (7.3)	.154
	Originality	8.5 (11.5)	7.2 (8.5)	.136
	Creativity	25.3 (42.2)	31.9 (56.9)	.135
Fluency: Food	Fluency	7.2 (3.1)	8.6 (2.5)	1.998
	Flexibility	32.1 (8.4)	42.4 (9.5)	10.258**
	Originality	1.8 (2.6)	8.1 (7.2)	10.293**
	Creativity	5.2 (4.2)	49.1 (60.8)	7.767**
Fluency: Picnic	Fluency	5.1 (2.6)	7.4 (2.2)	6.503*
	Flexibility	22.7 (9.5)	32.1 (6.2)	10.959**
	Originality	6.2 (12.7)	8.0 (9.7)	.217
	Creativity	18.3 (38.9)	40.7 (47.8)	2.049

* p<.05, ** p<.01, *** p<.001

PMS Task

All the bilingual children performed the PMS task in Hebrew, although they were offered a choice of language. The children's answers in both groups were identical in character. On average, children offered between 3 and 6 solutions (Table 3, Fluency), and their answers were sufficiently varied. The most common solution was to use an object on which the kitten could climb in order to reach its cap (e.g., " climb on the chair"). Most often these were the objects represented in the picture: the chair, the stool, and the bedside table. In some cases the children suggested the use of a ladder ("climb on a ladder" or "build a ladder") or of some other real or unreal object (e.g., "a giraffe"). Another relatively frequent solution was to ask for the help of

adults (parents, relatives, etc.). Other solutions such as “climb on a rope,” “grow longer hands,” or “rise on the tail” were rare if not unique.

Table 3. Children's performance on two creativity tests (*M* and *SD*)

	Measure	Monolingual group n=15	Bilingual group n=16	*F*
Pictorial Multiple Solution Task	Fluency	4.6 (1.5)	5.7 (2.1)	2.854
	Flexibility	31.4 (8.8)	27.9 (12.3)	.799
	Originality	11.7 (9.9)	9.8 (12.5)	.214
	Creativity	93.3 (85.4)	65.5 (76.5)	.912
Creating Equal Number Task	Fluency	6.8 (3.3)	8.4 (3.2)	1.831
	Flexibility	32.8 (11.9)	49.6 (18.1)	9.003**
	Originality	8.6 (9.4)	21.8 (13.2)	10.071**
	Creativity	54.5 (64.4)	191.9 (124.6)	14.593***

** p<.01, *** p<.001

Overall, the two groups achieved similar results on the PSM task. The findings presented in Table 3 show that there were no statistically significant distinctions between monolingual and bilingual children in any of the creativity measures.

CEN Task

Both monolingual and bilingual children coped rather well with the task. The most frequent solutions were: (a) to transfer two bottle caps (at times one by one) from the group of 7 to the group of 3 (for a result of 5-5), (b) to transfer two caps from the group of 7 to the group of 3 and afterwards to remove 1 cap from each of the two equal groups (4-4), (c) the same as (b) but removing two caps from each group (3-3), and (d) removing all caps and afterwards using two of them (1-1). Thus, the children chose the four solutions that were most obvious from the quantitative point of view and at the same time relatively simple. They resorted mostly to a two-step method that had not been considered by the authors of the test (Tsamir et al., 2009): step 1 – method *b* (removing four elements from the set of seven), and step 2 – methods *d* (removing a number of elements from both sets in order to obtain the same number of caps in each set). Occasionally the children arranged, one after another, several variants of a solution: 4-4, 3-3, 2-2, 1-1. In this case, the first solution received the highest score, 10 (on flexibility), and the others only 0.1. At the same time, from the point of view of originality all these solutions should received a low score of 0.1. But there were other solutions and strategies as well, for example, the solution of 0-0. This was not only extremely rare but also original, and consequently was awarded the highest score for originality and flexibility: 10. The following solutions were equally original: (a) five groups of 2 caps (arranged vertically so that in at each horizontal level there were only two sets (2-2); (b) two groups of 4 caps formed by addition: “Two caps and two more caps make four caps.” Both monolingual and bilingual children tended to use two- and three-stage strategies for problem solving (e.g., collecting all caps, then removing caps from one group in order to create equal groups).

The results obtained on the CEN task (Table 3) show considerable differences between bilingual and monolingual children on all creativity measures except the fluency measure. Children in both groups produced a nearly identical number of solutions, but bilingual children were characterized by higher flexibility and originality. And unlike on the PMS task, on this task the standard deviations were closer to normal distribution, especially in the bilingual group. Finally, a Pearson correlation analysis showed no significant correlations between the creativity measures of the three creativity tasks: Verbal Fluency, PMS, and CEN.

Conclusion. In sum, our findings add to the theoretical knowledge about the relationship between bilingualism and various types of creativity in early childhood. The study demonstrates that balanced bilingualism has a positive effect on the development of creativity. This effect, however, differs for various domains of creativity: verbal, general, and mathematical. Moreover, creative ability together with the forms and the extent of the influence of bilingualism on creativity seem to develop as children grow.

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