Thinking & Reasoning

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ptar20

Divergent thinking is linked with convergent thinking; implications for models of creativity

Bruce, S. Rawlings, Daisy Chetwynd-Talbot, Erin Husband, Aisling Nuttall, Elissa Quinn, Rosie Taggart & Hannah E. Roome

To cite this article: Bruce, S. Rawlings, Daisy Chetwynd-Talbot, Erin Husband, Aisling Nuttall, Elissa Quinn, Rosie Taggart & Hannah E. Roome (29 Mar 2025): Divergent thinking is linked with convergent thinking; implications for models of creativity, Thinking & Reasoning, DOI: 10.1080/13546783.2025.2485059

To link to this article: https://doi.org/10.1080/13546783.2025.2485059

Published online: 29 Mar 2025.

THINKING & REASONING
https://doi.org/10.1080/13546783.2025.2485059

Divergent thinking is linked with convergent thinking; implications for models of creativity

Bruce, S. Rawlings[a,b], Daisy Chetwynd-Talbot[a], Erin Husband[a], Aisling Nuttall[a], Elissa Quinn[a], Rosie Taggart[a] and Hannah E. Roome[c]

[a]Department of Psychology, Durham University, Durham, UK; [b]Durham Cultural Evolution Research Centre, Durham, UK; [c]School of Psychology, Newcastle University, Newcastle, UK

ABSTRACT
Creativity is a critical 21st-century skill, encompassing the ability to generate unique, diverse ideas (divergent thinking) and evaluate them to select optimal ones (convergent thinking). Despite attempts to integrate convergent thinking into creativity frameworks, most research focuses on divergent thinking, and studies assessing their association remain inconclusive. We examined the relationship between performance on two widely used measures of divergent and convergent thinking—the Alternate Uses task and the Remote Associations test—in UK adults. Alternate Uses scores of fluency, originality, elaboration, and a composite score were all positively associated with Remote Associations test scores. We also replicated findings that Alternate Uses scores of fluency, originality, and elaboration were intercorrelated. This study reports a direct positive association between these measures, suggesting individuals who generate numerous unique, detailed ideas are also adept at identifying correct solutions. We discuss the implications and the need to integrate convergent thinking into creativity models.

HIGHLIGHTS

- We examined the relationship between convergent thinking and divergent thinking in UK adults, using the Remotes Associations Test and the Alternate Uses task, respectively.
- Fluency, originality, and elaboration, and a composite score of each were positively associated with remote associations test scores.
- These findings suggest that those who are able to generate multiple novel, rich and unique ideas are those who can hone in on correct ones from a range of alternatives.
- Our findings imply that convergent thinking should continue to be integrated into theoretical frameworks of creativity.

ARTICLE HISTORY Received May 3, 2024; Accepted March 21, 2025

KEYWORDS Divergent thinking; convergent thinking; creativity; problem-solving; cognition

CONTACT Bruce Rawlings bruce.rawlings@durham.ac.uk Department of Psychology, Durham University, Upper Mountjoy, South Road, DH1 3LE, UK

Introduction

Creativity is frequently described as fundamental to human success and a standout characteristic of our species (Fogarty et al., 2015; Fuentes, 2017; Rawlings et al., 2021; Yusuf, 2009). The ability to colonise the planet, develop biomedicine, and invent artificial intelligence is a result of humans' capacity for creative thought and problem-solving. Creativity is also increasingly recognised as a fundamental 21st-century skill: in the face of the global pandemic, the World Economic Forum Future of Jobs Reports in 2023 and 2025 outlined creative thinking as the first and fifth most important skill for future employees, respectively. Consequently, creativity has been the subject of intense scientific investigation over recent decades, with researchers aiming to understand, for example, the association between creativity and workplace performance (Sauermann & Cohen, 2010; Baer et al., 2015), personal, cognitive, social, and cultural predictors of creativity (Baer, 2010; Köster et al., 2020; Rawlings & Cutting, 2024; Shi et al., 2017; Tan et al., 2019), how it develops in children (Bijvoet-van den Berg & Hoicka, 2014; Hoicka et al., 2023; Rawlings et al., 2022; Runco, 1992; Said-Metwaly et al., 2021), whether it is domain-specific or general (An & Runco, 2016; Qian et al., 2019; Rawlings & Reader, 2024), and indeed whether other animals are capable of creativity (Kaufman & Kaufman, 2015; Kuczaj, 2017).

Although defining creativity has proven difficult, a broad and widely used definition is that it is the generation of novel and useful ideas (Acar et al., 2017; Diedrich et al., 2015; Harvey & Berry, 2023; Sánchez-Dorado, 2020). In this view, creative thought encompasses two fundamental processes; divergent thinking—the ability to generate multiple novel ideas, solutions, or possibilities in an open-ended manner—and convergent thinking—homing in on single, correct solutions from a range of alternatives (Evans et al., 2021; Evans & Jirout, 2023; Guilford, 1967; Zhu et al., 2019). Divergent thinking (DT) involves thinking fluently (to generate multiple ideas), originally (to generate unique ideas), flexibly (to generate diverse ideas), and elaborately (to generate detailed ideas) (Runco, 1992; Runco & Acar, 2012). Conversely, convergent thinking (CT) requires logical thinking, accuracy, and deduction to evaluate a range of potential solutions and identify the optimal one (Cropley, 2006). Thus, the major qualitative distinction between the two is that while DT involves variation, CT involves evaluation (Cropley, 2006). CT and DT are considered by some as opposing approaches to creativity (Eysenck, 2003), and many researchers have treated DT as a proxy for overall creativity (Paek et al., 2021), while others argue that both are required for true creative cognition (Cropley, 2006; Gabora, 2018; Rawlings & Cutting, 2024). Individuals must both produce as many novel ideas or solutions as possible, as well as integrate and evaluate them to select the most appropriate (Cropley, 2006; Guilford, 1967). While the latter is critical for maximising the value of generated ideas, most creativity research has focussed on divergent thinking, and we have relatively little understanding of the relationship between the two. Specifically, it remains unclear whether individuals who are better able to generate multiple, novel, and unique ideas are also those who can efficaciously search solution spaces to identify optimal ones or not. This study aims to investigate the nature of this relationship, providing insights into the cognitive mechanisms that underlie creative problem-solving.

Divergent thinking has long been the focus of creativity research. Since Guilford's seminal work arguing that creativity is a core cognitive skill and should be the target of objective empirical study (Guilford, 1950; Guilford, 1967), it has been the subject of intense scientific scrutiny. DT tests have, in particular, been frequently used to measure creative problem-solving. Widely used measures of DT are alternate uses tasks (AUT), which require participants to list as many uses as they can think of for everyday objects (i.e., a brick or newspaper). Scores of one or more of the following are usually calculated: fluency (total number of uses provided), originality (rarity of uses compared to other participants), flexibility (diversity of uses) and elaboration (level of detail provided). Over the years, DT, and especially AUT performance, has been linked to a range of cognitive and noncognitive variables including intelligence (Gerwig et al., 2021), attention and attentional disorders (Zmigrod et al., 2015), workplace performance (Kwon et al., 2017), personality (McCrae, 1987), and have been used to examine cultural differences in creativity (Köster et al., 2020).

Conversely, convergent thinking has received far less empirical attention. This is somewhat surprising given that CT involves evaluating the quality of ideas, and thus is a core component of creativity (Cropley, 2006; de Vink et al., 2022; Goldschmidt, 2016; Rawlings, 2022; Rawlings & Cutting, 2024; Runco, 2008; Zhu et al., 2019). A commonly used measure of CT is the Remote Associations Test (RAT: Mednick & Mednick, 1971), in which participants are presented with three words and are asked to produce a fourth word that can be associated with each of them (i.e., semantically, as a synonym, or with compound word), or a compound only version (Bowden & Jung-Beeman, 2003).

Despite many researchers treating DT as a representation for creativity (Paek et al., 2021; Runco & Acar, 2012), there have been some attempts to theoretically integrate CT into creativity models with researchers arguing that CT and DT work in tandem to support creative cognition (Goldschmidt, 2016). For example, some have argued that for maximal creative performance, individuals require CT above a certain threshold, which facilitates effective DT (Cropley, 2006). That is, while DT involves the generation of multiple approaches and solutions to a posed problem, CT involves the selection and refinement of ideas to identify the best possible solution to the problem (Brophy, 2001). Thus, it has been proposed that full models of creativity need to account for the way individuals use their knowledge to generate and evaluate solutions for maximally effective creativity

(Brophy, 2001; Cropley, 2006; de Vink et al., 2022; Guilford, 1967). As a result, there have been recent increases in CT research, with studies showing that it is linked to problem-solving (Wigert et al., 2024), scientific thinking (Zhu et al., 2019), children's mathematics performance (de Vink et al., 2022) and other educational experiences (Rawlings & Cutting, 2024).

Despite this, there is surprisingly little research directly examining the relationship between the two constructs. To our knowledge, only a handful of studies have directly examined correlations between DT and CT, and the findings are equivocal. In a series of experiments, Chermahini and Hommel (2010) reported inconsistent findings, where in some experiments DT fluency and originality were negatively correlated with remote associations test performance but positively associated in others. The authors concluded that CT and DT are not directly opposite processes, but they may draw on shared cognitive processes such as executive functions. It is, however, important to note that each experiment involved relatively small sample sizes (*Ns* = ~35). Vartanian et al. (2007) found that alternate uses fluency was negatively correlated with remote associations test performance, suggesting they are dissociable processes. However, this study included only males and did not examine other subcomponents of DT (e.g., originality, elaboration, or flexibility), and imposed a time limit on participant responses, which has been shown to negatively impact creative performance (Said-Metwaly et al., 2020). Chermahini and colleagues found that remote association test scores were positively associated with insight intelligence measures (as measured by Raven's Advanced Progressive Matrices) and insight problem solving, but not alternate uses performance, in Dutch students (Chermahini et al., 2012)—though it should be noted that this study also involved developing the remote associations test in Dutch for the first time. Beisemann and colleagues reported weak correlations between compound remote association test and alternate uses performance in German adults. However, rather than the typically used alternate uses categories such as fluency, flexibility, elaboration or originality, responses were coded in different dimensions, including uncommonness, remoteness, cleverness, and appropriateness, meaning direct comparisons to other studies is difficult (Beisemann et al., 2020). A recent meta-analysis of 20 studies focussed on the relationship between DT and evaluative thinking, defined as the ability to recognise creative ideas (Guo et al., 2022). Results showed a moderate, positive association between the two, with the type of DT and evaluative tasks reported as moderators. Yet, although evaluative thinking is conceptually closely linked to CT, the authors noted that they are distinct cognitive processes (Guo et al., 2022; Runco & Smith, 1992). Thus, the generalisability of the conclusions in these studies remains unclear, and more work directly examining the relationship between the two is needed.

Several other studies have examined whether a given variable is individually associated with DT and CT and used the results to infer an association or dissociation between the two. Research taking this approach has also reported inconsistent findings, however. Some work has shown that DT and CT have similar relationships with performance on other measures. For example, research has shown that DT and CT are both involved in problem-solving (Goldschmidt, 2016) and scientific reasoning (Zhu et al., 2019). Myszkowski and colleagues reported that the personality trait agreeableness was positively associated with DT and CT in a student population (Myszkowski et al., 2015). However, in this study DT and CT measures were specific to managerial/organisational problem solving, meaning generalisability beyond these contexts is unclear.

One topic of particular focus has been the association between divergent and convergent thinking with psychometric measures of intelligence. Divergent thinking has long been considered closely linked with intelligence (Hocevar, 1980; Torrance, 1967), though correlations are generally weak to moderate (Batey & Furnham, 2006; Gerwig et al., 2021; Kim, 2005), and the nature of the relationship is complex (Plucker & Esping, 2015) leading researchers to suggest that DT is a (contributing) factor below general intelligence (Weiss et al., 2021), or a subset of it - though the disparity in measures and definitions precludes a strong conclusion (Plucker & Esping, 2015). The nature of convergent thinking tasks—identifying one correct solution—has also been suggested to share overlap with measures of intelligence, and Remote Associations test performance has been shown to correlate more strongly with general intelligence measures than DT tests, leading some to suggest that the RAT taps into a narrow set of creative skills (Lee et al., 2014). However, Lee and Therriault (2013) found that compound remote associate test scores but not divergent thinking scores were positively linked with a range of intelligence measures (Lee & Therriault, 2013). Thus, although intelligence has been indicated as a mechanism underpinning both types of creativity, results remain inconclusive.

Other work also suggests a dissociation between the two. For instance, listening to "happy" music improved alternate uses but not remote associations performance (Ritter & Ferguson, 2017) and exposure to Ayahuasca (a psychotropic plant tea native to South America) increased DT but decreased CT (Kuypers et al., 2016). de Vink and colleagues found that compound remote associations test scores, but not alternate uses performance, was positively related to single and multiple solution mathematics tasks in Dutch children (de Vink et al., 2022). Likewise, undertaking DT but not CT tasks enhanced the virtual hand illusion (Ma & Hommel, 2020), while neuroscientific studies suggest that DT and CT activate some different regions of the brain. For example, functional near-infrared spectroscopy work in school-aged children showed that neural activation was higher in the middle frontal gyrus (MFG) during the AUT than when completing the RAT, and conversely, that RAT success was associated with activity in the inferior parietal lobule (Hou et al., 2023). This is broadly in line with other work, including with adults, suggesting that CT is associated with brain regions such as the angular gyrus, inferior parietal lobule, and fronto-parietal regions, while DT tends to involve areas including the anterior hippocampus, the inferior occipital gyrus, fusiform gyrus, (left) inferior frontal gyrus, as well as the inferior parietal lobule (for reviews, see Hou et al., 2023; Zhang et al., 2020). Further, transcutaneous vagus nerve stimulation (tVNS) enhances DT but not CT (Colzato et al., 2018). Thus, CT and DT appear to have somewhat distinct neurological profiles—with some potential overlap, particularly in the inferior parietal lobule.

However, the presence or absence of a shared relationship between a third variable is not conclusive evidence that DT and CT are related or unrelated. Research is needed to more directly examine the relationship between CT and DT globally, and its individual components (Cortes et al., 2019). The objective of this study was to examine the relationship between DT and CT using standard measures of each. To this end, we examined whether scores of alternate uses fluency, originality, elaboration, and a composite divergent thinking score were associated with remote associations test performance—using both validated and widely used measures of DT and CT, respectively - in a large sample of male and female UK undergraduate university students. For DT, we focussed on fluency, originality, and elaboration, because in unison these provide an assessment of an individual's ability to generate a) a large number of creative ideas indicating expansive thinking (fluency), b) uncommon ideas that others are less likely to produce (originality), and c) to expand creative ideas to make them more complete and potentially more practical (elaboration). We used the Alternate Uses Task (AUT) and the Remote Associations Task (RAT). These measures capture some aspects of ill-defined (those that do not have clear solutions) and well-defined (those with clear solutions) problems. The AUT involves generating as many possible for everyday items and has elements of an ill-defined problem in that the process for generating solutions is open-ended, multiple responses are possible, and their quality is subjective such that there is no one correct answer. In contrast, the RAT—requiring generating a word that can be linked with three unrelated stimuli words - is a concrete example of a well-defined problem in that there is a clear objective (provide the correct response), with a single answer, the evaluation criteria are unambiguous (the response is correct or not) and involves a structured approach to solving it, usually by finding a semantic or conceptual link between the given words.

Another key reason for using the AUT and RAT is that they are widely used and extensively validated measures of DT and CT, respectively. Research shows that AUT has concurrent and construct validity—it is associated with creative achievement and idea generation in other domains (Olson et al., 2021) as well as predictive validity—it is associated with future creative achievements (Erwin et al., 2022; Runco, 2004). The AUT also has higher reliability scores than other measures of divergent thinking, with good internal consistency (Silvia, 2011). Likewise, extensive work has shown that the RAT displays high concurrent, construct, and predictive validity, correlating significantly with other established creativity measures and real-world creative performance (Cropley, 2006; de Vink et al., 2022; Forbach & Evans, 1981; Lazonder et al., 2022; Lee et al., 2014; Marko et al., 2019), while also demonstrating good reliability (Lee et al., 2014).

Given that many previous studies have found strong correlations between the subcomponents of DT (Abdulla Alabbasi et al., 2021; Chermahini & Hommel, 2010; Dumas & Dunbar, 2014; Silvia, 2008a), to test whether our data replicated these findings, we also measured whether the subcomponents of DT were associated with one another. Given that in unison DT and CT are core components of creative cognition, we predicted that CT would be positively associated with DT performance. In line with prior research, we also predicted that scores of alternate uses fluency, originality, and elaboration would be positively correlated with one another.

Methods

A power analysis with a small-medium effect size (Cohen's $f^2 = 0.15$), in line with prior literature, indicated that we would need to test at least 64 participants. In the end, to broadly match the literature described above (e.g., Beisemann et al., 2020; Chermahini et al., 2012; Colzato et al., 2018; Vartanian et al., 2007), our sample was 137 adults (44 males, 93 females) aged 18-35 based at Durham University who were recruited for course credits (i.e., were students enrolled on a psychology degree course).This study was ethically approved by the Department of Psychology at Durham University's ethics committee, approval number: PSYCH-2022-06-24T12:09:39-gssg49, and all participants gave consent to participate.

Materials and procedure

Participants completed two standard and widely used measures of CT and DT (see below). Tasks were administered *via* a computer, and in all cases, participants completed the convergent thinking task before the divergent thinking one. In line with some other studies using the RAT and AUT (e.g., Becker & Cabeza, 2023; Colzato et al., 2018), because we were interested in individual differences, we kept the order the same to ensure standardisation such that all participants were tested under the same conditions. Order consistency can also help avoid differential priming effects across measures. For example, starting with the RAT might prime participants to focus on finding single solutions, potentially constraining performance on the subsequent AUT task. Conversely, starting with the AUT task could prime more open-ended thinking, which may affect performance on the RAT. As such, keeping a consistent order ensures that any priming effects are uniform across participants.

Convergent thinking

Participants completed the remote associations test (Mednick & Mednick, 1971). 60 sets of words taken from the compound RAT used by Bowden and Jung-Beeman (2003), were presented to the participants, and for each set they were asked to produce the correct fourth word which can be a compound associated with each of the three stimuli words (Beisemann et al., 2020; Zhu et al., 2019). As part of the instructions, participants were given an example item for clarity: "Opera/Dish/Hand", where the linking word is "Soap". Participants were given no time limit and were told to answer as many as possible with their best guesses. We solely focussed on success rates, and scores were summed, giving a maximum of 60.

Divergent thinking

Participants completed an Alternate Uses task (Guilford, 1967) in which they had to name potential uses for two everyday objects (an egg carton and a pen). Participants were instructed as follows: "Here is a photo of a pen/egg carton. Can you write down all the things that you can do with a pen/egg carton? What are different things can a pen/egg carton be used for? There is no limit on how many things you can list. List as many ideas as possible, and don't stop until you run out of ideas". These were chosen as hybrid instructions, encouraging participants to generate multiple novel ideas, as such instructions have been shown to facilitate creative responses (Reiter-Palmon et al., 2019). To facilitate creativity, no time limit was given (Cropley, 1972; Rawlings et al., 2022; Said-Metwaly et al., 2020). Responses were required to be deemed appropriate to be scored. For example, for the pen, if a participant gave answers of "drawing" and "sketching", only the former would qualify as the uses would be considered too similar. Our coding protocol followed recent studies and recommendations (Abdulla Alabbasi et al., 2021, 2023; Habib et al., 2024; Rawlings et al., 2022), including those described above examining DT and CT (Chermahini et al., 2012; Colzato et al., 2018; Zhu et al., 2019).

Responses were summed, by one of the research team, across the two objects (pen and egg carton), and scores of fluency, elaboration, and originality were calculated. Fluency denotes the total number of responses provided by participants. Originality reflects the rarity of responses compared to others' responses. For originality, responses given by 2–5% of participants were scored one point and responses given by 1% or less were assigned two points. Responses given by over 5% of participants were scored 0 (Rawlings et al., 2022; Said-Metwaly et al., 2020). Elaboration represents the richness of responses and was scored on a 6-point scale, where 0 indicates no elaboration and 6 indicates a highly elaborated and detailed response (Vartanian et al., 2020). Inter-rater reliability was conducted by a coder blind to the study aims for DT scores of elaboration and originality, and there was good overall agreement with the original coder, Kappa = .79.

Statistical approach

We used multiple regressions to examine the relationship between CT and DT. RAT score was entered as the dependent variable and, in separate models, scores of alternate uses fluency, originality, elaboration, and a composite measure of these (termed composite alternate uses) were entered as predictor variables. For the composite alternate uses regression, z-standardized indices were used to avoid an overly strong weighting on fluency (Runco et al., 1987). Because some previous research has shown gender differences in divergent and convergent thinking (Abraham et al., 2014; Pagnani, 2011; Zhu et al., 2019), we controlled for gender in all analyses. To calculate effect sizes for significant predictors, we used Cohen's f^2 which reflects the proportion of variance explained by one or more predictors relative to the unexplained variance. Following Cohen's (1988) guidelines, we used $f^2 \geq 0.02$ as a small effect, $f^2 \geq 0.15$ as a medium effect, and $f^2 \geq 0.35$ as a large effect size. To test the relationship between alternate uses fluency, elaboration and originality, Pearson correlations were conducted. Statistical analysis and data visualisation were conducted using the R Studio platform (R Core Team, 2021), using the "lme4", "ggplot", "Hmisc" and "corrplot" packages. Before running any model, they were checked for assumption violations using the package "performance". Assumption checks included linearity, homoscedasticity, normality of residuals, multicollinearity, and outliers[1].

Results

Table 1 presents descriptive information for participants' performance on the CT and DT tasks.

Was divergent thinking related to convergent thinking?

Regression models were used to examine whether alternate uses fluency, originality, elaboration, and a composite measure of each of these were

Table 1. Descriptive statistics for performance on the alternate uses and remote associations tasks.

	Mean (SD)	Min	Max
RAT score	14.85 (11.56)	0	52
AUT fluency	9.01 (3.88)	2	20
AUT originality	3.41 (2.88)	0	14
AUT elaboration	4.19 (3.12)	0	12
Composite AU (raw scores)	16.68 (8.33)	3	41

[1]Across all models, multicollinearity was low (VIFs < 1.5 for all predictors), residuals were approximately normal (Shapiro-Wilk test, *ps* = .057-.181), and no evidence of heteroscedasticity was found (Breusch-Pagan test, *ps* = .059-.276). Linearity checks indicated no major violations (*ps* = .069-.098), and no significant outliers were detected.

related to convergent thinking, controlling for gender. Gender was not a significant predictor in any models, nor were there any gender differences in performance on the RAT task (Figure 1; males $M = 15.3$, $SD = 11.5$, females $M = 16.6$, $SD = 11.6$, $t = -0.31$, $p = .80$, CI: −4.82-3.57). Gender was also not a significant predictor for DT fluency (males $M = 9.55$, SD = 4.22, females $M = 8.86$, $SD = 3.72$ $p = .034$), originality (males $M = 3.77$, SD = 2.55, females $M = 3.24$, $SD = 3.02$, $p = 0.31$), elaboration (males $M = 4.64$, SD = 3.33, females $M = 3.98$, $SD = 3.01$, $p = 0.25$), or the composite AUT score (males $M = 18.00$, $SD = 8.39$, females $M = 16.10$, SD = 8.27, $p = 0.22$).

Results showed that fluency (beta = 1.03, $t = 4.23$, $p < .001$, CI: 0.55 – 1.50, Cohen's $f^2 = 0.13$), originality (beta = 1.09, $t = 3.26$, $p = 001$, CI: 0.43 – 1.76, Cohen's $f^2 = 0.08$), elaboration (beta = 1.16, $t = 3.82$, $p < .001$, CI: 0.56 – 1.77, Cohen's $f^2 = 0.16$), and composite alternate uses (beta = 4.324, $t = 4.64$, $p < .001$, CI: 2.48-6.17, Cohen's $f^2 = 0.16$) were all positively associated with convergent thinking performance, controlling for gender. Thus, for the relationship between CT and DT fluency and originality the effect size was small, while for the relationship between CT and DT elaboration and composite alternate uses the effect size was medium. This indicates that those who scored higher on all measures of divergent thinking showed greater convergent thinking scores (Figure 2).

Were divergent thinking components related to one another?

Pearson's correlations showed that fluency, originality, and elaboration were all significantly positively correlated with one another, with fluency and originality showing the strongest correlation coefficient ($r_s = .72$, $p < .001$)

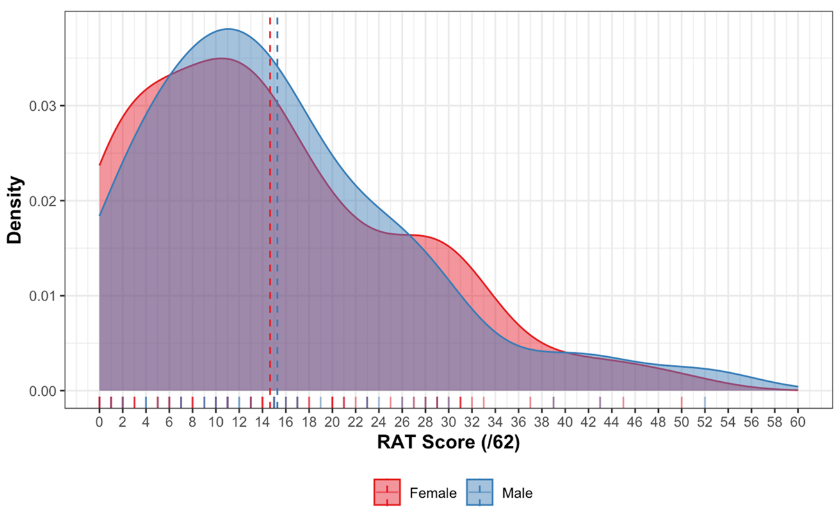

Figure 1. Remote Associations Test performance by gender. Dashed vertical lines represent mean scores.

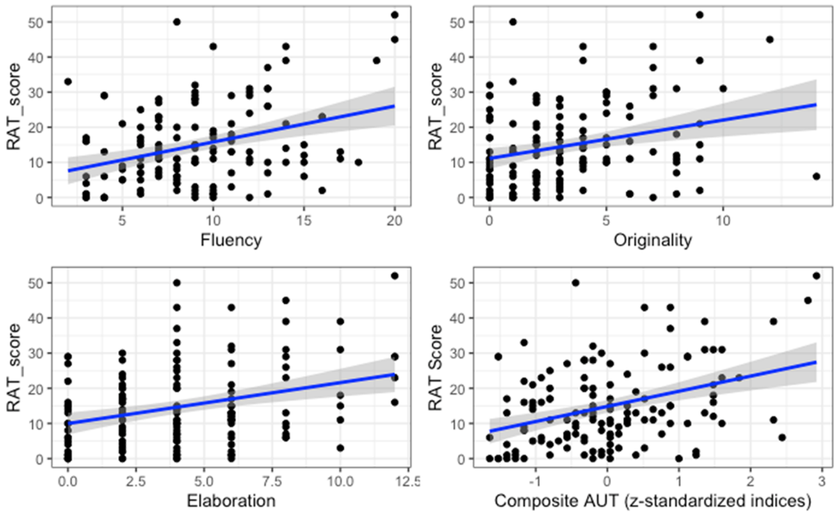

Figure 2. The relationship between Remote Associations scores and fluency, originality, elaboration, and the composite alternate uses scores.

and originality and elaboration showing the weakest correlation coefficient (r_s = .43, p < .001). For full correlation coefficients, see Figure 3.

Discussion

Humans stand alone in their capacity for creativity. Despite divergent and convergent thinking being the two fundamental components of creative cognition, relatively few studies have empirically examined the relationship between the two, and within those that have, results remain inconclusive. Using widely used measures of each, we found a strong positive relationship between sub-measures of divergent thinking and convergent thinking performance, indicating that those who showed a greater capacity for generating multiple novel, unique and detailed solutions were also those who were better able to identify single, correct solutions from a range of alternatives. We describe our findings in more detail below and explore their implications for models of creativity as well as broader potential applications, before discussing the study limitations and next steps for future research.

True creative cognition is a multi-step process, involving idea generation, searching and selection (Zhu et al., 2019). For much of the history of creativity research, there has been a strong focus on the first step - divergent thinking—with a vast battery of measures existing for it (Weiss et al., 2024) and some even claiming that DT fully encompasses individual creativity (Baas et al., 2008; Silvia, 2008a; but see Runco, 2008). There have, however, been attempts to integrate convergent thinking into a holistic

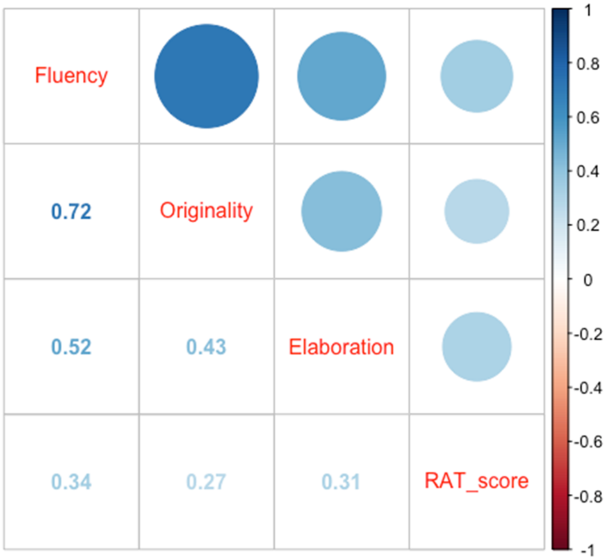

Figure 3. Pearson correlation coefficients for the alternate uses scores of fluency, originality and elaboration, plus remote associations test scores. Darker blues and larger circles represent stronger correlations.

framework of creativity, where, for example, some suggest it should be alternated with divergent thinking to evaluate and refine ideas to maximise their efficacy (Cropley, 2006; Goldschmidt, 2016; Lazonder et al., 2022; Zhu et al., 2019). Indeed, a widely used definition of creativity is that it involves the generation of novel and *valuable* ideas, and effective convergent thinking is required to maximise the value of ideas.

Despite this, there are limited studies directly examining the relationship between CT and DT, and those that have reported inconsistent findings, or required validation owing to factors such as small sample sizes or a narrow focus. Other previous research involving examining whether CT and DT are similarly associated with a third variable has also provided equivocal findings, with some studies indirectly suggesting a positive relationship with both being associated with intelligence (Lee & Therriault, 2013), problem-solving (Goldschmidt, 2016), personality traits (Myszkowski et al., 2015) and scientific reasoning (Goldschmidt, 2016; Zhu et al., 2019). Yet others indicate a dissociation between the two processes (Colzato et al., 2018; de Vink et al., 2022; Kuypers et al., 2016; Ma & Hommel, 2020). Theoretically, however, researchers have suggested that they should be associated with one another, in a similar manner to the G factors of intelligence, and that current methodology may prohibit documenting these types of findings (Cortes et al., 2019). Our findings move this discussion forward by showing that they may indeed be highly related constructs of creativity.

Our results align with theoretical frameworks conceptualising creativity as a dynamic interplay between idea generation and evaluation (e.g., Cropley, 2006; Goldschmidt, 2016; Zhu et al., 2019; Rawlings & Cutting, 2024). In doing so, our findings provide an important contribution to our understanding of the relationship between DT and CT, their role in broader creative cognition, and the potential overlap in skills associated with their measurement. While the AUT and RAT are widely used and validated as measures of DT and CT, respectively, it is possible that there are overlapping skills associated with each. Indeed, some researchers have argued that solving RAT items may require some degree of divergent thinking and equally, that completing AUT tasks could call upon convergent thinking skills (Cortes et al., 2019; Salvi et al., 2020). For instance, some RAT items could be solved by generating multiple associative pathways to identify potential solutions, while answering AUT questions may engage convergent thinking to refine and select the most appropriate or original uses for an object. This overlap reflects broader theoretical perspectives suggesting that creativity arises from the interplay between divergent and convergent cognitive processes and aligns with models of creative cognition that emphasise the iterative movement between idea generation and idea evaluation (Cropley, 2006; Goldschmidt, 2016; Zhu et al., 2019; Rawlings & Cutting, 2024). It is important to note that our use of the AUT and RAT tasks was designed to assess DT and CT separately, using established tasks in a holistic approach, and in doing so we employed the widely accepted framework of divergent and convergent thinking as distinct (but overlapping) constructs. We do acknowledge, however, that others have argued that creativity and problem-solving often unfold as a series of iterative, non-linear steps, where elements of both DT and CT may operate simultaneously (Buijs et al., 2009; Childs et al., 2022). Our study does not disentangle these finer cognitive sub-processes but instead provides insights at the broader task level, allowing for comparability with previous research. We encourage future studies to assess the relationship between such potential smaller steps of DT and CT.

However, as has been identified, there has been a lack of work examining the potential overlapping skills involved in CT and DT in meaningful detail, and future research should use appropriate statistics to do so (Cortes et al., 2019). Additionally, designing tasks that specifically manipulate the balance of DT and CT demands could provide further insights into their distinct and shared contributions to creativity. Importantly, though, we encourage researchers to incorporate both constructs into models of creativity and to use multidimensional task batteries to better capture their interaction. Future studies could explore whether training one aspect (e.g., DT) enhances the other (e.g., CT), investigate whether the relationship generalises across creative domains, and examine cultural or contextual factors that may moderate these effects.

These results also shed important light on convergent thinking. The vast majority of creativity research focuses on divergent thinking—the ability to generate multiple novel ideas or solutions. Conversely, the ability to find the single, correct answer from multiple options has been comparatively overlooked - despite the fact that there have been attempts to theoretically integrate CT into models of creativity (Cropley, 2006; de Vink et al., 2022; Goldschmidt, 2016; Runco, 1991; Zhu et al., 2019). Our findings suggest that greater focus should be given to CT in creativity research. Researchers have noted that there are not enough validated measures of CT to attempt to dissociate it into subcomponents in the same way as has been done for DT (Cortes et al., 2019). We share this view, and without further research on convergent thinking, this may impede theoretical progress in creativity research (Cortes et al., 2019).

Finally, we also found that performance on the subcomponents of DT—fluency, originality, and elaboration—were positively correlated with one another. This was especially true for fluency-originality, and fluency-elaboration. This is in line with previous work in North America (Dumas & Dunbar, 2014; Silvia, 2008a) and China (Zhu et al., 2019) showing that performance on DT subcomponents are associated. By replicating previous work, we add to the literature showing that individuals who tend to generate multiple ideas are also those who generate rich and unique ones.

Broader implications

Our findings, demonstrating a positive relationship between divergent thinking (DT) and convergent thinking (CT), have important implications for wider creativity research, training, and application. Creativity is often taught and evaluated with a focus on idea generation (DT), but our results suggest that successful creative outcomes also require the capacity to evaluate and refine ideas (CT). This underscores the need for creativity training programs to adopt a more integrated approach, including both DT and CT. For example, workshops or educational curricula could combine activities that promote expansive, open-ended thinking with tasks that encourage narrowing and selecting optimal solutions.

In other applied contexts, our findings highlight the potential for innovation and problem-solving strategies to benefit from balanced approaches that prioritise both generative and evaluative skills. For instance, organisations seeking to foster innovation and creativity may achieve better outcomes by designing team processes or decision-making strategies that integrate diverse perspectives with structured evaluation mechanisms. Broadening the scope of creativity research and practice to include both DT and CT, can help move towards a more comprehensive understanding of creative cognition and its applications.

Study limitations

One limitation is that we only included the alternate uses and remote associations tests. While, as noted, these are widely used and validated measures of divergent and convergent thinking, respectively, they only capture specific aspects of each. For example, our measures were verbally based, but nonverbal (figural) tests of each exist. Likewise, there is a vast range of experimentally administered DT measures, including storytelling, drawing, sentence-finishing and dancing (Weiss et al., 2024). It would be interesting for future research to examine whether different formats of CT and DT are related to each other and whether they similarly predict performance in real-world contexts (Yang et al., 2022) to move the field forward.

Relatedly, our approach does not afford disentanglement of the relative contributions of DT and CT to creative achievement (i.e., how much of creative achievement is driven by one component or the other). Longitudinal work, or measuring additional variables alongside CT and DT performance would provide insights into how much, or which aspects of, creativity are driven by DT or CT. Nevertheless, our results add important value to the literature by emphasising that these constructs are not independent but instead interact in meaningful ways. We encourage researchers to develop multi-task batteries to better capture the interplay between them (Cortes et al., 2019).

Further, although the RAT is a clear example of a well-defined problem, it could be argued that the AUT does not represent *purely* an ill-defined problem, because it has a clear objective (generate uses for an object), some boundaries (responses must be useful) and explicit scoring criteria. This would imply that the AUT falls somewhere between a well-defined and ill-defined task, involving both structured and open-ended characteristics. Creativity itself can manifest in multiple and diverse ways, and many creative tasks are ill-defined (do not have clear solutions) and how well these measures generalise to "real-world" creative achievements remains unclear. Future work examining the relationship between CT and DT could also include clearer measures of ill-defined creativity, such as generating stories, drawings or other open-ended problems.

Intelligence has been linked to both DT and CT (Lee & Therriault, 2013; Silvia, 2008b), and some work includes measures of intelligence to control for it when assessing creativity. We did not do so here, firstly because our primary aim was to investigate the direct relationship between DT and CT as core components of creative cognition. Second, the relationship between intelligence and creativity is nuanced, varying with factors such as task types and scoring criteria. For instance, intelligence correlates more strongly with CT than with DT, but even these associations are context-dependent (Lee & Therriault, 2013). Without distinguishing subcomponents of intelligence, controlling for it could obscure meaningful patterns between DT and CT. We acknowledge, however, that including intelligence as a control variable could potentially strengthen the findings. Future research could address this by incorporating measures of verbal or fluid intelligence to explore their role in the DT-CT relationship. Likewise, other individual differences could play also a crucial role in moderating the relationship between CT and DT. Factors such as personality traits, socio-economic status, motivation, or executive control ability may moderate or mediate how DT and CT interact. Our study, showing CT and DT as distinct yet complementary creative processes, provides a strong platform for future research to build upon in examining how measures of individual differences such as these, and intelligence, influence the relationship between DT and CT.

Our sample also comprised undergraduate university students. Such samples continue to make up the majority of psychological research, which has rightly been criticised for its lack of generalisability (Burger et al., 2023; Henrich, 2020; Henrich et al., 2010; Sanches de Oliveira & Baggs, 2023; Wen et al., 2025). We acknowledge that these results, and indeed much of the literature cited in this manuscript, are limited in generalisability to affluent, western populations and we strongly encourage future work to examine the relationship between divergent and convergent thinking in culturally and geographically diverse populations.

Finally, we kept the task order (RAT before AUT) consistent for all participants. Our rationale was that we were interested in individual differences, and this approach aligns with prior studies that have used fixed task orders to prioritise consistency and comparability across participants (e.g., Becker & Cabeza, 2023; Colzato et al., 2018). We acknowledge, however, that this approach might limit our ability to assess whether task order itself moderates the relationship between divergent and convergent thinking. We encourage future research to explore this possibility, as it could provide additional insights into how task sequencing influences creative cognition.

Conclusions

There has been a growing recent movement to integrate convergent thinking into theoretical frameworks of creativity. Yet most creativity research has focussed on divergent thinking. Here, by showing that individuals who performed well on a measure of convergent thinking also performed well on a measure of divergent thinking, our data suggests that convergent thinking is a key component of creative cognition. We argue that more work needs to be done to develop and validate convergent thinking measures to fully understand its relationship with divergent thinking.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research was supported by a UKRI ESRC grant awarded to Bruce Rawlings, ES/Z503605/1.

ORCID

Bruce, S. Rawlings http://orcid.org/0000-0001-9682-9216
Hannah E. Roome http://orcid.org/0000-0002-7311-3642

Data availability statement

Data is uploaded to the Figshare repository, doi: 10.6084/m9.figshare.23634678.

References

Abdulla Alabbasi, A. M., Alansari, A. M., AlSaleh, A., Salem, A. H., & Ayoub, A. E. A. (2023). Predictors of academic success among undergraduate medical programs: The roles of divergent and convergent thinking. *Journal of Creativity*, *33*(2), 100058. https://doi.org/10.1016/j.yjoc.2023.100058

Abdulla Alabbasi, A. M., Reiter-Palmon, R., Sultan, Z. M., & Ayoub, A. E. A. (2021). Which divergent thinking index is more associated with problem finding ability? The role of flexibility and task nature. *Frontiers in Psychology*, *12*, 671146. https://doi.org/10.3389/fpsyg.2021.671146

Abraham, A., Thybusch, K., Pieritz, K., & Hermann, C. (2014). Gender differences in creative thinking: Behavioral and fMRI findings. *Brain Imaging and Behavior*, *8*(1), 39–51. https://doi.org/10.1007/s11682-013-9241-4

Acar, S., Burnett, C., & Cabra, J. F. (2017). Ingredients of creativity: Originality and more. *Creativity Research Journal*, *29*(2), 133–144. https://doi.org/10.1080/10400419.2017.1302776

An, D., & Runco, M. A. (2016). General and domain-specific contributions to creative ideation and creative performance. *Europe's Journal of Psychology*, *12*(4), 523–532. https://doi.org/10.5964/EJOP.V12I4.1132

Baas, M., De Dreu, C. K. W., & Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: Hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, *134*(6), 779–806. https://doi.org/10.1037/a0012815

Baer, M. (2010). The strength-of-weak-ties perspective on creativity: A comprehensive examination and extension. *The Journal of Applied Psychology*, *95*(3), 592–601. https://doi.org/10.1037/a0018761

Baer, M., Evans, K., Oldham, G. R., & Boasso, A. (2015). The social network side of individual innovation: A meta-analysis and path-analytic integration. *Organizational Psychology Review*, *5*(3), 191–223. https://doi.org/10.1177/2041386614564105

Batey, M., & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs*, *132*(4), 355–429. https://doi.org/10.3200/MONO.132.4.355-430

Becker, M., & Cabeza, R. (2023). Assessing creativity independently of language: A language-independent remote associate task (LI-RAT). *Behavior Research Methods*, *55*(1), 85–102. https://doi.org/10.3758/s13428-021-01773-5

Beisemann, M., Forthmann, B., Bürkner, P., & Holling, H. (2020). Psychometric evaluation of an alternate scoring for the remote associates test. *The Journal of Creative Behavior*, *54*(4), 751–766. https://doi.org/10.1002/jocb.394

Bijvoet-van den Berg, S., & Hoicka, E. (2014). Individual differences and age-related changes in divergent thinking in toddlers and preschoolers. *Developmental Psychology*, *50*(6), 1629–1639. https://doi.org/10.1037/a0036131

Bowden, E. M., & Jung-Beeman, M. (2003). Normative data for 144 compound remote associate problems. *Behavior Research Methods, Instruments, & Computers: A Journal of the Psychonomic Society, Inc*, *35*(4), 634–639. https://doi.org/10.3758/BF03195543

Brophy, D. R. (2001). Comparing the attributes, activities, and performance of divergent, convergent, and combination thinkers. *Creativity Research Journal*, *13*(3-4), 439–455. https://doi.org/10.1207/S15326934CRJ1334_20

Buijs, J., Smulders, F., & Van Der Meer, H. (2009). Towards a more realistic creative problem solving approach. *Creativity and Innovation Management*, *18*(4), 286–298. https://doi.org/10.1111/j.1467-8691.2009.00541.x

Burger, O., Chen, L., Erut, A., Fong, F. T. K., Rawlings, B., & Legare, C. H. (2023). Developing cross-cultural data infrastructures (CCDIs) for research in cognitive and behavioral sciences. *Review of Philosophy and Psychology*, *14*(2), 565–585. https://doi.org/10.1007/s13164-022-00635-z

Chermahini, A. S., Hickendorff, M., & Hommel, B. (2012). Development and validity of a Dutch version of the Remote Associates Task: An item-response theory approach. *Thinking Skills and Creativity*, *7*(3), 177–186. https://doi.org/10.1016/j.tsc.2012.02.003

Chermahini, S. A., & Hommel, B. (2010). The (b)link between creativity and dopamine: Spontaneous eye blink rates predict and dissociate divergent and convergent thinking. *Cognition*, *115*(3), 458–465. https://doi.org/10.1016/j.cognition.2010.03.007

Childs, P., Han, J., Chen, L., Jiang, P., Wang, P., Park, D., Yin, Y., Dieckmann, E., & Vilanova, I. (2022). The creativity diamond—A framework to aid creativity. *Journal of Intelligence*, *10*(4), 73. https://doi.org/10.3390/jintelligence10040073

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203771587

Colzato, L. S., Ritter, S. M., & Steenbergen, L. (2018). Transcutaneous vagus nerve stimulation (tVNS) enhances divergent thinking. *Neuropsychologia*, *111*, 72–76. https://doi.org/10.1016/j.neuropsychologia.2018.01.003

Cortes, R. A., Weinberger, A. B., Daker, R. J., & Green, A. E. (2019). Re-examining prominent measures of divergent and convergent creativity. *Current Opinion in Behavioral Sciences*, *27*, 90–93. https://doi.org/10.1016/j.cobeha.2018.09.017

Cropley, A. (2006). In praise of convergent thinking. *Creativity Research Journal*, *18*(3), 391–404. https://doi.org/10.1207/s15326934crj1803_13

Cropley, A. J. (1972). Originality scores under timed and untimed conditions. *Australian Journal of Psychology*, *24*(1), 31–36. https://doi.org/10.1080/00049537208255782

de Vink, I. C., Willemsen, R. H., Lazonder, A. W., & Kroesbergen, E. H. (2022). Creativity in mathematics performance: The role of divergent and convergent thinking. *The British Journal of Educational Psychology*, *92*(2), e12459–501. https://doi.org/10.1111/bjep.12459

Diedrich, J., Benedek, M., Jauk, E., & Neubauer, A. C. (2015). Are creative ideas novel and useful? *Psychology of Aesthetics, Creativity, and the Arts*, *9*(1), 35–40. https://doi.org/10.1037/a0038688

Dumas, D., & Dunbar, K. N. (2014). Understanding fluency and originality: A latent variable perspective. *Thinking Skills and Creativity*, *14*, 56–67. https://doi.org/10.1016/j.tsc.2014.09.003

Erwin, A. K., Tran, K., & Koutstaal, W. (2022). Evaluating the predictive validity of four divergent thinking tasks for the originality of design product ideation. *PloS One*, *17*(3), e0265116. https://doi.org/10.1371/journal.pone.0265116

Evans, N. S., & Jirout, J. J. (2023). Investigating the relation between curiosity and creativity. *Journal of Creativity*, *33*(1), 100038. https://doi.org/10.1016/j.yjoc.2022.100038

Evans, N. S., Todaro, R. D., Schlesinger, M. A., Golinkoff, R. M., & Hirsh-Pasek, K. (2021). Examining the impact of children's exploration behaviors on creativity. *Journal of Experimental Child Psychology*, *207*, 105091. https://linkinghub.elsevier.com/retrieve/pii/S0022096521000084 https://doi.org/10.1016/j.jecp.2021.105091

Eysenck, H. (2003). Creativity, personality, and the convergent-divergent continuum. In M.A Runco (Ed.), *Critical creative processes* (pp. 95–114). Hampton Press.

Fogarty, L., Creanza, N., & Feldman, M. W. (2015). Cultural evolutionary perspectives on creativity and human innovation. *Trends in Ecology & Evolution*, *30*(12), 736–754. https://doi.org/10.1016/j.tree.2015.10.004

Forbach, G. B., & Evans, R. G. (1981). The remote associates test as a predictor of productivity in brainstorming groups. *Applied Psychological Measurement*, *5*(3), 333–339. https://doi.org/10.1177/014662168100500306

Fuentes, A. (2017). *The Creative Spark: How Imagination Made Humans Exceptional*. Penguin Publishing Group. https://www.goodreads.com/en/book/show/31626670-the-creative-spark

Gabora, L. (2018). The neural basis and evolution of divergent and convergent thought. In *The Cambridge handbook of the neuroscience of creativity* (pp. 58–70). Cambridge University Press. https://doi.org/10.1017/9781316556238.005

Gerwig, A., Miroshnik, K., Forthmann, B., Benedek, M., Karwowski, M., & Holling, H. (2021). The relationship between intelligence and divergent thinking—A meta-analytic update. *Journal of Intelligence*, *9*(2), 23. https://doi.org/10.3390/jintelligence9020023

Goldschmidt, G. (2016). Linkographic evidence for concurrent divergent and convergent thinking in creative design. *Creativity Research Journal*, *28*(2), 115–122. https://doi.org/10.1080/10400419.2016.1162497

Guilford, J. P. (1950). Creativity. *American Psychologist*, *5*(9), 444–454. https://doi.org/10.1037/h0063487

Guilford, J. P. (1967). *The nature of human intelligence*. McGraw-Hill.

Guo, Y., Lin, S., Acar, S., Jin, S., Xu, X., Feng, Y., & Zeng, Y. (2022). Divergent thinking and evaluative skill: A meta-analysis. *The Journal of Creative Behavior*, *56*(3), 432–448. https://doi.org/10.1002/jocb.539

Habib, S., Vogel, T., Anli, X., & Thorne, E. (2024). How does generative artificial intelligence impact student creativity? *Journal of Creativity*, *34*(1), 100072. https://doi.org/10.1016/j.yjoc.2023.100072

Harvey, S., & Berry, J. (2023). Toward a meta-theory of creativity forms: How novelty and usefulness shape creativity. *Academy of Management Review*, *48*(3), 504–529. https://doi.org/10.5465/amr.2020.0110

Henrich, J. (2020). *The WEIRDest people in the world: How the west became psychologically peculiar and particularly prosperous*. Farrar, Straus and Giroux. https://

www.amazon.com/WEIRDest-People-World-Psychologically-Particularly-ebook/dp/B07RZFCPMD

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *The Behavioral and Brain Sciences*, *33*(2-3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Hocevar, D. (1980). Intelligence, divergent thinking, and creativity. *Intelligence*, *4*(1), 25–40. https://doi.org/10.1016/0160-2896(80)90004-5

Hoicka, E., Powell, S., Rose, S. E., Reindl, E., & Tennie, C. (2023). The early independent problem solving survey (EIPSS): Its psychometric properties in children aged 12–47 months. *Cognitive Development*, *68* 101366. https://doi.org/10.1016/j.cogdev.2023.101366

Hou, S., Chen, S., Huang, Z., Yin, X., Zhao, K., & Zou, J. (2023). Mapping the neural mechanisms of creativity by convergent and divergent thinking in school-aged children: A functional near-infrared spectroscopy study. *Thinking Skills and Creativity*, *49*, 101300. https://doi.org/10.1016/j.tsc.2023.101300

Kaufman, A., & Kaufman, J. (2015). Animal creativity and innovation. In *Animal creativity and innovation*. Elsevier. https://doi.org/10.1016/C2013-0-18605-9

Kim, K. H. (2005). Can only intelligent people be creative? A meta-analysis. *Journal of Secondary Gifted Education*, *16*(2-3), 57–66. https://doi.org/10.4219/jsge-2005-473

Köster, M., Yovsi, R., & Kärtner, J. (2020). Cross-cultural differences in the generation of Novel ideas in middle childhood. *Frontiers in Psychology*, *11*, 1829. https://doi.org/10.3389/fpsyg.2020.01829

Kuczaj, S. A. (2017). Animal creativity and innovation. In *APA handbook of comparative psychology: Perception, learning, and cognition* (pp. 627–641). American Psychological Association. https://doi.org/10.1037/0000012-028

Kuypers, K. P. C., Riba, J., de la Fuente Revenga, M., Barker, S., Theunissen, E. L., & Ramaekers, J. G. (2016). Ayahuasca enhances creative divergent thinking while decreasing conventional convergent thinking. *Psychopharmacology*, *233*(18), 3395–3403. https://doi.org/10.1007/s00213-016-4377-8

Kwon, J., Bromback, L., & Kudrowitz, B. (2017, August 6). Divergent thinking ability + interest = creative ideas: Exploring the relationships between cognitive creativity assessments and product design idea generation. *Volume 7: 29th International Conference on Design Theory and Methodology*. https://doi.org/10.1115/DETC2017-67261

Lazonder, A. W., Willemsen, R. H., Vink, I. C. D., Roseboom-Folmer, J., Arends, O., Jongen, A. P., van Keulen, Y. Q., Oudenhoven, L. J. G., & Kroesbergen, E. H. (2022). Development and validation of RATje: A remote associates test for Dutch children. *Thinking Skills and Creativity*, *44*, 101042. https://doi.org/10.1016/j.tsc.2022.101042

Lee, C. S., & Therriault, D. J. (2013). The cognitive underpinnings of creative thought: A latent variable analysis exploring the roles of intelligence and working memory in three creative thinking processes. *Intelligence*, *41*(5), 306–320. https://doi.org/10.1016/j.intell.2013.04.008

Lee, C. S., Huggins, A. C., & Therriault, D. J. (2014). A measure of creativity or intelligence? Examining internal and external structure validity evidence of the Remote Associates Test. *Psychology of Aesthetics, Creativity, and the Arts*, *8*(4), 446–460. https://doi.org/10.1037/a0036773

Ma, K., & Hommel, B. (2020). Metacontrol and body ownership: Divergent thinking increases the virtual hand illusion. *Psychological Research*, *84*(1), 120–127. https://doi.org/10.1007/s00426-018-0976-9

Marko, M., Michalko, D., & Riečanský, I. (2019). Remote associates test: An empirical proof of concept. *Behavior Research Methods*, *51*(6), 2700–2711. https://doi.org/10.3758/s13428-018-1131-7

McCrae, R. R. (1987). Creativity, divergent thinking, and openness to experience. *Journal of Personality and Social Psychology*, *52*(6), 1258–1265. https://doi.org/10.1037//0022-3514.52.6.1258

Mednick, S. A., & Mednick, M. (1971). *Remote associates test: Examiner's manual*. Houghton Mifflin.

Myszkowski, N., Storme, M., Davila, A., & Lubart, T. (2015). Managerial creative problem solving and the Big Five personality traits. *Journal of Management Development*, *34*(6), 674–684. https://doi.org/10.1108/JMD-12-2013-0160

Olson, J. A., Nahas, J., Chmoulevitch, D., Cropper, S. J., & Webb, M. E. (2021). Naming unrelated words predicts creativity. *Proceedings of the National Academy of Sciences*, *118*(25), e2022340118. https://doi.org/10.1073/pnas.2022340118

Paek, S. H., Abdulla Alabbasi, A. M., Acar, S., & Runco, M. A. (2021). Is more time better for divergent thinking? A meta-analysis of the time-on-task effect on divergent thinking. *Thinking Skills and Creativity*, *41*, 100894. https://doi.org/10.1016/j.tsc.2021.100894

Pagnani, A. R. (2011). Gender differences. In *Encyclopedia of creativity* (pp. 551–557). Elsevier. https://doi.org/10.1016/B978-0-12-375038-9.00106-0

Plucker, J. A., & Esping, A. (2015). Intelligence and creativity: A complex but important relationship. *Asia Pacific Education Review*, *16*(2), 153–159. https://doi.org/10.1007/s12564-015-9374-9

Qian, M., Plucker, J. A., & Yang, X. (2019). Is creativity domain specific or domain general? Evidence from multilevel explanatory item response theory models. *Thinking Skills and Creativity*, *33*, 100571. https://doi.org/10.1016/j.tsc.2019.100571

R Core Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Rawlings, B. S. (2022). After a decade of tool innovation, what comes next? *Child Development Perspectives*, *16*(2), 118–124. https://doi.org/10.1111/cdep.12451

Rawlings, B. S., & Cutting, S. J. (2024). Linking disparate strands: A critical review of the relationship between creativity and education. *Educational Psychology Review*, *36*(4), 135. https://doi.org/10.1007/s10648-024-09973-z

Rawlings, B. S., & Reader, S. M. (2024). What is innovation?: A review of definitions, approaches, and key questions in human and non-human innovation. In J. J. Tehrani, J. Kendal, & R. Kendal (Eds.), *The Oxford handbook of cultural evolution (first)*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198869252.013.11

Rawlings, B. S., Flynn, E. G., & Kendal, R. L. (2022). Personality predicts innovation and social learning in children: Implications for cultural evolution. *Developmental Science*, *25*(1), e13153. https://doi.org/10.1111/desc.13153

Rawlings, B., Legare, C. H., Brosnan, S. F., & Vale, G. L. (2021). Leveling the playing field in studying cumulative cultural evolution: Conceptual and methodological advances in nonhuman animal research. *Journal of Experimental Psychology. Animal Learning and Cognition*, *47*(3), 252–273. https://doi.org/10.1037/xan0000303

Reiter-Palmon, R., Forthmann, B., & Barbot, B. (2019). Scoring divergent thinking tests: A review and systematic framework. *Psychology of Aesthetics, Creativity, and the Arts*, *13*(2), 144–152. https://doi.org/10.1037/aca0000227

Ritter, S. M., & Ferguson, S. (2017). Happy creativity: Listening to happy music facilitates divergent thinking. *PloS One*, *12*(9), e0182210. https://doi.org/10.1371/journal.pone.0182210

Runco, M. A. (1991). The evaluative, valuative, and divergent thinking of children. *The Journal of Creative Behavior*, *25*(4), 311–319. https://doi.org/10.1002/j.2162-6057.1991.tb01143.x
Runco, M. A. (1992). Children's divergent thinking and creative ideation. *Developmental Review*, *12*(3), 233–264. https://doi.org/10.1016/0273-2297(92)90010-Y
Runco, M. A. (2004). Creativity. *Annual Review of Psychology*, *55*(1), 657–687. https://doi.org/10.1146/annurev.psych.55.090902.141502
Runco, M. A. (2008). Commentary: Divergent thinking is not synonymous with creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *2*(2), 93–96. https://doi.org/10.1037/1931-3896.2.2.93
Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal*, *24*(1), 66–75. https://doi.org/10.1080/10400419.2012.652929
Runco, M. A., & Smith, W. R. (1992). Interpersonal and intrapersonal evaluations of creative ideas. *Personality and Individual Differences*, *13*(3), 295–302. https://doi.org/10.1016/0191-8869(92)90105-X
Runco, M. A., Okuda, S. M., & Thurston, B. J. (1987). The psychometric properties of four systems for scoring divergent thinking tests. *Journal of Psychoeducational Assessment*, *5*(2), 149–156. https://doi.org/10.1177/073428298700500206
Said-Metwaly, S., Fernández-Castilla, B., Kyndt, E., & Van den Noortgate, W. (2020). Testing conditions and creative performance: Meta- analyses of the impact of time limits and instructions. *Psychology of Aesthetics, Creativity, and the Arts*, *14*(1), 15–38. https://doi.org/10.1037/aca0000244
Said-Metwaly, S., Fernández-Castilla, B., Kyndt, E., Van den Noortgate, W., & Barbot, B. (2021). Does the fourth-grade slump in creativity actually exist? A meta-analysis of the development of divergent thinking in school-age children and adolescents. *Educational Psychology Review*, *33*(1), 275–298. https://doi.org/10.1007/s10648-020-09547-9
Salvi, C., Costantini, G., Pace, A., & Palmiero, M. (2020). Validation of the Italian Remote Associate Test. *The Journal of Creative Behavior*, *54*(1), 62–74. https://doi.org/10.1002/jocb.345
Sanches de Oliveira, G., & Baggs, E. (2023). *Psychology's WEIRD problems*. Cambridge University Press. https://doi.org/10.1017/9781009303538
Sánchez-Dorado, J. (2020). Novel & worthy: Creativity as a thick epistemic concept. *European Journal for Philosophy of Science*, *10*(3), 40. https://doi.org/10.1007/s13194-020-00303-y
Sauermann, H., & Cohen, W. M. (2010). What makes them tick? Employee motives and firm innovation. *Management Science*, *56*(12), 2134–2153. https://doi.org/10.1287/mnsc.1100.1241
Shi, B., Wang, L., Yang, J., Zhang, M., & Xu, L. (2017). Relationship between divergent thinking and intelligence: An empirical study of the threshold hypothesis with Chinese children. *Frontiers in Psychology*, *8*(FEB), 254. https://doi.org/10.3389/FPSYG.2017.00254/BIBTEX
Silvia, P. J. (2008a). Creativity and intelligence revisited: A latent variable analysis of Wallach and Kogan (1965). *Creativity Research Journal*, *20*(1), 34–39. https://doi.org/10.1080/10400410701841807
Silvia, P. J. (2008b). Another look at creativity and intelligence: Exploring higher-order models and probable confounds. *Personality and Individual Differences*, *44*(4), 1012–1021. https://doi.org/10.1016/j.paid.2007.10.027

Silvia, P. J. (2011). Subjective scoring of divergent thinking: Examining the reliability of unusual uses, instances, and consequences tasks. *Thinking Skills and Creativity*, *6*(1), 24–30. https://doi.org/10.1016/j.tsc.2010.06.001

Tan, C., Lau, X., Kung, Y., & Kailsan, R. A. (2019). Openness to experience enhances creativity: The mediating role of intrinsic motivation and the creative process engagement. *The Journal of Creative Behavior*, *53*(1), 109–119. https://doi.org/10.1002/jocb.170

Torrance, E. P. (1967). The Minnesota studies of creative behavior: National and international extensions. *The Journal of Creative Behavior*, *1*(2), 137–154. https://doi.org/10.1002/j.2162-6057.1967.tb00021.x

Vartanian, O., Martindale, C., & Kwiatkowski, J. (2007). Creative potential, attention, and speed of information processing. *Personality and Individual Differences*, *43*(6), 1470–1480. https://doi.org/10.1016/j.paid.2007.04.027

Vartanian, O., Saint, S. A., Herz, N., & Suedfeld, P. (2020). The creative brain under stress: Considerations for performance in extreme environments. *Frontiers in Psychology*, *11*, 585969. https://doi.org/10.3389/fpsyg.2020.585969

Weiss, S., Steger, D., Kaur, Y., Hildebrandt, A., Schroeders, U., & Wilhelm, O. (2021). On the trail of creativity: dimensionality of divergent thinking and its relation with cognitive abilities, personality, and insight. *European Journal of Personality*, *35*(3), 291–314. https://doi.org/10.1002/per.2288

Weiss, S., Wilhelm, O., & Kyllonen, P. (2024). An improved taxonomy of creativity measures based on salient task attributes. *Psychology of Aesthetics, Creativity, and the Arts*, *18*(3), 429–448. https://doi.org/10.1037/aca0000434

Wen, N. J., Amir, D., Clegg, J. M., Davis, H. E., Dutra, N. B., Kline, M. A., Lew-Levy, S., MacGillivray, T., Pamei, G., Wang, Y., Xu, J., & Rawlings, B. S. (2025). Construct validity in cross-cultural, developmental research: Challenges and strategies for improvement. *Evolutionary Human Sciences*, 1–45. https://doi.org/10.1017/ehs.2025.3

Wigert, B. G., Murugavel, V. R., & Reiter-Palmon, R. (2024). The utility of divergent and convergent thinking in the problem construction processes during creative problem-solving. *Psychology of Aesthetics, Creativity, and the Arts*, *18*(5), 858–868. https://doi.org/10.1037/aca0000513

Yang, W., Green, A. E., Chen, Q., Kenett, Y. N., Sun, J., Wei, D., & Qiu, J. (2022). Creative problem solving in knowledge-rich contexts. *Trends in Cognitive Sciences*, *26*(10), 849–859. https://doi.org/10.1016/j.tics.2022.06.012

Yusuf, S. (2009). From creativity to innovation. *Technology in Society*, *31*(1), 1–8. https://doi.org/10.1016/j.techsoc.2008.10.007

Zhang, W., Sjoerds, Z., & Hommel, B. (2020). Metacontrol of human creativity: The neurocognitive mechanisms of convergent and divergent thinking. *NeuroImage*, *210*, 116572. https://doi.org/10.1016/j.neuroimage.2020.116572

Zhu, W., Shang, S., Jiang, W., Pei, M., & Su, Y. (2019). Convergent thinking moderates the relationship between divergent thinking and scientific creativity. *Creativity Research Journal*, *31*(3), 320–328. https://doi.org/10.1080/10400419.2019.1641685

Zmigrod, S., Zmigrod, L., & Hommel, B. (2015). Zooming into creativity: Individual differences in attentional global-local biases are linked to creative thinking. *Frontiers in Psychology*, *6*, 1647. https://doi.org/10.3389/fpsyg.2015.01647