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Bilingual education enhances creative fluency and flexibility over the first year of primary school

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Research Article

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Abstract

Can exposure to a foreign language in the first year of school enhance divergent thinking skills? Ninety-nine monolingual children from predominantly White neighbourhoods (M_{Age} = 57.7 months, SD 1.2; 47 girls) attending bilingual schools, schools with weekly foreign language lessons, or schools without a foreign language provision (= controls) completed divergent thinking and executive function tasks at the beginning of the school year and 24 weeks later. The groups did not differ on creativity measures at the beginning of the school year. Only bilingual school children and weekly language learners improved divergent thinking at the second testing point, with the former significantly outperforming controls on creative fluency and flexibility. Improvements could not be explained by executive function development. Therefore, a considerable amount of exposure to a foreign language in early formal education appears to boost creative thinking.

Highlights

- Longitudinal study suggests that foreign language exposure in early formal education boosts creative thinking skills
- Children attending a bilingual school for six months significantly showed enhanced creative thinking skills compared to a monolingual control group without any foreign language provision
- Children exposed to weekly language lessons for six months increased creative thinking skills but not significantly compared to a monolingual control group
- Enhancements of creative thinking skills were unrelated to enhancements of cognitive control or cognitive flexibility skills

1. Introduction

Early bilingual experience, that is the experience of growing up with two languages from early childhood, has been shown to be beneficial for creative skills, most notably divergent thinking skills, which is the ability to produce a number of unique and original solutions to a problem[1] (e.g., Adi-Japha et al., 2010; Leikin, 2013; Leikin & Tovli, 2014; Leikin et al., 2014; review in Ricciardelli, 1992; van Dijk et al., 2019) (but see Booton et al., 2021; Lange et al., 2020). There is some evidence that similar benefits are achieved via learning a second language (L2) in formal education, which is generally referred to as foreign language learning (e.g., Ghonsooly & Showqi, 2012; Landry, 1974). However, these studies have been cross-sectional, have not evaluated what "dose" of L2 might be required, and have not controlled for potential group differences such as general intelligence (that is the ability to solve complex problems) or socio-economic status, and have not examined whether improved creativity may be a secondary effect of L2 education on improved executive function. The present study addressed these shortcomings.

Enhancements in creative thinking through speaking a second language are important because higher creativity is positively related to children's school performance (e.g., Hansenne & Legrand, 2012), and on a societal level, creativity is crucial for the creation of new products and jobs (Sternberg, 1999). Being able to speak another language might therefore benefit children's academic success and society as a whole. For this reason, it is important to establish whether advancements in creative thinking are limited to individuals who learn to speak another language from very early on, or whether later exposure to a foreign language at school (i.e. "L2 exposure") is similarly beneficial.

There is indeed some limited evidence that creativity might not only be boosted through learning an L2 in natural settings as in bilingualism. There are reports for creative benefits for

[1]While divergent thinking is only one aspect of creativity, namely the thought processes for creative thinking, we here use the terms creativity, creative thinking and divergent thinking interchangeably for the ability to produce multiple solutions to a problem (Guildford, 1967).

individuals who are acquiring a second language through foreign language classes (Carringer, 1974; Ghonsooly & Showqi, 2012; Landry, 1973a, 1973b, 1974). What is unknown, though, is whether participants who showed advanced creative thinking skills in these studies already differed in these skills before they started learning a foreign language. Also, creativity in children is related to socio-economic status (SES; Hendrie Kupczyszyn et al., 2024) and general intelligence (Krumm et al., 2018; Silvia, 2008). Previous studies had not sufficiently controlled such factors. It is therefore important to conduct a longitudinal study that takes into account potential confounding variables.

While bilingualism has been found to positively impact creative thinking, it has been suggested that enhancement in creative thinking depends on the degree of bilingualism. It seems that a high degree of proficiency in both languages is needed (Creo et al., 2021; Kharkhurin, 2011; Kim, 2011; Lee & Kim, 2010, 2011; Leikin et al., 2020; Ricciardelli, 1992; van Dijk et al., 2019) (but see Hommel et al., 2011). This means that learning an L2 in formal education should have no effect on creative thinking until a high proficiency in L2 is reached. However, enhancements in creative thinking have been reported also for those who were in the process of acquiring a second language through foreign language classes (Ghonsooly & Showqi, 2012; Landry, 1973a, 1973b, 1974). It is therefore unclear whether the amount of L2 exposure in educational settings would make a difference, that is whether only a high exposure leads to enhanced creativity.

Apart from the question of whether learning an additional language in an educational setting impacts creative thinking skills, it is also still unclear how it might do so. Creativity has been related to basic executive functions (EFs), especially cognitive flexibility, that is the ability to shift between rules or sets, and to attentional control (e.g., Chen et al., 2022; Edl et al., 2014; Kharkhurin, 2011; Pasarín-Lavín et al., 2023; Sampedro & Peña, 2019; Zabelina & Robinson, 2010). Because bilingualism has been related to enhanced EFs (review in Barac et al., 2014), advantages in creative thinking skills in bilinguals have been argued to be due to enhanced EFs. Sampedro and Peña (2019) found that cognitive flexibility was the mediating factor between the level of bilingualism and creativity in preadolescent Basque-Spanish bilinguals, and Kharkhurin (2011) found that selective attention contributed to differences in creative abilities in a group of bilingual college students with various language backgrounds. However, Leikin et al. (2020) found no relationship between EFs and creativity in a sample of bilingual adults. It has not been tested yet whether any advancement in creativity through L2 learning in the classroom is mediated by an accelerated development in EFs.

Given these open questions, the present study addressed three aims. The first and main aim was to test whether creative abilities can be enhanced by exposure to a foreign language in the first year of formal education. More specifically, we tested children with and without a foreign language provision at school on their divergent thinking abilities. Given the shortcomings of previous studies, we recruited monolingual children from monolingual households and checked that participant groups did not differ in confounding variables such as SES, IQ, language skills or extra-curricular activities when they embarked on their L2 learning journey (Table 1). It is likely that learning a foreign language enhances children's expressive language skills. Since we were interested in children's creative thinking skills and not so much in their language skills, we tested children's divergent thinking abilities by administering a non-verbal task, namely a modified version of the "repeated figures" task of the Torrance Test of Creative Thinking (TTCT; Torrance, 1966). Applying a longitudinal design, we administered the test at the beginning of the first year of primary school and 24 weeks later. We expected children to perform very similarly at the beginning of primary school. If exposure to a foreign language enhances creative skills, we expected that children with a foreign language provision would score higher on divergent thinking skills than children without any foreign language provision at the second testing point.

Table 1. Participant characteristics by group

	BilS (n = 32)	L2 learners (n = 29)	NoL2 (n = 38)
M age in months (range)	56.0 (50–62)	57.2 (51–64)	59.5 (53–65)
Gender (f/m)	11/21	15/14	21/17
Maternal background UK[a]	96.9%	96.5%	100%
Paternal background UK[b]	93.8%	100%	100%
M SES (0–1) (SD)	.78 (.19)	.71 (.21)	.76 (.16)
M hours of extra-curricular activities/week (SD)	1.2 (.3)	1.6 (.2)	1.4 (.2)
M hours of computer usage/week (SD)	2.2 (.5)	2.4 (.4)	2.6 (.6)
Mdn number of siblings (IQR)	1.0 (1–2)	1.0 (1–2)	1.0 (1–1.25)
Mdn number of older siblings (IQR)	.5 (0–.5)	1.0 (1–1.5)	1.0 (0–1)
M BPVS score (SD)	74.1 (12.6)	70.9 (13.7)	72.6 (14.0)
M IQ (Raven's)	15.4 (3.3)	14.8 (3.7)	15.1 (3.6)

Note:[a]Non-UK places of birth for mothers were USA (n = 1) in the BilS group and Ireland (n = 1) in the WL2 group.
[b]Non-UK places of birth for fathers were New Zealand (n = 1) and South Africa (n = 1) in the BilS group.

The second aim of the study was to investigate the effect of the amount of second language exposure and therefore, indirectly, the effect of L2 proficiency. We therefore tested two groups of children with a foreign language provision. The first group attended bilingual schools (BilS) and therefore had substantial exposure to a new language. The second group (L2) attended mainstream education and had very limited L2 exposure through weekly short lessons. These groups were compared against a third group that attended schools without any L2 provision (NoL2). We expected that children exposed to a second language would show enhanced progress in divergent thinking measures, with the caveat that the very limited exposure to a second language in the weekly language learner group might not be sufficient to significantly boost children's creative development compared to no second language exposure.

The third aim of the study was to investigate whether any advanced creative skills development due to second language exposure would be related to accelerated development in EFs skills. More specifically, we tested whether children's divergent thinking development could be explained by their development of two EFs sub-skills, namely selective attention and general switching abilities. These were measured by means of the Attentional Network Task (ANT; Rueda et al., 2004) and the Dimensional Change Card Sort task (DCCS; Zelazo, 2006), respectively. We expected EFs skills to increase between the two testing points. If accelerated development in divergent thinking skills in the two foreign language learning groups was related to enhanced development in EFs skills, then the development in EFs should mediate development in divergent thinking.

2. Method

2.1. Participants

We estimated that we would need at least 87 participants for a medium effect size f = .25, alpha = .05, power = .90, three participant groups, two measurements, correlation among repeated measures = .2 and a nonsphericity correction ε = 1. Participants were recruited by approaching parents via schools that fell into our three target categories (BilS, L2, NoL2). We recruited 103 4–5-year-old children who attended the first year of primary school in predominantly White neighbourhoods in the United Kingdom and who were monolingual before entering school. Four of these children were removed from the analyses because they did not complete all tasks. The remaining 99 participants belonged to three different groups: One group was recruited from two bilingual schools (BilS) (n = 32), located in Oxfordshire and South East London (United Kingdom). About 50% of their education was taught in a language other than English. One school taught core subjects (English, maths, and science) in English in the mornings and the remaining subjects (e.g., sports, arts) in French in the afternoons. The other school taught all subjects in English for half the week and in German, French, or Spanish for the other half. The second group of children (L2 learners, n = 29) attended one of four mainstream schools that provided weekly 30–60 min foreign language lessons (German, French, or Spanish). The third group of children (NoL2, n = 38) attended one of two mainstream schools without a foreign language provision. All schools followed the national curriculum. The first year of primary school teaches children primarily through games and play, with activities in small groups and free play. Expressive arts and design is one of the seven areas of learning next to communication and language, personal, social and emotional development, physical development, literacy, mathematics and understanding the world. We are not aware of any engagement in expressive arts that went beyond the curriculum in any of the schools. The majority of schools were state-funded, but two of the four schools with weekly language provision were private schools that charge a fee.

Table 1 lists the characteristics of the children in the three groups. All children and their parents were born in the United Kingdom or another English-speaking country. They had lived in the United Kingdom since birth, apart from two bilingual school children who had lived in Singapore in their first year of life (between five weeks and 15 months). All children were exposed exclusively to English at home. To ensure that the three groups of children did not differ in terms of cognitive abilities at the beginning of the study, we tested them on an English vocabulary test and a non-verbal IQ measure. We also compared them on age, gender, maternal and paternal background, SES, hours of extra-curricular activities, hours of computer usage, and number of (older) siblings. The three participant groups did not significantly differ with regards to any of these characteristics at the start of the study, apart from age, $F(2,96) = 7.2$, $p = .001$, $\eta p2 = .131$. NoL2 children were significantly older than BilS children, $p = .001$, and marginally older than L2 learners, $p = .063$. Importantly, age did not correlate with any measures of divergent thinking or EF at either T1 or T2 but with improvement on the DCCS, Pearson $r(99) = -.252$, $p = .012$, and creative flexibility improvement, Pearson $r(99) = -.221$, $p = .028$, all other ps > 0.05. We thus partialled out any effect of age when analyzing improvements.

3. Materials

3.1. Background information questionnaire

We administered a modified version of the Language and Social Background Questionnaire (Luk & Bialystok, 2013) to gather information on, for instance, children's gender, date of birth, extra-school activities, computer usage, maternal and paternal level of education, annual family income, and languages spoken by participants. We only tested children who were monolingual and had no exposure to any non-English language.

Each child's socio-economic status (SES) was determined by averaging indices of parental education, occupational status and annual family income. The level of each parent's education was measured on a 6-point scale, with 1 being 'no formal educational qualification' and 6 'masters/doctoral degree, National Vocational Qualification level 5, or equivalent'. A parental index was obtained by averaging the scores of both parents. Occupational status was classified according to the Standard Occupational Classification Hierarchy redacted by the Office for National Statistic. An occupational index was calculated by averaging the scores of both parents (if applicable). Annual family income was obtained via a 7-point scale, with 1 being 'less than £15,000' and 7 '£65,000 or more'. To combine these indexes into an SES index, all three indices were converted onto a scale of 0–1.

3.2. General intelligence

We measured children's intelligence with the means of Raven's Coloured Progressive Matrices (Raven et al., 1990), a widely-used measure of non-verbal abstract reasoning. Participants are asked to complete visual patterns by choosing from six options of missing parts. The test was presented using E-prime (E-Studio 2.0), with participants pointing to the chosen missing part and the experimenter pressing a corresponding button on a keyboard. Each correct answer was given one score (maximum 36).

3.3. Vocabulary

We assessed children's language ability with the British Pictures Vocabulary Scale III (BPVS; Dunn et al., 2009), a standardized measure of receptive vocabulary for children aged 3 to 16 years. Children are asked to point to pictures (out of four options) that correspond to words produced by the experimenter. The test contains 14 sets of 12 words. The test is terminated when a child makes eight or more errors within a set. The test score is calculated as the total number of tables presented minus the total number of errors.

3.4. Divergent thinking

We tested divergent thinking skills with means of a modified version of the "Repeated figures" task from the figural form of the TTCT (Torrance, 1966), using different stimuli. This task assesses the ability to respond to a repeated stimulus with different ideas. At T1 children were presented with a landscape-oriented A4 sheet of paper with eighteen 28×28mm squares arranged in three rows of six squares. At T2, each square was replaced with two 3-cm-long horizontal parallel lines. Thus, children were given squares at T1 and lines at T2. Children were asked to "turn the squares (or the lines) into something else with their drawing". They were given 10 min to produce as many different responses as they could. They were told to think of something different every time and to think of something that only they could think of. The experimenter explained the task at both T1 and T2 by showing two example responses. At T1, the experimenter pointed to the first example response and said: "For example, I turned this square into a house" and, tracing over the drawing with a pencil, continued "I drew a roof here on top, a door, windows… and now it is not a

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square anymore, it is a house!". Pointing to the second example, they continued "Then, I thought of something else and turned this other square into a window. You need to turn each square into something different every time. You have 10 minutes to turn as many squares as you can into something else." The same procedure was followed at T2. This time, the children were presented with two pairs of lines turned into a butterfly and a bag, respectively.

If children duplicated the examples given or replicated their own responses, the experimenter encouraged them to think of something different for the next square or pair of lines. If children stopped drawing, the experimenter praised the responses that they had already given and encouraged them to think of something else to turn the squares/lines into. After each drawing children were asked to say what they drew, and, whenever it was not evident, they were also asked to explain what the square (or the lines) represented in their drawing. Children's answers were noted by the experimenter.

Responses were scored after all children had participated. A general rule for accepting or rejecting participants' responses was to determine whether the stimulus had been integrated into the drawing. Given the young age of the children and their poor fine motor skills, it was sometimes not easy to establish the role of the stimulus (the square at T1 and the lines at T2) in their responses purely based on what they drew. Therefore, we also took into account what children said about their drawings. As mentioned, whenever the role of the stimulus was not obvious, children were asked "What is the square/are the lines in your drawing?". If children's answers clearly showed that they meant to incorporate the stimulus but failed to do so because of practical inability, then the response was deemed valid. For example, sometimes children tried to trace over the square to integrate it into their drawing but, not being able to do so, drew a line around it instead. When asked what the square was, they answered that it was a part of the object that they depicted, for instance, the seat of a chair. In such a case, the response was counted as valid. Conversely, if children showed that they used the stimulus only as an area to draw in and produced a drawing unrelated to the stimulus, then the response was deemed invalid. This happened especially at T1, when children tended to draw something inside the squares. For example, one child drew a snowman inside the square and said that the square was "snow around the snowman". This response was rejected.

As typical for the TTCT, responses were scored on three components of divergent thinking, namely fluency, flexibility, and originality. For the fluency score, one point was given for each valid response. Plain replications of the examples presented to them or of their own previous responses were not considered as valid. However, variations of the examples given (e.g., "a haunted house") or of their previous responses (e.g., "a doll's face", "a pirate's face", "a dog's face", etc.) were counted for fluency. A higher fluency score corresponded to superior creative fluency.

As for flexibility, the number of different response categories was counted. Following Beck et al. (2016), categories were determined across all responses of all participants at each testing point. This was done unanimously by the experimenter and a blind scorer. Categories are listed in Supplementary Table 1. Additional categories with single members were established when responses could not be assigned to any of these categories. Children were given one point for flexibility for each category they produced. A higher flexibility score corresponded to superior creative flexibility. The maximum possible score for both fluency and flexibility was 18 points.

For originality scores, we determined how many children gave a specific response. Thus, if 10 children had turned the square into a school, a 'school response' would be given 10 points. To determine an originality score for a particular child, we averaged the points for their responses and subtracted the score from the maximum score of 99 (see 99 participating children), so that a higher originality score corresponded to superior originality (maximum possible score of 98). We then divided this number by their fluency score. The latter was done to avoid the originality score being conflated with fluency (Hocevar, 1979).

3.5. Selective attention

We measured selective attention skills by implementing a common task, the Attention Network Test for children (ANT). We used a child-friendly version of the task by Rueda et al. (2004), in which participants were presented with rows of five identical fish. They were asked to 'feed' the central fish by pressing a left button with a fish facing left or right button with a fish facing right, depending on the direction of the central fish. There were three conditions. In the neutral condition, a single fish was presented. In the congruent condition, the flanking fish faced in the same direction as the target fish, while in the incongruent condition, they faced in the opposite direction. A trial started with a fixation cross in the centre of a laptop screen for 400 ms, followed by a 150 ms attentional cue (an asterisk) and the stimulus which appeared after 450 ms. Attentional cues were presented either in the position of the fixation cross or above or below it, while stimuli were presented above or below the fixation cross. The maximum response time was 1700 ms.

In case of a correct response, the target fish opened its mouth and bubbles appeared, while a "woohoo" sound played. In case of incorrect or missing responses, a 'wrong buzzer' sound was played. The experiment was implemented in E-prime (E-Studio 2.0). Responses were recorded using a Cedrus RB-844 response pad. The experiment started with 24 practical trials, followed by two blocks of 48 trials each, with an equal number of all conditions and an equal number of right and left-facing target fish. Trials were presented randomly. We recorded both reaction times (RTs) and accuracy.

We followed the procedure by Rueda et al. (2004) to introduce the task to the participants. The experimenter placed a picture of a right-facing fish on the table above the button box. They told the participant that the fish was very hungry and that they needed to feed him by pressing one of the two buttons on the button box. After pointing to the picture and the corresponding button, the experimenter explained "Sometimes the fish is facing this way. In this case, you need to press this button". They then presented a picture with a target fish facing left and pointed to the left button, while explaining "But sometimes the fish is facing the other way. So, which button do you need to press if he is facing the other way?". They showed them the correct button if the child did not respond. Next, they presented a picture with a row of fish all facing left. While pointing to the central one, they said "Sometimes the fish is not alone on the screen, he is with other fish, but you need to look at him in the middle. Which button do you press to feed him?" The same was repeated with a row of fish facing to the right, asking "which button do you press if he is facing the other way?". Finally, the experimenter presented a picture with incongruent flankers (either facing right or left). While pointing to the target fish, they explained: "I told you that you always have to look at the fish in the middle and not at the others because sometimes the other fish are tricky. They want to trick you and they go in the opposite

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direction. But you need to feed the fish in the middle and not the others. So which button do you press for the fish in the middle?". The same was repeated for the other incongruent stimulus, asking "and which button do you press for this other one?". In case of erroneous responses, correct responses were indicated and further explanations were given. The experimenter explained to the children that there would be a small cross on the screen and they had to keep their eyes on the cross as the target fish would occur above or below. Attentional cues were not mentioned. In addition, children were told to keep their index fingers on the two buttons and to press the buttons as quickly as possible when they saw the fish.

The ANT provides indices for three skills: inhibitory (or cognitive) control, alertness and orientation. We calculated the conflict index by subtracting performance on congruent trials from that on incongruent trials, and we did so for both accuracy and RT. These two subindices were standardized and summed, after reversing RTs so that higher values of both RT and accuracy represented better performance. For the alerting index, we subtracted the mean of the Double Cue condition from the mean of the No Cue condition so that a low value corresponded to higher alertness for accuracy and a high value corresponded to higher alertness for RTs. We calculated an alerting index by adding standardized reversed accuracy scores and standardized RTs so that higher values corresponded to better performance. For the orienting index, we subtracted the mean of the Spatial Cue condition from the mean of the Central Cue condition. This way, a low value corresponded to a better orienting for accuracy and a high value corresponded with better orienting for RTs. We calculated the orienting index by adding standardized reversed accuracy scores and standardized RTs so that higher values corresponded to higher performance.

3.6. Cognitive flexibility

We assessed children's cognitive flexibility by means of the DCCS (Zelazo, 2006). Given the children's ages, we administered both the standard and the advanced versions, summing the two scores into a total score. Both versions of the task required children to sort two practice cards and 12 experimental cards (7x11 cm) according to either the shape or colour of the object they depict. In the standard version, children were asked to sort the first half of cards by colour and the second half by shape. At the first testing point, 50% of the cards showed a red rabbit and 50% a blue boat. Children were asked to sort the cards into two transparent containers (16.8 cm × 11.6 × 4.5 cm). The containers were marked with one card each (that is a target card), attached to the back and clearly visible to the participants. One target card depicted a red boat, the other one a blue rabbit. This meant that the target cards did not show identical pictures to the ones that needed to be sorted.

Children were told that they were going to play a game with some cards. The experimenter explained: "The first game is called the *colour game.* In the colour game, you need to sort the cards by colour, so all the red cards go here [pointing to the container featuring the red target card] and all the blue cards go here [pointing to the container featuring the blue target card]". Next, the experimenter presented a red rabbit practice card, explaining: "Here's a red card. Where does it go?" After the children pointed to the correct container, they were asked to place the card into it turning it facedown. This was repeated for a blue boat practice card. If a child placed the card into the wrong container, the correct response was demonstrated. From then on, three red rabbit cards and three blue boat cards were presented in random order and children did not receive any feedback. After the completion of the six pre-switch trials, the experimenter introduced the switch by explaining: "Now we are changing game, we are playing another game called *picture game.* In the picture game, you need to sort cards by picture, so all the rabbits go here [pointing to the container with the target rabbit card] and all the boats go here [pointing to the container with the boat target card]. Here's a rabbit, where does it go?". The experimenter handed the card to the child who placed it without receiving feedback. Again, the child was asked to sort three red rabbit cards and three blue boat cards in pseudorandom order. Notably, in each trial of the standard version of the task, the experimenter mentioned the relevant feature of the card before handing it to the child. Thus, they would say "Here's a red/blue card" for pre-switch trials and "Here's a rabbit/boat card" for post-switch trials. Each correct response was awarded one point, with a maximum of 12 points.

After the completion of the standard version, the experimenter moved on to the advanced version of the task, in which the sorting rule could change from card to card and was depicted on the cards. Cards to be sorted by colour showed a rainbow, and cards to be sorted by shape showed black outlines of a rabbit and a boat. Again, children were asked to sort two practice cards and 12 testing cards, that is eight red rabbit cards and six blue boat cards. Half the cards indicated the colour sorting rule, and the other half indicated the shape-sorting rule. Cards were given to the child in a pseudorandomized order. In half the trials, the rule stayed the same as the previous one, while in the other half, the rule switched.

The experimenter explained the advanced version of the task to the participant by saying: "Now we are going to play another game with this special set of cards. In this set, some cards have a rainbow and some cards have two small pictures. If the card has got a rainbow [showing a rainbow-labelled rabbit card], it's a colour-game card and you have to play the colour game, but if the card has got two small pictures [showing an outlines-labelled rabbit card], it's a picture-game card and you need to play the picture game". The experimenter handed the rainbow card to the child, explaining: "This has got a rainbow, so it's a colour game card. Can you remember the rule for the colour game?" In case the child did not remember the rule, the experimenter said: "In the colour game, red cards go here and blue cards go here [pointing to the corresponding target cards]. This is a colour game card, where does it go?" In case the child did not place the card into the correct container, the experimenter showed them where it goes and explained the rule again. This was repeated with the second practice card, a picture-rule rabbit card. After the practice trials, 12 trials followed (three colour-rule rabbit cards, three picture-rule rabbit cards, three picture-rule boat cards and three colour-rule boat cards), presented in a pseudo-random order. For all cards, the experimenter indicated the rule of the card when handing it to the child by saying, "Here's a colour-game/picture-game card". As for the standard version, each correct response was awarded one point, with a maximum of 12 points. When scoring responses, only first attempts were counted, ignoring if the child changed their mind. Taking the scores for the two versions of the task together, children could reach a maximum of 24 points.

The same procedure was repeated at the second testing point but with different objects depicted on the cards and different colours (yellow flower and blue car).

4. Procedure

The parents of all children consented to the participation and filled in the Background Information questionnaire. Children were tested on a set of tasks at the beginning of the first year of primary school and repeated 24 weeks later. Testing at both time points took place in the same order on three days over the course of two weeks. On day one, children completed the Coloured Progressive Matrices (Raven et al., 1990), the modified version of the figural thinking task of the TTCT (Torrance, 1966), and the DCCS (Zelazo, 2006). On day two, they took part in the ANT (Rueda et al., 2004) and the British Picture Vocabulary Scale III (BPVS; Dunn et al., 2009). On day three, they took part in a Theory of Mind task, which is unrelated to the present research questions and will be reported elsewhere.

5. Results

In the following, we started by addressing our first two aims, namely whether creative abilities can be enhanced by exposure to a foreign language in the first year of formal education, and if so, whether this relationship is moderated by the amount of second language exposure. For that, we report the results of the divergent thinking task. Next, we tested whether similar changes were observed for EFs. Finally, we tested whether changes in EFs mediated the effects of foreign language exposure on creative abilities.

5.1. Divergent thinking task

Responses were scored independently by the experimenter and a blind scorer. Both scorers were blind as to the group membership of the children. The two agreed on the scores in 76% of all responses at T1 and in 78% at T2. Differences in scoring were discussed and a final score was agreed upon. A similar number of responses were rejected in the three groups due to being invalid (BilS: T1: mean 2.0 (SD 1.5), T2: mean 0.6 (SD 1.0); L2: T1: mean 2.2 (SD 1.7), T2: mean 1.6 (SD 1.6); NoL2: T1: mean 2.6 (SD 2.5), T2: mean 1.9 (SD 2.0)). Figure 1 shows the groups' valid creative fluency, flexibility and originality scores at T1 and T2.

We analyzed potential group differences in the multivariate pattern of the three divergent thinking measures (fluency, flexibility, and originality) across the two time points using a two-way multivariate analysis of variance (MANOVA) with the within-subjects factor Time (T1 vs T2) and the between-subjects factor Group (BilS, L2, No-L2). In the case of a Time x Group interaction, we report two series of posthoc MANOVAs. First, we report group comparisons at T1 and T2. For any significant group effect, we report post-hoc MANOVAs comparing pairs of groups. Second, we report development in divergent thinking between T1 and T2 for each group. In order to better understand the development of the groups in the submeasures of divergent thinking (fluency, flexibility and originality), we also report the results of univariate analyses.

The MANOVA for the multivariate pattern of fluency, flexibility and originality and age as covariate showed a significant effect of Time, *Wilks' Lambda* = .611, $F(3, 93) = 19.7$, $p < .001$, $\eta p^2 = .389$, a significant effect of Group, *Wilks' Lambda* = .817, $F(6, 186) = 3.3$, $p = .004$, $\eta p^2 = .096$, and a marginally significant Time x Group interaction, *Wilks' Lambda* = .880, $F(6, 186) = 2.0$, $p = .062$,

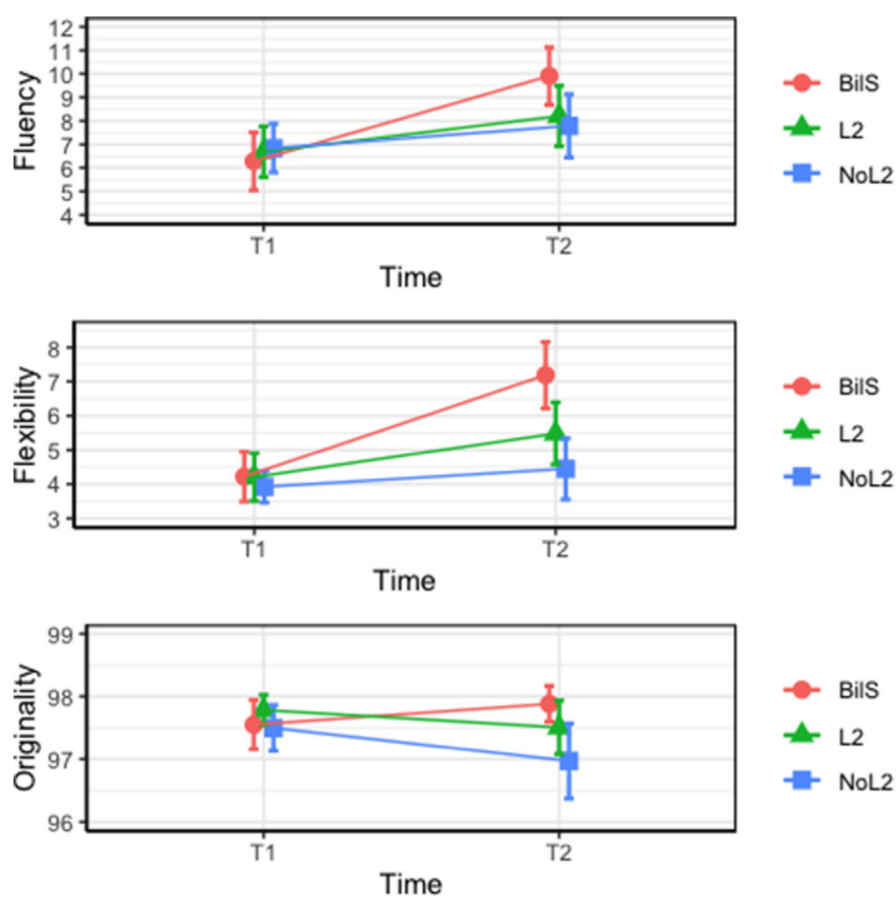

Figure 1. Average creative fluency, flexibility and originality scores for the three participant groups (BilS = bilingual schools, WL2 = weekly second language learners, NoL2 = no second language provision) and testing points (T1 and T2). Error bars represent 95% confidence intervals.

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ηp^2 = .062. Posthoc multivariate ANOVAs at each time point with age as covariate showed no effect of Group at T1, *Wilks' Lambda* = .952, $F(6, 186) = .8$, $p = .594$, $\eta p^2 = .024$, but an effect of Group at T2, *Wilks' Lambda* = .836, $F(6, 186) = 2.9$, $p = .010$, $\eta p^2 = .085$. Follow-up MANOVAs comparing pairs of groups on the multivariate pattern of the divergent thinking measures at T2 (with age as a covariate) showed that BilS scored higher than NoL2 children, *Wilks' Lambda* = .840, $F(3, 65) = 4.1$, $p < .010$, $\eta p^2 = .160$. L2 learners fell in between the other groups, not scoring significantly different from either, BilS: *Wilks' Lambda* = .904, $F(3, 56) = 2.0$, $p = .125$, $\eta p^2 = .096$; NoL2 children: *Wilks' Lambda* = .934, $F(3, 62) = 1.5$, $p = .236$, $\eta p^2 = .066$.

While the groups differed at T2, post-hoc MANOVAs for each group with age as covariate showed that all groups improved their divergent thinking across the two timepoints, BilS: *Wilks' Lambda* = .475, $F(3, 28) = 10.3$, $p < .001$, $\eta p^2 = .525$; L2 learners: *Wilks' Lambda* = .599, $F(3, 25) = 5.6$, $p = .004$, $\eta p^2 = .401$; NoL2 children: *Wilks' Lambda* = .763, $F(3, 34) = 33.5$, $p = .025$, $\eta p^2 = .237$.

Figure 1 suggests that the groups' development somewhat differed for the three divergent thinking measures (fluency, flexibility, and originality). Univariate analyses of the measures showed a divergent pattern for originality, but results for creative fluency and flexibility confirm the overall MANOVA pattern (see Table 2 and Supplementary Material).

In sum, the three participant groups did not differ in their divergent thinking skills at T1. They improved their skills across the two time points to different degrees so that they differed at T2, particularly for creative fluency and flexibility. BilS children outperformed NoL2 children and L2 learners fell in between, not significantly differing from either of the other two groups.

Table 2. Results of univariate analyses for all measures (creative thinking and EF)

Measure	Time F	Time p	Group F	Group p	Time × Group F	Time × Group p
Creative thinking						
Fluency	32.6	<.001*	.7	.515	5.4	.006*
T1			.3	.753		
T2			3.1	.049*		
Flexibility	29.4	<.001*	7.0	.001*	6.3	.003*
T1			.3	.721		
T2			9.6	<.001*		
Originality	.9	.334	3.1	.048*	2.6	.083(*)
T1			.8	.474		
T2			4.0	.022*		
Executive functions (EFs)						
DCCS	101.5	<.001*	2.0	.142	7.8	<.001*
T1			.3	.758		
T2			9.1	<.001*		
Conflict index	.003	.960	2.0	.139	1.2	.317
Orienting index	.008	.930	.184	.832	3.58	.033*
T1			2.22	.116		
T2			1.3	.270		
Alerting index	.004	.952	4.0	.023*	1.8	.173

Note:
*marks significance at 0.05 level, (*) a trend for significance. Comparisons between the three groups for significant effects of Group are reported in the Supplementary Material.

5.2. Executive Function measures

Next, we tested whether the groups differed in their development of EF, conducting equivalent MANOVAs as for the divergent thinking measures above, but with DCCS and ANT indices (ANT measures inhibition, alertness, and orienting) as dependent variables. Again, we explored the development of the groups in the EF sub-measures with univariate analyses.

Some children had a high error rate in the ANT task. We, therefore, included only children who reached at least 60% accuracy at T1 (57 trials) in the analysis of EFs, which corresponded to above-chance performance (57 out of 96 total responses have a one-tailed probability of 0.041). This led to a reduction of the sample from 99 to 76 children (26 BilSs, 24 WL2s and 26 NoL2s). For the analysis, we removed all errors, and response omissions, as well as responses <200 ms (anticipatory responses) and > 2.5 SDs above the mean of each participant (19.5% of all trials).

Figures 2 and 3 show the development of the three groups in the EFs measures across the two time points. A two-way MANOVA of the multivariate pattern of EFs (DCCS scores and the ANT measures of conflict index, alerting index, and orienting index) and age as a covariate showed a significant effect of Time, *Wilks' Lambda* = .394, $F(4, 69) = 25.6$, $p < .001$, $\eta p^2 = .5606$, no significant effect of Group, *Wilks' Lambda* = .829, $F(8, 138) = 1.7$, $p = .104$, $\eta p^2 = .090$, and a significant Time x Group interaction, *Wilks' Lambda* = .720, $F(8, 138) = 3.1$, $p = .003$, $\eta p^2 = .151$. Posthoc MANOVAs at each timepoint (controlling for age) showed an effect of Group at both timepoints, T1: *Wilks' Lambda* = .666, $F(8, 138) = 2.5$, $p = .016$, $\eta p^2 = .125$; T2: *Wilks' Lambda* = .770, $F(8, 138) = 2.4$, $p = .018$, $\eta p^2 = .123$.

We followed up these results with MANOVAs comparing pairs of groups on the multivariates pattern of the executive function measures at each timepoint, controlling for age. At T1, L2 learners scored overall lower than both BilS children and NoL2 children, BilS: *Wilks' Lambda* = .768, $F(4, 46) = 3.3$, $p = .018$, $\eta p^2 = .232$; NoL2 children: *Wilks' Lambda* = .793, $F(4, 44) = 2.9$, $p = .034$, $\eta p^2 = .207$, while BilS children and NoL2 children did not significantly differ, *Wilks' Lambda* = .860, $F(4, 46) = 1.9$, $p = .131$, $\eta p^2 = .2140$. At T2, BilS children scored overall higher than NoL2 children: *Wilks' Lambda* = .691, $F(4, 46) = 5.1$, $p = .002$, $\eta p^2 = .309$, while L2 learners did not score significantly different from either group, BilS children: *Wilks' Lambda* = .882, $F(4, 44) = 1.5$, $p = .228$, $\eta p^2 = .118$; NoL2 children: *Wilks' Lambda* = .876, $F(4, 44) = 1.6$, $p = .202$, $\eta p^2 = .124$.

Figures 2 and 3 suggest that the groups' development in cognitive flexibility, measured by means of the DCCS, mirrors their development in creative fluency and flexibility, while the results of the ANT indices showed a very different pattern. Univariate analyses of the four measures confirm this impression (see Table 2 and Supplementary Material). It is striking that the ANT indices did not show any improvement over time. Only the orienting index showed a crossover Group x Time interaction, with no group differences at either time point. And BilS children had generally higher alerting scores than the other two groups.

We also tested how each group changed across the two time points. All groups significantly improved their EFs skills, BilS: *Wilks' Lambda* = .187, $F(4, 21) = 22.9$, $p < .001$, $\eta p^2 = .813$; L2 learners: *Wilks' Lambda* = .304, $F(4, 19) = 10.9$, $p < .001$, $\eta p^2 = .696$;

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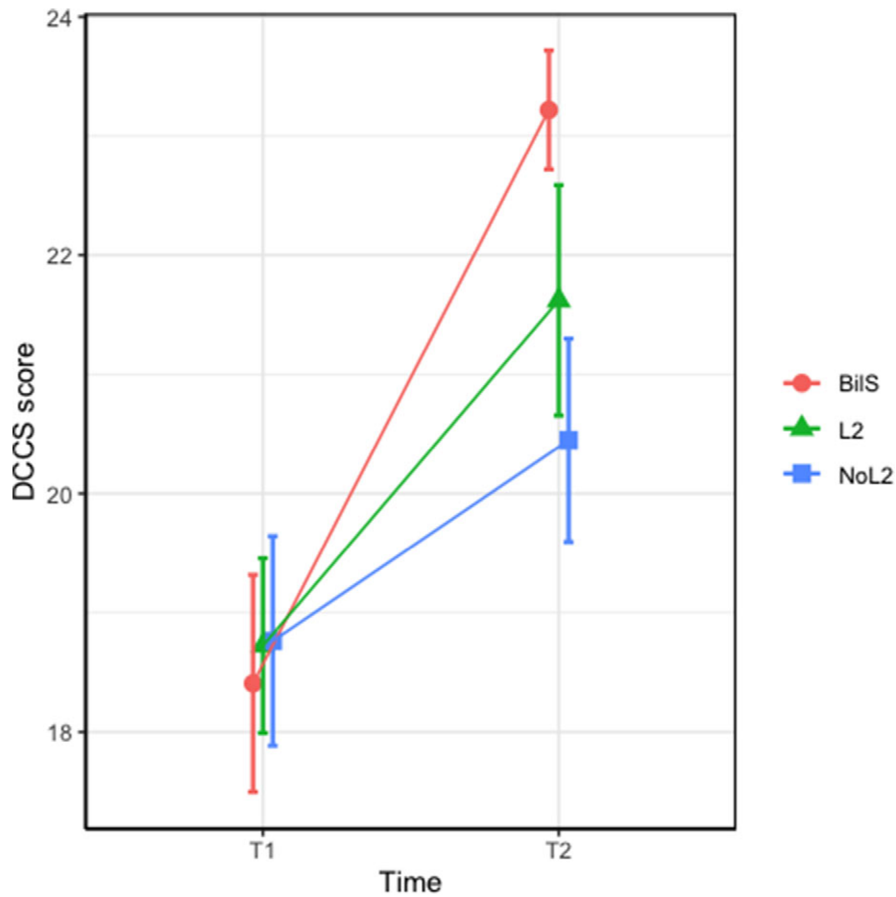

Figure 2. DCCS scores for the three participant groups (BilS = bilingual school children, L2 = L2 learners, NoL2 = children without L2 provision) at T1 and T2. Error bars represent 95% confidence intervals.

NoL2 children: *Wilks' Lambda* = .635, $F(4, 21) = 3.0$, $p = .041$, $\eta p^2 = .365$.

In sum, the groups' development in EFs was similar to that of their creative thinking development, but this was driven by the development in cognitive flexibility (DCCS).

5.3. Relationships between improvement in divergent thinking and EF measures

Since the groups differed in terms of both divergent thinking development and EFs development, we conducted a mediation analysis to test whether children's creative thinking improvement might have been driven by EFs improvements. For that, we created compositive scores for both divergent thinking improvement and EFs improvement for each participant by taking three steps. First, we standardized all scores and calculated improvements across the two time points for all measures. Second, we averaged these standardized improvement scores for each factor, that is a) improvement scores of fluency, flexibility, and originality to create a composite measure for divergent thinking and b) improvement scores of DCCS, conflict index, alerting index, and orienting index to create a composite measure of EF. Third, we conducted a mediation analysis with Group as the independent variable, the composite divergent thinking development measure as the dependent variable, and the composite EFs development measure as the mediator.

We next checked whether the following four conditions of mediation (Judd & Kenny, 1981) were met, basing the analysis on the reduced set of 76 participants (see explanation for ANT measures above). 1) The independent variable (Group) needed to significantly affect the outcome variable (critical thinking development) when the mediator (EFs development) was not taken into account. 2) The independent variable (Group) had to significantly affect the mediator (EFs development). 3) The independent variable (Group) needed to affect the outcome variable (critical thinking development) to a lesser degree or not at all when the mediator (EFs development) was controlled. 4) the mediator (EFs development) had to affect the outcome variable (critical thinking development). While there were significant effects and trends for other relations, EFs development did not predict critical thinking development, $b = 0.08$, $t(71) = 0.6$, $p = 0.554$, meaning condition (4) was not met. The same was the case for an exploratory mediation analysis that only took measures into account that had the same pattern (DCCS for EFs development and creative fluency and flexibility for creative thinking development) and that was based on the full 99 participants, $b = 0.01$, $t(94) = 0.17$, $p = 0.867$. Thus, the data suggest that EFs development did not mediate the effect of Group on divergent thinking development.

6. Discussion

We explored the impact of being exposed to a second language at school on divergent thinking skills, the effect of the amount of L2 exposure and whether any improvement in creative thinking could be explained by an improvement in EFs. We found that exposure to

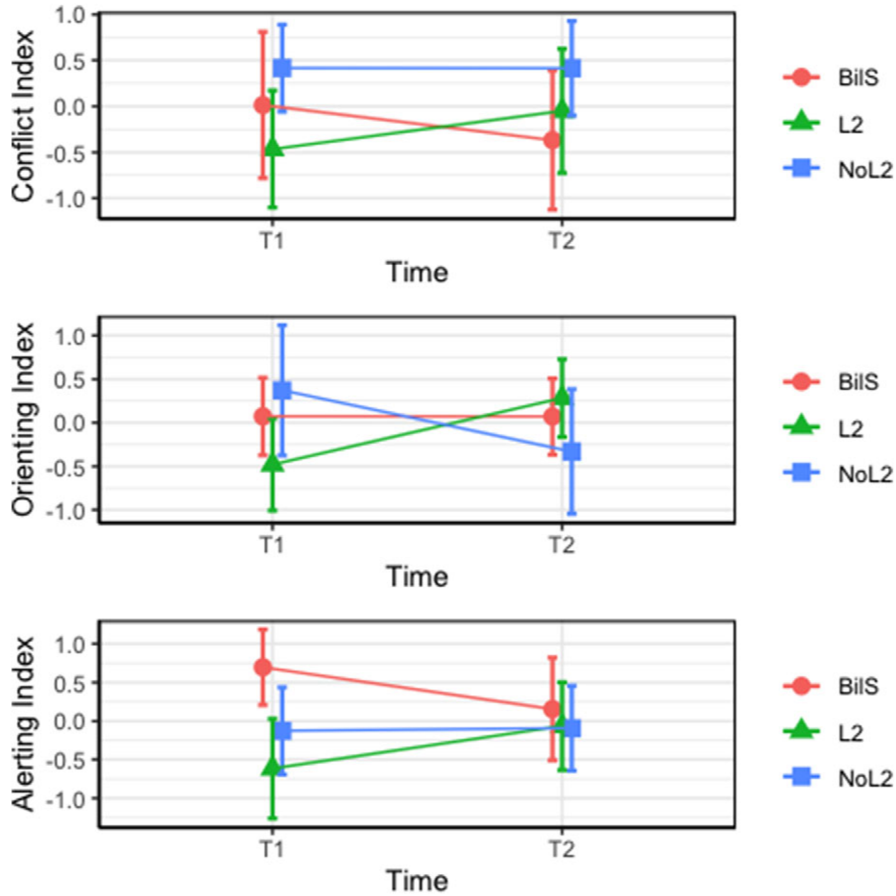

Figure 3. Mean conflict, orienting, and alerting indices of the ANT for the three participant groups (BilS = bilingual school children, L2 = L2 learners, NoL2 = children without L2 provision) at both testing points (T1 and T2). Error bars represent 95% confidence intervals.

a second language in formal settings seems to enhance divergent thinking. Also, while the three groups did not differ in divergent thinking at the first testing point, at the second testing point, bilingual school children outperformed children without a foreign language provision (control group). Weekly language learners fell in between the two groups, not scoring significantly different from either group. A more fine-grained analysis of the three divergent thinking submeasures showed the same general pattern for fluency and flexibility as for the multivariate pattern as a whole, while the results for originality somewhat differed in that none of the groups significantly improved over time. Together, the data suggest that attending a bilingual school enhanced creative thinking. In contrast, they provide no firm evidence of the efficacy of weekly foreign language teaching, even though the trend in the data suggests an effect in the same direction, but of a smaller magnitude.

Our findings are in line with a body of literature which found a bilingual advantage over monolinguals in creative fluency (Leikin, 2013; Leikin et al., 2014; Leikin et al., 2020) and flexibility (Adi-Japha et al., 2010; Carringer, 1974; Kharkhurin, 2017; Kharkhurin & Motalleebi, 2008; Leikin et al., 2014) as well as with studies which compared L2 learners at school to a group of children without a foreign language provision (Ghonsooly & Showqi, 2012; Landry, 1973a, 1973b, 1974). Unlike previous studies, though, we conducted a longitudinal study, checking divergent thinking ability at the start of foreign language exposure and carefully controlling for potential confounds. Thus, our results provide more controlled evidence that foreign language exposure in primary school seems to promote children's divergent thinking. As we observed advantages after only six months within the first year of formal education, our study also suggests that enhancement in divergent thinking can be achieved quite quickly. This stands in contrast to the findings by Landry (1973a, 1973b, 1974) who found a benefit only in higher grades of school and thus at more advanced stages of L2 acquisition. These differences might be due to our careful control of confounding factors.

Similar to the study by Leikin (2013), we found evidence of a benefit of a bilingual educational environment on creative originality. But the results for originality are less conclusive than those for fluency and flexibility. This is because originality scores for neither participant group significantly changed across the two testing points. Those for L2 learners and monolingual control children seemed to have rather decreased than increased, but the difference between testing points was very small. Notably, Leikin (2013) found a very similar pattern of results, using a different divergent thinking test. Just like in the present study, fluency and flexibility scores, but not originality scores, increased between the ages of ~46 and ~ 58 months, and this was the case for different types of children. In their case, these were monolingual children, children attending a bilingual kindergarten and children immersed in an L2 environment at kindergarten. And just like in our study, children attending a bilingual kindergarten scored higher on originality than monolingual children at the second testing point. The two studies together thus suggest that bilingual educational settings lead to higher creative originality, even though originality scores did not

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increase significantly. Instead, the difference between groups at time two appeared due to different trajectories of change in the three groups – something that requires confirmation in a sample tested over a longer period of time.

The question arises why originality develops differently from fluency and flexibility. The development of the latter two has been linked to children's increasing experiences and, related to that, their increasing long-term semantic and episodic memory (e.g., Bai et al., 2023). More experience and more associations in semantic memory can help children arrive at more solutions to a problem or task. While a similar argument could be made for originality – more experience can lead to more unique solutions – originality relies additionally on deep category exploration (Nijstad et al., 2010; Weiss & Wilhelm 2022). This is evidenced in the serial order effect of originality in divergent thinking tasks (Christensen et al., 1957): participants first respond with common ideas and produce increasingly original ideas with increasing number of responses. For instance, in our divergent thinking task, a child might have first turned a square into a simple house and later into a castle. Thus, they did not stop at an easy solution, but kept thinking beyond the prototype (that is a simple house). Due to the serial order effect, creative originality has been linked to persistence and effort (Nijstad et al., 2010; Weiss & Wilhelm 2022). Since originality is much more strongly related to effort than fluency and flexibility, it might be this additional aspect that causes a different development.

Our results suggest that one weekly session of L2 over six months is not sufficient to result in significant changes compared to no foreign language provision. However, it is important to note that weekly language learners did improve in both fluency and flexibility, while the control group did not. They also numerically fell in between the two other groups at T2, not differing as clearly from the bilingual school children as from the control group. A somewhat higher amount or a longer period of exposure might have potentially impacted their creative thinking more clearly.

We also tested whether any enhancement in creative thinking might have been due to enhancement in EFs. The mediation analyses suggested that this was not the case, despite the pattern of results for cognitive flexibility (measured by means of the DCCS) resembling that for creative fluency and flexibility. Thus, while EFs might play a role in divergent thinking (Beaty et al., 2014; Benedek et al., 2012; Benedek et al., 2014; Pan & Yu, 2018), our results suggest that enhanced EFs do not explain the bilingual advantage in creativity tasks as previously proposed (Hommel et al., 2011; Kharkhurin, 2011; Sampedro & Peña, 2019).

If improvements in divergent thinking due to foreign language exposure are not due to improvements in EFs, what can be the mechanism? Bilingual enhanced divergent thinking ability has also been explained by richer and more elaborate conceptual and semantic networks (Adi-Japha et al., 2010; Kharkhurin, 2017). Kharkhurin (2017) showed that bilinguals' enhanced flexibility in creative production was linked to the fact that semantic networks in bilinguals connect words that are semantically unrelated for monolinguals. It is possible that our children learning a foreign language, especially those in bilingual education, had already enriched their networks of conceptual associations.

Alternatively, increased divergent thinking skills by children exposed to a foreign language might have been prompted not only by their encounter to a new language but also by their exposure to a bicultural or multicultural environment. There is evidence that experience of culturally diverse environments (Goclowska & Crisp, 2014) or cultural experience through living abroad (Creo et al., 2021; Maddux & Galinsky, 2009) leads to creativity enhancements and that cultural diversity in school settings favours children's divergent thinking (review in Dunne, 2017; Vezzali et al., 2016). As we strictly limited the participation in our study to children from English monolingual households, it is very likely that especially BilS, with staff and teachers that are native speakers of non-English languages, offered children a very first experience of a new culturally diverse context. This experience might have played a key role in their divergent thinking development.

Our study has both strengths and limitations. Its strengths are its longitudinal design and its control for various confounding variables. Not finding differences between the participant groups in terms of gender, parental background, SES, hours of extracurricular activities, computer use, number of siblings, English vocabulary and non-verbal IQ at the beginning of the studies ensured that any differences in creative thinking development was not due to participant differences. However, the fact that children were educated in different schools meant that their educational experiences (in addition to exposure to an L2) might not have been the same. Since all schools followed the national curriculum, core teaching is unlikely to have differed. But we do not know whether implementations of the curriculum differed or whether any additional enrichment activities might have affected their development of creative abilities. It is worth noting that any confounding effect of school differences would have somewhat be mitigated by the fact that each participant group was recruited from more than one schools. We recruited participants from two bilingual schools, four schools with L2 provision and two mainstream schools without L2 provision. It will be important to control for any differences in curriculum implementation in future studies, especially those related to expressive art.

A further limitation of our study is that we did not test children's L2 proficiency at the end of the study. Given the potential link between vocabulary knowledge and creative thinking, it is possible that only those children who showed considerable L2 learning exhibited boosted creative thinking skills. It would be interesting to test in future studies in how far L2 language proficiency within a language learning group might be related to development in creative thinking. This would particularly be interesting to test in children who have limited L2 provision as in our weekly L2 group.

In conclusion, the results of our longitudinal study corroborate earlier findings of the impact of L2-learning in primary school settings on divergent thinking skills. Our findings clarify that significant advantages in creative thinking can be achieved in early stages of L2 learning, provided that children receive L2 instructions for a considerable amount of time. Our longitudinal design enabled us to investigate whether creative thinking changes were related to EFs changes. We found that this was not the case. This speaks against an EFs account of the bilingual creativity advantage. Instead, we speculate that bilingual school children might have developed an enriched lexical-semantic network with more elaborate semantic associations. This might derive from the acquisition of a new language and/or exposure to a new culturally diverse environment. Future studies should consider whether increasing the amount of L2 exposure in mainstream schools could positively impact children's divergent thinking skills.

Supplementary material. To view supplementary material for this article, please visit http://doi.org/10.1017/S1366728924000579.

Data availability statement. All data, analysis and materials for the experiment are available at the open science framework at https://osf.io/z7p23/?view_only=4fa2dbbb2623468b9b6a60a61c714829

Competing interest. The authors declare no conflicts of interest.

Ethics approval statement. The study protocol received full ethical approval from the Science, Technology, Engineering and Mathematics ethics Committee of the University of Birmingham, United Kingdom (ERN_17–0324).

References

Adi-Japha, E., **Berberich-Artzi, J.**, & **Libnawi, A.** (2010). Cognitive flexibility in drawings of bilingual children. *Child Development*, **81**(5), 1356–1366. doi: 10.1111/j.1467-8624.2010.01477.x

Bai, H., **Mulder, H.**, **Moerbeek, M.**, **Leseman, P. P. M.**, & **Kroesbergen, E. H.** (2023). The Development of Divergent Thinking in 4- to 6-Year-Old Children. *Creativity Research Journal*, **36**(4), 656–674. https://doi.org/10.1080/10400419.2023.2182492

Barac, R., **Bialystok, E.**, **Castro, D. C.**, & **Sanchez, M.** (2014). The cognitive development of young dual language learners: A critical review. *Early Childhood Research Quarterly*, **29**(4), 699–714. doi:10.1016/j.ecresq.2014.02.003

Beaty, R. E., **Silvia, P. J.**, **Nusbaum, E. C.**, **Jauk, E.**, & **Benedek, M.** (2014). The roles of associative and executive processes in creative cognition. *Memory & Cognition*, **42**(7), 1186–1197. doi:10.3758/s13421-014-0428-8

Beck, S. R., **Williams, C.**, **Cutting, N.**, **Apperly, I. A.**, & **Chappell, J.** (2016). Individual differences in children's innovative problem-solving are not predicted by divergent thinking or executive functions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **371**(1690). https://doi.org/https://doi.apa.org/doi/10.1037/0003-066X.55.1.151

Benedek, M., **Franz, F.**, **Heene, M.**, & **Neubauer, A. C.** (2012). Differential effects of cognitive inhibition and intelligence on creativity. *Personality and Individual Differences*, **53**(4), 480–485. doi:10.1016/j.paid.2012.04.014

Benedek, M., **Jauk, E.**, **Sommer, M.**, **Arendasy, M.**, & **Neubauer, A. C.** (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, **46**, 73–83. doi:10.1016/j.intell.2014.05.007

Booton, S. A., **Hoicka, E.**, **O'Grady, A. M.**, **Chan, H. Y. N.**, & **Murphy, V. A.** (2021). Children's divergent thinking and bilingualism. *Thinking Skills and Creativity*, **41**. doi:10.1016/j.tsc.2021.100918

Carringer, D. C. (1974). Creative thinking abilities of Mexican youth: The relationship of bilingualism. *Journal of Cross-Cultural Psychology*, **5**(4), 492–504. doi:10.1177/002202217400500409

Chen, X., **He, J.**, & **Fan, X.** (2022). Relationships between openness to experience, cognitive flexibility, self-esteem, and creativity among bilingual college students in the U.S. *International Journal of Bilingual Education and Bilingualism*, **25**(1), 342–354. doi:10.1080/13670050.2019.1688247

Christensen, P. R., **Guilford, J. P., and Wilson, R. C.**, 1957. Relations of creative responses to working time and instructions . *Journal of Experimental Psychology*, **53**, 82–88.

Creo, E. D., **Mareque, M.**, & **Pino-Juste, M.** (2021). Deciphering the role of multilingualism in creativity at university: The influence of context. *Iral-International Review of Applied Linguistics in Language Teaching.* doi: 10.1515/iral-2020-0170

Dunn, L. M., **Dunn, D. M.**, **Sewell, J.**, **Styles, B.**, **Brzyska, B.**, **Shamsan, Y.**, & **Burge, B.** (2009). *British picture vocabulary scale III*. London: GL Assessment Limited.

Dunne, C. (2017). Can intercultural experiences foster creativity? The relevance, theory and evidence. *Journal of Intercultural Studies*, **38**(2), 189–212. doi:10.1080/07256868.2017.1291495

Edl, S., **Benedek, M.**, **Papousek, I.**, **Weiss, E. M.**, & **Fink, A.** (2014). Creativity and the stroop interference effect. *Personality and Individual Differences*, **69**, 38–42. doi:10.1016/j.paid.2014.05.009

Ghonsooly, B., & **Showqi, S.** (2012). The effects of foreign language learning on creativity. *English Language Teaching*, **5**(4), 161–167.

Goclowska, M. A., & **Crisp, R. J.** (2014). How dual-identity processes foster creativity. *Review of General Psychology*, **18**(3), 216–236. doi:10.1037/gpr0000008

Guildford, J. P. (1967). *The nature of human intelligence*. Cambridge: Cambridge University Press.

Hansenne, M., & **Legrand, J.** (2012). Creativity, emotional intelligence, and school performance in children. *International Journal of Educational Research*, **53**, 264–268. doi:10.1016/j.ijer.2012.03.015

Hendrie Kupczyszyn, K., **Arán Filippetti, V.**, & **Oros, L.** (2024). Socioeconomic status effects on children's creativity: The mediating role of executive functions. *Thinking Skills and Creativity*, **51**, 101437. doi:10.1016/j.tsc.2023.101437

Hocevar, D. (1979). A comparison of statistical infrequency and subjective judgment as criteria in the measurement of originality. *Journal of Personality Assessment*, **43**(3), 297–299. doi:10.1207/s15327752jpa4303_13

Hommel, B., **Colzato, L.**, **Fischer, R.**, & **Christoffels, I.** (2011). Bilingualism and creativity: benefits in convergent thinking come with losses in divergent thinking. *Frontiers in Psychology*, **2**(273). doi:10.3389/fpsyg.2011.00273

Judd, C. M., & **Kenny, D. A.** (1981). Process analysis: Estimating mediation in treatment evaluations. *Evaluation Review*, **5**(5), 602–619. doi:10.1177/0193841X8100500502

Kharkhurin, A. V. (2011). The role of selective attention in bilingual creativity. *Creativity Research Journal*, **23**(3), 239–254. doi:10.1080/10400419.2011.595979

Kharkhurin, A. V. (2017). Language mediated concept activation in bilingual memory facilitates cognitive flexibility. *Frontiers in Psychology*, **8**(1067). doi: 10.3389/fpsyg.2017.01067

Kharkhurin, A. V., & **Motalleebi, S. N. S.** (2008). The impact of culture on the creative potential of American, Russian, and Iranian college students. *Creativity Research Journal*, **20**(4), 404–411. doi:10.1080/10400410802391835

Kim, K. H. (2011). Proven reliability and validity of the Torrance Tests of Creative Thinking (TTCT). *Psychology of Aesthetics Creativity and the Arts*, **5**(4), 314–315. doi:10.1037/a0021916

Krumm, G., **Filippetti, V. A.**, & **Gutierrez, M.** (2018). The contribution of executive functions to creativity in children: What is the role of crystallized and fluid intelligence? *Thinking Skills and Creativity*, **29**, 185–195. doi: 10.1016/j.tsc.2018.07.006

Landry, R. G. (1973a). The enhancement of figural creativity through second language learning at the elementary school level. *Foreign Language Annals*, **7**, 111–115.

Landry, R. G. (1973b). The relationship of second language learning and verbal creativity. *The Modern Language Journal*, **57**(3), 110–113.

Landry, R. G. (1974). A comparison of second language learners and monolinguals on divergent thinking tasks at the elementary school level. *The Modern Language Journal*, **58**(1/2), 10–15. doi:10.2307/323983

Lange, K. V., **Hopman, E. W. M.**, **Zemla, J. C.**, & **Austerweil, J. L.** (2020). Evidence against a relation between bilingualism and creativity. *PLoS One*, **15**(6), e0234928. doi:10.1371/journal.pone.0234928

Lee, H., & **Kim, K. H.** (2010). Relationships between bilingualism and adaptive creative style, innovative creative style, and creative strengths among Korean American students. *Creativity Research Journal*, **22**(4), 402–407. doi: 10.1080/10400419.2010.523409

Lee, H., & **Kim, K. H.** (2011). Can speaking more languages enhance your creativity? Relationship between bilingualism and creative potential among Korean American students with multicultural link. *Personality and Individual Differences*, **50**(8), 1186–1190. doi:10.1016/j.paid.2011.01.039

Leikin, M. (2013). The effect of bilingualism on creativity: Developmental and educational perspectives. *International Journal of Bilingualism*, **17**(4), 431–447. doi:10.1177/1367006912438300

Leikin, M., & **Tovli, E.** (2014). Bilingualism and creativity in early childhood. *Creativity Research Journal*, **26**(4), 411–417. doi:10.1080/10400419.2014.961779

Leikin, M., **Tovli, E.**, & **Malykh, S.** (2014). Bilingualism and creative abiliities in early childhood. *English Linguistics Research*, **3**(2), 54–63. doi:10.5430/elr.v3n2p54

Leikin, M., **Tovli, E.**, & **Woldo, A.** (2020). The interplay of bilingualism, executive functions and creativity in problem solving among male university students. *Creative Studies*, **13**(2), 308–324. doi:10.3846/cs.2020.10397

Luk, G., & **Bialystok, E.** (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, **25**(5), 605–621. doi:10.1080/20445911.2013.795574

Maddux, W., & **Galinsky, A.** (2009). Cultural borders and mental barriers: The relationship between living abroad and creativity. *Journal of Personality and Social Psychology*, **96**, 1047–1061. doi:10.1037/a0014861

Nijstad, B. A., **De Dreu, C. K. W.**, **Rietzschel, E. F.**, & **Baas, M.** (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *European Review of Social Psychology*, **21**(1), 34–77. https://doi.org/10.1080/10463281003765323

Pan, X., & **Yu, H. H.** (2018). Different effects of cognitive shifting and intelligence on creativity. *Journal of Creative Behavior*, **52**(3), 212–225. doi:10.1002/jocb.144

Pasarín-Lavín, T., **Abín, A.**, **García, T.**, & **Rodríguez, C.** (2023). Relationship between executive functions and creativity in children and adolescents: A systematic review. *Children*, **10**(6), 1002. https://www.mdpi.com/2227-9067/10/6/1002

Raven, J. C., **Court, J. H.**, & **Raven, J. C.** (1990). *Manual for Raven's progressive matrices and vocabulary scales – Section 2: Coloured progressive matrices*. Oxford: Oxford Psycholigists Press.

Ricciardelli, L. A. (1992). Creativity and bialingualism. *Journal of Creative Behavior*, **26**(4), 242–254.

Rueda, M. R., **Fan, J.**, **McCandliss, B. D.**, **Halparin, J. D.**, **Gruber, D. B.**, **Lercari, L. P.**, & **Posner, M. I.** (2004). Development of attentional networks in childhood. *Neuropsychologia*, **42**(8), 1029–1040. doi:10.1016/j.neuropsychologia.2003.12.012

Sampedro, A., & **Peña, J.** (2019). Executive functions mediate the association between bilingualism and creativity in preadolescents. *Thinking Skills and Creativity*, **34**, 100605. doi:10.1016/j.tsc.2019.100605

Silvia, P. J. (2008). Creativity and intelligence revisited: A latent variable analysis of Wallach and Kogan(1965). *Creativity Research Journal*, **20**(1), 34–39. doi:10.1080/10400410701841807

Sternberg, R. J. (1999). *Handbook of creativity*. Cambridge: Cambridge University Press.

Torrance, E. P. (1966). *The Torrance test of creative thinking*. Lexington, MA: Personnel Press.

van Dijk, M., **Kroesbergen, E. H.**, **Blom, E.**, & **Leseman, P. P. M.** (2019). Bilingualism and creativity: Towards a situated cognition approach. *Journal of Creative Behavior*, **53**(2), 178–188. doi:10.1002/jocb.238

Vezzali, L., **Goclowska, M. A.**, **Crisp, R. J.**, & **Stathi, S.** (2016). On the relationship between cultural diversity and creativity in education: The moderating role of communal versus divisional mindset. *Thinking Skills and Creativity*, **21**, 152–157. doi:10.1016/j.tsc.2016.07.001

Weiss, S., & **Wilhelm, O.** (2022). Is Flexibility More than Fluency and Originality? *Journal of Intelligence*, **10**(4), 96. https://doi.org/10.3390/jintelligence10040096

Zabelina, D. L., & **Robinson, M. D.** (2010). Creativity as flexible cognitive control. *Psychology of Aesthetics Creativity and the Arts*, **4**(3), 136–143. doi:10.1037/a0017379

Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, **1**(1), 297–301.