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Are Bilinguals More Creative Than Monolinguals? A Meta-Analysis

ABSTRACT

This study synthesizes quantitative research on the relationship between creativity and bilingualism. Extant literature underlines the role of developmental, cognitive, and socio-cultural factors to explain the nature of the relationship between creativity and bilingualism. While decades of research frequently indicate a positive link, contrary or mixed evidence has also been documented, necessitating a comprehensive analysis of existing quantitative data to understand the direction and strength of this relationship. Additionally, identifying factors contributing to inconsistent outcomes is crucial. Thus, we estimated the mean effects and examined various potential sources of variation, including study and participant characteristics, as well as measurement and bilingualism-related factors, to shed light into the heterogeneity. Addressing these objectives, we analyzed 312 effect sizes from 39 studies ($N = 4,917$) and found a mean effect size of Pearson $r = .181$, 95% CI [.096, .263]. This finding shows that bilinguals are overall more creative than monolinguals. Furthermore, a significant difference was observed in the mean effects between test modality categories, with studies using numerical modality reporting significantly larger effect sizes compared to those using action/movement modality. We discuss the findings with research and practical implications.

Keywords: creativity, bilingualism, meta-analysis, test modality.

Between 1980 and 2019, the number of people in the United State who spoke a language other than English at home nearly tripled, while the number of English-only speakers grew by about one-fourth during the same period (Dietrich & Hernandez, 2022). The U.S. Census Bureau (2023) reports indicated that 20 to 22% of Americans can speak two or more languages. 65% of the working-age adults in Europe and about half of the world population are considered bilingual (Eurostat, 2018; Matthews, 2019). The growing number of bilinguals are attributed to reasons such as immigration, globalization, and growing appreciation for the benefits of bilingualism (Housman, 2023). In our increasingly interconnected and diverse world, the intersection of languages and cognitive processes has become a significant area of academic research. Over the past few decades, substantial progress has been made in understanding bilingual cognitive and linguistic development. Empirical studies demonstrated that bilingual development could create distinct mental frameworks, which may lead to cognitive advantages later in life (e.g., Bialystok & Craik, 2022). One notable advantage is the ability to engage in creative thinking.

Initially, scholars in either field did not take the relationship between bilingualism and creativity seriously (Simonton, 2008). Interest in this link was resurgent in the mid-2000s, and since then, the field has expanded considerably. The academic community has recognized the importance of integrating bilingualism and creativity research, leading to interesting findings (Kharkhurin, 2021). However, while the body of research on this topic has grown significantly, findings have been diverse and sometimes contradictory. Therefore, conducting a meta-analysis that can synthesize these results and provide a clearer overall picture of the relationship between bilingualism and creativity seems essential.

Bilingual creativity research spans several decades and includes various research designs, populations, and measures of creativity. These studies often demonstrate limitations in sample size, methodology, and context, which can affect the reliability and generalizability of their findings. A meta-analysis can systematically evaluate these variations and identify potential moderators influencing the relationship between bilingualism and creativity. Aggregated data can increase statistical power and enable more robust conclusions

transcending the limitations of individual studies. These conclusions can highlight existing literature gaps and suggest future research directions. Finally, they can help to clarify under what conditions and for whom bilingualism most strongly affects creativity. This can provide valuable insights for educators, policymakers, and practitioners.

EMPIRICAL EVIDENCE AND THEORETICAL FRAMEWORK

The evidence illuminating the link between bilingualism and creativity originates from research on multilingual creative cognition (Kharkhurin, 2015a, 2015b). This framework broadly defines bilinguals, including those fluent in both languages and those who actively use or strive to use multiple languages, even without complete fluency (Kroll & de Groot, 1997). In this framework, creativity is viewed through the lens of creative cognition, which considers creativity a result of standard cognitive processes (Ward & Kolomyts, 2019). This perspective asserts that creative outputs are both novel (original or unexpected) and appropriate (useful or meeting task constraints; see Mayer, 1999, for an overview), emerging from the application of ordinary cognitive functions to existing knowledge (Ward, 2007). Thus, creative performance is seen as a function of specific cognitive processes and the depth and adaptability of the knowledge structures they engage with (Ward, Smith, & Vaid, 1997), implying that enhancing cognitive functioning could boost creativity.

Therefore, these studies focused on the influence of bi-/multilingualism on the cognitive functions underlying creative thinking. Most of these studies assumed divergent thinking as an essential property of creative thinking (e.g., Guilford, 1950; Lubart, 2000; Runco & Acar, 2012). According to Guilford (1967), divergent thinking has four characteristics: fluency (an ability to generate as many ideas or solutions to a problem as possible in a given time), flexibility (an ability to consider a variety of approaches to a problem simultaneously), elaboration (an ability to think through the details of an idea), and originality (an ability to produce ideas that are different from what the majority has generated). Empirical evidence (see Kharkhurin, 2018; van Dijk, Kroesbergen, Blom, & Leseman, 2019, for an overview) often demonstrated a positive effect of bi-/multilingualism on all four divergent thinking components presented above, insight problems, which pose difficulty in identifying the correct strategy at first, followed by a sudden realization that leads to the solution. (Dow, 2024), and structured imagination tasks that require using imagination within a defined structure (Ward, 1994). Several developmental and socio-cultural factors, and cognitive mechanisms were proposed to explain the positive relationship between bilingualism and creativity. First, we focus on three key developmental factors: language proficiency, age of language acquisition, and socio-cultural context.

Developmental factors

Language proficiency was found crucial for linking bilingualism to creative thinking. Research shows that bilinguals with high proficiency in both languages generally outperform their less proficient counterparts in various measures of divergent thinking (see Kharkhurin, 2018, for an overview). For example, highly proficient English-Russian bilinguals showed superior elaboration and originality (Kharkhurin, 2008, 2011), and proficient Farsi-English bilinguals demonstrated greater fluency (Kharkhurin, 2009). Recent studies have further established that advanced second language skills enhance cognitive flexibility and creative activity (Fürst & Grin, 2018; Yang, Wu, Duñabeitia, Jiang, & Li, 2021). Additionally, bilinguals' proficiency positively correlated with convergent thinking, as seen in tests like Mednick and Mednick's (1967) Remote Associates Test (Leikin, Tovli, & Woldo, 2020; Xia, An, & Guo, 2022). Although the Remote Associates Test is verbal, the involvement of convergent thinking in this test supports the view that non-verbal intelligence is a potential confound on language proficiency (e.g., Kharkhurin, 2009), which needs to be controlled when examining the relationship between language proficiency and bilingualism.

Further evidence demonstrated that the age at which bilinguals learn their second language significantly influences their creative capacities. For example, simultaneous bilinguals who learned two languages from birth exhibited higher flexibility than sequential bilinguals who learned their second language later (Kostanyan & Ledovaya, 2013). Moreover, studies indicated that early second language acquisition is linked to better fluency and problem-solving abilities (Cushen & Wiley, 2011; Kharkhurin, 2008).

Finally, the context in which languages are acquired and used also impacts bilingual creativity. Bilinguals often experience diverse cultural environments and navigate different cultural cues, which may boost the development of unique multicultural values and beliefs (Pavlenko, 2000), fostering creativity. Research indicates that extended exposure to new cultural environments enhances creative performance (e.g., Kharkhurin, 2008; Maddux & Galinsky, 2009). Moreover, variations in socialization, education, and

self-expression across cultures can modulate creative thinking (e.g., Kharkhurin & Samadpour Motallebi, 2008; Niu & Sternberg, 2001).

Cognitive factors

Four cognitive mechanisms were identified to account for the positive relation between bilingualism and creativity: selective attention, code-switching, language-mediated concept activation, and metaphor processing.

Selective attention, crucial for convergent thinking, may present cognitive advantage for bilinguals. Convergent thinking involves narrowing down ideas to find the best solution (Cropley, 2006). Through managing two active languages, bilinguals develop enhanced attentional control, facilitating the focus on relevant information while inhibiting irrelevant data (Bialystok & Craik, 2022). This ability aids in convergent and divergent thinking by allowing efficient exploration and evaluation of various ideas (Kharkhurin, 2011). *Code-switching*, the practice of alternating between languages, supports creativity by allowing flexible cognitive processing. This flexibility enables bilinguals to draw from a broader linguistic repertoire, enhancing their problem-solving and idea-generation capabilities. Studies have demonstrated that habitual code-switchers exhibit higher originality in creative tasks (Kharkhurin & Wei, 2015; Storme et al., 2017). Both selective attention and code-switching are related to executive functions, defined as “the set of neuro-cognitive skills involved in goal-directed problem-solving, including working memory, inhibitory control, and set shifting/flexibility” (Carlson, Zelazo, & Faja, 2013, p. 706). There is evidence that creativity benefits from stronger engagement of executive functions (e.g., Zhao, Zhang, Tong, & Maes, 2023) and the latter benefits from bilingualism (Grundy, 2020). Hence, bilingualism may influence creativity through a greater use of executive functions (Sampedro & Pena, 2019) whereas this link is questionable to some based on recent work that challenged the findings showing a greater use of executive functions among bilinguals (Paap, 2022; Paap, Mason, Zimiga, Ayala-Silva, & Frost, 2020).

Language-mediated concept activation (Kharkhurin, 2017) suggests that bilinguals’ divergent thinking benefits from activating diverse conceptual representations across languages. This activation occurs through spreading activation (McClelland & Rumelhart, 1985), where semantically related words in different languages influence each other (e.g., Unsworth, 2023). Bilinguals activate translation equivalents, which expands the range of accessible concepts (Kroll & de Groot, 1997), thereby enhancing divergent thinking. *Metaphor processing*, involving the connection of disparate concepts, also links bilingualism to creativity. Bilinguals demonstrate enhanced metaphor use, which suggests greater cognitive flexibility and a broader range of semantic associations (Furlong, 2009; Onysko, 2016). Multilingual experience further strengthened the ability to interpret and create novel metaphors supporting divergent thinking and creative expression (Werkmann Horvat, Bolognesi, & Kohl, 2021).

The Multilingual Creative Cognition (Kharkhurin, 2015a, 2015b) presented the above-explained findings by positing that developing several languages enhances cognitive functions, which can subsequently foster creative thinking. On one hand, empirical evidence demonstrated that bilingual development could lead to cognitive advantages later in life (e.g., Bialystok & Craik, 2022). On the other hand, according to the creative cognition approach, enhancing cognitive functioning could boost creativity (Ward et al., 1997). Hence, by using multiple languages, individuals develop more complex cognitive functions, which promote creative capabilities.

Socio-cultural factors

Multilingual Creative Cognition’s focus on cognitive processes should be considered along with environmental factors. The situated cognition approach fills this gap by emphasizing that cognitive processes are deeply embedded in socio-cultural and physical contexts (van Dijk et al., 2019). This perspective suggests multilinguals’ diverse linguistic and cultural experiences create unique cognitive environments. These environments influence how they perceive and generate creative ideas. Interaction with different languages and cultures heightens sensitivity to environmental cues, which enhances the perception of affordances—opportunities for action that inspire creativity. Affordances, shaped by one’s goals, abilities, and experiences, guide creative endeavors by allowing individuals to interact with their surroundings adaptively (Chemero, 2003). Multilingualism enriches the perception of affordances, providing diverse frameworks for interpreting the environment and boosting creative capacities. Thus, multilingual individuals’ heightened sensitivity to their environments enhances creativity (Furlong, 2009).

MODERATORS

Empirical research on the bilingualism-creativity link shows mixed outcomes despite showing largely a positive relationship (Kharkhurin, 2018; van Dijk et al., 2019). Thus, potential factors that contribute to inconsistent results are important to take into consideration especially when heterogeneity is large. In the present work, we present the moderators in five clusters.

Study characteristics

Like in any other meta-analysis, study characteristics such as *year of publication* and *publication type* may influence the study outcomes. These two are exploratory moderators and relevant to the current study. Year of publication is important in a meta-analysis of bilingualism and creativity because theories, methodologies, and societal attitudes towards bilingualism have evolved over time (Bialystok, Hawrylewicz, Grundy, & Chung-Fat-Yim, 2022; Fitzgerald, 1993; Genesee, 2016; Peal & Lambert, 1962). Advances in technology, changes in sample characteristics, and shifts in publication trends can all influence study outcomes. Including the year of publication helps identify these changes, assess the consistency of results, and ensure that the meta-analysis accurately reflects the progression and current state of research in the field. The type of publication, specifically articles versus dissertations, matters in a meta-analysis because journal articles generally undergo rigorous peer review, ensuring high quality and reliability, but they may be subject to publication bias favoring significant results (Song, Hooper, & Loke, 2013). In contrast, dissertations are often more comprehensive and provide detailed methodologies but may vary in quality due to less stringent review processes in certain fields (Conn & Rantz, 2003; Vickers & Smith, 2000). Dissertations can help mitigate publication bias and include recent findings, though they can be harder to access. Considering both types allows for a more balanced and comprehensive meta-analysis, capturing a broader range of research and reducing potential biases. In a multilevel meta-analysis where effects sizes are clustered in studies, both year of publication and publication type are study level moderators.

Sample characteristics

Sample characteristics such as *age*, *participant type*, *gender*, and *culture* are also relevant. First, maturation and developmental factors affect both bilingualism and creativity (Gralewski, Lebuda, Gajda, Jankowska, & Wiśniewska, 2016; Kim, 2011; Said-Metwaly, Fernandez-Castilla, Kyndt, Van den Noortgate, & Barbot, 2021). Thus, the relation between creativity and bilingualism may be influenced by the *age* at which creativity was measured. Additionally, schooling may further shape their interplay (Karwowski, 2021), making grade level (referred to as participant type) another factor for consideration. For this reason, we distinguished elementary school children from middle and high school students, as well as from other groups such as college students, adults, and mixed-grade samples, by coding them into distinct categories within the participant group moderator. Further, empirical research shows that bilingualism develops differently between men and women (Piller & Pavlenko, 2004; Subramaniapillai, Rajah, Pasvanis, & Titone, 2019). While small differences in creativity generally favor women (Abdulla Alabbasi, Thompson, Runco, Alansari, & Ayoub, 2022; Taylor, Said-Metwaly, Camarda, & Barbot, 2024; Thompson, 2016), the opposite pattern has been observed in creative performance, with men showing higher outcomes in some cases (Hora, Badura, Lemoine, & Grijalva, 2022). Participants' culture may also play a role due to differences in bilingualism due to the varied perceptions of attitudes towards bilingualism, language policies, immigration laws, and national identity (Peréa & Coll, 2011). These moderators are typically coded at the study level whereas some studies provide more detailed reports, allowing for coding them at the effect size level.

Creativity measurement

The way creativity is measured varies remarkably across the studies (Runco & Acar, 2024) and may influence the outcomes. Divergent thinking tests (Runco & Acar, 2012) are commonly used to measure creativity, instructing to generate responses to open-ended questions. They can be compared to other kinds of tests such as self-reports that involve participants' own evaluations and reports of their creativity or creative activity (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012), or verbal or figural fluency tasks (e.g., Ruff, Light, & Evans, 1987). Some of these tests may also differ in their selection of *response modality* where participants may be asked to respond to a prompt with actions and movement (Torrance, 1981), verbally (Torrance, 1966), figuratively (Torrance, 1974), or numerically (Creating Equal Number Task; Tsamir, Tirosh, Tabach, & Levenson, 2009), each corresponding to different domains of ability (Richardson, 1986; Zyga, Ivcevic, Hoffmann, & Palomera, 2022). This moderator is particularly important for the present study as

bilingualism is primarily related to language development, affecting verbal skills because of lower experience in each of the languages (Hammer et al., 2014; Hoff et al., 2012). Further, responses to such tests may be scored in more than a single *index* (Runco & Acar, 2012) such as fluency (number of responses produced), originality (rarity, cleverness, and remoteness of the responses), flexibility (diversity of the responses produced), and elaboration (level of detail in responses). Use of measures with multiple modalities and scoring indices also informs analytical decisions in meta-analyses because most creativity research provides multiple effect sizes corresponding to these individual effect sizes, measurement types, or test modality. This is why this and many other meta-analyses (Acar, Tadik, Uysal, Myers, & Inetas, 2023; Rominger et al., 2022) adopt a multilevel or multivariate approach to account for dependency among the effect sizes from a single study. This category of moderators is coded at the effect size level.

Bilingualism characteristics

We considered *bilingualism measurement* approach as a moderator because research practices show that bilingualism is sometimes measured using a psychometric instrument or based on existing records, or parent or teacher report. The former approach then produces a report of bilingualism measured on a continuous scale based on the performance on the test items whereas the latter characterizes bilingualism as a categorical phenomenon. Quality and precision of measurement may ultimately influence the reported relationship of creativity and bilingualism. Bilingualism may also produce different outcomes depending on the distance of the languages, which can be determined if the two languages belong same or different *language family* (e.g., Indo-Iranian, Germanic, Uralic). When a mix of languages was involved in the bilingual sample, we coded the sample as the “same” only when *all* languages belong to the same family. It is easier to learn languages within the same language family, and cognitive benefits, including divergent thinking, may be different when the languages are more similar than different (Carthery-Goulart, Privitera, & Weekes, 2023; Radman, Jost, Dorood, Mancini, & Annoni, 2021).

Study design and quality

Study design, quality of reporting, and presence of restricted range are study-related considerations that may influence the outcomes. Some studies were either designed to compare monolinguals and bilinguals as two different groups whereas some others turned continuously measured bilingualism into different levels of bilingualism (e.g., low, moderate, high). Yet another group of studies did not use any groups and assessed the relationship between bilingualism and creativity as two psychometrically measured phenomenon. Thus, the distinction of correlational versus comparative design may alter the reported outcomes. Further, some studies failed to provide non-significant findings (low reporting quality) and some others compared bilinguals with a moderately bilingual group rather than monolinguals or low-proficient bilinguals. The former is an indicator of study quality due to poor reporting and the latter was referred to as restricted range. We coded all such instances to be able to control the influences of such factors related to study design and reporting.

THE PRESENT STUDY

In this study, we synthesized quantitative research on the creativity–bilingualism relation. Past meta-analyses have explored cognitive correlates of bilingualism (i.e., Adesope, Lavin, Thompson, & Ungerleider, 2010; Gunnerud, ten Braak, Reikerås, Donolato, & Melby-Lervåg, 2020) but focused meta-analytic evidence on the creativity and bilingualism relationship has been missing in the literature. Gunnerud et al. (2020) investigated a specific set of cognitive factors (e.g., executive functions) in relation to bilingualism and excluded creativity and divergent thinking tasks from their investigation. Adesope et al. (2010) included these concepts, but they were combined with symbolic and abstract representation skills and results specific to creativity and divergent thinking were missing. Furthermore, new research on creativity–bilingualism relationship has been published since 2010, justifying meta-analytic research uniquely focusing creativity and bilingualism relationship. This is the first meta-analysis focusing on the relationship between creativity and divergent thinking.

Decades of research on creativity and bilingualism has frequently indicated a positive link (Ricciardelli, 1992; van Dijk et al., 2019) whereas contrary or mixed evidence has also been documented (Hommel, Colzato, Fischer, & Christoffels, 2011; Lange, Hopman, Zemla, & Austerweil, 2020). Thus, understanding the direction and strength of the relation between the two constructs requires an analysis of extant quantitative evidence to take a comprehensive picture of the literature. In addition to exploring the strength of the

relation, factors that contribute to inconsistent outcomes are important to identify. We considered a diverse set of potential variation sources such as study and participant characteristic and measurement-related factors. Pursuing these two objectives, we addressed the following research questions:

1. How strong is the relationship between creativity and bilingualism?
2. Which factors explain the variation in the relation between creativity and bilingualism?

METHOD

DATA SOURCES AND SEARCH STRATEGIES

The research team followed a three-step strategy to identify the relevant studies. In the first step, a database search was conducted using the following keywords: “creativity” OR “creative thinking” OR “creative ability” OR “creative ideation” OR “creative activity” OR “creative performance” OR “creative behavior” OR “creative achievement” OR “creative accomplishment” OR “divergent thinking” OR “divergent production” AND “Bilingual” OR “Bilingualism” OR “multilingual” OR “multilingualism” OR “multi-lingualism” OR “multi-lingual”. This search covered available work until January 15, 2023, and involved the following databases: Academic Search Complete, APA PsycArticles, APA PsycInfo, ERIC, Psychology and Behavioral Sciences Collection, Web of Science, ProQuest Dissertations and Theses. In the second step, forward and backward search was conducted using *paperfetcher* tool (Pallath & Zhang, 2023) to identify further relevant studies through the reference lists of the identified and eligible work as well as those citing them. In the third step, we reached out to the researchers and professional research networks to identify works from gray literature.

INCLUSION AND EXCLUSION CRITERIA

The eligibility of the studies was determined on the basis of the following criteria:

1. Only quantitative works were included. Qualitative and theoretical works were excluded because they do not provide an effect size.
2. Only studies published in English were included because it was the only language both primary coders were proficient.
3. Studies that involved a creativity measure were included, whereas others were excluded.
4. Studies had to either include a measure of bilingualism or they had to include a reference or control group to compare with the bilinguals.
5. Sufficient statistics were necessary for inclusion and studies that do not provide statistics to obtain an effect size were excluded.
6. Irrelevant or indirectly related studies were excluded because they do not provide a direct observation about bilingualism—creativity link.
7. Overlapping or repeated use of the dataset across various studies were determined to include them only once.

Applying this criteria, two of the authors reviewed the studies for eligibility and the third author reviewed the list and reconciled the disagreements (16%). Figure 1 presents the flowchart. The final dataset included 312 effect sizes in 39 studies.

STUDY VARIABLES AND DATA CODING

Two authors coded the studies for relevant statistics (mean, standard deviations, Pearson r , F , t), study information (Study title, authors), and moderators. Another author compared the codes by two authors and resolved the discrepancies by revisiting the original studies. Study moderators (and their definitions) are presented in Table 1 under the following five clusters: (a) Study characteristics, (b) Participants characteristics, (c) Creativity measurement, (d) Bilingualism, and (e) Study Design and Quality.

EFFECT SIZE CALCULATION

The studies were either correlational or comparative. However, some of the comparative designs did not provide standard deviation values and the coding relied on alternative statistics such as t -test or F -test values. Thus, Hedge’s g could not be calculated for such studies. Due to ease of conversion from multiple types of statistical reporting, the analyses employed Pearson correlation (r) as the metric for effect size along

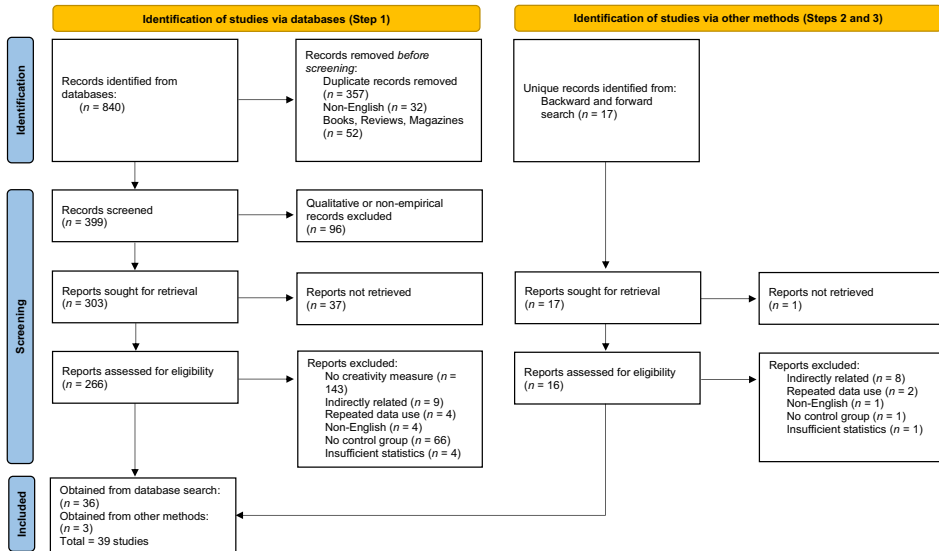


FIGURE 1. PRISMA Flowchart.

with inverse variance weighting. For studies that provided descriptive statistics, t -tests, F tests, or chi-square tests, the data were converted to Pearson r . Since Pearson r was chosen as the effect size metric, analyses were carried out using Fisher's r -to- z transformation, and the mean effect sizes were subsequently converted back to Pearson r for the final reports.

PUBLICATION BIAS

Publication bias was assessed using a funnel plot and evaluated with Egger's regression test (Egger, Smith, Schneider, & Minder, 1997) as well as funnel plot tests (Macaskill, Walter, & Irwig, 2001). The former assesses whether the intercept of a regression line significantly deviates from zero in a funnel plot of the effect sizes against their standard errors whereas the latter focuses on sample size. Non-significant results from these tests indicate that publication bias is unlikely to seriously affect the study's outcomes.

ANALYTICAL APPROACH AND STATISTICAL ANALYSES

We initially calculated the overall mean effect size and assessed heterogeneity statistics. Given that most studies provided multiple effect sizes, which were dependent, we used a multilevel/multivariate approach. Specifically, we employed a multivariate meta-analysis approach (Riley, 2009) and included a robust variance estimation (RVE) to account for correlations among the dependent effect sizes (Hedges, Tipton, & Johnson, 2010; Riley, 2009). This model structured individual studies at the second level and effect sizes at the first level, incorporating sampling variance for each effect.

All the analyses including mean effect size estimation, meta-regression, and publication bias (i.e., Egger's regression and funnel plot tests) were conducted using the R packages *metafor* for the hierarchical model (Viechtbauer, 2010) and *clubSandwich* (Pustejovsky, 2020) to incorporate RVE (Hedges et al., 2010; Pustejovsky & Tipton, 2022).

We assessed heterogeneity in a few different ways. First, Cochran's Q test and I^2 statistics were utilized. The Q test is distributed as a chi-square test and indicates heterogeneity when the Q value is large relative to the degrees of freedom. I^2 , calculated from the Q value using the formula, $((Q - df)/Q) \times 100$ (Higgins & Thompson, 2002), is interpreted as a percentage, with higher values indicating greater heterogeneity. Additionally, prediction intervals were reported to show the dispersion level for each mean effect size (Borenstein, Hedges, Higgins, & Rothstein, 2009; Higgins, Thompson, & Spiegelhalter, 2009). We also calculated the distribution of the variance at study and effect size levels by using median variance as an estimate of sampling variance.

TABLE 1. Study Moderators and Definitions

Moderators	Definition
<i>1. Study characteristics</i>	
Publication year	The year in which the study was published (mean centered)
Publication type	(0) Articles (1) Dissertations and theses
<i>2. Participant characteristics</i>	
Age	Participants age (mean centered)
Participant group	(0) Pre-K and elementary, (1) middle or high school, (2) university and other or mixed
Gender	Ratio of males to total sample (0 to 1)
Culture	(0) <i>Non-Western</i> : China, India, Iran, Israel, Mexico, Nigeria, Russia, Saudi Arabia, Singapore, Turkey, United Arab Emirates (1) <i>Western</i> : Australia, Canada, Spain, Switzerland, United Kingdom, United States of America, Wales (2) <i>Mixed</i>
<i>3. Creativity measure</i>	
Type of creativity test	(0) <i>Divergent thinking</i> : Alternate Uses Tests, Torrance Tests of Creative Thinking (Verbal, Figural, Action and Movement, or Abbreviated); Pictorial Multiple Solution task, Creating Equal Number task, Passi Test of Creativity, Instances, Williams Test for Divergent Thinking, Test of Creative Thinking—Drawing Production (1) <i>Self-reports</i> : Creative Achievement Questionnaire, Creative Personality Scale, Williams Test for Divergent Feeling, Group Inventory For Finding Interests (Creative Potential Subscale), (2) <i>Cognitive fluency tests</i> : Verbal fluency, Semantic fluency, Ruff Figural Fluency Test, (2) <i>Other tests</i> : Hypothesis Generating Test, Remote Associates Test, Creative Writing, Figural Convergent Thinking
Scoring index	(0) Fluency (1) Flexibility (2) Elaboration (3) Originality (4) Mixed or non-applicable
Response Modality	(0) Action/movement (1) Figural (2) Numerical (3) Mixed or not applicable (4) Verbal
<i>4. Bilingualism</i>	
Bilingualism measurement	(0) <i>Bilingualism measured</i> : Basic Inventory of Natural Languages, Bilingual Balance Test, Expressive Language Test, Hoffman Bilingual Schedule, Idea Proficiency Test-II, Language Assessment Battery, Language Performance Test, Language Proficiency Assessment, Language Proficiency Tests, National English Test for College Students, Peabody Picture Vocabulary Test, Picture Naming task, Subjective Self Rating, Word Association Test (1) <i>Bilingualism reported or recorded</i> : Background questionnaire, School personnel reported, Parent reported, Home Language Survey, Language of instruction, Language spoken at home, School records
Sameness of language family	(0) <i>Different language family</i> : Basque-English, Chinese-English, Malay-English, Polish-English, Hebrew-Russian, Indian-English, Japanese-English, Korean-English, Arabic-English, Spanish-Basque, Turkish-English, Vietnamese-English, Yoruba-English (1) <i>Same language family</i> : Arabic-Hebrew, English-Spanish, English-Urdu, English-French, English-Russian, English-Farsi, German-French, Welsh-English
<i>5. Study design and quality</i>	
Study design	(0) Comparative, (1) Correlational
Study quality	(0) Good: no major concerns (0) Low: Non-significant findings not reported, inadequate statistical reporting
Restricted range	(0) Not present (1) Present by comparing bilingual group to a moderately bilingual group (vs a monolingual group)

We conducted meta-regression analyses to explore the potential sources of heterogeneity. To minimize the risk of Type 1 error, we conducted a meta-regression with all moderators included simultaneously, using dummy-coded categorical moderators (Tipton & Pustejovsky, 2015), instead of testing each moderator separately. This approach required selecting a reference category, and the default in the *metafor* package assigned the first category alphabetically as the reference. To supplement them, we tested each moderator cluster individual to avoid overfitting. Finally, we evaluated the mean effect size for significant categories to interpret the meta-regression results. Materials and analysis code are available upon request via email to the author. Data analysis was performed using RStudio, version 2024.04.1 + 748 (RStudio Team, 2024). The study design and subsequent analysis were not pre-registered.

RESULTS

We synthesized 312 effect sizes (r) in 39 studies ($N = 4,917$). The mean effect size was, $r = .181$, CI 95% (.096; .263), $p < .001$. The data were heterogeneous, $Q_T(311) = 2244.580$, $p < .001$, $I^2 = 86\%$. Prediction interval was estimated as ranging between $-.406$ and $.662$. Of the total variance, 49.3% was observed at the study level, and 45.5% was observed in the effect size level (5.2% is sampling variance). Publication bias analyses showed that both Egger's regression test, $b = 1.121$, $SE = 0.807$, $z = 1.390$, $p = .165$; and Funnel test, $b = -0.000$, $SE = 0.000$, $z = -0.807$, $p = .419$, were non-significant. Figure 2 presents the funnel plot.

We examined the moderators at both study and effect size levels to explore variation in the mean effects. A meta-regression with all the moderators explained 10.5% of the variance, but none of the individual moderators was significant as indicated by Wald tests (See in Table 2). However, a significant difference was observed in the mean effects between the categories of test modality where the studies used a creativity measure with Numerical modality reported a significantly larger effect size than those with Action/Movement modality ($b = 0.344$, $SE = 0.111$, $p = .047$).

We also conducted follow-up meta-regression based on their clusters (Table 1) to rule out the possibility of overfitting. These focused analyses showed the same pattern (Table 3): none of the moderators was significant and the test modality categories still varied significantly ($b = 0.353$, $SE = 0.109$, $p = .045$). The mean effect sizes were calculated by controlling all other moderators (see Table 4). The mean effect size was the largest for Numerical modality ($r = .436$), followed by Mixed/other ($r = .413$), Figural ($r = .168$), Action/Movement ($r = .107$), and Verbal ($r = .089$).

DISCUSSION

In this study, we meta-analyzed the research on the relationship between creativity and bilingualism. Our analyses showed a small bilingual advantage in creativity ($r = .181$), showing that bilinguals overall tend to be more creative than monolinguals. Although it is considered small, the bilingual advantage seems to be larger than the advantage of socio-economic status ($r = .120$; Acar et al., 2023) and even explicit creativity instructions in divergent thinking tasks ($gs = .243$ to $.271$, which are equivalent to $rs =$ from $.121$ to $.135$, Acar, Runco, & Park, 2020). On the other hand, the magnitude of the relationship is similar to or slightly

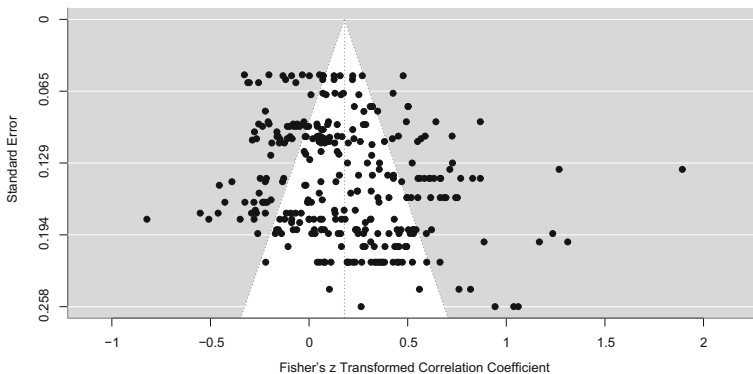


FIGURE 2. Funnel plot.

TABLE 2. Meta-Regression Analyses With All Moderators

Moderators	Estimate	SE	<i>t</i>	<i>df</i>	<i>p</i>	<i>F</i>	<i>df</i>	<i>p</i>
Intercept	0.133	0.256	0.520	7.65	.618			
Publication year (mean centered)	0.003	0.003	0.926	10.01	.376	0.858	1; 10.00	.376
Publication type—Dissertations & Theses	0.090	0.091	0.991	15.45	.337	0.981	1; 15.40	.337
Age (mean centered)	0.002	0.018	0.109	11.08	.916	0.012	1; 11.10	.916
Participant Group—PreK-Elementary	−0.159	0.100	−1.593	2.39	.232	2.260	2; 4.32	.213
Participant Group—College or mixed age	−0.328	0.192	−1.710	10.98	.115			
Gender	0.018	0.040	0.447	1.15	.725	0.200	1; 1.15	.724
Culture—Non-Western	0.194	0.118	1.635	2.98	.201	1.950	2; 4.28	.249
Culture—Western	0.055	0.119	0.462	2.92	.676			
Creativity Measure—Other	0.104	0.122	0.857	4.18	.438	2.380	3; 4.54	.196
Creativity Measure—Self-report	−0.262	0.148	−1.771	7.94	.115			
Creativity Measure—Cognitive fluency	0.186	0.081	2.298	2.05	.145			
Scoring Index—Flexibility	0.066	0.103	0.638	11.05	.537	0.315	4; 13.40	.863
Scoring Index—Fluency	0.027	0.101	0.265	10.96	.796			
Scoring Index—Originality	0.068	0.090	0.761	10.8	.463			
Scoring Index—Other-mixed	0.050	0.094	0.531	14.52	.604			
Response Modality—Figural	0.049	0.092	0.530	3.2	.705	2.470	4; 5.33	.167
Response Modality—Other-Mixed	0.305	0.158	1.938	9.65	.628			
Response Modality—Verbal	−0.038	0.093	−0.424	3.20	.705			
Response Modality—Numerical	0.344	0.111	3.091	3.32	.047			
Bilingualism—Reported	0.077	0.123	0.624	15.18	.542	0.390	1; 15.20	.542
Language Family—Same	0.066	0.084	0.785	15.53	.444	0.617	1; 15.50	.444
Study Design—Correlation	0.085	0.217	0.390	8.08	.707	0.152	1; 8.08	.707
Study Quality—Good	−0.187	0.129	−1.454	8.36	.183	2.110	1; 8.36	.182
Restricted Range—Present	−0.113	0.051	−2.234	2.75	.120	4.990	1; 2.75	.120

Note. References groups = Publication type—Articles; Participant Group—Middle or High School; Culture—Mixed; Creativity Measure—Divergent thinking; Scoring Index—Elaboration; Response Modality—Action/Movement; Bilingualism—Measured; Language Different; Study Design—Comparative; Study Quality—Low; Restricted Range—Not Present.

lower than the relationship with intelligence ($r_s = .250$ and $.174$, respectively, in Gerwig et al., 2021 and Kim, 2005), openness to experience ($r_s = .200$ and $.237$ in Grajzel, Acar, & Singer, 2023; Puryear, Kettler, & Rinn, 2017, respectively), academic achievement ($r_s = .220$; Gajda, Karwowski, & Beghetto, 2017); and remarkably lower than the impact of creativity training programs (estimated $r = .322$ based on $\Delta = .680$; Scott, Leritz, & Mumford, 2004). Although a direct test of differences between the reported correlations across various meta-analyses is not possible, these findings show that benefits of bilingualism can be considered stronger than socio-economic status and can be comparable to the potential benefits of schooling and general aptitude. Importantly, bilingualism is more amenable to intervention and programming than socio-economic status or general aptitude, particularly in a school context. This underscores the value of bilingual or multilingual education in fostering creativity** (Kharkhurin, 2015a, 2015b; Leikin, 2013) in addition to many other potential benefits (Wright, Boun, & García, 2015).

Bilingualism appears to be not as impactful as for example creativity training, especially when it is compared to the benefits for other cognitive and life outcomes. However, growing up bilingual may be viewed as having an implicit and unstructured creativity practice (Kim & Lee, 2019). Growing up bilingual implies using at least two different language systems simultaneously and switching from one to another as needed. This code-switching practice is likely to foster originality in thinking (Kharkhurin & Wei, 2015). Further, bilinguals develop two different vocabulary systems, and this brings about an opportunity to view and perceive the world from different perspectives and using different abstraction and representations skills for the same or similar ideas, objects, or concepts (Francis, 2005; Okoh, 1980). Third, bilinguals are exposed to different cultural experiences, helping them utilize various cultural lenses to make sense of the world. Scarce

TABLE 3. Meta-Regression With Clustered Moderators

Moderators	Moderators	Estimate	SE	t	df	p	F	df	p
Study characteristics	Intercept	0.186	0.058	3.190	17.70	.005			
	Publication year (mean centered)	0.001	0.003	0.460	12.90	.653	0.212	1; 12.90	.653
	Publication type—Dissertations & Theses	−0.008	0.086	−0.088	24.60	.931	0.008	1; 24.60	.931
Participant Characteristics	Intercept	0.288	0.136	2.117	4.31	.097			
	Age (mean centered)	0.001	0.016	0.081	9.07	.937	0.006	1; 9.07	.937
	Participant Group—PreK-Elementary	−0.133	0.111	−1.199	2.72	.325	1.910	2; 4.47	.252
	Participant Group—College or mixed age	−0.254	0.166	−1.525	7.53	.168			
	Gender	−0.024	0.143	−0.171	1.17	.889	0.029	1; 1.17	.889
	Culture—Non-Western	0.101	0.084	1.197	2.51	.332	0.697	2; 3.71	.553
	Culture—Western	0.012	0.094	0.125	2.50	.910			
Creativity Measurement	Intercept	0.062	0.104	0.597	3.98	.583			
	Creativity Measure—Other	0.193	0.109	1.768	3.62	.159	1.770	3; 4.18	.286
	Creativity Measure—Self-report	−0.191	0.138	−1.386	5.79	.217			
	Creativity Measure—Cognitive fluency	0.070	0.102	0.688	11.10	.506			
	Scoring Index—Flexibility	0.028	0.099	0.287	11.00	.779	2.330	4; 5.05	.188
	Scoring Index—Fluency	0.070	0.088	0.794	10.82	.444			
	Scoring Index—Originality	0.040	0.091	0.438	14.78	.668			
	Scoring Index—Other-mixed	0.181	0.083	2.194	2.10	.153			
	Response Modality—Figural	0.052	0.084	0.612	3.04	.583	0.355	4; 13.9	.836
	Response Modality—Mixed/other	0.242	0.146	1.662	6.60	.143			
Bilingualism	Response Modality—Numerical	0.353	0.109	3.233	3.14	.045			
	Response Modality—Verbal	−0.033	0.079	−0.413	2.77	.710			
	Intercept	0.099	0.073	1.360	11.80	.201			
	Bilingualism—Reported	0.128	0.098	1.300	32.70	.204	1.680	1; 32.7	.204
	Language Family—Same	0.046	0.066	0.700	7.10	.506	0.490	1; 7.10	.506
Study Design & Quality	Intercept	0.346	0.153	2.264	5.87	.065			
	Study Design—Correlation	−0.044	0.187	−0.236	4.93	.823	0.056	1; 4.93	.823
	Study Quality—Good	−0.172	0.157	−1.094	7.91	.306	1.200	1; 7.91	.306
	Restricted Range—Present	−0.089	0.055	−1.605	2.66	.218	2.570	1; 2.66	.218

Note. References groups = Publication type—Articles; Participant Group—Middle or High School; Culture—Mixed; Creativity Measure—Divergent thinking; Scoring Index—Elaboration; Response Modality—Verbal; Bilingualism—Measured; Language Different; Study Design—Comparative; Study Quality—Low; Restricted Range—Not Present.

TABLE 4. Mean Effect Sizes by Moderator Categories

Moderator categories	<i>k</i>	<i>m</i>	<i>r</i>	Lower CI	Upper CI	<i>t</i>	<i>df</i>	<i>p</i>
Publication type—Articles	172	22	.144	.046	.240	2.875	3.57	.052
Publication type—Dissertations & Theses	140	17	.212	.038	.373	2.372	5.00	.064
Participant Group—Middle or high	69	10	.319	.167	.456	4.008	4.57	.012
Participant Group—PreK-Elementary	192	20	.166	−.001	.324	1.943	4.14	.122
Participant Group—College or mixed age	51	11	.002	−.307	.311	0.012	9.37	.991
Culture—Mixed	18	3	.072	−.156	.294	0.616	3.40	.576
Culture—Non-Western	138	15	.260	.110	.398	3.359	4.55	.023
Culture—Western	156	24	.127	.018	.232	2.291	3.57	.092
Creativity Measure—Divergent thinking	278	36	.168	.052	.279	2.835	2.62	.077
Creativity Measure—Other	6	4	.257	.060	.434	2.541	5.22	.050
Creativity Measure—Self-report	7	3	−.116	−.362	.146	−0.864	9.47	.409
Creativity Measure—Cognitive fluency	21	3	.333	.198	.456	4.649	3.71	.012
Scoring Index—Elaboration	12	22	.127	−.058	.303	1.347	4.66	.240
Scoring Index—Flexibility	66	22	.189	.082	.291	3.439	3.22	.037
Scoring Index—Fluency	79	24	.151	.024	.273	2.321	3.04	.102
Scoring Index—Originality	75	23	.193	.080	.300	3.333	3.08	.043
Scoring Index—Other-mixed	70	24	.184	.054	.307	2.763	3.41	.061
Response Modality—Action/Movement	20	3	.107	−.035	.244	1.474	4.51	.207
Response Modality—Figural	117	19	.168	.060	.273	3.033	3.22	.051
Response Modality—Mixed/other	37	10	.413	.163	.612	3.140	8.72	.012
Response Modality—Numerical	12	3	.436	.199	.624	3.448	4.37	.023
Response Modality—Verbal	126	20	.089	−.068	.241	1.108	3.17	.345
Bilingualism—Measured	171	20	.138	−.018	.288	1.736	5.07	.142
Bilingualism—Reported	141	19	.218	.053	.372	2.581	6.08	.041
Study Design—Comparative	255	34	.161	.060	.259	3.105	3.05	.052
Study Design—Correlation	57	5	.236	−.165	.570	1.158	6.78	.286
Language Family—Different	180	18	.159	.057	.257	3.049	3.64	.043
Language Family—Same	132	44	.196	.034	.348	2.361	4.66	.069
Study Quality—Low	44	7	.316	.049	.541	2.306	8.13	.050
Study Quality—Good	268	32	.151	.044	.254	2.769	2.67	.079
Restricted Range—Not Present	273	34	.188	.079	.292	3.348	2.67	.052
Restricted Range—Present	39	8	.083	−.037	.200	1.359	4.57	.237
Overall mean	312	39	.181	.096	.263	4.154	311	.001

research showed that bilingualism influences creativity through various cognitive control and executive functions (e.g., Hommel et al., 2011; Kharkhurin, 2011). Executive functions, which were shown to relate to creativity (Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012), involve a set of cognitive processes such as inhibitory control and attention, working memory, shifting, and goal-orientation. In this regard, bilinguals’ advantage over monolinguals may occur due to their code-switching practice and selecting one language to the exclusion of the other fostering their selective attention (Barac, Bialystok, Castro, & Sanchez, 2014; Hommel et al., 2011; Poarch & Van Hell, 2012; Wei & Wu, 2009). However, a recent meta-analysis of the bilingual children’s advantage in EF demonstrated significant, albeit marginal effect ($g = 0.06$; Gunnerud et al., 2020). Paap et al. (2020) investigated the role of publication bias and researcher confirmation bias in the bilingual benefits in reported in the past meta-analyses and warned that the reported effects largely disappear when corrections are applied (see also Paap, 2022). Hence, it seems to be prudent to look for other cognitive mechanisms influencing bilinguals’ creativity beyond executive functions.

van Dijk et al. (2019) discussed the impact of bilingualism from the perspective of embodied cognition and socio-cultural influences where learning two different language systems and vocabulary involve exposure

and engagement with multiple cultures, and a strong multi-cultural experience. Multi-cultural experiences can enhance creativity (Fee & Gray, 2012; Kharkhurin, 2005, 2007; Leung & Chiu, 2010; Leung, Maddux, Galinsky, & Chiu, 2008; Tadmor, Satterstrom, Jang, & Polzer, 2012), so bilingualism could naturally impact the way individuals learn and socialize. Singh et al. (2024) described bilingual environments as highly complex and uncertain and argued that this difference enables them to explore and learn from their environment differently and more broadly compared to monolinguals. This connects to creativity because bilingualism, as a source of environmental diversity, allows individuals to attend to novelty. A related factor is the diversity of life experiences that also supports creativity. It is likely that bilingualism supports diversity of life experiences (Singh et al., 2024), which was shown to result in greater creativity (Pluut & Curşeu, 2013; Xu & Pang, 2020), due to a deep engagement with more than a single culture or lifestyle and experience-dependent plasticity (Bialystok, 2017). Research has shown that original ideas often come from experiences (Runco & Acar, 2010) and bilingualism may enhance creativity by enhancing the breadth of experiences beyond the constraints of a uniform lifestyle. Simonton (2003) used a similar term, diversified experiences, accounting for creativity through unusual life events such as parental loss and living abroad is one of them because such life events disrupt the cognitive schemata (Ritter et al., 2012). Diversified experiences include those that remove that boundaries imposed by conventional socialization (Simonton, 2003), and bilingualism may be considered one such factor. Likewise, the concept of asynchronicity (Acar, 2020; Gardner & Wolf, 1988) describes ways in which personal and social-cultural factors may cause a disequilibrium in human development and provide motivation and space for creative exploration.

Although statistically significant, the mean effect size should be interpreted as a summative value of highly heterogeneous data as seen in heterogeneity statistics. This is not surprising because creativity is a complex, multidimensional construct (Mumford & Gustafson, 1988; Runco, 2015) and bilingualism is also a heterogeneous experience, which largely depends on factors such as language proficiency, age and context of language acquisition and use, and language societal status. Other factors such as socio-economic status may further complicate the nature of the relationship between creativity and bilingualism (Buac & Kaushanskaya, 2014; Naem, Filippi, Periche-Tomas, Papageorgiou, & Bright, 2018). Unfortunately, these factors have often not been reported in primary studies, and thus could not be possibly coded in this study as potential moderators.

We coded many other moderators. The only significant moderator was the creativity test modality. We found that the creativity–bilingualism relationship was the highest when the creativity test was in numerical modality and lowest with verbal tests. Numerical modality can be viewed as a subset of symbolic and abstract representations, where bilinguals have outperformed the monolinguals (Adesope et al., 2010). These findings are also supportive of past research that investigated if the bilingual advantage extended equally to verbal and non-verbal creativity. For example, Kharkhurin (2010) found that Russian-English bilinguals excelled in non-verbal creativity compared to English monolinguals, whereas monolinguals outperformed bilinguals in verbal creativity. This pattern mirrors other findings: bilinguals showed lower performance on the language proficiency tests in each of their languages compared to monolinguals (Hammer et al., 2014), which could be due to the fact that they have relatively less experience in each of these languages (Hoff et al., 2012). Also important to note is that the relationship between bilingualism and creativity differed within various non-verbal modalities, where it was lowest with Action/Movement ($r = .107$), figural ($r = .168$), and highest with Numerical ($r = .436$). This variation seems to beg further explanation specific to numerical skills besides the role of symbolic and abstract representations. Hartanto, Yang, and Yang (2018) conducted two large-scale studies and found that bilinguals had higher emergent numeracy skills and higher mathematics test scores among preschool children. Daubert and Ramani (2019) also showed that bilinguals had higher performance on addition and numerical identification tasks. Thus, the stronger relationship between creativity and bilingualism when creativity tests with a numerical modality was used may indicate the possibility that bilinguals demonstrate their creativity more effectively in this particular modality. Future research is needed to pinpoint the exact reasons behind modality-specific variation in the creativity–bilingualism relationship. Practically speaking, the selection of cognitive performance tasks including creativity tests should take the nature of the test and test modality into consideration when studying the impact of bilingualism. Based on the current findings, caution should be used when using verbal creativity tests with bilinguals. A recommended practice is to measure verbal creativity in more than a single language and high-stakes decisions may be more accurate with non-verbal tests. The proficiency level of the bilinguals in the language(s) of the test must also be considered when selecting the language and interpreting the results (Cummins, 1976; Ricciardelli, 1992).

A less explored aspect of the relationship between creativity and bilingualism is the reverse direction: creativity may also influence bilingualism (Ricciardelli, 1992). From a developmental perspective, one could argue that individuals who master and process multiple languages more quickly and effectively may do so due to their greater openness to experiences, cognitive flexibility, and tolerance for ambiguity. For example, a series of recent studies with Russian native plurilingual participants demonstrated the mediating role of tolerance and intolerance of ambiguity (Kharkhurin, Koncha, & Charkhabi, 2023b) and the moderating role of personality traits (Kharkhurin, Koncha, & Charkhabi, 2023a) in the relation between linguistic and creative practices. These traits allow for engagement in diverse cultural experiences, the ability to shift perspectives and modes of thinking, and the capacity to perceive things differently—all of which are directly related to creativity (Davis, 2004).

LIMITATIONS

In this study, we coded many different moderators, which explained 10.5% of the variance, but we could not code some other potential important moderators such as age of bilingualism and context of language acquisition. Further, most of the creativity tests used in the present study were divergent thinking tests, and they are often administered with different instructions, time limits, and scoring procedures (Acar et al., 2020; Paek, Alabbasi, Acar, & Runco, 2021; Reiter-Palmon, Forthmann, & Barbot, 2019). And yet, these details are often not reported in primary studies. As a result, some of the factors that potentially contribute to heterogeneity cannot be examined due to lack of reporting details. Third, we found significant differences with numerical modality, but this is a rarely used modality in creativity assessment. In our sample, 12 effect sizes related to numerical modality were obtained from three studies (Leikin, 2013; Leikin et al., 2014; Leikin & Tovli, 2014) that used this modality, and these three studies were conducted in the same research lab using the Creating Equal Numbers task (Tsamir et al., 2009). This also means that the same tasks were used in the same way, and this may have contributed to more precise estimates of mean effects. On the other hand, we have followed stringent analytical procedures to avoid errors in statistical inferences. We took multilevel nature of the data into consideration and incorporated robust variance estimators, which reduces Type I error. Further, we conducted meta-regression analyses (versus univariate analysis of each individual moderator) in two different ways (i.e., altogether and in clusters) to mitigate the issues of overfitting with too many covariates and Type I error due to too many analyses (Geissbühler et al., 2021; Higgins & Thompson, 2004; Pigott & Polanin, 2020; Viechtbauer, 2007). These considerations help explain why some of our moderators were non-significant, despite clear differences between the moderator categories. Additionally, the relatively large standard errors of the mean effect size estimates may be attributed to inconsistencies in the administration and scoring of creativity assessments. Ultimately, these factors may have obscured effects that could have been detected in the meta-regression analyses with more precise and consistent use of creativity assessments and a larger pool of studies. Additionally, our study pool was limited to publications in English. Given concerns around the generalizability of research conducted with English speaking participants (Blasi et al., 2022; Levisen, 2019) and limiting the search to English can exacerbate this issue, future research should include publications in other languages to offer a more comprehensive representation of the existing literature.

Potential confounding factors should also be acknowledged. For example, in light of the linguistic multi-competence stance that bilingual mind differs from the monolingual one (e.g., Cook, 2016), monolingual and bilingual samples may not be comparable due to qualitative differences across the two samples including but not limited to socio-economic status, neighborhood, and schooling experiences (Bailey, Venta, & Langley, 2020). Furthermore, self-selection bias may also lead to qualitatively discrepant samples in terms of participants' perceptions of their language proficiency or other factors. As stated previously, the role of non-verbal intelligence may also account for the relationship between bilingualism and creativity (cf. Booton et al., 2022). Moreover, a large number of bilinguals in the meta-analyzed studies were immigrants, whose experience is largely related to the socio-economic status. This observation can suggest the confounding or moderating role of this factor.

IMPLICATIONS AND FUTURE RESEARCH

Our findings have implications for research and practice. Regarding research, future investigations on bilingualism should provide a more detailed description of the participants' characteristics including language and cultural background and context of language practice. Moreover, it should be taken into account that this phenomenon is not limited to command of two languages: most participants in the studies

included in our meta-analysis spoke more than two languages. Therefore, it is essential to take into account the entire language repertoire of the individuals speaking more than one language and their agency in language acquisition and use. These considerations were assumed in the framework of plurilingual creativity (Kharkhurin, 2021).

The same recommendation is also applicable to creativity research that uses divergent thinking tests. While some creativity tests (e.g., Torrance Tests of Creative Thinking) have specific guidelines for administration, other individual tests such as Alternate Uses Tests are often used without following standard protocol. It is often ideal to follow a standard protocol to restrict the amount of noise in the data, and yet when a deviation is necessary, researchers should provide a detailed report on instructions, time, modality, and scoring procedures of the divergent thinking tasks.

The present study reflects the general practices in research literature and our findings should be considered in the light of these practices. For example, creativity assessment has been predominantly (89% of the effect sizes coded) conducted with divergent thinking tests whereas creativity is broader than divergent thinking (Runco, 2008; Runco & Acar, 2012). Future studies may broaden the scope of creativity assessment by considering alternative measures beyond divergent thinking such as product evaluation, insight, and creative problem-solving tasks (Runco & Acar, 2024). Also, there was a limited number of studies with preschoolers, which were combined with elementary schoolers. More studies with this sample may allow for testing the influence of bilingualism on creativity without the influences of schooling.

It is a well-known observation that both creativity and bilingualism are nurtured in education (Karwowski, 2021; Piccardo, Germain-Rutherford, & Lawrence, 2021). Our findings hint at the possibility that investing in bilingual education could also imply an investment in creativity (Leikin, 2013). Moreover, bilinguals' experience with multiple cultural settings could develop additional skills such as intercultural competence (Griffith, Wolfeld, Armon, Rios, & Liu, 2016). Future investigation should look into the effectiveness of the educational programs that combine multiple languages, interculturality, and creativity (Kharkhurin, Kashirskaia, & Pasechnik, 2024).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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