Creativity Enhancement Methods for Adults: A Meta-Analysis

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Abstract

This meta-analysis synthesizes 332 effect sizes of various methods to enhance creativity. We clustered all studies into twelve methods to identify the most effective creativity enhancement methods. We found that, on average, creativity can be enhanced, Hedges' $g = 0.53$, 95%-CI [0.44, 0.61], with 70.09% of the participants in the enhancement conditions being more creative than the average person in the control conditions. Complex training courses, meditation and cultural exposure were most effective (gs = 0.66), while the use of cognitive manipulation drugs was least and also non-effective, $g = 0.10$. The type of training material was also important. For instance, figural methods were more effective in enhancing creativity, and enhancing converging thinking was more effective than enhancing divergent thinking. Study effect sizes varied considerably across all studies and for many subgroup analyses, suggesting that researchers can plausibly expect to find reversed effects occasionally. We found no evidence of publication bias. We discuss theoretical implications and suggest future directions for best practice in enhancing creativity.

Keywords: creativity training, manipulation, enhancement, assessment, effectiveness

Creativity Enhancement Methods: A Meta-Analysis

In times of rapid technological, cultural, and societal changes, creativity is increasingly important (Karwowski & Soszynski, 2008) and is valued by managers, politicians, employees, and scholars (Archibugi et al., 2013). The expanding use of artificial intelligence in workplaces makes creativity a vital human attribute to nurture (Aoun, 2017). Managers consider innovation one of the critical determinants of business success (Barsh et al., 2008). Especially with the current push towards digitization, an increased value is put on meta-skills in educational and occupational contexts, with creativity as one of the most sought-after skills (van Laar et al., 2017). Thus, teaching creative skills grows the need to prepare students and others for the future. For example, the Organization for Economic Co-operation and Development (OECD) decided to include a creativity assessment in the famous PISA study starting in 2022, which might increase the pressure on schools to equip their students with creative skills.

However, it remains unclear which methods are the most effective because previous integrative reviews have yielded contradictory findings (Ma, 2006; Scott et al., 2004a; Valgeirsdottir & Onarheim, 2017). For instance, it is unclear whether complex courses teaching creativity (e.g., Im et al., 2015) are more effective than the acquisition of particular creativity techniques (e.g., Ritter & Mostert, 2017) or adjustments to the working climate (e.g., Chen et al., 2014). To capture the variety of methods and approaches used to improve a person's creative performance, we refer to *creative enhancement methods*. As an intense body of research has accumulated throughout the years, the global question of how creativity can be most efficiently enhanced needs to be addressed through a systematic quantitative review. The latest comprehensive meta-analysis about creative training methods includes studies only published before 2001 (Scott et al., 2004a). In recent years, many new creativity enhancement approaches have been tested, such as using virtual reality techniques (Wang et al., 2018) or the use of cognitive enhancement drugs (e.g., Ilieva et al., 2013).

In this article, we quantitatively synthesize for the first time the effectiveness of a diverse set of methods to enhance creativity. We conduct a meta-analysis that allows us to test whether primary studies report consistent findings. Distinguishing between more and less effective methods is important for researchers who aim to test whether well-working methods can be further improved and relevant for practitioners (e.g., organizations). In addition, we aim to better understand under which conditions enhancement methods are more effective. Specifically, we explore the impact of a range of moderators, such as the type of assessment and congruence between training and test method. For example, as a prior meta-analysis found that the type of creativity assessment moderates the relations between creative performance and self-efficacy measures (Haase et al., 2018), we explored whether differences can be found for the type of assessment applied and the result found in a study. Further, studies found that congruence between the material and assessment resulted in larger effect sizes (e.g., Kim et al., 2008; Meyerhoff & Huff, 2016). We test whether congruence effects are also present for creative enhancement studies.

Below, we first discuss creativity theories relevant to understanding the differences between various enhancement methods. Next, we review the literature on creativity enhancement methods' effectiveness before describing our methodological approach.

Creativity Theories

Creativity can be defined as the ability to produce something new and useful (Runco & Jaeger, 2012). Specifically, creativity includes associative and analogical thinking, reformulation and removal of mental blocks (Dacey et al., 1998), knowledge activation, remote association, divergent thinking, and insight abilities (Chiu, 2015). Over the past seven decades, numerous attempts have been made to structure and cluster the diverse concepts of creativity. A prominent holistic approach is the *4-P model* (Rhodes, 1961), which proposes that creativity is fully represented by four main perspectives: *Person, Process, Product*, and *Press*. These can be used to differentiate the actor (person) from the act (process), the result (product), and the influencing environment (press). In the present paper, we use the 4-P model as a theoretical framework to categorize diverse approaches to enhancing and assessing creativity. Ideally, a holistic and promising enhancement method should focus on all four aspects to optimally account for the complexity of creativity. However, most studies focus on only one or two perspectives of the 4-P model. In the present meta-analysis, we overcome this constraint by analyzing the effectiveness of creative enhancement and assessment methods within the framework of these four perspectives.

Dual-process models in cognition (e.g., Evans, 2008; Stanovich, 1999) have also been applied to creativity research (Sowden et al., 2015). These models distinguish between "type 1" (rapid, automatic, associative processes) and "type 2" (conscious, structured, evaluated processes) thinking processes. For the creative process, a "type 1" process typically appears first (e.g., problem identification and brainstorming), followed by a "type 2" process (e.g., solution testing and evaluation; O'Connor, Gardiner, & Watson, 2016). Often, the creative process is iterative, with both types following each other repeatedly. This dyad corresponds to divergent and convergent thinking, often used to operationalize creative thinking in general (Cropley, 2006; Runco & Acar, 2012). Both processes are part of the definition of creativity: Divergent thinking reflects the generation of novel ideas, and convergent thinking reflects the evaluation of the novelty, which also includes judgments of usefulness. This work aims to analyze to what extent enhancement methods impact those two facets of creative thinking.

While the broad definition of creativity as the ability to produce something new and useful is widely cited (Runco & Jaeger, 2012), it has also been criticized: new to whom and useful for whom? To answer these questions, the concepts of *little-c* creativity and *Big-C* creativity were proposed, forming a continuum and allowing the impact of creative endeavors to be assessed (Karwowski, 2009). Little-c describes the more straightforward, around-the-corner ideas and solutions, which impact only the creator or close acquaintances, and can thus be found in everyday life. On the other end of the spectrum are Big-C accomplishments, which are much less likely to occur, typically rely on a great amount of work and professional expertise from the creator, and impact society (Simonton, 2013). In the context of enhancing and training creativity, it can serve as a model to differentiate between the scope of the training and the kind of creative expertise for which the training can be fruitful. For example, less-skilled people benefit more from training than those already skilled, as the former has more potential for development (e.g., Agnoli et al., 2018; Jaeggi et al., 2014).

Differentiating between Creativity Enhancement Methods

Creative enhancement has been defined as "to help people develop more of their potential" (Sternberg, 1999, p. 394). This broad definition matches the variety of approaches and methods found in the literature with the overall aim to enhance a person's creativity. Approaches can address the creative concept's cognitive, social, attitudinal, motivational, or environmental aspects (Plucker et al., 2011). However, we argue that a system to sort types of enhancement methods is missing so far and that the terminology used in the literature is ambiguous. For example, Cheung and colleagues (2006) argued that a distinction is missing within the training literature between acquiring new skills resulting in long-term effects vs. behavioral or emotional responses as an immediate reaction to the input. Building on this, we broadly distinguish between two types of creativity enhancement methods: training and *manipulation*. Training and manipulation differ in terms of effort, procedural rigor, and the awareness it takes for participants to go through the enhancement method. Below we provide a theoretical distinction between training and manipulation before discussing studies that used either method to enhance creativity.

We define *training* as a systematic process, a program, through which a person acquires specific skills (cf. Pike, 2003). This method necessitates an awareness of the learning process and the aim. Additionally, training is typically meant to have long-lasting effects, mainly as training is defined in the organizational context and sports sciences (Billat, 2001; Kirkpatrick & Mann, 1999). For example, Goldberg (1991, p. 508) defined training as "the systematic acquisition of attitudes, concepts, knowledge, roles, or skills that result in improved performance at work." In creativity research, the precise underlying mechanisms might differ between the various types of training.

Nevertheless, they often entail an understanding of the creative process, facilitated by self-efficacy and the acquisition of specific skills and techniques enabling creative efforts (Plucker & Runco, 1999). For example, Hargrove and Nietfeld (2015) developed a 37-hour training that took place over a period of 37 weeks. The course taught rapid prototyping methods, practical problem-solving tasks, and challenged participants to gain deeper insights into their thinking processes. Another creativity enhancement training was developed by Karakelle (2009), whose participants attended 30 hours of drama classes, which aimed to practice free imagination and associations to art such as poems, words, and music.

In comparison, we propose that a *manipulation* is typically less complex than training, shorter in time, and participants are generally unaware of its intended impact on their creativity. The effect of a manipulation is usually not intended to be long-lasting. For example, Jarosz and colleagues (2012) studied the impact of (non-)alcoholic intoxication on the immediate (within one hour) task performance on insight tasks. Similarly, Müller and colleagues (2016) led participants to meditate for 20 minutes and assessed their associative ability afterward. We argue that the underlying mechanism behind such manipulations is activating a creative mindset, which is a mental state in which a person can associate and think diversely and abstractly (Sassenberg et al., 2017). In other words, "the major variable in creativity is simply a mindset toward thinking in the novel, surprising, and compelling ways" (Kaufman & Sternberg, 2019, p. 88). Mindsets, in general, describe a person's mental adjustment to typical task demands, which result in being better prepared for such tasks (Gollwitzer et al., 2000). Specifically, a creative mindset allows broad associations between many cognitive categories, contributing to the global and flexible processing of information (Dreu et al., 2010).

Only a few studies directly used the mindset theory to explain how particular methods improve creative thinking skills (many studies that we categorized as manipulations here lack a detailed description of the underlying mechanism). While training methods may also activate a creative mindset, they include a deliberative learning process. Thus, by comparing training with manipulation, we can discern whether a manipulation is potent for enhancing creative performance or if more in-depth learning is more effective.

In sum, *training* is primarily about acquiring creativity-related skills, while *manipulations* are more casual and briefer. The distinction between training and manipulation is not entirely clear-cut. As creativity is a complex multidimensional concept, the underlying cognitive mechanisms are also complex and diverse methods addressing cognitive abilities, and motivational aspects can impact those. We believe it is helpful to divide the enhancement methods into two broad categories, which then can be subdivided into more subcategories. We briefly review creativity training programs and manipulations in the following two subsections.

Enhancement of creativity through training. Up until the late 1990s, whether creative thinking can be enhanced was debated among researchers (Plucker & Runco, 1999). Nowadays, it is widely accepted that various methods can improve creative thinking. Several reviews and meta-analyses have analyzed whether and how creativity training can succeed (Ma, 2006; Scott et al., 2004a, 2004b; Torrance, 1972a; Valgeirsdottir & Onarheim, 2017). In one of the first meta-analyses, Torrance (1972a) analyzed 142 studies, most of which used the Torrance Test of Creative Thinking (Torrance, 1972b) to evaluate creativity training in classroom settings, and reported a 73% success rate for these training programs.

Similarly, Mansfield and colleagues (1978) found training effects for six training programs, although the authors did not provide a quantitative estimate. Rose and Lin (1984) conducted a meta-analysis of 46 studies that included divergent thinking measures and found significant training effects for originality within verbal and figural divergent thinking tasks. Cohn (1984) analyzed 83 studies covering diverse training methods and included young children to adults' samples. The author found that training can increase creativity, but also precludes that the skills are transferable. All these meta-analytic reviews compared full training programs, only partially exploring specific components, such as duration of training and training contents, which might have shed more light on the underlying mechanisms.

This gap in the literature was noted by Scott and colleagues (2004b). They were the first to differentiate between types of training in their meta-analysis, encompassing 156 studies published before 2001. The authors distinguished between eleven training types based on the cluster of concepts addressed by the respective training. They found that the most effective training types were critical/creative thinking training and creative process training, while the training of analogies was the least effective. Additionally, Scott et al. (2004a) analyzed 70 of these studies in more detail to explore what type and part of a training program are most effective. The authors categorized and then compared separate training components. Training programs that focused on problem-solving (i.e., production of original solutions to novel problems) were most effective, Cohen's delta = 0.84, while programs that focused on attitude/behavior (e.g., reactions to creative ideas or creative efforts initiated) were the least effective, Cohen's delta = 0.24. Overall, a comparison of all training programs revealed a comparably medium-to-large effect size of Cohen's delta = 0.68. Converting Cohen's delta into the more informative Cohen's U3 (Hanel & Mehler, 2019) shows that 75.2% of the participants in the training group were more creative than the average person in the control group. Scott et al. compared single-treatments with multi-session treatment, which somewhat relates to our distinction between training and manipulation. Interestingly, they found that single-treatments are more effective compared to multi-session treatments.

The findings of Scott et al. (2004b) were replicated by Tsai (2013), Huang (2005) and partly reproduced by Ma (2006). The meta-analysis from Tsai (2013) included only 11 papers, as they had strict inclusion criteria for primary studies: the mean age of the sample had to be above 25 years, and a control group had to be present. The results show that creativity can be trained in adulthood. Huang (2005) compared 62 studies with samples from child age to adulthood. The differentiation between types of training they created is very broad: Huang compared the Creative Problem Solving program to other (unnamed) training programs, techniques, and school programs. Overall, very similar overall mean effect sizes to Scott et al. (2004a) were found. Ma (2006) compared the effectiveness of 12 types of training across 34 studies. The overall mean effect size of Cohen's delta = 0.77 was similar to the overall mean effect size of 0.68 that Scott et al. (2004a) found. However, Ma found that attitude training programs had the strongest effect, while a method to guide fluid and flexible thinking (SCAMPER method, Eberle, 1996) was the least effective. As a limitation, though, the findings for both of these training types were based on only four effect sizes, thus questioning the reliability of the results given the pool of 268 effect sizes that Ma had analyzed.

Bertrand (2005) analyzed 47 studies with creativity training from children to adulthood, and found overall positive effects (especially for verbal, compared to figural training). However, he expressed a very critical view of the quality of the primary studies. Valgeirsdottir and Onarheim (2017) have a similarly critical attitude and go one step further: they examined 22 publications. They argued that the different study designs and methodological approaches would render a quantitative comparison of effect sizes impossible. The authors mainly focused on gaps in primary studies and did not compare different training approaches based on their content. Instead, they came up with criteria for future study designs to facilitate comparability across studies. However, we believe that enhancement approaches described in the literature can be meaningfully compared, especially in a meta-analysis that includes a sufficient number of effect sizes for high-powered comparisons.

Other meta-analyses limited the included studies to scientific creativity in K-12 students in South Korea (Kwon et al., 2016), to the effects of instructional variables on children's creativity (Scope, 1998), or to the relation of creative abilities and the study of visual arts (Moga et al., 2000).

Taking the results of prior meta-analyses together, creative skills can be enhanced by drawing on various creative process steps, such as facilitating problem identification, problem-solving, and problem evaluation. Examples of such skills include associations, conceptual combinations, improvisations, synectics (Chiu, 2015), imaginations, lateral, fluid, flexible, and original and divergent thinking (Byrge & Tang, 2015; Karakelle, 2009). In addition to these cognitive abilities, training programs sometimes target personal attributes such as habit formation, risk-taking (Im et al., 2015), or support of creative self-beliefs (Meinel et al., 2018).

Researchers have identified numerous moderators of training success. For instance, people with lower creativity scores seem to benefit more from an intervention (e.g., Agnoli et al., 2018; Meinel et al., 2018). Moreover, Scott et al. (2004a) found that training was more effective in occupational samples than student samples. Ma (2006) found a tendency for a greater benefit of training in older than in younger participants.

Enhancement of creativity through manipulation. Creativity can be understood as one of the most complex cognitive processes capable of the human mind (Karakelle, 2009). Therefore, it is not surprising that researchers have tested diverse approaches to facilitate the creative thinking process that did not include training. These alternatives to training are often simpler, faster to implement, and less costly. While training programs are often cognitively based and require a basic understanding of creative skills and behavior (Byrge & Hansen, 2013), manipulation techniques focus on altering cognitive states, such as enhancing or activating a creative mindset.

By activating a person's creative mindset, associations can flow more easily and be less restricted, increasing the chance of successfully tackling open-ended questions (Sassenberg et al., 2017). Especially during the incubation and illumination phase of the creative process, following the four-stage approach of creativity from Wallas (1926), such altered states of consciousness (e.g., a dream-like condition) can foster the emergence of great ideas and associations (Boynton, 2001). Anecdotal evidence suggests that great discoveries are made within the realm of the three B´s: bus, bed, or bath (Corballis, 2015), implying that many ground-breaking ideas might have come about when the mind was relaxed. Such an altered state of consciousness might be created, for example, through meditation. In this respect, allocation of attentional resources (Colzato et al., 2012), transcendence of informational boundaries (Horan, 2009), and emotion regulation (Ding et al., 2014) are ways in which creativity can be enhanced. The creative mindset facilitates all parts of the creative process.

To the best of our knowledge, there is not yet any research that systematically compares manipulations of mindset for the induction of creativity. Previous studies suggest that a creative mindset can be activated or enhanced by approach motivation (Chiu, 2014) and positive mood (Baas et al., 2008; De Dreu et al., 2008). Furthermore, by experimentally loosening conceptual boundaries (Chiu, 2015), the flow of associations can be enhanced. A creative mindset can also be created through chemical interference with the dopaminergic system, associated with novelty-seeking and overall creativity (Gvirts et al., 2017). This can be achieved through drugs that enhance overall cognition and facilitate concentration (Farah et al., 2009).

Creativity Assessment Methods

In only one of the above-cited meta-analyses on the enhancement of creativity was, the potential impact of creativity assessment directly addressed. Ma (2006) considered assessment as a moderator and concluded that the type of creativity assessment did "not necessarily significantly influence the evaluation of the effectiveness of creativity training programs" (p. 443). However, it is unclear how Ma reached this conclusion, as the effect sizes reported for various measures of divergent thinking and problem solving ranged from $d = 0.44$ to 0.90. Furthermore, a recent meta-analysis found that the correlations between creative performance and creative self-efficacy beliefs depended on how creativity was assessed (Haase et al., 2018). The authors found congruency effects between the way creativity and self-efficacy were measured: self-rated creativity showed the strongest correlations with self-rated self-efficacy, $r = .53$, weaker correlations with divergent thinking tests, $r = .23$, and the lowest correlations with figural performance tasks, $r = .19$. Moreover, objective and subjective creativity measures were weakly correlated, suggesting that different "creativity" measures do not necessarily measure the same underlying ability or concept (Park et al., 2016). Thus, it is also essential to consider the type of creativity measure when evaluating the effectiveness of a creativity enhancement method.

The Present Research: Overview and Hypotheses

The present meta-analysis had three main aims: First, we explored whether we can broadly replicate the findings of previous related meta-analyses and in a set of more recent studies (published from 2000 onward). Second, we analyzed the literature to determine whether training or manipulation has a more substantial effect on creative performance. Building on the broad categorization of enhancement methods into training and manipulation, we further divided them into 12 fine-grained categories, as outlined below. Third, we explored whether congruence between the creativity enhancement method and creativity assessment method has a more substantial effect than incongruence.

We compute an overall mean effect size across all studies to determine whether our data reveals findings in line with previous meta-analyses. Hypothesis 1 states that creativity enhancement methods will positively affect, in line with Scott et al. (2004a) and Ma (2006). These two meta-analyses already included studies published up to 2001, so we use studies published from 2000 onward. Furthermore, unlike previous meta-analyses, we used recently introduced methods to test for publication bias.

Regarding the differentiation between training and manipulation of creative performance, we predict that manipulation will be more effective than training (Hypothesis 2). First, as most manipulations directly affect people's creative mindset, this should lead to a better cognitive adjustment to a creative task, resulting in a higher level of creativity. Second, we expect to find similar effects to those reported in Scott et al.'s (2004a) meta-analysis, in which short interventions lead to higher test scores compared to programs encompassing several sessions ($\Delta = 0.99$, SE = 0.11 vs. $\Delta = 0.43$, SE = 0.10), potentially because of positive recency effects on the following testing session.

Based on Haase et al.'s (2018) meta-analysis, which investigated the effects of congruency between measurements of creativity and self-efficacy, we expect more substantial effects when the enhancement methods correspond to the testing methods (Hypothesis 3a). Congruence occurs when an enhancement method, for example, contains divergent thinking tasks, and creativity is assessed with the *Alternate Uses Task*, which measures divergent thinking. Similarly, we predict that the effect size will be larger when the focus of the 4-P model of creativity is the same for the enhancement method and the measurement of creativity (Hypothesis 3b). Finally, we hypothesize the same principle of congruence for the type of enhancement and type of measurement (verbal and figural) (Hypothesis 3c).

We also performed several exploratory analyses. Previous meta-analyses yielded contradictory results regarding the effectiveness of training programs. We hope to shed more light on which enhancement method is most effective by systematically comparing three types of training programs and nine types of manipulations. We outline how we clustered the different training types and manipulations below. Further exploratory analyses are helpful to evaluate the possible impact of content-unrelated influences such as diverse types of study designs (e.g., between-subject vs. within-subject study design, pre-and post-test vs. post-test only design, with or without comparison groups) and possible content-related influences, such as sample types (e.g., students vs. employees), country of origin, average age, and proportion of women. Additionally, we explored whether congruency effects (Hypotheses 3a-3c) are moderated by enhancement method (training vs. manipulation). Finally, we meta-analytically investigated whether creativity enhancement methods last beyond the intervention.

Method

Below, we outline our literature search strategy, present the specific inclusion criteria, and describe how we coded the variables and computed the effect sizes.

Literature Search

From January to March 2019, we searched for relevant articles using the meta-database *EBSCOhost*. We included all databases that seemed loosely appropriate and were accessible through the first author's institution: PsycINFO, PsycARTICLES, PsycBOOKS, PSYNDEX, Education Full Text, Dissertation Abstracts International, Psychology & Behavioural Sciences Collection, Business Source Premier, eBook collection (EBSCOhost), Regional Business News, The Nation Archive (DFG), The New Republic Archive (DFG), RILM Abstracts of Music Literature, MLA Directory of Periodicals, and MLA International Bibliography. We included different types of publications such as journal articles, book chapters, or dissertations in our search. We used the search terms 'creativ*' AND 'training' OR 'manipulation' OR 'enhancement' OR 'improvement'. These terms had to appear either in the title, abstract, or keywords.

Because previous meta-analyses had already included papers until the year 2000, we only selected articles published from and after the year 2000. Using the advanced search options in *EBSCOhost*, the search mode of "Find all my search terms" was chosen, and publication date from January 2000 up to the present day. We then searched for 'creativ*' plus another of the search mentioned above terms. Although we had not prespecified a language, all hits were in English because of the language of our search terms. Altogether, 3523 records were identified and screened (Figure 1). We identified and read 326 suitable papers based on the titles and abstracts. If all requirements (see below) we set beforehand were met, we extracted the relevant information (e.g., sample characteristics and descriptive statistics). Next, we searched the reference sections of all 326 suitable papers for other potentially relevant papers. Additionally, using *Google Scholar*, we examined all 950 papers (as of March 2019) that cited the meta-analysis of Scott et al. (2004a). Many studies on creativity training cite this meta-analysis because Google Scholar also includes dissertations, PhD theses, and book chapters.

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We also examined the systematic review of creativity training programs by Valgeirsdottir and Onarheim (2017), which included 22 studies in its analysis, from which we selected four more papers.[1] Finally, in February 2019, we made a call for unpublished data on *Researchgate* and through mailing lists of the *European Association of Social Psychology* and APA's division *Society for the Psychology of Aesthetics, Creativity and the Arts*. Specifically, we asked for any unpublished data that relied on adult samples, used either a within- or between-subject design (or both), and examined any intervention, manipulation, or training that aimed to increase creativity. 84 studies were included in the final analysis, taking these various sources together. Of those 84 studies, 80 are published in peer-reviewed academic journals, three are dissertations, and one study is unpublished.

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[1] We dismissed eight other papers of said systematic reviews due to quality issues such as non-validated self-assessment measures of training impact on creative performance, fewer than 10 participants per condition, or lack of creativity performance measures.

Inclusion Criteria and Excluded Papers

The following inclusion criteria were applied: The purpose of the training or manipulation method had to be the *direct* enhancement of creativity; the paper had to report sufficient statistics to calculate Hedges' *g* (if those were missing, we contacted the corresponding author); and sufficient information needed to be provided about the exact enhancement method and the creativity measure(s) used. Further, the mean age of the sample had to be above 18.00 years, as the assessment of creativity in young children is an even more challenging endeavor (e.g., Punch, 2002, Saracho & Spodek, 2012). In the next step, all remaining 326 papers were read by the first author and checked for basic quality standards. In particular, missing descriptive statistics such as means, standard deviations, effect sizes, or an exact *p*-value led to the exclusion of papers if these were not shared with us by the respective authors upon request. Moreover, some creativity assessments were rated as being of insufficient quality for inclusion, such as the usage of single-item measures asking about participants' subjective beliefs regarding their creative ability. We also excluded papers that used questionable measures, such as the Myer-Briggs Type Inventory, which lacks predictive power (Stein et al., 2018). In addition, we did not include papers that used samples from special populations, such as sleep-deprived shift workers (Drake et al., 2014) or prison inmates (Bustillo & Garaizar, 2016), as this would have added some confounding variables. Papers including samples with fewer than 10 participants per condition were also excluded (applied to three studies) because small sample sizes include a very high risk of sample bias (Kahneman, 1971). Priming studies were included if creativity was directly primed (e.g., Sassenberg et al., 2017) but not if other content was primed, which in turn affected creativity, such as individualistic vs. collectivistic norms (Bechtoldt, Choi, & Nijstad, 2012), drug consumption (Hicks et al., 2011), or counter-stereotypes (Goclowska et al., 2013).

Coded Variables

We thoroughly read the final set of 84 papers and extracted information into a coding scheme, which contained all variables of interest: study characteristics, creativity enhancement method, creativity assessment method, descriptive information about the sample, descriptive statistics, and measures of effect sizes. We extracted the first author, title, year of publication, number of participants in each group, and the study design for the study characteristics. We classified the study design as either pre-enhancement-post or enhancement-post design and with or without a control group, respectively (i.e., within- or between-subject design). Additionally, we extracted the type and name of enhancement and assessment method separately for the pre-and post-measures. Moreover, both categories included parallel variables, assessing the same aspect of either the enhancement or the assessment method. These categories are based on previous research (Scott et al., 2004a) and the *4-P model* of creativity, differentiating between the *Person, Process, Product,* and *Press* (Rhodes, 1961). We applied these categorizations in parallel to the enhancement methods and creativity assessment methods to enable us to test whether congruency effects occurred between the two. We did not include reliability estimators of creativity measurements, as it is sometimes done within meta-analyses. Indications of reliability are somewhat challenging to assess for typical creativity measurements and thus rarely reported within primary studies (compare Baer, 2011; Kim, 2006; Silvia et al., 2008). Our approach is in line with other meta-analyses on creativity (e.g., Baas et al., 2008). As sample characteristics, we extracted the country in which the study was conducted, participants' mean age, percentage of female participants, and setting (student vs. occupational). For an overview of the coded variables, compare Table 1.

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To calculate effect sizes, we extracted sample size, means, and standard deviations whenever possible (no study reported Hedges' *g*, the effect size we consider suitable for the present study, see below). If this was not possible, we extracted Cohen's *d*. Failing that, we extracted the *t*-value or *F*-value for designs with two groups. We contacted all authors who had not reported sufficient statistics and asked for descriptive statistics.

The first author performed coding. All extracted information was double-checked by the second author, who was comprehensively introduced to the coding scheme. Both authors are experienced with coding creativity studies for a recently published meta-analysis and conducting creativity-related primary studies. The rare deviations between the coders were discussed until they agreed on a solution. For the statistical values, 90% were correct, 6% contained minor errors (e.g., a standard deviation was erroneously extracted as 0.67 when the correct figure was 0.77), 3% had a copy and paste errors (e.g., the means of one experimental condition were incorrectly also reported as the means of another experimental condition), and 1% contained substantial errors that would have impacted the conclusion (e.g., standard error erroneously reported as standard deviation).

Training and manipulation. Each enhancement method was coded as either training or manipulation based on our taxonomy, independent of the labels used by the authors of the original studies. To categorize the type of enhancement, we followed Scott et al. (2004a). We defined an enhancement method as either cognitive, social, based on personality, motivational, or other (when none of those mentioned above categories was suitable). We categorized an enhancement method as *cognitive* if the method focused on thinking and learning; as *social* if the method included teamwork or a social setting with interactions; as *personality*-related if the method aimed to alter creative self-perception and/or attitudes towards the concept of creativity; as *motivational* if the method aimed to increase the motivation for creative work; and as *other* if none of those mentioned above categories fitted. Some more complex training programs were placed into more than one category.

To categorize the perspective of the enhancement method, we applied the *4-P model* of creativity. We categorized enhancement methods as relevant for the *Person* if the cognitive state was manipulated or the person's self-perception of the creative concept was altered; as relevant for the *Process* if a specific method was taught, such as De Bono's six thinking hats (De Bono, 2017); as relevant for the *Product* if the primary goal was the production of creative output; and as relevant for the category *Place* if the manipulation concerned the environmental conditions. A complex training program could address several aspects of the *4-P model*.

We further categorized enhancement methods based on the *type of enhancement*, depending on the exact content of the training or manipulation. The subcategories were *verbal* (talking, reading), *figural* (drawing, sketching), *spatial* (moving around, dancing), and *cognitive-perceptive* (brain stimulation, drugs, meditation).

If possible, we extracted information about the number of minutes the course/session lasted overall, the number of sessions, whether the enhancement included domain-specific exercises (i.e., focusing on the arts, math, or engineering), involved a trainer, r was conducted under time pressure.

Creativity assessment. We categorized creativity assessment in the same way as the enhancement methods: *enhancement efforts*, the *4-P model* of creativity, and the *type of enhancement*. We used verbal, figural, and item-based categories to address the latter because *spatial* and *cognitive-perceptive* were not assessed. Additionally, we extracted relevant statistical information (e.g., means and standard deviations) separately for the five divergent thinking dimensions: fluency, flexibility, originality, elaboration, and quality.

All these variables were extracted separately for pre-and post-measures. Furthermore, for within-subject designs, we analyzed whether the type of creativity measure was the same at both time points and how much time in days passed between the training of manipulation and the final measure of creativity (e.g., to test for long-lasting effects).

Computation and Analysis of Effect Sizes

Sample size. Wherever possible, we determined the sample size based on the degrees of freedom and not the sample size reported in the Method section because researchers often do not report missing values. Indeed, on average, the sample size determined based on the degrees of freedom was 5-10% smaller.

General procedure. As effect sizes, we used the bias-corrected version of Cohen's *d*, Hedges' *g*, which is almost identical to *d* for larger sample sizes ($n > 100$) but smaller than *d* for smaller sample sizes. Additionally, for within-subject designs, Hedges' *g* itself is agnostic to the pre-post correlation of the creativity measure; only its variance decreases if the pre-post correlation increases (cf. Lakens, 2013; Viechtbauer, 2010). If possible, we computed Hedges' *g* based on the reported descriptive statistics (means and standard deviations) or effect sizes (typically Cohen's *d*). If only a *t*-value was reported, we first transformed it to Cohen's *d* and then to Hedges' *g*. If only an *F*-value was reported with one numerator degree of freedom (i.e., for two groups), we took the square root of the *F*-value to obtain the *t*-value. For all other *F*-values and types of analysis (e.g., regression), we e-mailed the authors and asked for descriptive statistics. We also asked the authors if the reported statistics seemed implausible (e.g., in one paper, the control group's mean was erroneously reported as over ten times larger than the mean of the experimental group; the authors of this paper confirmed that this was a typo).

To compute an effect size for the within-subject designs, the correlation between the pre- and post-measure is needed. Unfortunately, pre-post-test correlations were only reported for 18 effect sizes (median r = .4850). The pre-post-test correlations were unrelated to the time between pre-and-post in days, $r(16)$ = -.01. We, therefore, estimated a pre-post-test correlation of .50 for the missing pre-post correlations, which results in identical effect size estimates for the within-subject and between-subject designs, allowing us to average across designs.[2]

Determining the experimental and control group was straightforward in most studies. Two studies, however, tried to simultaneously enhance divergent and convergent thinking through two

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[2]We additionally explored whether estimated pre-post test correlations of r = .80 and .20 (vs .50) affect the variance of the effect sizes, which can influence the overall mean effect size as well as measures of dispersion. That is, we estimated the missing pre-post correlations to be either .80, .50, or .20. To be conservative, we only included studies with a within-subject design here because also including between-subject design studies would have reduced the unique impact of different pre-post test correlations. Further, we intentionally chose extreme and improbable pre-post correlations to rigorously explore their impact. The impact was overall small. For a pre-post test r = .80, we obtained g = 0.563, SE = 0.053, 95%-CI [.458, .669], I^2 = 93.17%, τ = .602. For a pre-post test r = .50, we obtained g = 0.568, SE = 0.054, 95%-CI [.461, .675], I^2 = 87.98%, τ = .592. Finally, for a pre-post test r = .20, we obtained g = 0.572, SE = 0.055, 95%-CI [.464, .681], I^2 = 84.40%, τ = .587. Overall, even extreme and unlikely pre-post test correlations have little impact on the results.

We used the standardized mean change using change score standardization. The use of the standardized mean change using raw score standardization resulted in an almost identical mean Hedges′ g (g = .527 vs. .529; overall mean effect size).

manipulations in a between-subject design (open meditation and focused attention; Colzato et al., 2012, 2018). Thus, for the divergent thinking outcome, we used the group that underwent a manipulation for convergent thinking as the control group and vice versa for convergent thinking as the outcome, following the authors' rationale.

When a study used several creativity measures (e.g., fluency, flexibility, originality), we first computed the effect sizes individually for each outcome variable. We then averaged across the individual measures to obtain an overall study effect size. Analyses were done in R using the package *metafor* using restricted maximum likelihood estimation (version 3.0-2; Viechtbauer, 2010). For all analyses, we ran a multi-level meta-analysis to account for the nested structure of the data with effect sizes nested in studies and studies nested in papers (Assink & Wibbelink, 2016; Cheung, 2019). The R-code, the data, and supplemental material can be found on https://osf.io/254sw/?view_only=0dff9e0477574ac28bd881c2814d290d.

As we compared various enhancement methods, we used multi-level random-effects models for all analyses (Borenstein et al., 2011). We computed several indices to test for heterogeneity of effect sizes within the overall sample and in the subgroups. We computed τ^2 as an absolute estimate of the variation in true effects by summing up the heterogeneity across all levels. τ can be understood as the standard deviation of true effects (Borenstein et al., 2017). The interval $[g – 1.96\tau, g + 1.96\tau]$ is also called the 95%-prediction interval and estimates the range in which approximately 95% of effects from future studies would fall. It is comparable to the prediction interval on a primary study level and conceptually independent of I^2 (IntHout et al., 2016). Additionally, we computed the I^2 statistic following Viechtbauer (2022), which estimates the proportion of variation in observed effects due to the variation of true effects. I^2 is the proportion of variability in effect sizes that cannot be attributed to sampling error and is therefore not an absolute value, unlike τ (Borenstein et al. 2017). We focus on τ and the prediction interval when discussing effect size heterogeneity because we believe they are more relevant for researchers.

Subgroup Analyses

To better understand the more and less effective enhancement methods, we further divided the training and manipulation methods using an inductive coding approach (Thomas, 2006). This is also important because the specific method and measurement features are similar to substantial features of studies (Lipset & Wilson, 2001). The overall aim was to create only as many types as needed by grouping similar methods together. For training, the most prominent distinction is the complexity, and time-investment participants had to undertake. We divided the training types into three categories: single-method training (e.g., brainstorming, Six Hats, or mind-mapping); brief courses with fewer than six sessions; and complex training courses which usually lasted for several weeks (e.g., long-lasting training or semester courses covering a variety of topics on creativity).

The manipulations used in the literature were more diverse. We separated them into nine categories: 1) performing an open-thinking technique (e.g., alternate categories task, improvisation, or insight problems), 2) sensory stimulation (e.g., listening to music, use of virtual reality devices), 3) direct brain stimulation (e.g., EEG neurofeedback, vagus nerve stimulation), 4) physical activity (e.g., walking, dancing, cycling), 5) meditation, 6) drugs (e.g., alcohol, Adderall, modafinil), 7) creativity awareness (e.g., priming, “be creative” instructions), 8) cultural exposure (e.g., ERASMUS exchange program) and 9) other (heart rate variability, controlled writing, self-management, and entitlement activation).

Results

Quality Assessment

A major threat to the validity of meta-analyses is publication bias (Hedges & Vevea, 1996; Simonsohn et al., 2014). There are two primary sources of bias: the tendency that statistically significant results of primary studies are more likely to be published (Rosenthal, 1979) and the phenomenon of researchers "playing with" (or "*p*-hacking") the data to obtain "statistical significance" – a common phenomenon among researchers (e.g., Head et al., 2015). Both would lead to an overestimation of effect sizes in the published literature. While a range of methods has been proposed to identify publication bias, none of them is superior to the others (Carter et al., 2017). Instead, Carter et al. recommend that meta-analysts "report on a variety of methods" (p. 2). Therefore, we used several tests of publication bias to establish whether the samples in our dataset are likely to be biased due to publication bias and if so, to estimate the publication bias-corrected effect size (for a thorough analysis, see supplemental analysis material document on https://osf.io/254sw/?view_only=0dff9e0477574ac28bd881c2814d290d). Although the optical evaluation of a funnel plot of all effect sizes of the study was inconclusive (compare Figure 2), the statistical measures of the Eggers test ($z = 1.03$ and $p = .30$), the trim-and-fill method (overall, we found zero fillings), the test of insufficient variance (variance across all 146 overall effect sizes is 2.08) and the *p*-curve analysis all suggested no bias (for a detailed analysis and explanation compare supplementary material).

---- insert Figure 2 about here ---

Despite this overwhelming evidence of a lack of publication bias, we estimated the overall mean effect size corrected for publication bias (Vevea & Hedges, 1995), using the R-package *weightr* (Coburn & Vevea, 2019). The adjusted overall meta-analytical effect size was slightly larger than the unadjusted one, g = 0.55, 95%-CI [0.44, 0.65] vs. Hedges' g = 0.52, 95%-CI [0.45, 0.59], further suggesting no evidence of publication bias.[3]

Preparatory Analyses

In a first step, we used meta-regressions to test whether the research design (e.g., between- vs. within-subject design) influenced the overall mean effect size of a study. The overall mean effect sizes (i.e., averaged across creativity measures, if applicable) did not differ based on whether studies used between- or within-subject designs, B = .02, SE = .07, p = .76. When we only compared the effect sizes of the 2 × 2 designs, the difference in between- and within-subject designs was also non-significant, B = .03, SE = .09, p = .78. Thus, we collapsed across research designs.

Overall, 84 papers were included in the analysis, with 332 effect sizes: 174 for manipulation and 158 for training. The overall sample size comprised 4,557 participants: n = 3,048 for manipulations and n = 1,509 for training. From 14 papers, we included one effect size, and from 70 papers, 2 to 12 effect sizes. The issue of dependency within the data arising from including several effect sizes from one sample also called nested data, is addressed in our test of Hypothesis

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[3] This package does not allow to run a multi-level meta-analysis. We therefore compared a standard single-level random-effects meta-analysis (g = 0.52) with the adjusted one (g = 0.55).

1 below. Table 3 reports all samples included in the analyses, along with key descriptions regarding the effect sizes, enhancement methods, creativity assessment methods, and sample types.[4]

---- insert Table 3 about here ---

Effectiveness of Enhancement Methods

Hypothesis 1. Hypothesis 1 states that creativity enhancement methods will positively affect, in line with Scott et al. (2004a) and Ma (2006). A multi-level random-effects meta-analysis revealed a medium effect across effect sizes derived from all samples of Hedges′ $g = 0.53$, $SE = .04$, 95%-CI [0.44, 0.61], $p < .0001$, $k = 332$. Although the overall mean effect size is significantly smaller than the effect sizes found by Scott et al. (2004a), for example (0.68), it points in the same direction and is statistically significant. Thus, Hypothesis 1 is supported.

The variability across effect sizes was substantial $\tau^2 = .19$, 95%-prediction interval [-0.84, 1.90], $I^2 = 82.14\%$ (Higgins & Thompson, 2002), indicating the existence of true group differences, which are not based on sample errors. This suggests that even though all studies in this review follow the same aim – improving creative behavior – the heterogeneity is substantial. Thus, the meaningfulness of one overall mean effect size is greatly diminished. The τ score also suggests that, although enhancement methods are effective on average, some future studies will find non-significant effects, but possibly also very large effect sizes (compare Table 5). As our sample includes nested data, we also calculated the overall mean effect size based on the

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[4] An outlier analysis revealed one effect size larger than 4SDs from the mean (e.g., Fernandes & Garcia-Marques, 2020; Morgenroth et al., 2020). However, as we could not identify any issue with the primary study, we decided not to exclude this effect size (excluding the outlier barely reduced the overall mean effect size, gs = 0.53 vs. 0.51).

aggregated effect sizes of each sample: Hedges' $g = 0.55$, $SE = .05$, 95%-CI [0.46, 0.64], $p < .0001$, $k = 146$, $\tau^2 = .14$, 95%-prediction interval [-0.43, 1.53], $I^2 = 79.57\%$.

Hypothesis 2. Hypothesis 2 states that manipulations are more effective than training. The hypothesis was not supported. Manipulations, $g = 0.45$, $SE = .06$, 95%-CI [0.33, 0.56], $p < .0001$, $k = 174$, $\tau^2 = .15$, $I^2 = 72.74\%$, were not more effective than training, $g = 0.61$, $SE = .06$, 95%-CI [0.48, 0.73], $p < .0001$, $k = 158$, $\tau^2 = .21$, $I^2 = 87.18\%$ (test of moderators: $B = .08$, $SE = .08$, $p = .29$).

Hypothesis 3a. Hypothesis 3a states that the overall effectiveness is higher if the enhancement methods correspond to the assessment methods. To test this hypothesis, we compared whether effect sizes were larger when the enhancement method and the creativity assessment method were congruent (e.g., both cognitive). For 264 effect sizes, there was a match between *cognitive enhancement method* and *cognitive measurement* (and no match for 68 effect sizes). However, the difference between cognitive-congruent effects, $g = 0.51$, $SE = 0.05$, 95%-CI [0.42, 0.60], $p < .0001$, $k = 264$, $\tau^2 = .17$, $I^2 = 81.85\%$, and incongruent effects, $g = 0.66$, $SE = 0.12$, 95%-CI [0.42, 0.89], $p < .0001$, $k = 68$, $\tau^2 = .24$, $I^2 = 82.54\%$, was not significant, $B = -.20$, $SE = .10$, $p = .051$. There were not enough congruent cases for the other four categories (social, personality, motivational, other) to aggregate across effect sizes. Hypothesis 3a was not supported.

In a next step, we explored whether the effects of (in)congruence between cognitive enhancement method and cognitive measurement would with trainings vs manipulations. However, the interaction was not significant, $B = -.25$, $SE = .24$, $p = .31$.

Hypothesis 3b. Hypothesis 3b states that the effect size would be larger when the focus of the *4-P model* of creativity was the same for the enhancement and assessment methods. However, we only found two matches between the enhancement and creativity assessment methods for the *person* category, four for the *process* category, and no match for *press*. Because of the small number of effect sizes, we decided not to perform any moderation test for these three of the four elements of the *4-P model*. Only for *product,* we found 138 matches. The effect of the enhancement method was not larger when the enhancement method and the creativity assessment method were congruent, $g = 0.65$, $SE = 0.07$, 95%-CI [0.51, 0.78], $p < .0001$, $k = 138$, $\tau^2 = .21$, $I^2 = 87.55\%$, than when they were incongruent, $g = 0.43$, $SE = 0.05$, 95%-CI [0.33, 0.53], $p < .0001$, $k = 194$, $\tau^2 = .15$, $I^2 = 73.45$, (test of moderators: $B = .14$, $SE = .08$, $p = .07$). Thus, Hypothesis 3b was not supported.

In a next step, we explored whether (in)congruence for *product* interacted with type of enhancement method (training vs manipulation). The two-way interaction was not significant, $B = -.11$, $SE = .34$, $p = .74$.

Hypothesis 3c. Hypothesis 3c states that the effect size would be higher if type of enhancement and type of measurement matched (verbal and figural). The enhancement method had not a stronger effect when both the enhancement method and the creativity assessment method were verbal, $g = 0.58$, $SE = 0.05$, 95%-CI [0.48, 0.69], $p < .0001$, $k = 193$, $\tau^2 = .19$, $I^2 = 85.64\%$, than when they were not, $g = 0.41$, $SE = 0.06$, 95%-CI [0.30, 0.53], $p < .0001$, $k = 139$, $\tau^2 = .14$, $I^2 = 70.70\%$ (test of moderator: $B = .11$, $SE = .08$, $p = .14$).

Moreover, when both the enhancement method and creativity assessment method were figural, the enhancement method had not a stronger effect, $g = 0.71$, $SE = 0.09$, 95%-CI [0.54, 0.88], $p < .0001$, $k = 64$, $\tau^2 = .17$, $I^2 = 84.43\%$, than when there was no match, $g = 0.49$, $SE = 0.05$, 95%-CI [0.49, 0.59], $p < .0001$, $k = 268$, $\tau^2 = .18$, $I^2 = 80.64\%$ (test of moderator: $B = .14$, $SE = .09$, $p = .14$. Thus, Hypothesis 3c was not supported.

In a next step, we explored whether (in)congruence for verbal and figural interacted with type of enhancement method (training vs manipulation). However, the interaction was neither significant verbal, *B* = .03, *SE* = .17, *p* = .85, nor figural congruence, *B* = .04, *SE* = .09, *p* = .64.

Exploratory Analyses

In the following section, we report exploratory analyses to further understand under what conditions and for whom creativity enhancement methods are more effective. Whenever feasible, we reported *p*-values up to 4-digits to allow readers to adjust the alpha-threshold of significance using their preferred method. However, we recommend that especially practitioners focus more on (differences in) effect sizes rather than *p*-values when deciding which approach to enhance creativity they want to use.

Recently, it was recommended that all moderators should be included into the same analysis to identify the strongest predictors (Pigott & Polanin, 2020), which we report first below. This approach is also useful to reduce issues caused by confounding moderators. However, this multiple-moderator analysis answers a different research question than single-moderator analyses (i.e., including moderators separately; cf. Lynam et al., 2006). We therefore decided to follow recent practice and report both multiple-moderator and single-moderator analyses (e.g., Abdulla Alabbasi, et al. 2022; Said-Metwaly, et al., 2022).

Multiple-moderator Analyses

We included all moderators listed in Table 1 together in one model as predictors to test which ones are most robustly associated with larger effect sizes. We found that studies which used figural types of enhancement to be more effective than studies which used no figural types of enhancement; studies which focused on convergent thinking were more effective than those that focused on divergent thinking; effects were larger on fluency and originality than on other operationalizations of creativity (Table 2).

---- insert Table 2 about here ---

Single-moderator Analyses**Training vs. manipulation.** The effects of the different training and manipulation types can be found in Table 4, where we report the number of effect sizes (*k*), Hedges′ *g*, the 95% confidence interval of *g*, the I^2, τ^2, and the 95% prediction interval based on τ as measures for the heterogeneity of effects found within enhancement subgroup.

Complex courses were the most effective training method, $g = 0.66$, $SE = 0.07$, 95%-CI [0.53, 0.79], $p < .0001$, $k = 69$, although they only differed significantly from brief courses ($g = 0.47$, $SE = 0.07$, 95%-CI [0.28, 0.66], $p < .0001$, $k = 41$) and not from single-method training ($g = 0.61$, $SE = 0.09$, 95%-CI [0.18, 1.03], $p < .0001$, $k = 48$). The effectiveness of the nine manipulation methods varied to a greater extent. On average, cultural exposure ($g = 0.66$, $SE = 0.15$, 95%-CI [0.30, 1.03], $p < .0001$, $k = 8$) and meditation ($g = 0.66$, $SE = 0.13$, 95%-CI [0.38, 0.94], $p < .0001$, $k = 19$) were similarly highly effective, whereas drug use was least effective ($g = 0.10$ $SE = 0.06$, 95%-CI [-0.08, 0.29], $p = .26$, $k = 20$) and did not significantly enhance creativity. Simultaneously, the heterogeneity in effect sizes of studies that used drugs to enhance creativity was lowest, $\tau^2 = .02$, $SE = .02$, $I^2 = 26.24\%$, suggesting that the effect is similar across different drug types. Despite the relatively narrow confidence intervals of the effect sizes *g*s, the prediction intervals are wider. Recall that they estimate in which 95% of the effects of future similar studies would fall (Borenstein et al., 2017; IntHout et al., 2016). For example, the prediction interval for single methods ranges from -1.43 to 2.64, suggesting that some future studies will not find that complex courses enhance creativity. In contrast, others will find large effects (i.e., $g \geq .80$). The latter is especially likely for cultural exposure (95%-PI [0.21, 1.15]), meditation (95%-PI [0.07, 1.25]) and open-thinking techniques (95%-PI [0.09, 1.11]), as those PIs include only positive values. The most diverse results will likely arise from single methods (95%-PI [-1.43, 2.64]), creativity awareness (95%-PI [-1.22, 1.58]), and physical activity (95%-PI [-1.18, 1.69]). The prediction intervals include negative effect sizes of up to -1.43. This suggests that some future studies will find that these creativity enhancement methods *reduce* creativity (i.e., participants in the control condition will show, on average, higher creativity scores than participants in the experimental enhancement condition). However, the majority of future studies are likely to find small-to-large positive effects.

---- insert Table 4 about here ---

In a next step, we divided the enhancement methods further (Table 5). For example, if a trainer was present during the enhancement method, the effect was stronger (g = 0.62, SE = 0.06, 95%-CI [0.52, 0.74], p < .0001, k = 121) then if no trainer was present (g = 0.47, SE = 0.06, 95%-CI [0.34, 0.58], p < .0001, k = 211). A comparison between training and manipulations revealed that manipulation methods were more effective in the presence of a trainer (gs = 0.67 vs 0.38), whereas a training being present had little impact on the effectiveness of trainings (gs = 0.61 vs 0.60; Table 6). An analysis of time pressure was not possible as we were only able to derive four effect sizes from studies which put participants under time pressure. Figural methods (g = 0.76, SE = 0.05, 95%-CI [0.58, 0.93], p < .0001, k = 86) were more effective than verbal, spatial, or cognitive-perceptive methods, with the latter being the least effective (g = 0.33, SE = 0.04, 95%-CI [0.17, 0.48], p < .0001, k = 73). Furthermore, convergent thinking methods were more effective (g = 1.23, SE = 0.249, 95%-CI [0.14, 2.32], p < .0001, k = 11) than methods that did not rely on either convergent or divergent thinking (g = 0.37, SE = 0.011, 95%-CI [0.23, 0.51], $p < .0001$, k = 130). However, the eleven effect sizes of convergent thinking showed a wide spread, resulting in a 95%-PI of [-1.92, 4.38]. Moreover, studies from Australia, New Zealand, or Argentina did not find a significant effect of creativity enhancement (g = 0.16, SE = 0.13, 95%-CI [-0.14, 0.45], p > .10, k = 10), while studies from three other world regions did (Europe: g = 0.51, SE = 0.06, 95%-CI [0.39, 0.63], $p < .0001$, k = 167; North America: g = 0.52, SE = 0.07, 95%-CI [0.438, 0.66], $p < .0001$, k = 77; Asia: g = 0.68, SE = 0.013, 95%-CI [0.42, .93], $p < .0001$, k = 77). Differences in the 4-P framework, specific enhancement efforts (e.g., cognitive, social), and sample characteristics (e.g., average) had little impact.

---- insert Table 5 about here ---

The aforementioned moderator analyses differed in part when analyses were conducted for training and manipulation separately (as reported above, trainings were more effective than manipulations, gs = 0.61 vs. 0.45). The total amount of variability was substantial, with τ^2 = .21, SE = .03, and I^2 = 86.18%, for training and τ^2 = .15, SE = .02, and I^2 = 72.74% for manipulation. This justified the use of subgroup analyses, which also shed some light on why trainings were, on average, more effective than manipulations (Table 6). Furthermore, the *Person* focus of the 4-P framework was also more effective for training, B = .25, p = .004, compared to manipulations. Finally, in particular, *cognitive,* B = .19, p = .04, enhancement efforts were more effective if the enhancement method was a training program and not a manipulation.

---- insert Table 6 about here ---

Creativity assessment methods. To explore whether the effectiveness of the enhancement is dependent on how creativity is assessed, we compared different types of assessment (Table 7).

The impact of enhancement methods on divergent thinking tests ($g = 0.54$, $SE = .04$, 95%-CI [0.45, 0.63], $p < .0001$, $k = 275$) was similar to the impact on other creativity tests ($g = 0.47$, $SE = .14$, 95%-CI [0.27, 0.67], $p < .0001$, $k = 57$, Table 6).

The time between the enhancement method and the post-test ranged from 0 to 730 days ($M = 25.7$ days, *median* = 0). However, the mean effect sizes did not significantly differ depending on whether creativity was assessed on the same day, $g = 0.452$, $SE = .03$, 95%-CI [0.40, 0.63], $p < .0001$, $k = 233$, or at a later time point, $g = 0.56$, $SE = .06$, 95%-CI [0.44, 0.68], $p < .0001$, $k = 89$. On average, the effects of training after over 100 days were still comparable to the overall mean effect size, $g = 0.74$, $SE = .21$, 95%-CI [0.44, 0.1.06], $p < .0001$, $k = 28$ (no manipulation study employed a follow-up measurement with such a delay), suggesting long-lasting effects of the training methods. However, this overall positive effect comes with a great amount of variability and heterogeneity between studies, 95%-PI [-0.69, 2.55].

Next, we re-ran the same analyses for creativity assessment methods but separately for training and manipulation studies (Table 6). The effect sizes show differences, however almost none were significant on the multi-level meta-regression (with the exception of *Person* and *cognitive* already mentioned above). Further, a significant difference could be found between trainings and manipulations for those who have not trained the assessment directly ($B = .18$, $p = .03$)

---- insert Table 7 about here ---

Sample Characteristics. Sample type (occupational vs. student), age, and gender did not impact the overall effectiveness of the enhancement methods (cf. Table 5). Some differences emerged on the training vs. manipulation level, although none are significant (cf. Table 6).

Discussion

Across 332 effect sizes derived from 84 studies, we found that creativity can, on average, be enhanced through various forms of training and manipulation. Although all studies in this review follow the same aim – improving creativity – the variability between effect sizes was substantial. This reduces the informative value of an overall mean effect size. The overall mean effect size strongly depends on the number of studies included in each subgroup. For example, if more studies had investigated the impact of a less effective enhancement method, the overall mean effect would have been smaller. That being said, we only report and interpret the overall mean effect size over all studies to allow comparisons with prior meta-analyses. In the remainder of the Discussion, we then focus on subgroup analyses, as we believe they are more meaningful.

The overall mean effect was of medium size, g = 0.53, which can be converted into the more informative Cohen's U3 (Hanel & Mehler, 2019): 70.09% of the participants in the enhancement group were more creative than the average person of the control group. Our aggregated effect size estimate points, as predicted in Hypothesis 1, in the same direction as the one found by Scott et al. (2004a) but was smaller. This can partly be attributed to different inclusion criteria: We included more less effective enhancement methods (e.g., drugs). Further, the relatively large prediction intervals of our overall mean effect size estimate exacerbate a comparison: 32% of the studies we included found an effect size larger than the one found by Scott et al. of 0.68. Together, this hampers a meaningful comparison of the two meta-analyses.

To test which enhancement methods are most effective, we divided them into twelve categories. Of these, all the methods, except drugs, enhanced creativity. Complex training programs, meditation and cultural exposure are comparably highly effective. However, the prediction interval for the mean effect size of complex training programs suggests that some future studies will also find non-significant results with effect sizes around 0, even though the majority of studies will find effect sizes that are at least small ($g \geq 0.20$) and can range up to 1.86. While manipulation methods were, on average, less effective than trainings, meditation, cultural exposure and open thinking techniques were among the most successful manipulations. Especially for those three, the prediction intervals suggest that future studies will likely find effects of at least a small magnitude (Cohen, 1992). Across training programs and manipulations, methods that focused on convergent thinking and used figural material were, on average, more effective. Importantly, we did not find evidence of publication bias, which reinforces confidence in the findings. Below, we describe our findings in detail and discuss limitations and implications.

Creativity Enhancement Methods

This section discusses which attributes of enhancement methods were more and which were less successful. The results of the multi-moderator analysis showed that studies using figural types were more successful in enhancing creativity than studies which did not use figural types. This effect could be due to pictures eliciting more emotions compared to words (Holmes & Mathews, 2005), which supports broader idea generation. Conversely, associations based on words are tied to the learned word associations. Usually there are clear associations to words that pop up first: Dog follows cat, light follows dark. This effect could limit idea generation processes based on words, such as the AUT, compared to pictures (Wettler et al., 2005).

The multi-moderator analysis further showed studies which focused on convergent thinking were more effective than those focused on divergent thinking. Problem solving, which is a form of convergent thinking, could be better trainable as it relies on recalling knowledge, compared to divergent thinking, which requires to think of less common associations (Cropley, 2006). Finally, the multi-moderator analysis revealed that effects were larger on fluency and originality than on other operationalization of divergent thinking measures. Creative enhancement methods impacted more strongly the number of ideas generated (fluency) and the uncommonness of ideas (originality) than the number of details provided (elaboration) and the number of different categories in which the ideas fall (flexibility). Future research is needed to get a better understanding of the underlying mechanisms. Overall, our results can help to decide on what to focus when designing creativity enhancement methods.

The results displayed in Tables 4 and 6 from single-moderator analysis show wide prediction intervals for most subgroups. This heterogeneity can be partly attributed to differences between trainings and manipulations (Table 6). Therefore, it is more sensible to focus additionally on the training vs. manipulation distinction. For example, comparing the four P's of creativity, training addressing the *person* were more effective than manipulations, whereas the effectiveness of other enhancement methods did not differ depending on the P-focus. This also indicates that enhancement methods that manipulate the *place* around people, such as cultural exposure, showed a similarly positive overall effect on people's creative performance as methods from the other three categories.

The enhancement efforts did not differ significantly from each other. Most methods addressed the *cognitive* aspects of the creative performance, followed by *social* and *motivational* efforts. Training programs were more effective than manipulations with regard to cognitive efforts. In contrast to Scott et al.'s (2004a) findings, we found that methods addressing *personality*, which might be most comparable with the "Attitude/Behavior" training type of Scott et al.'s research, are as effective as other methods (Scott et al. found the lowest average effect size estimates for this assessment category). Although methods that foster the awareness of creativity, such as priming and “be creative” instructions, are less effective, they are still reasonably effective considering the low effort required by the manipulation. Thus, a simple prime can improve creative performance in the short term. This finding is especially relevant in organizational settings as it suggests that a brief reminder to be more creative before a, for example, brain-storming session can result in a beneficial output. However, the dispersion of effect sizes was quite wide, suggesting that a minority of future studies will not find a significant effect or even a negative effect of such enhancement methods.

Additionally, it is unclear whether such short-time manipulations would still be effective when applied repeatedly (e.g., when employees receive daily reminders to be creative), as no manipulation study used a repeated exposure design. Most manipulation studies miss a detailed explanation of why a specific manipulation has a (positive) impact on creative performance. This creates a great gap for future studies to analyze the cognitive basis of this creative mindset in more detail. Understanding this mindset might also only be the start, as the underlying cognitive mechanisms might be diverse for the different types of manipulations.

Finally, enhancement methods focused on improving convergent thinking were more effective than those focused on divergent thinking. This is especially interesting, as almost all studies focusing on convergent thinking used manipulations. Methods that included both convergent *and* divergent thinking were especially effective for training. This effect might be explained by the fact that convergent tasks are more likely to have concrete methods and guidance. In contrast, divergent tasks may depend more on situational influencing factors due to the need for broad associations.

Creativity Assessment Methods

A unique focus within this meta-analysis was placed on which type of creativity was assessed. The vast majority of studies assessed divergent thinking. A detailed analysis of the studies assessing divergent thinking revealed different effects for the subscales of these measures. *Fluency* and *originality* were assessed most often, followed by *flexibility.* Our findings suggest that all three can be enhanced to a similar extent. *Elaboration* benefited least from enhancement methods but could still be enhanced on average. However, the prediction interval suggests that a few future studies will find negative effects, especially in the case of training. *Quality*, which was rarely assessed, showed almost no enhancement effect. Overall, this pattern indicates that the different enhancement methods have similarly positive impacts on the diverse aspects of divergent thinking. This pattern might indicate that enhancement methods positively impact the amount and breadth of ideas generated but less so on the actual quality of the idea. This is important for practitioners as it helps them to get realistic expectations of what enhancement methods in the workplace can achieve.

Furthermore, we found that when the *product* categories of enhancement and assessment matched, the enhancement method was more effective. Similarly, the effect sizes were larger when *verbal* and *figural* types of enhancement and assessment matched. Thus, the more similar the assessment is to the enhancement method, the stronger the effect size found within the sample. This suggests that enhancement methods should generally be chosen to be relevant, task-specific, and similar to the kind of task that is aimed to be improved. This congruency effect aligns with findings from cognitive psychology: Retrieval is typically higher when the learning and testing stimuli match (Cooper et al., 1992; Jolicoeur, 1987; & Huff, 2016).

Interestingly, we found no congruency effects, suggesting that the enhancement methods had showed similar results unrelated to the (mis)match between the type of assessment and type of thinking (i.e., convergent vs. divergent). Also interesting was the overall positive effect found for studies that did not train the assessment directly. This suggests that the training methods provide a learning experience which allows the participant to generalize the learning outcome to other contexts. The positive effect of training methods also lasts over time, at least for the subset of studies conducting follow-up measures.

Study and Sample Characteristics

The study design itself was unrelated to the effectiveness of the enhancement methods. Specifically, whether studies used a within- or between-subject design or a mixed 2×2-design did not impact effect sizes. However, the designs differ in their predictive power and quality to assess treatment outputs. We believe that the best way to test whether a specific method enhances creativity is a mixed design of 2 (pre vs. post) × 2 (treatment vs. control group). A between-subject design itself does not reveal individual improvements. A within-subject design alone cannot rule out testing effects (i.e., whether the training or manipulation exerted an effect or whether participants merely improved because they completed a similar creativity test twice). At least 36% of all effect sizes included in the present meta-analysis were based on a 2×2-design. Furthermore, 59% of effect sizes were derived from between-subject designs and 41% from within-subject designs. While we did not find that the design itself influences the effectiveness of creativity enhancement methods, the conclusions derived from 2×2 design studies are typically more robust.

Further analyses revealed that the effectiveness of enhancement methods did not vary between demographic samples. Student samples benefitted similarly like occupational samples from manipulations and training. This challenges studies indicating that it is difficult to generalize from student samples to other populations (Hanel & Vione, 2016; Peterson, 2001).

People tested in Europe, North America, or Asia benefitted similarly from enhancement methods. However, studies conducted in New Zealand, Australia, and Argentina found no overall mean effect, with a high spread across the ten available effect sizes. The latter finding is only based on ten effect sizes, so future research is needed to replicate this. Nevertheless, as the countries with larger and lower effect sizes are from Western and non-Western countries this suggests that creative enhancement methods work for people from WEIRD and non-WEIRD countries (cf. Henrich et al., 2010). However, as a limitation, we could not find any studies from relatively deprived, lower-income countries, meaning that more research is needed to test whether the same creative enhancement methods are beneficial to people in nations with much lower levels of prosperity.

Research on gender differences in creative abilities has produced inconclusive results (for an overview, see Abraham, 2016). Nevertheless, our results indicate that women and men benefitted similarly from training and manipulations.

Limitations

We aimed to obtain a comprehensive review of creative enhancement methods. However, we did not use the search engine ProQuest, which means we might have missed some dissertations and theses, as ProQuest contains even more dissertations and theses than Dissertation Abstracts International, which we included in our literature search. We included studies with only primary standards of sufficient quality. Although stringent criteria are an essential requirement for meta-analytic procedures, this leads to exclusions of studies that have not sufficiently described their methods and results. It can be assumed that such studies are distributed evenly across the different categories and variables we assessed and upon which our analysis was based. However, we cannot rule out that excluding low-utility studies might have been a source of bias, as it may have led to certain types of enhancement being underrepresented.

The distinction we make between training and manipulation studies is pragmatic and theoretical. Although we apply clear criteria for both categories, these criteria did not arise from the original papers and could also be defined differently. It could be further argued that as training methods could (and most cases most probably would) impact the person's creative mindset, a continuum from training to manipulation would be more appropriate. Unfortunately, not enough information could be extracted from the primary studies to create such a continuous variable. Therefore, we applied the dichotic dimension pragmatically. The key conclusions reached from this approach are that both methods are effective, but that training methods are more effective. More relevant than this broad distinction for researchers and especially practitioners is presumably the fine-grained categorization of the enhancement methods into 12 categories (e.g., complex training, drugs), which provide more specific guidance.

The overall mean effects sizes for most of the 12 categories range from small to medium with relatively narrow confidence intervals. However, it is essential to keep in mind that the prediction intervals often included zero and sometimes even small or medium negative effect sizes, which is in line with many other meta-analyses (IntHout et al., 2016). This implies at least two things. First, there is substantial variance between studies that we have not captured, despite our numerous attempts to categorize studies (e.g., based on enhancement methods, congruence between materials and test, demographics). While many of our attempts were successful in that the overall mean effect sizes differed between our categories, the variability within categories was, in most cases, larger than between categories (e.g., training vs. manipulation). This is in line with primary studies in which variability within groups (e.g., within countries) is mostly substantially larger than between groups (e.g., between countries) for many psychological variables such as values, beliefs, personality traits, or moral foundations (e.g., Fischer & Schwartz, 2011; Saucier et al., 2015).

Second, the effect sizes of future studies will likely show substantial variability. While on average, they will be close to the overall mean effect sizes we found (assuming similar methods and context). Some will be towards the lower end of the prediction intervals and others towards the upper end. Some future studies will find no effect of creativity enhancement or even that a method reduces creativity, while others will find substantial effects. However, why could certain methods that aim to enhance creativity in specific instances actually reduce it? There are numerous possible explanations, such as induced lack of motivation, frustration, stress, or stereotype activation. For example, one enhancement category with a relatively great chance of finding some negative effect sizes in future studies is creative awareness. Making people aware that they have to come up with something creative on the spot might frighten and stress some participants, possibly those low on creative self-efficacy and high in performance anxiety, which could reduce their creativity (Byron & Khazanchi, 2011). Further, some participants might perceive physical activities as uncomfortable or fatiguing, worsening their creativity.

We described, analyzed, and discussed many of the variables used in the primary studies in detail. However, variables that were mainly absent from primary studies can also be informative. For example, although it has been postulated that prior creative abilities moderate the effectiveness of an enhancement method (e.g., Agnoli et al., 2018), prior creative ability was rarely assessed in the primary studies. Only two studies explicitly used a gifted study sample from arts education (Bonnardel & Didier, 2016; Ulger, 2016). Both studies showed mean effect sizes substantially above our meta-analytical estimate, suggesting an improved ability to enhance creative performance in gifted participants. However, based on the data set, it was not possible to run an analysis on the levels of giftedness in the *little-c* vs. *Big-C* context. Furthermore, alternative mechanisms might explain the effects found for some enhancement methods, such as enhanced motivation or concentration. For example, manipulations using virtual reality gear might increase task motivation, leading to better performance on creativity measures without actually increasing creative abilities. In some instances, concentration might be the underlying mechanism. For example, meditation might enhance the ability to concentrate on a specific task, leading to better test performances. Future studies should examine such parallel explanations for treatment effects.

Another limiting factor is the time between training or manipulation and the measurement of creativity (post-measure). For 70% of the effect sizes, creativity was assessed on the same day as the (final) enhancement session. According to the *honeymoon effec*t of training, the highest effects are found shortly after the training, but they fade rapidly over time (e.g., Agnoli et al., 2018). In this respect, it is noteworthy that studies with a longer time until post-measurement showed similar overall treatment effect sizes to those with measurements on the same day of enhancement. However, we cannot derive a clear conclusion about how quickly the different enhancement effects fade.

It has repeatedly been shown that selective publishing of significant findings and other questionable research practices such as *p*-hacking bias the scientific psychological literature (e.g., Simonsohn et al., 2014). While none of the tests we used showed clear signs of publication bias, none of them is perfect. They might fail to detect publication bias, especially in the presence of significant heterogeneity (Peters et al., 2010). Furthermore, the "Many Labs" replication project revealed that priming studies are mainly not replicable (Klein, 2014). We also included studies that used direct creativity primes, which raises the possibility that our meta-analysis is biased and that the tests we used to detect this bias failed. Nevertheless, we assume that studies on creativity enhancement are less prone to publication bias: Only 64 out of 146 effects reached statistical significance at $p < .05$ (44%), which is far below the average of at least 90% in psychological science (Fanelli, 2010; Open Science Collaboration, 2015). While this might seem surprising at first glance, based on our reading of the articles, researchers were able to publish findings even if only one of several sub-scores of creativity measurements reached statistical significance (e.g., elaboration, flexibility, fluency, originality). By averaging across all indicators, the effect might have become non-significant. Nevertheless, many studies on creativity enhancement are based on small samples. We, therefore, recommend that future research focuses more on larger sample sizes and applies a repeated measures design to reach more powerful conclusions about how enhancements work over more extended periods.

Conclusion

This meta-analysis shows that creativity in adults can be enhanced in multi-faceted ways. Overall, more complex, comprehensive but also more resource-consuming training programs are more effective. However, some manipulations are as effective as more complex training, even though they take less time and other resources to implement. This has important implications for practitioners and educators because it points to two strategies that can be applied to enhance individuals' creativity. First, complex creativity training can have a long-lasting positive impact on individuals' creative performance. Thus, it would be beneficial if schools, universities, and even organizations included complex creativity training more frequently (Jackson et al., 2006). Such training can equip individuals with a broad, trans-situational understanding of creative thinking and relevant techniques to form associations and evaluate them. The acquired knowledge, however, can get lost when not used. Our analysis shows that extensive training is not necessary to improve creativity because short-term actions like meditation sessions and open-thinking techniques are also effective. If the creative output is to be optimized in a specific situation (like workshops, meetings), this can be done very effectively using short manipulations.

Furthermore, manipulations such as cultural exposure show the potential to increase one's creative performance without conscious effort. Following the effectiveness of some manipulation studies, the second enhancement strategy could be a continuous on-point stimulation of a creative mindset integrated into the work processes of individuals. In a school setting, this might be realized by integrating short divergent thinking tasks whenever a creative learning session is scheduled. In occupational settings, this might be realized by consciously integrating time for brief interventions like meditation or single creativity methods. This might decrease the need to invest time and money into complex courses that might miss a connection to the actual work but still positively impact students' and employees' creative competencies.

Taking the results together, the materials used to enhance creativity should be figural and/or verbal. When the focus is on the creative person or particular cognitive abilities, a training program instead of a manipulation is likely more beneficial. In contrast, social aspects, like creative group work, are more efficiently enhanced through manipulations. Furthermore, the decision for or against a particular creativity assessment method should be a conscious process for researchers or other relevant parties (e.g., human resource departments in organizations). It should be critically reported in primary studies, as the assessment itself will most likely impact the effect size.

The compilation of studies analyzed here reflects a trend within research to explore diverse methods further to enhance creativity. Most of the manipulation studies were published after 2016. It is plausible to expect that more diverse methods will be explored in the future. Unfortunately, methods and techniques using the digital context were utterly missing in the literature we analyzed, which is in total contrast to the increasing need and growing usage of digitalized learning methods in an educational and occupational context. A transfer of methods to the online and virtual world might result in different effects. However, more research is needed to compare online with offline enhancement. This shows an excellent potential for future studies.

Improving creative performance is not a question of applying one perfectly designed training session; instead, it requires an understanding of and thus adaptation to the particular setting and the cognitive and motivational prerequisites of the creatively active person. Much is already known about the mechanisms underlying the variety of methods, but more refined analyses are needed to improve their effectiveness further.

Tables and Figures

Table 1

Overview of variables assessed for the enhancement methods and creativity assessments

Moderators	Explanation
Enhancement methods	
Training	Enhancement methods with a systematic process through which a person acquires specific skills
Manipulation	Enhancement methods with short-term impact on creative thinking, participants are typically unaware of the manipulations impact on creativity
Trainer present / not present	Indication whether a trainer was present during the execution of the enhancement method
Type of enhancement	
Figural	Enhancement method includes drawing, sketching
Verbal	Enhancement method includes talking, reading
Spatial	Enhancement method includes moving around, dancing
Cognitive-perceptive	Enhancement method includes brain stimulation, drugs, meditation
Focus on divergent-convergent thinking spectrum	
CT	Enhancement method focuses on convergent thinking mainly
DT + CT	Enhancement method is based on both, convergent and divergent thinking

DT	Enhancement method focuses on divergent thinking mainly
None	Enhancement method is not focused on convergent or divergent thinking

Focus within the 4-P framework

Product	Primary goal of the enhancement method is the production of a creative output
Process	Specific method was taught, such as De Bono’s six thinking hats
Press	Primary goal of the enhancement method addresses the environmental conditions
Person	Enhancement method alters cognitive state or the person’s self-perception of the creative concept

Enhancement efforts

Personality	Enhancement method aims to alter creative self-perception and/or attitudes towards the concept of creativity
Social	Enhancement method includes teamwork or a social setting with interactions
Motivational	Enhancement method aims to increase the motivation for creative work
Cognitive	Enhancement method focuses on thinking and learning
Other	None of the aforementioned enhancement efforts apply

Sample characteristics

Occupational	Majority of the study participants are employed.
Student	Majority of the study participants are students.

< 21.26yrs	Mean age of the sample is younger than 21.26 years old.
> 21.26yrs	Mean age of the sample is older than 21.26 years old.
> Women	Majority of the study participants are female.
> Men	Majority of the study participants are male.
Country of Origin	
Asia	Majority of the study participants come from Asia.
North America	Majority of the study participants come from North America.
Europe	Majority of the study participants come from Europe.
Diverse	Majority of the study participants come from other countries, like New Zealand, Australia and Argentina
Creativity assessment	
Assessment trained	Close match between applied enhancement method and the tasks used to assess creative performance
Time of post-assessment	
same day	Creativity assessment was done at the same day of the (last) enhancement method.
>1 day	Creativity assessment was done at least one day after the (last) enhancement method.
>100 days	Creativity assessment was done at least 100 days after the (last) enhancement method.
Class of assessment	

DT	Assessment method is based on divergent thinking
Non-DT	Assessment method is not based on divergent thinking and includes convergent thinking, cognitive style, creative performance and self-report measures

Type of assessment

Verbal	Assessment method includes talking, reading
Figural	Assessment method includes drawing, sketching
Item	Assessment method is based on items

Aspect of divergent thinking measurement

Originality	Assessment of the originality of a creative output
Fluency	Total number of responses
Flexibility	Breath of reported ideas
Elaboration	Specifics and expansion of ideas
Quality	Quality of reported ideas and measurement results

Focus within the 4-P framework

Product	Assessment method focuses on a final product
Process	Assessment method focuses on the performance
Press	Assessment method focuses on the surrounding environment
Person	Assessment method focuses on the actor

Testing efforts

Personality	Assessment method aims to alter creative self-perception and/or attitudes towards the concept of creativity
Social	Assessment method includes teamwork or a social setting with interactions
Motivational	Assessment method aims to increase the motivation for creative work
Cognitive	Assessment method focuses on thinking and learning
Other	None of the aforementioned testing efforts apply

Table 2

Multi-level meta-regression with all moderators as predictors

	B	SE	p-value
Intercept	0.41	0.64	0.5184
Manipulation vs Training	-0.53	0.28	0.0591
No trainer vs trainer	-0.21	0.26	0.4060
Type of enhancement			
Not figural vs figural	0.61	0.23	0.0084
Not verbal vs verbal	0.42	0.27	0.1228
Not spatial vs spatial	0.37	0.23	0.1084
Not Cognitive-perceptive vs perceptive	0.10	0.37	0.7782
Focus on divergent-convergent thinking spectrum			
Divergent vs convergent	1.04	0.36	0.0046
Divergent vs convergent and divergent	-0.44	0.33	0.1822
Divergent vs none	-0.35	0.19	0.0629
Focus within the 4-P framework			
No person vs person	-0.23	0.28	0.4129
No product vs product	-0.18	0.34	0.5936
No place vs place	0.52	1.21	0.6699
No process vs process	-0.03	0.30	0.9072
Enhancement efforts			

No cognitive vs cognitive	0.19	0.34	0.5685
No social vs social	0.18	0.25	0.4897
No motivational vs motivational	0.22	0.20	0.2710
No personality vs personality	0.06	0.24	0.7955
No other vs other	-1.41	1.11	0.2049
Sample characteristics			
Occupational vs student	0.30	0.16	0.0645
Mean age of sample	-0.02	0.01	0.1285
Percentage of women	0.00	0.00	0.6478
Country of Origin			
Europe vs North America	0.23	0.20	0.2420
Europe vs Asia	0.32	0.19	0.0939
Europe vs other	-0.22	0.36	0.5460
Creativity assessment			
No Assessment trained vs Assessment trained	0.19	0.32	0.5566
Time of post-assessment	0.00	0.00	0.8913
Class of assessment			
Cognitive styles vs creative performance	-0.25	0.29	0.3948
Cognitive styles vs convergent thinking	-0.25	0.26	0.3296
Cognitive styles vs divergent thinking	-0.38	0.27	0.1654
Cognitive styles vs self-report	-0.04	0.89	0.9671
Type of assessment			

Not verbal vs verbal	0.18	0.23	0.4359
Not figural vs figural	0.17	0.24	0.4742
Not items vs items	0.73	0.53	0.1668
Aspect of divergent thinking measurement			
No fluency vs fluency	0.18	0.08	0.0255
No originality vs originality	0.20	0.08	0.0118
No elaboration vs elaboration	-0.01	0.10	0.9291
No flexibility vs flexibility	0.03	0.09	0.7255
No quality vs quality	-0.11	0.18	0.5613
Focus within the 4-P framework of assessment			
No process vs process	0.16	0.52	0.7615
No cognitive vs cognitive	0.17	0.32	0.5930
No personality vs personality	-1.41	0.92	0.1255

Note. All predictors with “vs” were categorical and included as factors. For more details on the predictors, see Table 1. df = 188 for all predictors.

Table 3

Overview of samples included in the analysis and their characteristics

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Agnoli (2018)	3	0.06	0.05	80	2	4		Neurofeedback - alpha waves	6	AUT	1	21	1
	3	0.09	0.10	80	1	4		Neurofeedback - alpha waves	6	AUT	1	21	1
Barrett (2011)	1	-0.13	0.03	129	1	2	Informational training on day-to-day problems		3	Creativity of problem-solving tasks	3	18.7	1
	1	0.00	0.03	129	1	2	Interpersonal training on day-to-day problems		3	Creativity of problem-solving tasks	3	18.7	1
Baruah (2008)	2	0.71	0.03	165	1	2	Brainstorming		3	Brainstorming	1	21.5	1
Basadur (2000)	2	0.61	0.01	85	2	2	Creative process training		2	Ideational skill – open-ended problems	1		2

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Benedek (2006)	1	0.52	0.17	11	1	2	Verbal C training		1	VKT	1	31	2
Bonnardel (2016)	1	1.20	0.14	32	1	5	CQFD: Brainstorming with focus on broad, wild ideas		1	Results from training	1		1
Byrge (2013)	6	0.92	0.06	28	2	2	3D didactic		2	TTCT	1	23.9	1
Byrge (2015)	3	0.44	0.00	180	1	2	Embodied C-Training		1	TTCT	1	22.17	1
Campion (2014)	4	-0.37	0.15	28	1	4		Dancing	7	TTCT	1	20.4	1
	4	0.04	0.15	27	1	4		Music	5	TTCT	1	20.4	1
	4	0.00	0.15	27	1	4		Cycling	7	TTCT	1	20.4	1
	4	0.30	0.07	28	2	4		Dancing	7	TTCT	1	20.4	1
	4	0.38	0.08	27	2	4		Music	5	TTCT	1	20.4	1
	4	0.15	0.08	27	2	4		Cycling	7	TTCT	1	20.4	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Chiu (2014)	3	0.43	0.04	94	1	2		Controlled writing	12	UUT	1	19.19	1
Chiu (2015)	3	0.54	0.10	39	1	1		Over-inclusive thinking training	4	UUT	1	21.03	1
	3	0.17	0.08	49	1	1		Over-inclusive thinking training	4	UUT	1	21.26	1
Chrysikou (2006)	1	1.10	0.07	70	1	2		Alternate Categories task practiced	12	Insight Problems	2	19.06	1
	1	0.84	0.11	40	1	2		Alternate Categories task practiced	12	Insight Problems	2	20.53	1
Colzato (2012)	5	0.52	0.11	19	1	2		Meditation - focused attention	8	AUT /RAT	1 / 2		2
Colzato (2017)	5	0.79	0.11	19	1	2		Meditation - focused attention	8	AUT /RAT	1 / 2	43.7	2
Colzato (2018)	9	0.58	0.05	80	1	2		Vagus nerve stimulation	6	AUT / RAT / CPS / Idea selection task	1 / 2 / 3	20.96	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Ding (2014)	1	1.18	0.12	40	1	1		Integrative Body-Mind Training	8	TTCT	1	21	1
Ding (2015)	1	0.82	0.05	84	1	1		Integrative body-mind training	8	TTCT	1	21	1
Dyson (2016)	4	0.37	0.11	39	1	2	Tabletop role-playing game (TRPGs)		2	ATTA	1	20.64	1
	4	0.14	0.05	39	2	2	Tabletop role-playing game (TRPGs)		2	ATTA	1	20.64	1
Eskine (2018)	1	0.71	0.08	16	2	2		Listening to Hip-Hop	5	RAT	2	19.8	1
Farah (2009)	4	0.29	0.13	16	1	2		Adderall	9	AUT / RAT /group embedded figures test / TTCT	1 / 2 / 4	21.25	1
Fink (2015)	1	0.02	0.04	24	2	2	CreTrain		1	AUT	1	24.04	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	1	0.17	0.04	29	2	2	CreTrain		1	AUT	1	24.04	1
Flood (2006)	1	-0.06	0.07	57	1	4	Creative group Sessions		1	SPI	4	76.46	2
	1	0.01	0.03	57	2	4	Creative group Sessions		1	SPI	4	76.46	2
Gruzelier (2014)	1	-0.18	0.12	33	1	2		Alpha-theta neurofeedback	6	Insight Problems	2		1
	1	-0.10	0.13	32	1	2		Heart rate variability	12	Insight Problems	2		1
Gvirts (2017)	6	-0.01	0.06	36	1	2		Methylphenidate	9	AUT / TTCT	1	25.36	1
Hargrove (2015)	3	1.44	0.06	88	1	4	Creativity course + Metacognition		1	DT - similarities / RAT	1 / 2		1
	3	0.79	0.03	88	2	4	Creativity Course + Metacognition		1	DT - similarities / RAT	1 / 2		1
Hocking (2017)	3	-0.25	0.05	78	1	2	Six Hats		3	Six Hats	1	19.5	1
	3	0.25	0.05	78	1	2	Six Men		3	Six Men	1	19.5	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Huang (2018)	1	2.69	0.04	116	2	2	RAT		3	RAT	2	20	1
Ilieva (2013)	2	0.18	0.02	46	2	4		Adderall	9	RAT / embedded figures	2 / 4	24	1
Im (2015)	2	1.17	0.04	45	2	2	Creative thinking course		1	TTCT	1	21.36	1
Jarosz (2012)	1	0.68	0.11	40	1	2		Alcohol	9	RAT	2		1
Karakelle (2009)	3	0.99	0.15	30	1	4	Creative drama		1	DT	1	24.5	1
	3	0.54	0.08	30	2	4	Creative drama		1	DT	1	24.5	1
Karkockiene (2005)	3	0.97	0.03	160	1	2	Creativity course		1	TTCT	1	23	1
Karpova (2011)	1	1.11	0.01	114	2	2	Creative thinking course		1	TTCT	1	21.38	1
Karwowski (2008)	4	0.67	0.03	48	2	1	Role-play training in C		2	TCI	1	21.9	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Kienitz (2014)	1	0.67	0.15	28	1	2	CCBP		2	TTCT	1	29.21	2
	1	0.94	0.10	28	2	2	CCBP		2	TTCT	1	29.21	2
Kuo (2019)	4	1.01	0.04	45	2	2	Design thinking course		1	ATTA	1		1
Leung (2010)	2	0.02	0.16	27	1	2		Cultural exposure - China	11	Story writing / finding analogies	3	19.05	1
	2	0.95	0.18	26	1	2		Cultural exposure – China + USA	11	Story writing	3	19.05	1
	2	0.60	0.15	28	1	2		Cultural exposure - China within USA	11	Story writing	3	19.05	1
Lewis (2013)	4	0.54	0.10	41	1	2		Improvisation training	4	AUT	1	22	1
	4	0.78	0.07	41	2	2		Improvisation training	4	AUT	1	22	1
Lin (2016)	4	0.51	0.14	30	1	1		EEG neurofeedback: enhance a tone	6	TTCT-Chinese	1	20.8	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	4	0.62	0.14	30	1	1		EEG neurofeedback: suppress a tone	6	TTCT-Chinese	1	20.8	1
Lustenberger (2015)	1	0.54	0.06	20	2	2		Transcranial altering current stimulation	6	TTCT	1	20.9	1
	1	0.09	0.05	20	2	2		Transcranial altering current stimulation	6	TTCT	1	20.5	1
Malycha (2017a)	1	0.42	0.04	114	1	2	Mind-mapping		3	AUT-Mind-map	1	23.94	1
Malycha (2017b)	3	1.30	0.12	40	1	2	Mind-mapping		3	TTCT-improvement task - Mind-map	1	22.71	1
	3	0.99	0.11	40	1	2	Random-input		3	TTCT-improvement task - Random Input	1	22.71	1
	3	1.93	0.15	40	1	2	Random-map		3	TTCT-improvement task - Random map	1	22.71	1
Marcy (2007)	1	0.11	0.02	180	1	2	Social systems problem-solving course		3	Social problem solving	1	19	2

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Meinel (2018)	2	0.17	0.04	223	1	2	Course creativity and design in innovation management		1	ATTA	1	24.46	2
	2	0.75	0.01	223	2	2	Course creativity and design in innovation management		1	ATTA	1	24.46	2
Merill (2014)	1	0.58	0.07	80	1	4	Creativity course		1	TTCT	1	19	1
	1	0.20	0.01	80	2	4	Creativity course		1	TTCT	1	19	1
Mogan (2019)	4	0.21	0.09	46	1	2		Synchrony movements	7	AUT / RAT	1 / 2	19	1
	4	0.01	0.09	46	1	2		Asynchrony movements	7	AUT / RAT	1 / 2	19	1
Mohamed (2016)	7	-0.11	0.07	64	1	2		Modafinil	9	AUT / ATTA / RAT / group embedded figures test / Pattern	1 / 2 / 3 / 4	25.34	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
										meaning / Line drawing			
Morin (2018)	4	0.42	0.02	59	2	2	Creative engineering creativity course		1	CEDA	3	25	1
Müller (2016)	4	0.14	0.03	37	2	3		Meditation (concentrative + mindful)	8	AUT / TCT-DP	1	32.82	2
Nusbaum (2014)	2	-0.34	0.01	141	1	1		"Be creative" instruction for halve the DTs	10	AUT	1		1
O'Connor (2016)	1	0.95	0.04	113	1	2		Relaxation training	8	AUT / Welch test	1	22.5	2
	1	0.60	0.04	100	1	2		Ideation training	4	AUT / Welch test	1	22.5	2
O'Connor (2016)	1	0.97	0.02	113	2	2		Relaxation training	8	AUT / Welch test	1	22.5	2
	1	0.58	0.02	100	2	2		Ideation training	4	AUT / Welch test	1	22.5	2
Oettingen (2012)	1	0.33	0.03	151	1	1		Positive feedback for creative potential	10	Insight problems	2	19.34	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	1	0.30	0.03	139	1	1		Positive feedback for creative potential	10	Insight problems	2	23.2	1
O'Mara (2017)	1	0.74	0.08	57	1	2		Self-enhancement of C	12	AUT	1		2
	1	-0.04	0.05	74	1	2		Self-enhancement of C	12	AUT	1		2
	1	0.32	0.02		1	2		Self-enhancement of C	12	AUT	1		2
	1	0.00	0.02		1	2		Self-enhancement of C	12	AUT	1		2
Onarheim (2013)	1	0.66	0.05	99	1	2	Applied NeuroCreativity		1	AUT	1	26	1
	1	0.52	0.02	99	2	2	Applied NeuroCreativity		1	AUT	1	26	1
Oppezzo (2014)	2	0.34	0.03	48	2	2		Walking	7	AUT	1		1
	1	0.97	0.09	16	2	2		Walking	7	AUT	1		1
	1	1.21	0.12	40	1	2		Walking outside	7	AUT	1		1
	1	0.89	0.12	38	1	2		Walking in- and outside	7	Barron's symbolic equivalence task	1		1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Ostafin (2012)	1	0.54	0.06	71	1	2		Mindfulness training	8	Insight problem	2		1
Patrick (2014)	1	1.18	0.13	36	1	2		Nature of insight problems	4	Insight problem	2		1
	1	1.09	0.19	24	1	2		Nature of functional fixed problems	4	Insight problem / functional fixed problems	2		1
Perry (2017)	1	0.45	0.03	40	2	2	Creative thinking course		1	TTCT	1	20.49	1
Ritter (2017)	5	0.55	0.04	32	2	2	SCAMPER method		3	AUT / RAT / CPS	1 / 2 / 3	23.13	1
Robbins (2010)	3	0.71	0.02	51	2	2	Creative thinking course - online - following the book Thinkertoys		1	TTCT	1	19.76	2
Saggar (2017)	1	0.14	0.13	30	1	2	Creative capacity-building program		2	C ratings on drawing	3		1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	1	0.41	0.07	30	2	2	Creative capacity-building program		2	C ratings on drawing	3		1
Samašonok (2015)	4	0.56	0.05	80	1	4	Course on creative thinking		1	TTCT	1		1
	4	0.57	0.03	80	2	4	Course on creative thinking		1	TTCT	1		1
Sassenberg (2017)	1	1.04	0.10	46	1	2		Priming C - based on past experience	10	Generating names for products	1	19	1
	1	0.94	0.06	48	1	2		Priming C - based on past experience	10	Generating names for products	1	25	1
	1	0.52	0.06	40	1	2		Priming C - based on past experience	10	RAT	2	25	1
	1	0.74	0.08	40	1	2		Conceptual C Priming	10	Generating names for products	1	22	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
Sassenberg (2004, unpublished)	1	0.43	0.07	67	1	2		Conceptual C Priming	10	Brainstorming	1	22.28	1
Sassenberg (2008, unpublished)	1	0.37	0.07	69	1	2		Conceptual C Priming	10	Brainstorming	1	24.81	1
Sassenberg (2004, unpublished)	1	0.81	0.08	53	1	2		Conceptual C Priming	10	Brainstorming	1	23.35	1
Sassenberg (2004, unpublished)	1	0.22	0.05	86	1	2		Conceptual C Priming	10	Brainstorming	1	23.2	1
	1	0.02	0.10	45	1	2		Conceptual C Priming	10	Brainstorming	1	24.87	1
Sassenberg (2005, unpublished)	1	0.08	0.07	59	1	2		Conceptual C Priming	10	Brainstorming	1	22.1	1
	1	0.29	0.04	111	1	2		Conceptual C Priming	10	Brainstorming	1	21.7	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	1	0.21	0.10	46	1	2		Conceptual C Priming	10	Brainstorming	1	22.37	1
Sassenberg (2006, unpublished)	1	0.32	0.13	36	1	2		Conceptual C Priming	10	Brainstorming	1	21.94	1
	1	0.18	0.05	98	1	2		Conceptual C Priming	10	Brainstorming	1	21.41	1
	1	0.11	0.03	117	1	2		Conceptual C Priming	10	Brainstorming	1	22.73	1
Smith (2009)	1	0.58	0.01	241	2	2	Creative problem-solving – computer-based		2	AUT	1	20.17	1
Stevenson (2014)	3	0.37	0.12	61	1	2	AU training		3	AUT	1	25.3	1
	3	0.48	0,10	61	2	2	AU training		3	AUT	1	25.3	1
Stolaki (2018)	4	0.62	0.01	90	2	2	Creative challenge - game inside FB		1	DT	1	18.38	1
Sun (2016)	2	0.81	0.16	28	1	2	Divergent Thinking Battery		3	DT	1	19.5	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	2	1.01	0.12	28	2	2	Divergent Thinking Battery		3	DT	1	19.5	1
	2	0.32	0.08	13	2	2	Divergent-Thinking Battery		3	DT	1	22.38	1
Tang (2017)	2	0.80	0.03	66	2	3		ERASMUS intensive program (international exchange)	11	Self-report	5	24.98	1
Trench (2015)	1	0.00	0.13	30	1	1	Creative metaphorical titles		3	Title creation	3	22.3	1
Tull (2014)	1	0.44	0.15	51	1	2	Creative nursing course		2	TTCT	1	29	1
Ulger (2016)	3	0.89	0.17	26	1	4	University course - integrated brainstorming, association, open-ended problems		1	TTCT	1	20.65	1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	3	0.32	0,10	26	2	4	University course - integrated brainstorming, association, open-ended problems		1	TTCT	1	20.65	1
Unsworth (2016)	1	0.43	0.01	131	2	3		Self-management-strategies	10	Axtell's 6-Item Scale: change at work	5	38.44	2
Vally (2019)	3	0.88	0.01	133	2	2	Creativity and innovation course		1	Association task	1	20.51	1
van Elk (2016)	2	0.81	0.01	116	2	3		Art exhibition	12	AUT	1	45.6	2
Vernon (2014)	3	0.45	0.06	99	1	2	6 Thinking Hats		3	Six Hats	1	48	2
	3	0.48	0.06	99	1	2	6 Good Men		3	Six Men	1	48	2
Wang (2002)	4	0.44	0.05	39	2	2	TTCT		3	TTCT	1		1
	4	0.13	0.05	39	2	2	TTCT		3	TTCT	1		1

Author (Year)	*k*	*g*	*v*	*N*	S	Exp	Training	Manipulation	E	C assessment	A	Age	Setting
	4	0.41	0.06	39	2	2	TTCT		3	TTCT	1		1
Wang (2018)	3	1.19	0.12	41	1	2		Breaking the wall in VR-game	5	AUT	1	21	1
West (2012a)	3	0.08	0.01	93	2	2	Creative process course		2	TTCT	1		1
West (2017)	1	0.53	0.04	93	1	3		Improvisation training	4	TCT-DP	1	42	2
	1	0.80	0.03	93	2	3		Improvisation training	4	TCT-DP	1	42	2
Yakar (2014)	3	1.10	0.05	36	2	2	Science Laboratory Application course		1	TTCT	1		2
Yang (2018)	2	0.47	0.07	60	1	2		VR HMD usage	5	design task / K-DOCS	3 / 5	21	1
Zitek (2015)	4	0.95	0.05	99	1	2		Entitlement	12	AUT / Structured imagination task	1	20	2
	1	0.49	0.04	98	1	2		Entitlement	12	RAT	2	27	2

Notes. k = Number of effect sizes from one sample aggregated to a *g*; *g* = Hedges´*g*; v = Variance for *g;* N = sample size; S = study design: 1 = between, 2 = within; Exp = Experimental design: 1 = enhancement – post, 2 = enhancement – post + comparison, 3 = pre – enhancement – post, 4 = pre – enhancement – post

+ comparison, 5 = enhancement equals post; E = type of enhancement: 1 = Complex course, 2 = Brief course, 3 = Single method, 4 = Open-thinking techniques, 5 = Sensory stimulation, 6 = Direct brain stimulation, 7 = Physical activity, 8 = Meditation, 9 = Drug, 10 = Creativity awareness, 11 = Cultural exposure, 12 = Other; C assessment = creativity assessment method: AUT = Alternate Uses task, VKT = Verbaler Kreativitätstest (German for "verbal creativity test"), TTCT = Torrence Test of Creative Thinking, UUT = Unusual Uses Test, RAT = Remote Association task, ATTA = Abbreviated Torrance Test for Adults, SPI = Similes Preference Inventory, DT = Divergent thinking, TCI = Test of Creative Imagination, CEDA = Purdue Creativity Test adapted for engineering population, TCT-DP = Test of Creative Thinking – Drawing Production, CPS = Creative Problem Solving, K-DOCS = Kaufman Domains of Creativity Scale, A = type of creativity assessment: 1 = divergent thinking, 2 = convergent thinking, 3 = creative performance, 4 = cognitive style, 5 = self-assessment; Age = mean age of the sample; Setting = sample setting: 1 = student, 2 = occupational.

Table 4

Effect size measures of the twelve enhancement methods

			95% CI based on g				95% PI based on τ	
Variables	k	Hedges′g	*LL*	*UL*	τ^2	I^2 *in %*	*LL*	*UL*
Types of enhancement methods								
for training:								
Complex courses	69	0.66	0.53	0.79	0.43	86.00	-0.54	1.86
Single method	48	0.61	0.18	1.03	0.53	90.14	-1.43	2.64
Brief courses	41	0.47	0.28	0.66	0.13	79.57	-0.52	1.46
for manipulation:								
Meditation	19	0.66	0.38	0.94	0.09	61.73	0.07	1.25
Cultural exposure	8	0.66	0.30	1.03	0.03	22.52	0.21	1.15
Open-thinking technique	20	0.60	0.41	0.79	0.03	33.71	0.09	1.11
Other	17	0.58	0.30	0.88	0.15	81.65	-0.48	1.66
Sensory stimulation	14	0.53	-0.05	1.10	0.24	70.46	-0.67	1.72
Direct brain stimulation	28	0.32	0.06	0.59	0.06	45.14	-0.15	0.80
Physical activity	29	0.26	-0.14	0.65	0.22	72.76	-1.18	1.69
Creativity awareness	19	0.18	-0.28	0.65	0.26	86.58	-1.22	1.58
Drug	20	0.10	-0.08	0.29	0.02	26.24	-0.36	0.57

Notes. k = Number of effect sizes from one sample aggregated to Hedges´*g*, CI = Confidence Interval, I^2 = proportion of variation between studies within a group, τ^2 = variation of true effects, PI = Prediction Interval.

Table 5

Effect size measures for the characteristics of Enhancement methods and Samples

			95% CI based on *g*				95% PI based on τ	
Variables	*k*	Hedges´*g*	*LL*	*UL*	τ^2	I^2 *in %*	*LL*	*UL*
Enhancement methods								
Training	158	0.61	0.48	0.73	0.21	86.18	-0.88	2.09
Manipulation	174	0.45	0.33	0.56	0.15	72.74	-0.63	1.52
Trainer present	121	0.62	0.52	0.74	0.15	82.61	-0.60	1.85
Trainer not present	211	0.47	0.34	0.58	0.21	81.42	-0.79	1.72
Type of enhancement								
Figural	86	0.76	0.58	0.93	0.23	88.65	-0.64	2.15
Spatial	58	0.62	0.39	0.85	0.24	86.16	-0.86	2.11
Verbal	226	0.58	0.49	0.68	0.19	84.54	-0.72	1.89
Cognitive-perceptive	73	0.33	0.17	0.48	0.85	52.03	-0.20	0.85
Focus on divergent-convergent thinking spectrum								
CT	11	1.23	0.14	2.32	0.95	92.79	-1.92	4.38
DT + CT	89	0.62	0.50	0.75	0.14	86.72	-0.63	1.88
DT	102	0.56	0.42	0.70	0.14	71.07	-0.60	1.71
None	130	0.37	0.23	0.51	0.16	73.84	-0.73	1.48

Focus within the 4-P framework								
Product	140	0.65	0.52	0.79	0.21	87.23	-0.84	2.14
Process	168	0.59	0.48	0.70	0.19	85.49	-0.82	1.99
Press	10	0.51	0.07	0.95	0.11	55.68	-0.59	1.61
Person	223	0.53	0.43	0.61	0.14	77.16	-0.51	1.56
Enhancement efforts								
Motivational	67	0.66	0.49	0.82	0.16	83.36	-0.44	1.76
Personality	33	0.62	0.41	0.82	0.11	75.15	-0.04	1.27
Other	11	0.61	0.21	1.01	0.24	75.37	-0.36	1.57
Social	109	0.59	.048	0.70	0.14	79.73	-0.41	1.59
Cognitive	285	0.53	0.44	0.62	0.19	82.76	-0.79	1.85
Sample characteristics								
Occupational	58	0.59	0.45	0.72	0.11	77.40	-0.49	1.66
Student	274	0.52	0.41	0.62	0.21	82.93	-0.94	1.97
< 21.26yrs[1]	136	0.55	0.37	0.72	0.23	81.48	-0.89	1.99
> 21.26yrs[1]	133	0.54	0.43	0.66	0.14	80.35	-0.50	1.58
> Women[2]	185	0.52	0.41	0.64	0.19	80.89	-0.67	1.71
> Men[3]	96	0.52	0.33	0.72	0.24	85.87	-1.02	2.06
Country of Origin								

Asia	77	0.68	0.42	0.93	0.31	84.56	-1.11	2.46
North America	77	0.52	0.38	0.66	0.19	86.61	-0.90	1.95
Europe	167	0.51	0.39	0.63	0.14	76.47	-0.61	1.62
Diverse[4]	10	0.16	-0.14	0.45	0.09	57.10	-0.41	0.73

Notes. k = number of effect sizes (we do not report categories with fewer than ten effect sizes), LL = lower limit of the 95% confidence interval (CI), UL = upper limit of the 95% CI, I^2 = proportion of variation between studies within a group, τ^2 = variation of true effects, PI = prediction Interval, DT = Divergent thinking, CT = Convergent thinking

[1] Two age groups were created via median split (median = 21.26 years)

[2] Comparing samples with more than 50% females as participants

[3] Comparing samples with more than 50% males as participants

[4] Diverse includes New Zealand, Australia and Argentina.

Table 6

Differences in effect size measures for training and manipulation

	Training								Manipulation									
			95% CI based on *g*				95% PI based on *τ*				95% CI based on g				95% PI based on *τ*		Difference	
Variables	*k*	*g*	*LL*	*UL*	τ^2	I^2 *in %*	*LL*	*UL*	*k*	*g*	*LL*	*UL*	τ^2	I^2 *in %*	LL	UL	B	SE
Enhancement methods																		
Trainer yes	90	.61	.47	.75	.18	87.54	-.78	1.99	31	.67	.56	.79	.01	11.13	.05	.87	-.08	.14
Trainer no	68	.60	.32	.89	.35	89.17	-.48	1.68	142	.38	.26	.51	.16	75.18	-.72	1.50	.20	.13
Type of enhancement																		
Spatial	22	.78	.58	.98	.16	88.05	.002	1.57	36	.44	.06	.82	.27	72.98	-1.23	2.11	.37	.21
Figural	78	.77	.57	.97	.24	89.60	-.76	2.30	8	.61	.13	1.09	.22	80.72	-.31	1.53	.13	.32
Verbal	158	.61	.548	.73	.21	87.18	-.88	2.09	68	.52	.36	.68	.15	75.62	-.53	1.58	.08	.11
Cognitive-perceptive	0	-	-	-	-	-	-	-	73	.30	.21	.38	.20	48.55	-.60	1.20	-	-
Focus on divergent - convergent thinking spectrum																		
CT	1	-	-	-	-	-	-	-	10	.71	.36	1.11	.12	59.51	-.04	1.80	-	-

DT + CT	77	.66	.54	.78	.13	86.68	-.50	1.82	8	.07	-.15	.29	.00	7.67	.07	.07	.58	.24
DT	68	.53	.33	.673	.18	75.75	-.84	1.39	34	.60	.47	.72	.06	50.32	.13	1.06	-.10	.15
None	8	.22	-.03	.47	.004	5.59	.10	.35	122	.38	.24	.52	.17	75.10	-.75	1.51	-.14	.37
Focus within the 4-P framework																		
Person	63	.71	.57	.83	.16	86.66	-.32	1.72	160	.43	.32	.54	.11	64.60	-.56	1.42	.25**	.08
Process	137	.59	.547	.671	.17	85.24	-.76	1.94	32	.60	.31	.89	.27	83.23	-.82	2.02	-.10	.13
Press	0	-	-	-	-	-	-	-	10	.53	.24	.83	.10	54.67	-.12	1.18	-	-
Product	130	.64	.50	.78	.19	88.33	-.88	2.17	10	.76	.40	1.12	.04	30.75	.18	1.34	-.14	.27
Enhancement efforts																		
Cognitive	158	.61	.48	.73	.21	86.18	-0.88	2.09	127	.41	.28	.54	.14	69.89	-.63	1.44	.19**	.09
Social	87	.57	.44	.70	.16	83.42	-0.50	1.64	22	.70	.55	.86	.02	20.03	.45	.95	-.12	.14
Motivational	22	.69	.49	.90	.18	91.18	-0.21	1.60	45	.66	.42	.89	.15	71.64	-.45	1.77	.06	.17
Personality	14	.60	.26	.94	.53	81.55	-0.16	1.36	19	.64	.36	.91	.10	70.15	-.09	1.36	-.03	.21
Other	-	-	-	-	-	-	-	-	11	.61	.25	.96	.24	74.36	-.38	1.60	-	-
Assessment methods																		
Assessment trained	60	.55	.20	.90	.44	89.06	-1.09	2.19	2	-	-	-	-	-	-	-	-	-

Assessment not trained	98	.64	.52	.75	.15	85.84	-.57	1.84	164	.45	.32	.56	.15	73.02	-.61	1.45	.18*	.08
Time to post-test																		
Same day	72	.63	.41	.86	.32	86.85	-1.21	2.47	159	.44	.32	.56	.16	73.24	-.67	1.55	.15	.11
>1 day	75	.58	.44	.71	.14	85.53	-.49	1.64	14	.51	.27	.75	.07	61.26	-.18	1.19	.09	.14
>100 days	28	.74	.40	1.09	.24	87.43	-.76	2.25	0	-	-	-	-	-	-	-	-	-
Class of assessment for post-test																		
DT	142	.63	.51	.74	.16	83.99	-.66	1.91	133	.44	.28	.60	.19	77.10	-.76	1.64	.09	.09
Non-DT	16	.54	.-13	1.21	.76	95.90	-1.17	2.25	41	.43	.27	.59	.09	60.25	-.14	.99	.10	.23
Aspect of Divergent thinking measurement																		
Fluency	62	.63	.52	.74	.11	78.93	-0.38	1.63	54	.46	.28	.63	.13	70.25	-.50	1.42	.17	.10
Originality	59	.65	.50	.80	.17	85.35	-.66	1.95	47	.46	.22	.70	.29	83.41	-.74	1.66	.12	.13
Elaboration	19	.54	.22	.85	.37	94.15	-.65	1.72	20	.32	.02	.61	.14	62.25	-.55	1.18	.23	.22
Flexibility	40	.56	.43	.71	.10	75.33	-.46	1.60	37	.49	.29	.70	.14	72.12	-.29	1.28	.07	.11
Quality	7	.05	-.13	.23	.00	0.02	.05	.06	3	-	-	-	-	-	-	-	-	-
Type of assessment																		

Figural	91	.65	.51	.79	.18	85.71	-.64	1.95	49	.36	.18	.54	.11	58.75	-.70	1.41	.13	.32
Verbal	134	.61	.47	.74	.22	88.09	-.94	2.15	136	.47	.34	.59	.16	74.59	-.64	1.59	.08	.11
Focus within the 4-P framework[1]																		
Product	158	.61	.49	.73	.21	87.18	-.88	2.09	170	.44	.33	.56	.15	72.70	-.66	1.54	.09	.08
Testing efforts[2]																		
Cognitive	158	.57	.45	.69	.18	86.41	-.61	1.76	170	.46	.34	.57	.16	74.42	-.64	1.55	.05	.08
Sample characteristics																		
Occupational	25	.58	.34	.83	.13	82.52	-.61	1.77	33	.58	.40	.77	.11	75.85	-.34	1.50	.007	.14
Student	133	.62	.47	.76	.23	88.09	-.94	2.18	142	.40	.26	.53	.16	70.28	-.70	1.49	.11	.23
< 21.26yrs[3]	42	.59	.23	.94	.41	93.44	-1.36	2.54	93	.51	.35	.68	.11	56.62	-.32	1.34	.06	.18
> 21.26yrs[3]	75	.62	.47	.76	.15	82.49	-.57	1.80	58	.43	.26	.62	.13	74.74	-.54	1.41	.18	.12
> Women[4]	67	.62	.44	.79	.19	85.06	-.80	2.03	117	.45	.30	.60	.18	76.71	-.73	1.63	.17	.12
> Men[5]	57	.57	.20	.94	.43	93.18	-1.39	2.53	39	.45	.29	.61	.06	48.99	-.02	.92	.08	.20
Country of Origin																		
Asia	47	.83	.45	1.20	.41	89.42	-.91	2.56	29	.53	.21	.85	.16	66.37	-.43	1.48	.28	.21
North America	40	.54	.35	.74	.15	86.74	-.62	1.71	37	.47	.26	.68	.23	83.98	-.78	1.72	.09	.14

Europe	69	.56	.39	.74	.17	83.70	-.67	1.79	98	.46	.29	.63	.13	68.18	-.51	1.43	.11	.12
Diverse	1	-	-	-	-	-	-	-	9	.16	-.16	.49	.10	61.61	-.45	.78	-	-

Notes. k = number of effect sizes, g = Hedges´*g*, LL = lower limit of the 95% confidence interval (CI), UL = upper limit of the 95% CI, I^2 = proportion of variation between studies within a group, τ^2 = variation of true effects, PI = prediction Interval, *B* = difference between the two effect sizes, *SE*: standard error. $^*p < .05$, $^{**}p < .01$.

[1] Only three studies applied the person perspective, five applied the process perspective and one study applied the press perspective

[2] Only one effect size was found for social, personality and two for other testing efforts.

[3] Two age groups were created via median split (median = 21.26 years)

[4] Comparing samples with more than 50% females as participants

[5] Comparing samples with more than 50% males as participants.

Table 7

Effect size measures for the characteristics of the creativity assessment methods

			95% CI based on g				95% PI based on τ	
Variables	k	Hedges´g	*LL*	*UL*	τ^2	I^2 in %	*LL*	*UL*
Creativity assessment								
Assessment trained	62	0.58	0.25	0.92	0.43	88.68	-1.04	2.20
Assessment not trained	262	0.53	0.45	0.62	0.16	80.80	-0.60	1.66
Time of post-assessment								
same day	233	0.52	0.40	0.63	0.22	80.11	-0.86	1.89
>1 day	89	0.56	0.44	0.68	0.13	83.57	-0.50	1.61
>100 days	28	0.74	0.44	1.06	0.22	86.46	-0.69	2.19
Class of assessment								
DT	275	0.54	0.45	0.63	0.18	81.82	-0.81	1.88
Non-DT[1]	57	0.47	0.27	0.67	0.26	84.78	-0.51	1.47
Type of assessment[2]								
Verbal	269	0.54	0.45	0.64	0.19	83.52	0-.79	1.81
Figural	140	0.53	0.45	0.61	0.17	82.60	-0.30	1.36
Aspect of divergent thinking measurement								

Originality	106	0.57	0.44	0.69	0.21	85.10	-0.82	1.95
Fluency	115	0.55	0.46	0.65	0.12	76.52	-0.57	1.67
Flexibility	77	0.53	0.42	0.65	0.11	73.47	-0.51	1.58
Elaboration	39	0.47	0.25	0.67	0.27	88.17	-0.98	1.91
Quality	11	0.19	-0.02	0.40	0.03	47.40	-0.15	0.53
Focus within the 4-P framework[3]								
Product	330	0.53	0.44	0.61	.19	82.23	-0.85	1.90
Testing efforts[4]								
Cognitive	329	0.51	0.43	0.60	.17	81.87	-.75	1.77

Notes. k = number of effect sizes, LL = lower limit of the 95% confidence interval (CI), UL = upper limit of the 95\% CI, I^2 = total amount of variability, DT = Divergent thinking, CT = Convergent thinking

[1] Non-DT assessments include CT, cognitive style, creative performance and self-report measures

[2] Measurements using items appeared only for four effect sizes

[3] Only three studies applied the person perspective, five applied the process perspective and one study applied the press perspective

[4] Only one effect size was found for social, personality and two for other testing efforts.

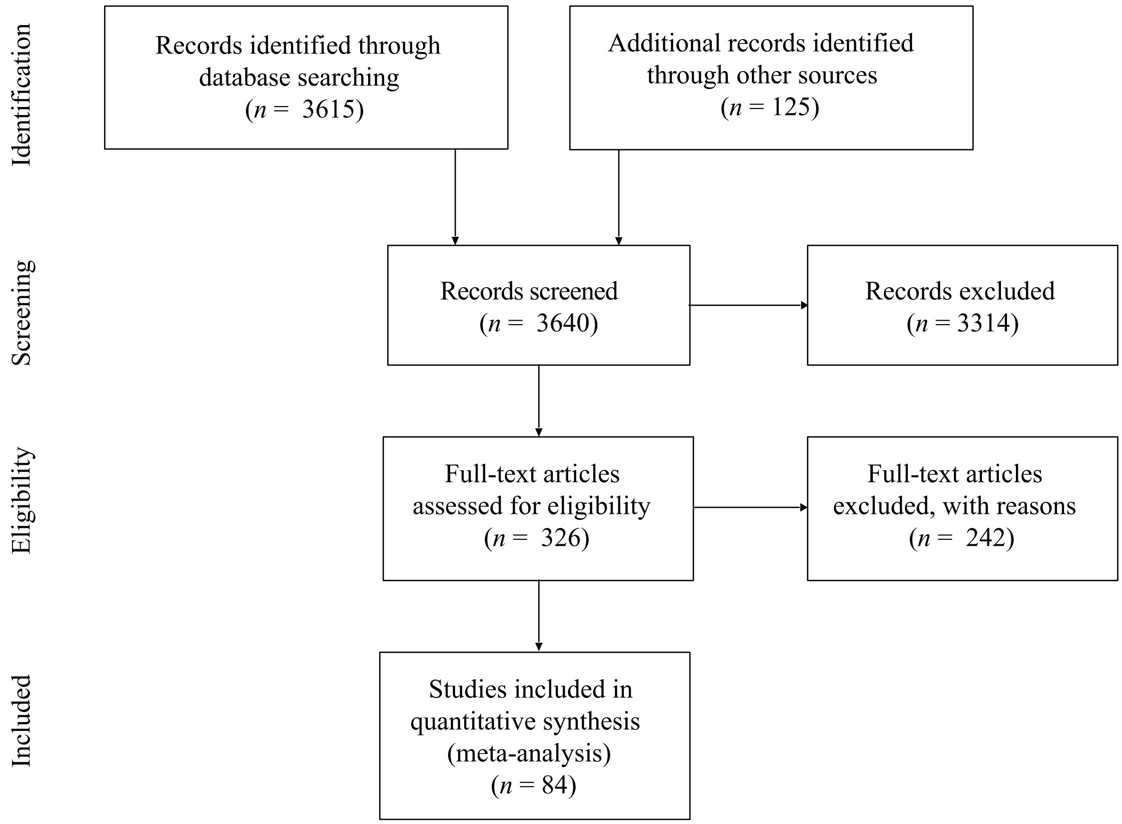

Figure 1. The flow diagram following the PRISMA guidelines (Moher et al., 2010) for the numbers identified, included, and excluded in the literature search. Only non-redundant papers are reported.

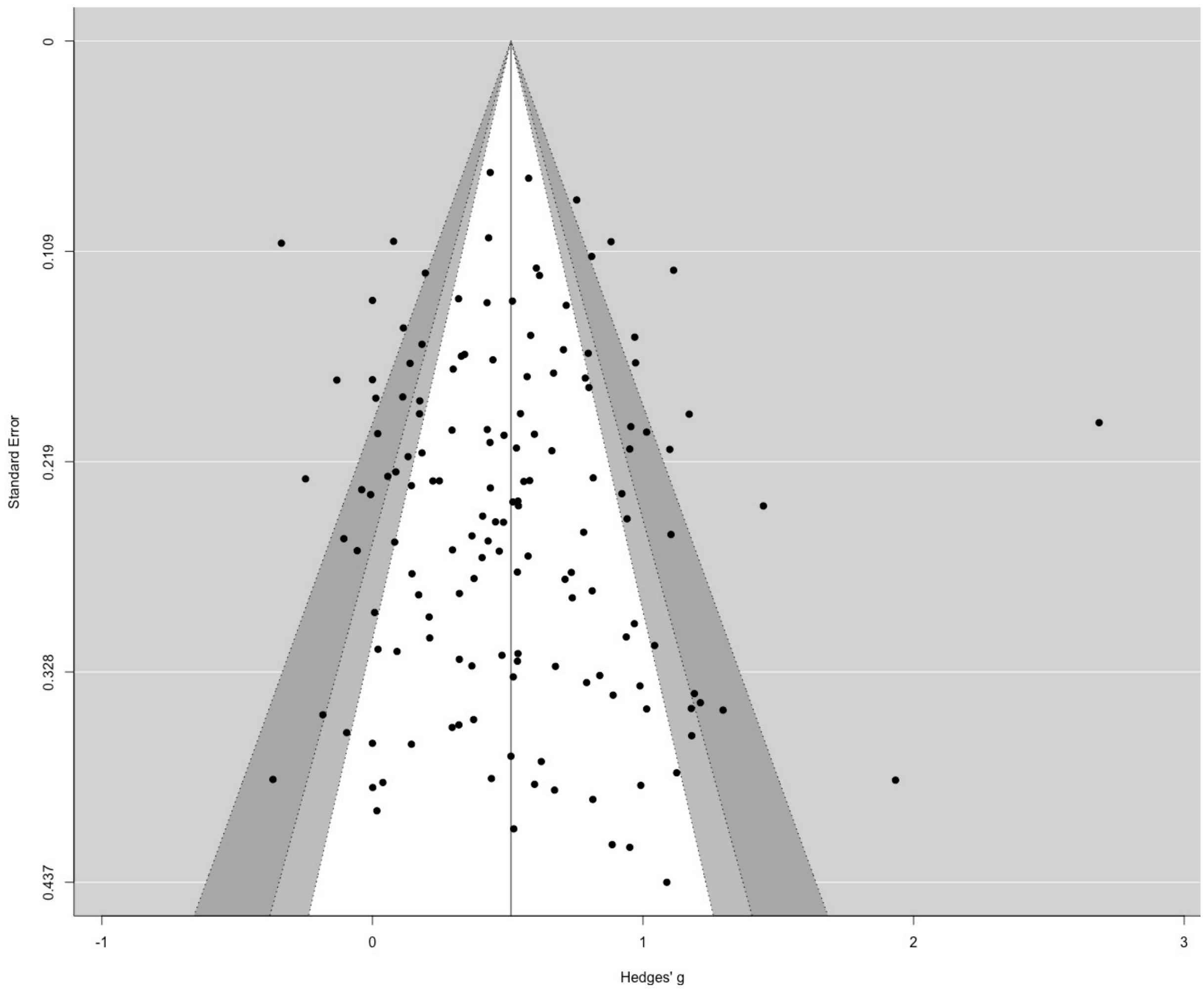

Figure 2. Funnel plot for all effect sizes from the analysis.

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The * indicates that a paper was included in the meta-analysis.

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