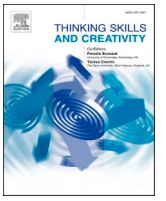
Thinking Skills and Creativity 60 (2026) 102119

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: www.elsevier.com/locate/tsc



Exploring the intersection of creativity and critical thinking among students: A meta-analysis

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ARTICLE INFO

Keywords:
Creativity
Critical thinking
Meta-analysis

ABSTRACT

Both creativity and critical thinking are considered key skills for students to navigate the complexities of the 21st century. However, there is relatively scarce literature that points to how these two constructs may be related. The lack of clarity on this relation undermines the understanding of their interplay in education and learning and might hinder opportunities for joint training and assessment. Following a recent review of the literature, which suggested a link between creativity and critical thinking in the general population, we proposed to estimate and test the overall correlation between the two constructs in educational contexts using a meta-analysis. A total of 51 correlation estimates (in 29 different studies) were extracted from a systematic review, representing a total sample size of 12548. Because some effect sizes were nested in publications, we used a 3-level meta-analysis and meta-regressions. Despite significant heterogeneity, we found a significant positive moderate correlation between the two constructs $r = 0.386$ [.296, .470], $p < 0.001$, with no significant publication bias. The effect was not significantly moderated by student education level, age of participants, geographical region, or year of publication, but was significantly moderated by the type of measurement used, with larger effects observed when both creativity and critical thinking measures were self-reports. Implications for education, training, and assessment of both skills, as well as future research, are discussed.

1. Introduction

In the recent decade, there has been an increased educational and scholarly interest in the study of creativity and critical thinking. For instance, the National Education Association named creativity and critical thinking as essential skills for educators to help students foster and develop in the 21st century (National Education Association, 2012). Other prominent organizations, such as the American Psychological Association and World Economic Forum, have emphasized the significance and economic value of developing creative and critical thinking skills (American Psychological Association, 2016; Di Battista et al., 2023). This trend is also corroborated by a recent bibliometric review of critical thinking research, which demonstrates a steady increase in publications on the topic between 2000 and 2021 (Dong et al., 2023), and by a recent review article that frames creativity and critical thinking as core components of 21st-century skills now studied widely in educational research (Thornhill-Miller et al., 2023). With the accelerating developments in artificial intelligence (AI) and the attendant debates about the extent to which artificial creativity or "thinking" might encroach upon or replace human intellectual capacities, the debates on whether artificial creativity and critical thinking can replace human intellect has also contributed to the interest in the study of these two essential 21st century skills (Partnership for 21st Century Skills, 2009;

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https://doi.org/10.1016/j.tsc.2025.102119
Received 28 August 2024; Received in revised form 18 November 2025; Accepted 23 December 2025
Available online 25 December 2025

Runco, 2023; Spector & Ma, 2019)

As a psychological construct, creativity was first highlighted by Guilford's APA presidential address as a critical component of intelligence (Guilford, 1950). Since this point, the definition of creativity has evolved as researchers began investigating the multi-faceted and multidomain nature of creativity. There is some consensus among creativity researchers that creativity involves an idea or a product that is both original and useful in a particular domain Amabile (2019); Kaufman and Beghetto (2009); Stein (1953); Sternberg and Lubart (1998).

The study of critical thinking expands multiple academic fields, including philosophy, education, and psychology. The concept of critical thinking has become a scientific construct as researchers have attempted to measure and quantify it as a study variable (Lamont, 2020). Similar to creativity, the definition of critical thinking has evolved over decades to include a person's attitude, knowledge, skills, and dispositions; as well as the ability to question, analyze, interpret, evaluate, judge, and discern information, in order to reach a strong, credible, objective, and logical solution (Glaser, 1941). The nature of self-regulation is important to critical thinking, which emphasizes a need to control, maintain, and manage one's thoughts, feelings, and behaviors in order to achieve the desirable goal (Dwyer, 2017). The domain specificity of critical thinking has also been highlighted by researchers in a variety of fields. For instance, Lawson (1999, 2015) describes psychological critical thinking as one's ability to evaluate information in ways that explicitly incorporate basic principles of psychological science whereas critical thinking in nursing is defined as skills that include components such as critical analysis, introductory and concluding justification, and recognition of conditions in order to improve patient care (Alfaro-LeFevre, 1999; Bandman & Bandman, 1988; Papathanasiou et al., 2014).

Relative to the interest in the study of these two skills, the investigation of the relationship between creativity and critical thinking has been scarce (Runco, 2003; Runco & Chand, 1994). Creative thinking is often associated with unexpected and unconventional thinking processes, whereas critical thinking is associated with rational, purposeful, and often criteria-based thinking style (Ennis, 1987; Sternberg & Halpern, 2020). These ostensibly opposing conceptual definitions present a challenge to understanding how one engages in different thought processes for problem-solving and innovation. Regardless, deepening the understanding of the relationship between creativity and critical thinking has been suggested to assist the development of educational curricula that foster students' development of these two skills, as well as enhance our understanding of how we think (Park et al., 2023).

Educators and academic institutions commonly emphasize critical thinking as a core outcome or an essential product of a student's educational experiences (Andreucci-Annunziata et al., 2023; Golden, 2023). On the other hand, enhancing creativity and creative thinking have historically received less attention as compared to critical thinking, especially in academic institutions. However, scholars and researchers have suggested that there is a positive relationship between creativity and critical thinking. Research has pointed to shared underlying conceptual principles as well as developmental trajectories that connect creative and critical thinking (Baer, 2003; Halpern, 2003), while others have investigated the benefits of educational curricula or academic intervention by measuring the increase in students' creative and critical thinking skills (Park et al., 2023).

Although creativity and critical thinking are often conceptualized as distinct, they share several underlying cognitive and meta-cognitive components. Both involve processes of evaluation, judgment, and self-regulation that require flexible yet goal-directed reasoning (Halpern, 2003; Sternberg & Halpern, 2020). Creative thinking emphasizes the generation of novel and useful ideas through divergent thought processes, whereas critical thinking emphasizes the analysis and evaluation of information through convergent reasoning (Runco & Chand, 1994). Yet, both processes rely on executive functions such as inhibition, cognitive flexibility, and working memory (Benedek et al., 2012, 2014). Moreover, both can be viewed as complementary stages in complex problem solving. For instance, creativity facilitates the production of possibilities, and critical thinking supports their refinement and selection (Cropley, 2006; Sternberg & Lubart, 1998). This conceptual overlap provides a theoretical basis for the empirical correlations observed between the two constructs and underscores the potential for educational programs to foster them jointly.

Park, Li and Niu (2023) conducted a systematic review of empirical studies that investigated the relationship between creativity and critical thinking. In their study, the correlation coefficient between person-oriented (using self-reports, therefore more subjective) and product-oriented (objective) creativity and critical thinking measures was studied, as well as the varying degrees of effect sizes of interventions that were proposed to enhance the creativity and critical thinking abilities of their participants. Although their systematic review of creativity and critical thinking research provided insights into the nature of the relationship between these constructs, a few gaps in Park et al.'s (2023) study prompt further investigation into the study of creativity and critical thinking. For instance, the included studies relied solely on a single database (i.e., PsycINFO), and their keyword searches were limited to terms such as *critical thinking, creative thinking*, and *creativity*, which may have restricted the inclusiveness of the review. Second, Park et al.'s (2023) study did not provide an analysis of publication bias that may exist in empirical studies of creativity and critical thinking, and how the potential existence of publication bias may influence the reported correlation coefficient between creativity and critical thinking. Third, the average correlation between creativity and critical thinking reported in their review was based on a simple average without the consideration of the sample sizes of the studies that were involved in their investigation. Given that there was heterogeneity in the correlation coefficient reported (with some reporting on non-significant results), the exact magnitude of the overall correlation between creativity and critical thinking remains uncertain. Fourth, a few studies included in Park et al.'s (2023) review included nested studies, which require a 3-level meta-analysis for a comprehensive analysis. Lastly, the study suggests that moderators that influence the relationship between creativity and critical thinking exist. Further investigation into the potential moderators prompts a meta-regression analysis, which the authors did not provide.

1.1. Aims of the current study

In the current study, we aim to address these gaps using meta-analysis and meta-regression and to further illuminate the nature of

the relationship between creativity and critical thinking. The current study also aims to take this line of research further through an investigation of the relationship between creativity and critical thinking, specifically among students.

Because previous research (Park et al., 2023) indicated that creativity and critical thinking were positively correlated in most empirical studies, we hypothesized that this meta-analysis would also show a positive overall correlation between the two constructs. The same review also noted that, although more correlations were positive, some correlations were negative and/or non-significant (e.g., Liang & Lin, 2015). Therefore, we hypothesized that there would be significant heterogeneity in the reported effects across studies.

Previous research (Park et al., 2023) noted that the relationship between creativity and critical thinking is likely to strengthen over development, so we hypothesized that the level of the students would be a significant moderator of the relationship between the two constructs. In addition, the same review suggested that the type of test measuring creativity and critical thinking could modify the correlation between the two constructs, which is also a phenomenon that has been observed in other similar contexts in creativity research (e.g., Storme et al., 2021). Consequently, we hypothesized that the types of measurement used for creativity and critical thinking would explain some heterogeneity in correlations observed, in the direction of higher correlations observed when both subjective (e.g., self-report) measurements are used for creativity and critical thinking, which would be speculatively due to both attributes being socially desirable, thus making their subjective measurements contaminated by a common nuisance factor of social desirability and/or self-esteem.

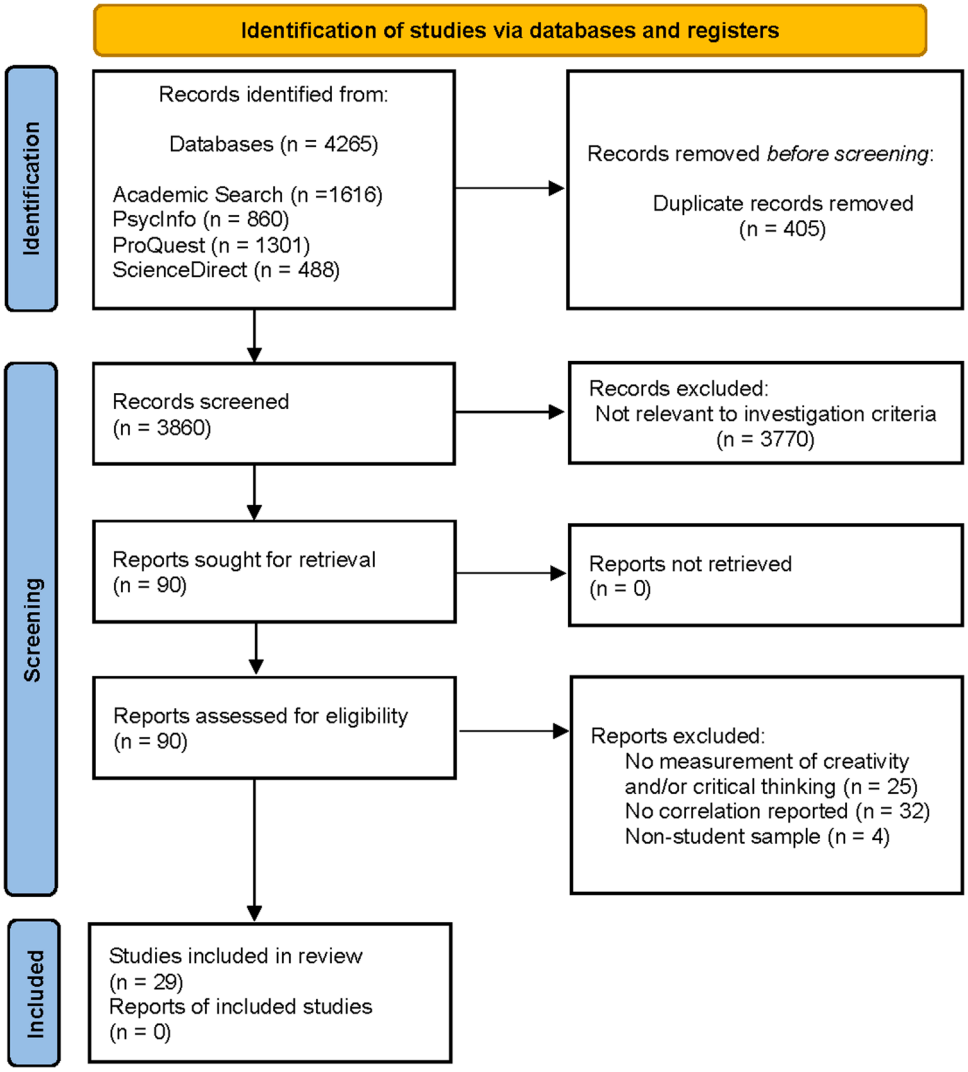

Fig. 1. Article search and selection process.

2. Methods

2.1. Systematic review and coding

Adding to the existing data from Park et al.'s (2023) systematic review of studies of creativity and critical thinking research, we included 16 new publications which resulted in a total of 29 publications for the current meta-analysis. The current analysis excluded 4 publications from Park et al.'s (2023) data, which failed to reach the criteria for the current investigation. The selection process involved a keyword search on PsycINFO, Academic Search Ultimate, ProQuest, and ScienceDirect with the keywords "creativity", "creative", "creativ*", and "critical thinking". Using the advanced search function, book chapters/reviews and non-peer-reviewed research papers were excluded from the data collection. The search was narrowed down to empirical research published in peer-reviewed journals and publicly available dissertations. Publications were excluded from the current study if it did not include both measures of creativity and critical thinking, did not report a correlation between a quantitative measure of creativity and critical thinking, or did not involve a student sample. Once the research was identified as meeting the inclusion criteria, the necessary data for analysis were extracted and coded. The correlation coefficient of creativity and critical thinking measures reported was extracted from the research. A PRISMA chart of the study selection process is presented in Fig. 1.

As commonly done in creativity meta-analyses (e.g., Storme et al., 2021) and in discussions of creativity measurement (e.g., N. K. Park et al., 2016), measurements of creativity and critical thinking were categorized into subjective and objective categories: studies that utilized the method of self-report or self-rating (i.e., creative self-efficacy, critical thinking disposition scale) were coded as using "subjective" measures of the construct whereas studies that involved the production of ideas/products or measurement of performance (i.e., Alternate Uses Test, California Critical Thinking Skills Test) were coded as "objective" measures of the construct. Data regarding moderators were extracted, such as the average age of participants, the level of the students' education, the year of publication, and the geographical region of the participants. There was a total of 51 ($k = 51$) correlation estimates retained for meta-analysis, clustered in a total of 29 studies and representing a total sample size of 12,548 ($N = 12{,}548$). The clustering consisted of publications which reported estimates using the same participants but different measures (Eggers et al., 2017; Gilbert, 1961; Guan et al., 2024; Komsu, 2021; Long & Long, 2023; Lu et al., 2024; Misset, 2012; Qiang et al., 2020; Runco & Smith, 1992), and publications which reported estimates using different participants but the same measures (Brubaker, 1971; Li et al., 2022; Shaber et al., 2025; Silva et al., 2023; Yurt, 2025). The studies included in the analysis are reported in Table 1.

2.2. Statistical analysis

Since multiple effect sizes were reported within some studies, effect sizes were not statistically independent. Therefore, we used a three-level random-effects meta-analysis to appropriately account for the nested structure of the data. In this model, variance is partitioned into (a) sampling error of each effect size (Level 1), (b) variation among multiple effect sizes taken from the same study (Level 2), and (c) variation between studies (Level 3). All models were estimated using the R package "meta" (Balduzzi et al., 2019). Effect sizes were Fisher's z-transformed correlations, which stabilize variance and normalize the distribution. Each effect size was weighted by the inverse of its sampling variance (i.e., larger samples contribute more precise estimates). Variances were computed using established formulas for Fisher's z. We quantified heterogeneity (the extent to which effect sizes differ beyond what would be expected by sampling error) using the I^2statistic, which estimates the proportion of total variation reflecting true differences across studies, and the Q test, which tests whether the variability in effect sizes is greater than expected by chance.

To assess the robustness of results to potential dependencies among effect sizes within studies, we additionally conducted a robust variance estimation (RVE) analysis (Pustejovsky & Tipton, 2022). This approach provides small-sample–adjusted standard errors that remain valid even when effect sizes from the same study are correlated. The RVE model was implemented using the R package "clubSandwich" (Pustejovsky, 2023) applied to the three-level meta-analytic model estimated with metafor (Viechtbauer, 2010).

We examined publication bias using the Egger's regression test of funnel plot asymmetry (Egger et al., 1997) as well as the funnel plot. We used contour-enhanced funnel plots, which shade areas of statistical significance to clarify whether any asymmetry is more likely due to missing non-significant studies (a pattern consistent with publication bias) or due to genuine differences in effect sizes across studies (Peters et al., 2008).

Using (3-level) meta-regression, we investigated the effect of several moderators, including the average age of the participants of the study, the levels of the student's education (middle or high school students vs. college students), the year of publication, the geographical region of the participants, the type of creativity test used, and the type of critical thinking test used. Since we hypothesized that using subjective measures for both constructs might lead to biased estimates of the relation between creativity and critical thinking, we also tested a two-way interaction effect between the types of creativity and critical thinking measures. We quantified heterogeneity using the Q-statistic and the I^2 statistic, which estimate whether and to what extent the variability in effect sizes exceeds what would be expected by sampling error alone. To assess whether moderator variables explained this variability, we used omnibus moderator tests (QM). They evaluate whether adding a moderator—or a set of moderators—to the model accounts for a statistically significant amount of the remaining heterogeneity, either when entered alone or in combination with other predictors. Moderators were tested both individually and in models that included one additional moderator to evaluate their effects while accounting for another study characteristic.

Table 1
Studies included in analysis (with moderator variables).

Author/Country	Age of Participants	Student Level	Geographical Region	CT Measurement (S/O)	CR Measurement (S/O)
Akpur (2020)	NA	College	Middle East	The Critical Thinking Scale (Objective)	Marmara Creative Thinking Dispositions Scale (Subjective)
AlMahdawi et al. (2021)	16.5	Middle/High school	Middle East	Online Survey Questionnaire for High School Students' Performance Indicators in Distance Learning in Chemistry during the COVID-19 Pandemic - Critical Thinking Domain (Subjective)	Online Survey Questionnaire for High School Students' Performance Indicators in Distance Learning in Chemistry during the COVID-19 Pandemic - Creativity and Innovation Domain (Subjective)
Álvarez-Huerta et al. (2022)	20.35	College	Other countries	Critical Thinking Disposition Scale (Spanish adaptation) (Subjective)	Creative Self-Efficacy Instrument (Subjective)
Anderson and Beach (2022)	14.5	Middle/High school	North America	Student MetaSkills Survey - Critical Thinking Domain (Subjective)	Student MetaSkills Survey - Creativity Domain (Subjective)
Brubaker (1971)	NA	College	North America	The Critical Thinking Scale (Objective)	Creative Personality Scale (Subjective)
Egger et al. (1997)	NA	College	North America	Written analysis provided by students assessed using a critical thinking rubric (Objective)	Creation of Product Design (Objective)
Gadzella and Penland (1995)	NA	College	North America	WGCTA (Objective)	16 Personality Factor Creativity scale (Subjective)
Gibson et al. (1968)	NA	College	North America	WGCTA (Objective)	Alternate Uses Test (Objective)
Gilbert (1961)	NA	Middle/High school	North America	WGCTA (Objective)	Alternate Uses Test (Objective)
Gilbert (1961)	NA	Middle/High school	North America	WGCTA (Objective)	Guilford Associational Fluency Test (Objective)
Gilbert (1961)	NA	Middle/High school	North America	WGCTA (Objective)	Guilford Ideational Fluency Test – Fluency (Objective)
Gilbert (1961)	NA	Middle/High school	North America	WGCTA (Objective)	Guilford Ideational Fluency Test – Originality (Objective)
Guan et al. (2024)	20.29	College	East Asia	Critical Thinking Scale (Subjective)	Creative Self-Efficacy Scale (Subjective)
Guan et al. (2024)	20.29	College	East Asia	Runco Ideational Behavior Scale (Subjective)	Creative Self-Efficacy Scale (Subjective)
Khatami et al. (2023)	22.5	College	Middle East	Critical Thinking Questionnaire (Subjective)	TTCT (Objective)
Kocak et al. (2021)	21.82	College	Middle East	Computational Thinking Scale – Critical Thinking subdimension (Subjective)	Computational Thinking Scale - Creativity subdimension (Subjective)
Komsu (2021)	24.5	Postgraduate	Middle East	UF/EMI Critical Thinking Disposition Scale	Kaufman Domains of Creativity Scale - Academic Creativity sub-dimension (Investigative Creativity) (Subjective)
Komsu (2021)	24.5	Postgraduate	Middle East	UF/EMI Critical Thinking Disposition Scale (Subjective)	Kaufman Domains of Creativity Scale - Academic Creativity sub-dimension (Analytical Creativity) (Subjective)
Li et al. (2022)	NA	College	East Asia	4C Skills – Critical Thinking Domain (Subjective)	4C Skills - Creativity Domain (Subjective)
Ling and Loh (2020)	17.5	Middle/High school	East Asia	CCTT (modified) (Objective)	Creativity Selected Elements Questionnaire (modified) (Subjective)
Long and Long (2023)	19.08	College	East Asia	Critical Thinking Scale (Subjective)	Creative Self-Efficacy Scale (Subjective)
Long and Long (2023)	19.08	College	East Asia	Critical Thinking Scale (Subjective)	Creativity Scale (Subjective)
Lu et al. (2023)	20.13	College	East Asia	Critical Thinking Disposition Scale (Subjective)	Creative Self-Efficacy Scale (Subjective)
Lu et al. (2023)	20.13	College	East Asia	Critical Thinking Disposition Scale (Subjective)	Creative Achievement Questionnaire (Subjective)
Misset (2012)	NA	Middle/High school	North America	CCTT (Objective)	TTCT - Verbal Fluency (Objective)

(*continued on next page*)

Table 1 (*continued*)

Author/Country	Age of Participants	Student Level	Geographical Region	CT Measurement (S/O)	CR Measurement (S/O)
Misset (2012))	NA	Middle/High school	North America	CCTT (Objective)	TTCT - Verbal Flexibility (Objective)
Misset (2012)	NA	Middle/High school	North America	CCTT (Objective)	TTCT - Verbal Originality (Objective)
Orakci (2023)	NA	College	Middle East	Critical Thinking Scale (Subjective)	Creativity Scale (How Creative Are You?) (Subjective)
Pepe (2018)	23.5	College	Middle East	CCTDI (Subjective)	The Creativity Level Scale (Subjective)
Prakoso et al. (2021)	NA	College	East Asia	Critical Thinking Disposition Instrument (Subjective)	Creativity Scale (Subjective)
Qiang et al. (2020)	16.2	Middle/High school	East Asia	CCTDI (Subjective)	Scientific Creativity (Objective)
Qiang et al. (2020)	16.2	Middle/High school	East Asia	CCTDI (Subjective)	Trait-like Creative Self Efficacy (Subjective)
Runco et al. (1992)	21.7	College	North America	The Advanced Structure of Intellect Test for Critical and Analytical Thinking (Objective)	Divergent Thinking Test (Originality - uniqueness) (Objective)
Runco et al. (1992)	21.7	College	North America	The Advanced Structure of Intellect Test for Critical and Analytical Thinking (Objective)	Divergent Thinking Test (Fluency - popular) (Objective)
Shaber et al. (2025)	18.5	College	Middle East	Critical Thinking Assessment Tool (Objective)	Adapted version of Torrance Test of Creative Thinking – Verbal (Objective)
Silva et al. (2023)	21.4	College	Other countries	Critical Thinking Disposition Scale (Subjective)	Critical and Creative Thinking Test – Fluency (Objective)
Silva et al. (2023)	21.4	College	Other countries	Critical Thinking Disposition Scale (Subjective)	Critical and Creative Thinking Test – Flexibility (Objective)
Silva et al. (2023)	21.4	College	Other countries	Critical Thinking Disposition Scale (Subjective)	Critical and Creative Thinking Test – Originality (Objective)
Ulger (2016)	21.74	College	Middle East	CCTDI (Subjective)	TTCT (Objective)
Wechsler et al. (2018)	21.35	College	Other countries	PENCRISAL Critical Thinking Test (Objective)	Verbal Creative Thinking (based on TTCT - Verbal) (Objective)
Yang and Lin (2004)	18	Middle/High school	East Asia	WGCTA (Objective)	Chopsticks Creativity Test (Objective)
Yurt (2024)	21.48	College	Middle East	Critical Thinking Disposition Scale (Subjective)	Marmara Creative Thinking Disposition Scale (Subjective)

Note. CCTDI = California Critical Thinking Disposition Inventory; CCTT = Cornell Critical Thinking Test; TTCT = Torrance Test of Creative of Creative Thinking; WGCTA = Watson-Glaser Critical Thinking Appraisal.

3. Results

3.1. Effect size and heterogeneity

As hypothesized, a significant positive correlation was found across studies – $r = 0.386$, 95% CI [0.296, 0.470], $z = 7.81$, $p < 0.001$. The forest plot is presented in Fig. 2, and includes the correlations in each study, along with sample sizes and the weight of each study in the computation of the overall effect. There was significant heterogeneity across the reported effect sizes – $I^2 = 95.6\%$, 95% CI [94.8%; 96.2%], $Q(50) = 1133.19$, $p < 0.001$. A sensitivity analysis using robust variance estimation (RVE) produced an equivalent estimate – $r = 0.386$, 95% CI [.292, 0.473], $t(27.81) = 7.81$, $p < .001$ – indicating that the overall correlation was robust to within-study dependence.

3.2. Publication bias

In Fig. 3, we present the funnel plot (Light & Pillemer, 1984), which is contour-enhanced (Peters et al., 2008) to show the significance of the estimates reported. No significant publication bias was found based on Egger's regression test – $t(149) = 0.29$, $p = 0.771$ – together with visual inspection of the funnel plot. Although these results suggest that publication bias does not appear to be a major threat to the conclusions of this meta-analysis, we note that non-significant tests of funnel asymmetry do not demonstrate the absence of publication bias.

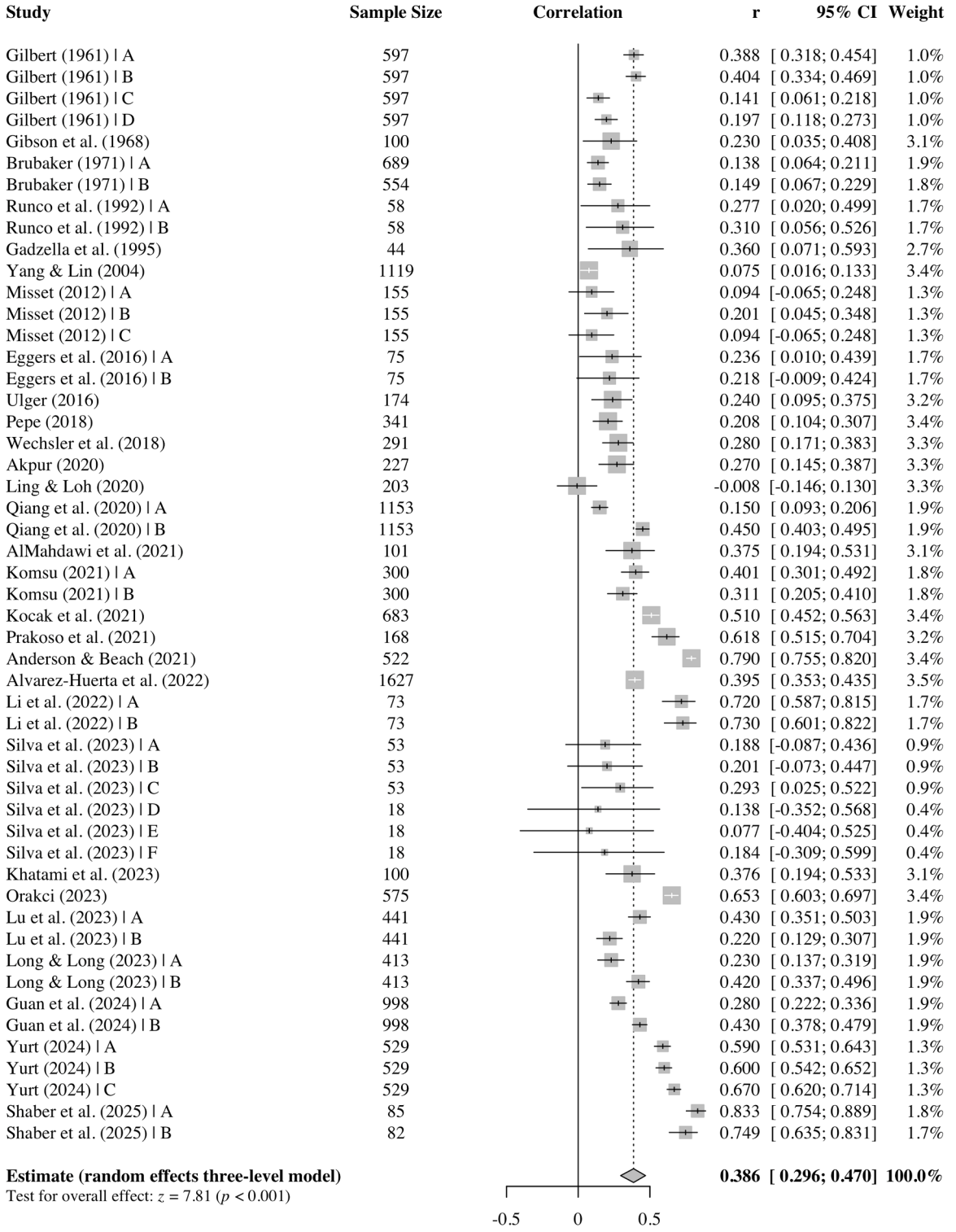

Fig. 2. Forest plot.

3.3. Moderators

As expected, the average age of the participants of the study did not significantly moderate the relation between creativity and critical thinking – $QM(1) = 1.203$, $p = .273$. It had, however, a significant effect (at $p<.05$) when controlling for grade level and

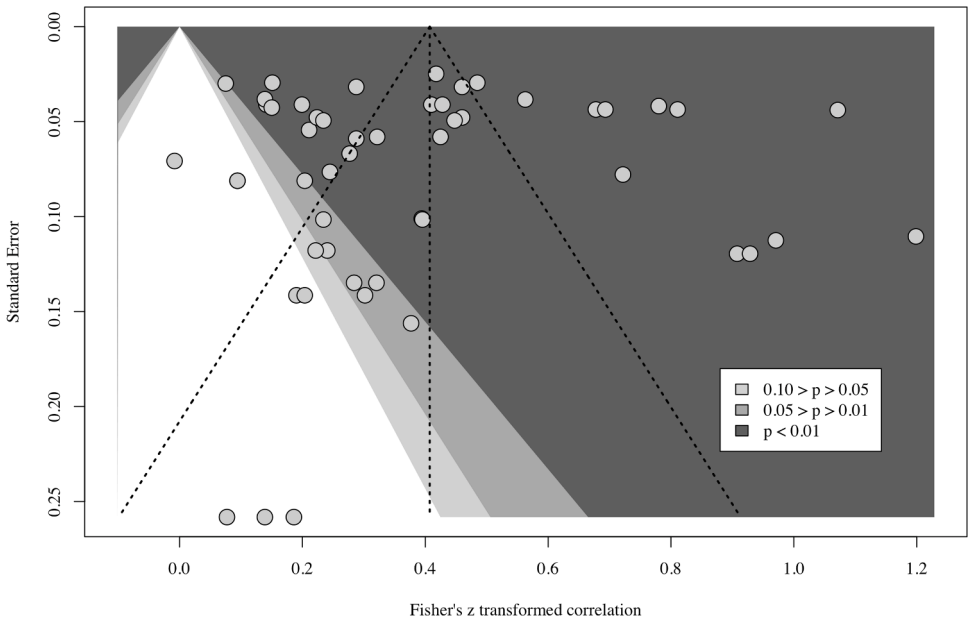

Fig. 3. Contour-enhanced funnel plot.

controlling for geographical region (in the direction of correlations decreasing with age), but not when controlling for the year of publication, for the type of critical thinking test, and for the type of creativity test. Contrary to our hypothesis, the correlation was not significantly moderated by the grade level of the students – $QM(1) = 0.875$, $p = .350$. This effect was, however, significant (at $p<.05$)

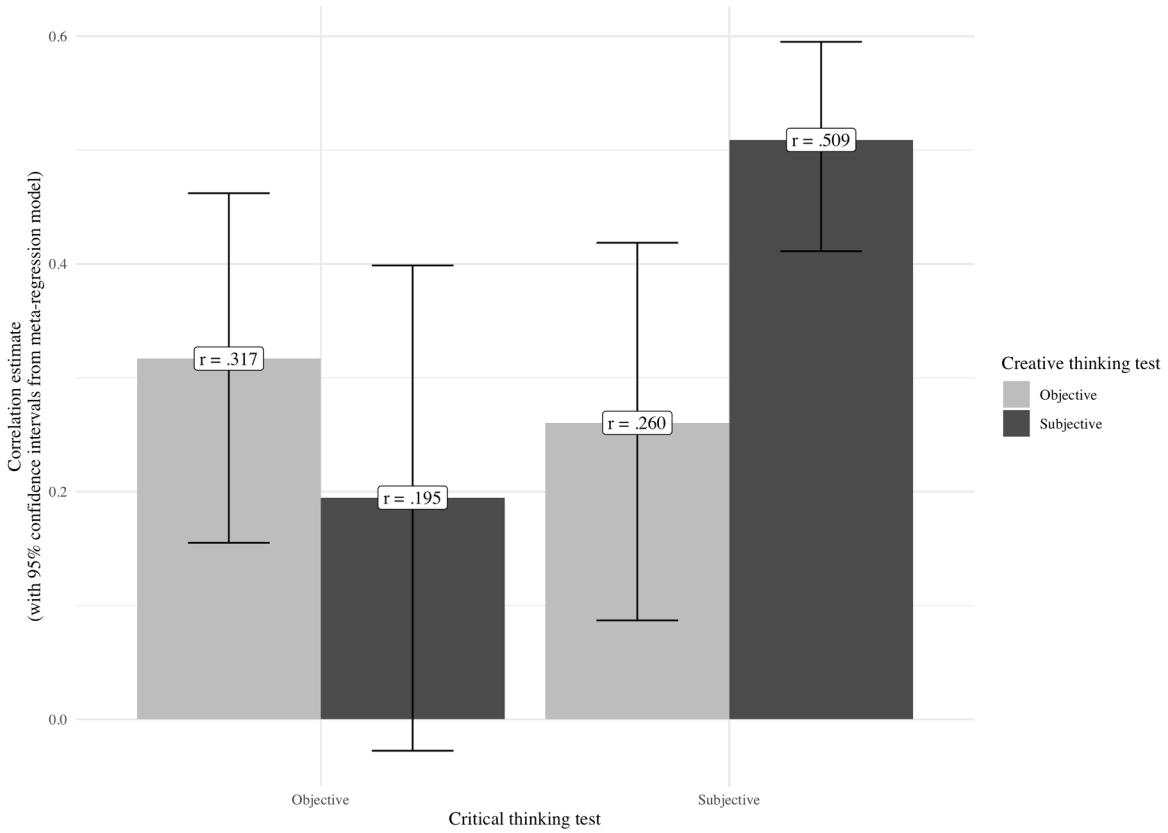

Fig. 4. Correlation estimates.

when controlling for age (in the anticipated direction of stronger correlations among college students as opposed to middle/high school students), but not significant when controlling for year of publication, for geographical region, for type of critical thinking test, and for type of creativity test. The year of publication marginally significantly moderated the correlation – $QM(1) = 3.707,\ p = .054$ – in the direction of correlations increasing with the year of publication. This effect remained non-significant or marginally significant ($p > .05$) when controlling for age, for grade level, for geographical region, for type of critical thinking test, and for type of creativity test. The geographical region did not have a significant effect on the correlation estimates – $QM(3) = 2.270,\ p = .518$. The effect was significant (at $p<.05$) when controlling for age (in the direction of lower correlations in East Asia compared with other regions), but remained non-significant when controlling for grade level, for year of publication, for type of critical thinking test, and for type of creativity test.

As hypothesized, we observed moderating effects from the type of test used. More specifically, we found that using subjective critical thinking measures resulted in significantly stronger correlation estimates – $QM(1) = 5.234,\ p = .022$. This effect remained significant ($p<.05$) when controlling for grade level, for year of publication, for geographical region, and for type of creativity test, but not when controlling for age. Similarly, using subjective creativity measures also resulted in significantly stronger correlation estimates – $QM(1) = 10.133,\ p = .002$. This effect remained significant ($p<.05$) when controlling for each of the other moderators.

As expected, there was a significant interaction effect between the types of test used for both constructs – $QM(1) = 6.524,\ p = .011$ – in the direction of increased correlations when tests of the same type are used for both measures. In Fig. 4, we show the correlation estimates (and their 95% confidence intervals from the meta-regression) across the different combinations of types of tests.

4. Discussion

The current study aimed to elucidate the relationship between creativity and critical thinking through a meta-analysis of the correlations observed between creativity and critical thinking measures completed by students. Additionally, we also investigated the existence of a potential publication bias as well as the moderating effects of selected variables. Overall, as discussed in previous research (Park et al., 2023), the effect sizes observed were significantly heterogeneous, which is not surprising, considering the variety of methods used to measure both constructs. However, as hypothesized, we found an overall correlation estimate that clearly fell in the moderate range and was significantly positive, which indicates that some overlap between measures of the two constructs exists. This conclusion is further substantiated by the fact that we did not find any evidence of significant publication bias, whether using the regression test or the visual inspection of the funnel plot.

The current findings extend prior qualitative and theoretical discussions (Baer, 2003; Halpern, 2003; Runco & Chand, 1994) by quantitatively confirming that creativity and critical thinking are positively related among student samples. Whereas earlier work primarily proposed conceptual links or examined isolated intervention effects, our meta-analytic evidence demonstrates a moderate, robust correlation across diverse measures and contexts. These results empirically substantiate long-standing theoretical claims that the two constructs represent complementary modes of higher-order cognition rather than independent domains. In doing so, our findings bridge theoretical discourse and quantitative evidence, strengthening the foundation for integrated models of creative-critical thinking in education.

In subsequent analyses, we examined whether study characteristics moderated the association between creativity and critical thinking. Overall, there was little consistent evidence that publication year, participant age, educational level, or geographical region substantially influenced the size of the correlation. Although a few moderator effects reached statistical significance in certain model specifications, these effects were small and not robust across analyses, suggesting that these characteristics do not meaningfully alter the relation between creativity and critical thinking.

Nevertheless, as hypothesized and consistent with other meta-analyses involving creativity measures (Storme et al., 2021), we found that the type of test used was a significant moderator. More specifically, although correlations remained positive for all combinations of types of measurements (subjective and objective) of creativity and critical thinking, the largest correlations were observed when both measures were of the same kind, particularly if they were both subjective.

The stronger correlations observed when both creativity and critical thinking were measured through subjective (e.g., self-reports) measures may partially reflect common method variance. When both variables are assessed using similar self-perception instruments, correlations can be inflated by shared response tendencies such as social desirability, acquiescence, or self-esteem bias (Podsakoff et al., 2003). In this case, students who view themselves as generally competent or intellectually capable may rate themselves highly on both creative and critical thinking dispositions, regardless of their actual performance. Future studies should therefore triangulate self-report measures with performance-based assessments or behavioral indicators to mitigate method bias and better capture the unique contributions of each construct.

4.1. Implications

As was previously suggested (Park et al., 2023), our meta-analysis provides evidence to indicate that creativity and critical thinking are overlapping constructs, or that they might tap into common skills, abilities, or personality traits among students. Although some may consider creativity and critical thinking as unrelated or even as opposite constructs, the results from the current meta-analysis clearly suggest that these two skills are in fact interrelated in a positive direction.

The differences in correlation based on the type of measurement used provide important insights into how creativity and critical thinking are operationalized in current research. The highest correlation was observed when both creativity and critical thinking were measured subjectively ($r = 0.509$), followed by objective measures of both constructs ($r = 0.317$). Moderate correlations were found

when creativity was measured objectively and critical thinking subjectively ($r = 0.260$) and when creativity was measured subjectively and critical thinking objectively ($r = 0.195$). This pattern suggests that the type of measurement substantially influences the observed relationship between the two constructs. One interpretation of these results is that method similarity contributes to stronger observed correlations, particularly when both constructs are measured through self-reports, which may share common variance related to self-perception or social desirability. However, the relatively higher correlation observed between objective measures compared to mixed-method pairs indicates that there is also genuine overlap in performance-based measures of creativity and critical thinking. Objective assessments of both constructs often tap into similar cognitive processes such as reasoning, problem solving, and associative flexibility (e.g., the Alternate Uses Test and the Watson–Glaser Critical Thinking Appraisal). In contrast, mixed-method pairs likely yield lower correlations because they draw from different sources of variance (e.g., subjective self-assessments versus externally rated task performance), which are not directly comparable. This pattern suggests that when both constructs are evaluated through structured, task-based performance indicators, they may rely on shared underlying cognitive mechanisms, supporting the view that creativity and critical thinking converge most strongly when both are measured as active cognitive processes rather than self-perceived dispositions.

A further interpretation of the observed relationship concerns the cognitive processes embedded in the tests themselves. Several measures of creativity, such as the Remote Associates Test (RAT) or divergent-thinking tasks, emphasize analytic reasoning and associative fluency, which are processes closely aligned with critical thinking (Mednick, 1962; Silvia et al., 2013). In contrast, product-based assessments relying on expert ratings (e.g., the Consensual Assessment Technique) may engage different evaluative criteria. The convergence observed in studies employing "thinking-focused" creativity measures, therefore, suggests that shared cognitive operations (e.g., semantic association, hypothesis testing, solution evaluation) constitute a common foundation linking creativity and critical thinking. Future meta-analytic work could explicitly separate product-based from thinking-based creativity measures to clarify these differential contributions.

Our results provide some implications for schools and school functioning. First, the results of this meta-analysis indicate that creative thinking has some predictive validity over critical thinking, suggesting that its measurement (directly or by proxy, using, for example, a creative achievement measure) might be helpful in academic selection contexts, especially when a prospective student's critical thinking is considered a particularly desirable skill.

Several theoretical frameworks explicitly integrate elements of both creativity and critical thinking within broader conceptions of problem solving and innovation. For example, the Creative Problem-Solving model (Isaksen & Treffinger, 2004) incorporates critical evaluation as an essential phase of creativity, while critical-thinking models often emphasize creative hypothesis generation as part of reflective judgment (Kuhn, 1999). Our findings are consistent with these frameworks, suggesting that the boundaries between the two constructs may be more porous than traditionally assumed. This integrative perspective supports pedagogical approaches that treat creative and critical thinking as mutually reinforcing components of adaptive cognition.

From an educational standpoint, these findings carry clear implications for teachers and curriculum designers. Instruction that simultaneously cultivates creative ideation and evaluative reasoning may yield broader cognitive benefits than programs targeting either skill in isolation. Teachers can promote this integration by embedding open-ended tasks that encourage divergent idea generation followed by structured reflection, critique, and revision (Abrami et al., 2015). Classroom practices such as design thinking, inquiry-based projects, and Socratic questioning exemplify pedagogies that nurture both creativity and critical thinking. Recognizing their interdependence enables educators to move beyond a dichotomous view of "creative vs. critical" to a more holistic model of innovative and reflective learning.

In addition, the results suggest that enhancing students' creativity might also enhance their critical thinking skills. In other words, educational approaches or curricula that are aimed at enhancing and fostering students' creativity may also enhance the students' critical thinking skills as a by-product. For instance, engaging students with academic exercises that involve creativity (i.e., divergent thinking tasks, brainstorming exercises) may not only allow students to develop creative thinking skills but also allow them to develop critical thinking skills (i.e., logical/analytic reasoning). Alternatively, we might speculate from our findings that educational approaches or curricula that aim to enhance critical thinking, which overall tend to have shown efficacy (Abrami et al., 2015), could also develop student creativity as a by-product.

Even though the current results suggest a potential for a synergetic relation between creativity and critical thinking where the enhancement of one is likely to enhance the other, further research is needed to validate such a claim, notably because here, the relationship between the two constructs is investigated at the between-individual level, and this relationship (or its strength) may not translate to the within-individual level (Molenaar, 2004). Thus, studies involving intraindividual variation (i.e., longitudinal studies) would be warranted to verify that creativity and critical thinking are associated at the within-person level. Provided that this is the case, one could envision that training one could help train the other. In addition, longitudinal studies – for example, using cross-lagged panel analysis (Kenny, 1975) – of the joint development of creativity and critical thinking would help disentangle the direction of the relation between the two constructs.

4.2. Limitations

One limitation of this study is that it does not allow for disentangling (or controlling for) what part of the relation between creativity and critical thinking might be attributable to some other set of psychological attributes – such as, but not limited to, general mental ability, openness/intellect, or need for cognition – explaining both constructs. Indeed, general mental ability has been shown to be related to creativity (e.g., Gerwig et al., 2021; Kim, 2008), and critical thinking has been discussed as a potential redefinition for intelligence (Halpern, 2003). It has even been suggested that both creativity and critical thinking may be thought of as components of it (Albergaria-Almeida, 2011). Similarly, both creativity (e.g., Feist, 1998) and critical thinking (e.g., Clifford et al., 2004) have been

found to be positively correlated with openness. As a consequence, it is possible that the common variance of creativity and critical thinking is at least partly explained by these common potential explanatory variables. Thus, it is likely that some part of the correlation observed could be attenuated by controlling for it, although this certainly deserves further investigation.

Another limitation of this study (or rather, of the current state of research on the topic) is that both creativity and critical thinking may be measured in ways that are very different. Notably, creativity is largely discussed as a multifaceted construct that is nearly impossible to measure "purely" (Baer, 2012) without a number of nuisance factors or facets, which include notably (sub-)domain effects, rater effects, and shared method effects (Myszkowski, 2024). For example, Measures of creativity that rely on divergent thinking fluency scores (e.g., Torrance, 2008), are very different from those that rely on self-reported creativity (e.g., Kaufman, 2012), or those that rely on (domain-specific) products judged by experts (e.g., Lubart et al., 2011). Seeing that, in our meta-analysis, different levels of correlations were observed for different combinations of types of tests, we would speculate that there could be relations between certain tasks themselves (beyond the broad constructs of critical thinking and creativity) – for example, we could imagine that an analytic thinking task (e.g., Hassan & Madhum, 2007) that is used to tentatively measure critical thinking may be strongly related to a scientific creativity test used to measure creativity (e.g., Hu & Adey, 2002), leading to a correlation between critical thinking and creativity that would be inflated by a specific overlap in the skills involved in the two tasks.

CRediT authorship contribution statement

Ji Hoon Park: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Nils Myszkowski:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Weihua Niu:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Data availability

Data will be made available on request.

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