Personal factors and group creativity characteristics: A correlational meta-analysis

The influential Yale study (Taylor et al., 1958) was the first one to test the performance of the brainstorming technique on idea generation. Since then, group creativity activities were extensively studied. Group creativity activity can be defined as a group activity designed to develop numerous ideas that are original and useful (Paulus & Nijstad, 2003; Taggar, 2019). In most cases, group creativity refers to activities done with explicit instructions, and is interchangeable with the term brainstorming (Meadow et al., 1959), also known as Creative Problem Solving (CPS, Osborn, 1963), collaborative idea generation or idea generation groups (Kenworthy et al., 2020). Creative tasks can be performed with a mere explicit instruction (e.g., "try to be as creative as possible") but they generally result in poorer creative performance compared to more elaborate instructions (Niu & Liu, 2009). Generally, a creative activity involves the generation of original and useful ideas, with a standard brainstorming instruction to not criticize ideas, to say whatever ideas came to mind, to focus on generating as many ideas as possible, to build on ideas and to stay focus on the task (Coursey et al., 2018; Osborn, 1963; Putman & Paulus, 2009). Creative activities have been studied notably in association with individual differences in creative processes. For example, extended research has been conducted regarding personality traits and creative self-beliefs. A meta-analysis from Karwowski and Lebuda (2016) found a correlation between creative self-beliefs and openness of r = .47, Extraversion of r = .26, Conscientiousness of r = .13, Neuroticism of r = -.12 and Agreeableness of r = 0.07 (95% confidence interval including the null) On the overall, the Big five traits explained 51% of variance in creative self-efficacy. On the contrary, less has been studies in individual differences in group creativity. Individual differences are important to our understanding of how and why creative groups generate

novel ideas and favor innovation. Particularly, personality traits and cognitive trait differences have been studied in group and team creativity (for a review, see Coursey et al., 2018).

Studies so far have provided preliminary evidence regarding the relationship between personal factors and group creativity characteristics. For example, researchers have looked at the influence of group composition on the creativity process (e.g., Moreland et al., 1996), cognitive ability/orientation (e.g., Devine & Philips, 2001), and personality trait (e.g., Litchfield et al., 2017). One small but significant relationship exists between creativity and dark triad traits machiavellianism and narcissism, (Lebuda et al., 2021), but not with psychopathy.

There have been no systematic mappings of the association between personal factors (i.e., personality, cognitive and emotional traits) and group creativity characteristics to help form a unified framework connecting these two constructs and reconcile conflicts in the concepts and empirical findings. We seek to answer two critical questions: (1) Which creative outcomes in group activities are associated with which personality traits; and (2) what type of group creative activity would be most suitable for each personality trait?

The present investigation aims to contribute to the literature on the association between creativity outcomes at the group-level and personal factors of members within the group. We begin with a theoretical account of the two constructs, and our hypotheses on why and how the two constructs may be connected.

Personal Factors

Extensive research has been conducted on personal factors or characteristics that influence individual creativity, but less research has been done on people in social contexts (Reiter-Palmon & Kaufman, 2018). Creativity was first investigated as an individual process, and teamwork was considered as facilitators or inhibitors of individual creativity (Amabile,

1996; Reiter-Palmon et al., 2012). Today, creativity is central in product design and development, and in teamwork to solve challenging problems. Understanding how each member of the creative team can have a different impact on the process of creative thinking is crucial, for it can improve the creative process and customize the creativity activity for the participants.

For a long time, empirical literature examining creativity activities mostly associated personal factors with personality traits (Barron & Harrington, 1981; McCrae & Costa, 1995; Puryear et al., 2017; Yao & Li, 2021). Recently, researchers have started looking into the effect of emotions (Kuška et al., 2020) such as anxiety (Camacho & Paulus, 1995), and emotional intelligence (Wang, 2015). They also investigated individual differences in term of cognitive processes such as cognitive orientation or cognitive styles (Brown et al., 1998), and other cognitive traits such as Personal Need for Structure (PNS, Rietzschel et al., 2014), creative self-efficacy (Taggar, 2019; Tierney & Farmer, 2002), motivation (Bechtoldt et al., 2010), Need for Closure (Chirumbolo et al., 2004, 2005), and Need for Cognition (Wu et al., 2014). Coursey et al. (2018) provided a review of individual differences in group and team creativity tasks. Their overview showed that group creativity is not simply an addition of the effects of many individual characteristics, but a combined effect that has yet to be shown. Indeed, in a group setting, certain social traits can improve creativity potential, for example, traits that lead group members to be more attentive to the ideas of others, to process the shared ideas including the more radical ones, to be more motivated and persistent in the search for new ideas, to build on the ideas of others, and to share new ideas.

We summarized a list of common subconstruct of personal factors in Table 1. With this meta-analytic review, we aspire to offer a new perspective in understanding the effect of personal factors in creative settings.

Table 1

Commonly used measures of personal factors in creative groups

Main term	Literature	Citation
Personality trait		
Openness to experience	Schilpzand et al. (2011, p. 67)	"As expected, we found that openness to experience was important for creative team outcomes."
Extraversion	Jung et al. (2012, p.30)	"In the first experiment, extraverts outperformed introverts in computer-mediated groups. In the second experiment, we exposed participants in computer-mediated groups to four levels of idea stimulation ranging from none to extremely high. Extraverts generated more unique and diverse ideas than did introverts in moderate- and high-stimuli conditions only."
Conscientiousness	Baer et al. (2008, p. 274)	"We found that ideation was correlated with extraversion and openness."
Agreeableness	Bechtoldt et al. (2010, p. 633)	"Current findings are also consistent with past work showing that group creativity increases when group members are in a positive rather than neutral mood (Grawitch et al., 2003) or when group members score high rather than low on dispositional agreeableness (Taggar, 2002)."

Neuroticism	Baer et al. (2008; p. 260)	The above arguments suggest that teams composed of members who are likely to criticize others' ideas and to provide candid feedback, that is, individuals high on neuroticism, should possess the potential to experience creative synergies.
Emotion		
Anxiety	Camacho & Paulus (1995, p.1078)	"The results reported suggest that when social anxiousness is minimized, group brainstorming can be nearly as productive as nominal group brainstorming. Our results thus suggest that interactive brainstorming may be best suited for people who are low in social anxiety."
Emotional intelligence	Wang (2015, p.340)	"The present study […] showed that average member EI increased elaboration, which in turn led to better performance in the informationally diverse condition."
Cognition		
Cognitive style	Brown et al. (1998, p. 519)	"When a divergent thinker changes from a divergent partner to a convergent partner, their output (spoken ideas) increases. When a convergent thinker changes from a convergent partner to a divergent partner, their output decreases."
Need for Structure	De Dreu et al. (2011, p.82)	"groups populated by individuals with high openness to experience, high need for cognition, or low ambiguity aversion can be expected to have higher average epistemic motivation and, therefore, to engage in more rather than less systematic and deliberate information search and processing."

Creative Self-efficacy	Richter et al. (2012, p.1287)	"The positive relation between [creative self-efficacy] and creativity was stronger in teams with greater shared [knowledge of who knows what]."
Motivation	Bechtoldt et al. (2010, p.633)	"We proposed that group creativity improves when members have high rather than low epistemic motivation. With regard to creative fluency—the number of nonredundant ideas and insights generated by the group— our hypothesis was supported in all three tests."
Need for Cognition	Huang and Liu (2021, p. 1)	"Psychological safety climate and the need for cognition were positively associated with team creativity through information elaboration"

Relationships between Personal Factors and Creative Activity Characteristics

There is a growing interest in the link between personal factors and group creativity characteristics. Many existing studies have been conducted regarding the personal factors involved in fluency and flexibility (Butler et al., 2003), originality and usefulness (Baer et al., 2008), and number of ideas (Brown et al., 1998). However, there have been debates regarding the relationship between personal constructs and group creativity characteristics due to mixed findings. Feist (1998) asserted that creative individuals need to balance between social stimulation and quiet reflection. Therefore, extroverted people may show better creative performance in some groups, depending on the need to interact with each other (see also Anderson et al., 2008). Conscientiousness, which leads people to adhere to rigid norms and rules (Roberts et al., 2009), may help generate a high number of ideas, but not necessarily ideas that are original or useful. This idea is supported by Feist (1998), who, at an individual level, found that artists, who need to develop original ideas, were generally low in conscientiousness. Agreeableness is a strong predictor of team performance, because it is related to trust and morale (Hogan et al., 1994). However, creative people are generally low in agreeableness (Bechtoldt et al., 2012; Karwowski & Lebuda, 2016). Emotional stability could be a more beneficial characteristic to have in a group creativity setting (Bell, 2007; Da Costa et al., 2015; Peeters et al., 2008). Other personal factors can have differential links with various creativity characteristics. For example, Need for Closure, a cognitive tendency to avoid ambiguity, is related to the quality of ideas generated but not originality (Watts et al., 2017). Most studies mentioned in the present paragraph were made at the individual level. At the time of writing, there is no literature review or meta-analysis on the relationship between personal characteristics and creativity outcomes in group setting

We conduct this meta-analysis for two reasons. First, a meta-analysis is necessary to synthesize the evidence regarding how groups are creative in respect to different creativity

dimensions. Second, it can help identify inconsistent findings, gaps in the literature, and the power of relationships evaluated (Siddaway et al., 2019).

Research Aims and Hypotheses

In this study, we seek to examine: (1) the overall relationship between personal factors and creativity characteristics in group setting; (2) moderators of these relationships; and (3) the potential effect of publication bias on the relationships.

Moderators

We examine different moderators in the relationships between personal factors and group creativity characteristics, including environmental influence on how the activity was conducted, tasks factors related to the rules of the creative activity, and personal factors such as demographic. Our moderator hypotheses are exploratory and mostly based on the last review available on the subject (Coursey et al., 2018). In this review, researchers indicated that there were very few studies on the subject, and we expect some moderators to be untestable in the absence of study. We will explore and report all available relationships. In italic are the hypotheses for which the literature on the subject tends to provide evidence for a relationship.

Familiarity

Familiarity of the group is the extent to which group members know each other (Sosa & Marle, 2013). For example, familiarity can range from participants who do not know each other in a laboratory setting to teammates who have already worked with each other for a long time. In Sosa and Marle (2013) study, it was found that the more familiar group members are to one another, the better the creative outcomes. We hypothesize that familiarity will strengthen the link between personal factors and creativity characteristics only for the groups that suffer from novelty. These groups include participants high in introversion (Orengo Castellá et al., 2000), Need for Closure (Chirumbolo et al., 2004), and social anxiety

(Camacho & Paulus, 1995). The effect of familiarity tends to be lower for people who bond easier with others, such as less anxious and extroverted individuals.

Familiarity: In familiar context, extraversion, need for closure and social anxiety is more strongly correlated with group creativity than in non-familiar context.

Skill Diversity

The idea behind skill diversity is similar to familiarity: people who are closer to each other tend to bond easier with others, leading to less perceived stress and a more positive social climate, resulting in better creative outcomes. On the contrary, synergy can be difficult to appear in an overly homogeneous group, because every member does not add creative value to others (Nijstad & De Dreu, 2002). A group with members who have substantial overlap in skills and knowledge may have limited creativity due to a lack of diversity. We will exploratory test the moderation hypothesis by skill diveristy. Furthermore, this variable is strictly associated with homogeneity in terms of skills and knowledge.

Group Demography

Diversity may be a key to group creativity. Having diversity in groups, such as having many hierarchical status, gender, age, field of study, leads groups to be more creative (Choi, 2007; Paulus & van der Zee, 2015). For example, Karwowski and Lebuda (2016) found that men had, on average, more ideas that were more original than women, who tended to have less ideas but more useful in individual creative process. However, for group creativity, the evidence is weak, and no clear relationships have been found. Testing this hypothesis could give more credit to the importance of diversity in group creativity.

Constraint

Constraint refers to the degree of freedom in creative activity. Two major types of constraint can appear in the activity: the production blocking where a rule was imposed on the members to not share their ideas as they come to mind, and the asynchrony where the

participants are generating ideas individually, before sharing them with each other. In the production blocking condition, individual factors are less important for creativity (Nijstad & Stroebe, 2006) than in the non-production blocking condition, whereas in the asynchronous condition, individual factors are more important than in synchronous condition (Paulus & Kenworthy, 2018). Thus, we hypothesize that constraint weakens the relationship between personal characteristics and creativity outcomes, operationalized as production blocking and synchrony conditions.

Constraint: In production blocking setting, the relationships between individual factors and creativity is lower than in non-production blocking setting.

In asynchrony setting, the relationships between individual factors and creativity is lower than in synchrony setting.

Type of Task

The type of task can influence the relationship between personal factors and creative outcomes. For conjunctive tasks, as a creative task in which a participant passes some ideas to one another, the performance of the group is mostly influenced by the least performant person. Consequently, the creative outcome might be poor with some personal factors, such as members who do not like imprevisibility (e.g., openness and Need for Structure). For disjunctive tasks, for example sharing all ideas and selecting the best of them, the influence of least able members is weaker because they do not influence the sharing process (Faddegon et al., 2009). We will explore the evidence for an effect of this type of task in creative processes.

Type of task: In conjunctive tasks, the relationships between openness to experience and need for structure, and creative outcomes is lower than for disjunctive tasks.

Creative phase

Harvey (2013) found that the diversity of ideas was related to divergent creativity, and to a diminishing of convergent thinking. Also, convergent thinkers could be better in convergent phase than in divergent phase, mirroring the divergent thinkers. As hypothesized in Coursey et al. (2018), introverts are better at building and integrating creative ideas in the convergent phase, while extroverts are less inhibited and make more contribution during the divergent phase.

Creative phase: Divergent thinking and extraversion are more associated with creative outcomes in the divergent phase than in the convergent phase.

Convergent thinking and introversion are more associated with creative outcomes in the convergent phase than in divergent phase.

Number of Participants

The number of participants is critical in creating, sharing, and transforming ideas and information into projects. Several studies have found a link among the number of participants, personal factors and creative outcomes. Barry and Stewart (1997) found an inverted U-shape problem-solving performance relationship for the number of extroverts, as the best performance was found for groups with a moderate number of extroverts. Baer et al. (2008) found that a number of individuals composing the team that are high in extraversion, high in openness and low on conscientiousness influence creativity but not the number of individuals high on neuroticism or low on agreeableness. Thus, we hypothesize that the number of participants influences creative outcomes for traits extraversion, openness to experience, and conscientiousness.

Number of participants: the more the participants, the less strong is the relationships between personal factors and creative outcomes.

Time

The possibility to create and share information depends on the time available. Most creative tasks are structured and time-limited, mostly because creativity is mentally effortful. Research has shown that time limits were inversely related to the amount of task focus shown by groups (Karau & Kelly, 1992). Current research supported the inverted U-shape relationship between time pressure and creativity: both scarcity and abundance of time can compromise creativity (Baer & Oldham, 2006; Liikkanen et al., 2009). The effect of time pressure on creativity was only found for participants high on openness to experience in Baer and Oldham (2006) study, we hypothesize to find the same effect in the present meta-analysis.

Time: In high time pressure, openness to experience is less associated with creative outcomes than in normal time pressure (such as the control condition).

In low or no time pressure, openness to experience is less associated with creative outcomes than in normal time pressure (such as the control condition).

Leadership

It is challenging to assess how the leadership type will influence the relationship between personal factors and creativity. We decided to split leadership into two traditional types: transformational and transactional. In transformational leadership, the leader clearly states the goal and pushes the group toward attaining this goal. In transactional leadership, the leader relies on an exchange process in which group members are rewarded for accomplishing specific goals (Jung, 2001; Mumford et al., 2019). Research has found that transformational leadership leads to higher creative outcomes than transactional leadership (Jung, 2001; Sosik & Cameron, 2010; Zhang et al., 2011). In particular, Sosik and Cameron (2010) indicated that transformational leadership was related to an increase in motivation to

create more ideas and ideas that are more original. On the contrary, Taggar (2019) explained that a cohesive team might follow the dominant actors in the team instead of trying to find more ideas. Thus, he hypothesized that a too strong cohesion in a team following a (transformational) leader could impair creative collective efficacy. Anderson and Fiedler (1964) also showed that groups with participatory leaders (i.e., transactional leader) had the highest number of ideas generated, and groups with supervisory leaders had the most original and useful ideas. We hypothesize that the leadership type has an effect in the relationship between personality and creative outcomes. Leaders that are close to the team and who create a non-judgmental climate will help improve the performance of anxious, introverted, and less motivated members. On the other side, leaders with a more distant relation with the group, in the exchange process to attain the goal and who do not contribute to the task, will reduce the performance of these members, reducing the global creative performance.

Leadership: in teams with a transformational leader, the relationship between personal factors and creative outcomes is less important than in teams with a transactional leader.

Publication Status

We examine publication status for possible moderating effects on the relationship between personal factors and creativity outcomes. Several recent meta-analyses (Mathur & VanderWeele, 2020; Moreau & Gamble, 2020; Schmucker et al., 2017; Vosgerau et al., 2019) have suggested that unpublished research can distort effect size found in meta-analyses. Accordingly, we expect that studies that were published are likely to report stronger associations than those that remained unpublished.

Publication status: published studies report stronger associations than unpublished studies.

Methods

Open Science Disclosures

We shared all procedures, materials, datasets, and analysis code on the Open Science Framework (https://osf.io/xwph9/?view_only=335369af22dc425096b1149cea66426a). The pre-registration and additional information about decisions are available in the supplementary materials.

Design

Our First construct, personal factors, is explained in Table 1. It is decomposed as personality traits: 1) Openness, 2) conscientiousness, 3) extraversion, 4) agreeableness, 5) neuroticism; emotion: 1) anxiety and 2) emotional intelligence; cognition: 1) Cognitive style, 2) motivation, 3) self-efficacy, 4) Need for Structure, 5) Need for Cognition. The three categories of our second variable, creative outcomes are 1) number of ideas generated, 2) originality of these ideas and 3) usefulness of the ideas.

Eligibility Criteria

Studies including personal factors (see Table 1) and measuring creative outcomes in group settings are included in our analysis. [note stage 1: We may include outcomes not listed in the table if they can be justifiably classified into one of our identified categories. Eventual changes will be explained in supplementary.]

Search Strategy

Database searches. To identify articles that are potentially relevant to our topic of investigation, we conducted searches using Google Scholar, Psychinfo, Web of Science - social science citation index, Scopus and Proquest- dissertations and theses (for suitability, see Gehanno et al., 2013; Martin-Martin et al., 2019; Moreau & Gamble, 2020).

For personal factors, the keywords were *personality trait, personality traits, openness, extraversion, introversion, conscientiousness, agreeability, neuroticism, anxiety, social*

anxiety, thinking style, convergent thinking, divergent thinking, Need for Closure, creative self-efficacy, motivation, Need for Cognition, emotional intelligence. For creative outcomes, the keywords are *number of ideas, originality, usefulness, fluidity, flexibility, feasibility*. On the overall, all search patterns will include following operator: “creativ*” OR “idea generation” OR “problem solving” OR "brains" OR "brainw" AND “group*” OR “collab*” OR "team".

[note stage 1: Additional keywords identified through the process that match the criteria for inclusion will be documented clearly and our search will be updated accordingly.]

During the search, keywords related to constructs were linked with the Boolean logic operators “OR” and keywords between construct 1 and construct 2 with “AND”. Variations of the keywords were included in the search with the original keywords if search results yield less than 100 results, linked with “OR”. (An example as follow: “personality trait*” AND “useful*”). More information on the search pattern process can be found in the coding sheet under tab “search pattern”. Database searches for each search pattern was terminated after combining through 30 records consecutively without potentially relevant papers for the inclusion criteria.

The search included papers listed under the “related articles” and “cited by” features in Google scholar to identify papers that are similar or have cited the identified articles that can be included in our analysis. We looked at other articles that were published by identified authors in the field to check if there were relevant papers that we may have missed. We systematically contacted the authors of the identified articles (see the pre-registered email template in supplementary) and issued a call for unpublished findings on Researchgate and Twitter in order to find relevant unpublished data. For all the articles, titles, abstracts, tables, and methods sections were scanned to identify the relevance of a source.

Inclusion and Exclusion Criteria

Correlational meta-analyses typically exclude studies that had manipulations of the target variable before the said variable was measured (e.g., Chevance et al., 2019), or conduct a separate meta-analysis for studies with manipulations or interventions (e.g., Schmitt et al., 2014; van Kleeck et al., 2010). First, we restricted our meta-analysis to correlational studies that measure personal factors in creative context. Studies were excluded if they 1) experimentally manipulated IV-related of personal factors (e.g., manipulated motivation, social climate and anxiety, information and Need for Closure…), 2) failed to report the crucial statistics necessary for a meta-analysis (i.e., correlation coefficient or other effect sizes that can be transformed into correlation coefficient, sample size), or 3) not written in English or French unless all necessary information are provided in English or can be obtain from authors.

Screening

Studies that met our criteria were coded into the "Searched articles" tab within the coding sheet. All preliminary studies included in the total search were saved into a cloud folder and accessible from the project OSF link or directly via (https://osf.io/xwph9/?view_only=335369af22dc425096b1149cea66426a). Articles were scanned to determine whether they should be included into the main coding sheet or not. If excluded, a reason will be documented along the article recorded. Authors of studies with missing statistics were contacted for relevant datasets/information through the "contacting author" tab and the corresponding mail template (see supplementary). If the dataset was provided, we included the article in the main coding tab. Finally, the process of inclusion can be found through the PRISMA diagram in Figure 1 and the included studies in Table 2.

Figure 1

Meta-analysis flow diagram in accordance with PRISMA 2020 (Page et al., 2020).

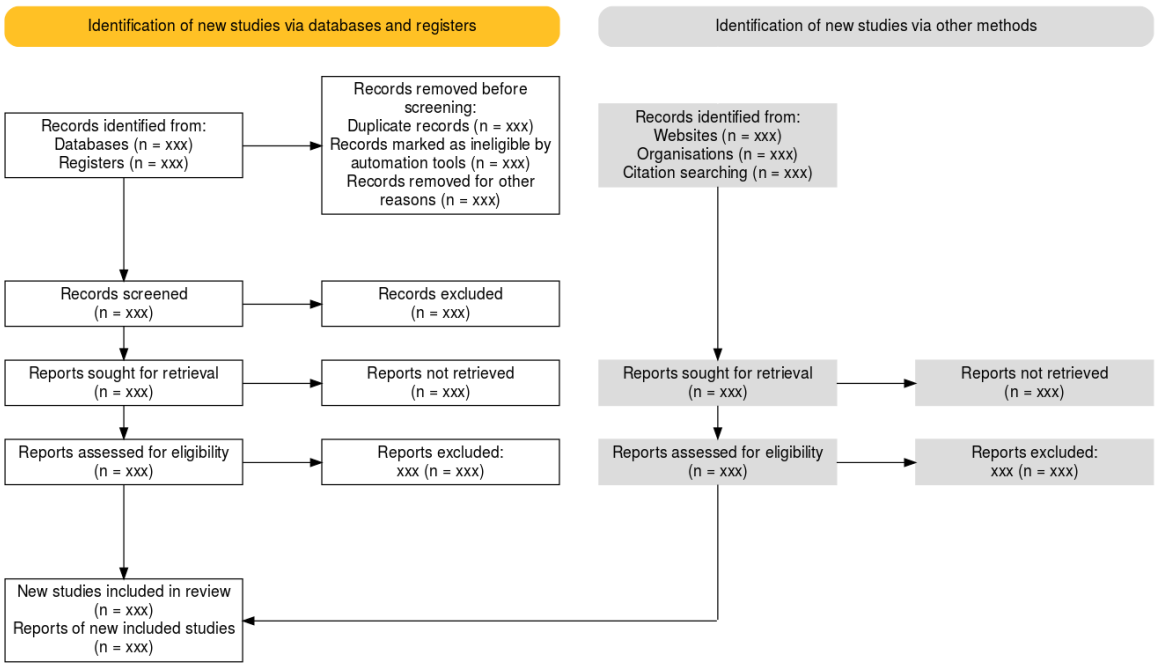

Identification of new studies via databases and registers
Identification of new studies via other methods
Records identified from:
Databases (n = xxx)
Registers (n = xxx)
Records removed before screening:
Duplicate records (n = xxx)
Records marked as ineligible by automation tools (n = xxx)
Records removed for other reasons (n = xxx)
Records identified from:
Websites (n = xxx)
Organisations (n = xxx)
Citation searching (n = xxx)
Records screened
(n = xxx)
Records excluded
(n = xxx)
Reports sought for retrieval
(n = xxx)
Reports not retrieved
(n = xxx)
Reports sought for retrieval
(n = xxx)
Reports not retrieved
(n = xxx)
Reports assessed for eligibility
(n = xxx)
Reports excluded:
xxx (n = xxx)
Reports assessed for eligibility
(n = xxx)
Reports excluded:
xxx (n = xxx)
New studies included in review
(n = xxx)
Reports of new included studies
(n = xxx)

Table 2

All studies/datasets included in the meta-analysis

No.	Article	N	Design	Personal factors measured	Creative outcome(s)	Publication status	Country
1							

Coding

Data extraction from the included studies was recorded in "main coding sheet" tab. When available, the main correlations between personal factors and creative outcomes were recorded, along with intercorrelations between creative outcomes, the type of scale used, sample demographics and publication information. During the coding process, if the correlation between a personal factor and a creative outcome were reported both as a single correlation and also as a result when split by a moderator, the results will be listed as separate rows. Moderator variables will be coded for each study.

Analysis

We developed an Rmarkdown Script for the statistical analyses. The packages used are indicated in supplementary. Our main package for meta-analysis is psychmeta (Dahlke & Wiernik, 2019). We used pearson's r as the main indicator of effect size. Whenever available, we used correlations obtained directly from authors of original papers. If only regression were available, we converted to correlation by using a transformation provided in the supplementary. If not possible, we asked the authors to provide a correlation or raw data. Correlations were corrected for attenuation by using the formula (Dahlke & Wiernik, 2020):

$$r_c = \frac{r_{obs}}{\sqrt{r_{xx'}}\sqrt{r_{yy'}}}$$

Given the range of different outcomes for each category, we expected the heterogeneity in the sample to be relatively high. Thus, a random effect model was used for all the relationships. Split conditions due to moderators were collapsed to allow for comparison of the

relationships. All conversions and coding decisions were documented. A meaningful association is expected as having a correlation of at least $r = .10$ (Cohen, 1988; Gignac & Szodorai, 2016; Schäfer & Schwarz, 2019). We documented all conversions and coding decisions. We included the original quotes and/or table/page numbers from the original articles into the coding sheet to facilitate reproducibility. We plotted forest plots presenting the correlation for every relationship. We presented the relation with confidence intervals and the sample size of each study.

Statistical heterogeneity between studies was determined using an 80% credibility interval (as used in Borenstein et al., 2009; Wiernik et al., 2017). Wiernik and Kostal (2019), explained how the credibility interval performed better than the most used *Q* significance test. The main reasons are that the *Q* test is underpowered in most situations and that it confounds the sample size of studies and the magnitude of effect found in the studies. Finally, Paterson et al. (2016) indicated the threshold for credibility interval as an indication for moderator (e.g., corrected correlations < .15 as negligible, .15–.24 as small, .25–.39 as moderate, and ≥ .40 as large). If there was indeed meaningful heterogeneity, we explored potential moderators. Our design for the analysis is shown in Table 3.

Table 3

Study design

Question	Hypothesis	Sampling plan	Analysis Plan	Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis	Interpretation given different outcomes	Theory that could be shown wrong by the outcomes
What is the relationship between personal factors and creativity outcomes in group setting?	A relationship between personal factors (big 5, emotional and cognitive traits) and creativity outcomes (originality, usefulness, number of ideas) in group setting exists.	Meta-analysis: we will systematically collect all the data available in databases and ask for unpublished studies on twitter and researchgate. We will report the sample size for every relationship.	We will analyze data with a psychometric meta-analysis using the psychmeta package (Dahlke & Wiernik, 2019). The effect size is Pearson's r corrected with internal consistency artifact distributions (alpha or composite reliability)	A meaningful association is expected as having a correlation of at least r = .10 (lowest side of the credibility interval).	An association > .10 will be interpreted as a meaningful association, an association < .10 will be interpreted as no association or not enough data to draw conclusion based on the number of studies and participants involved. In both cases, the lack of evidence will only be indicated and will not be interpreted.	Theories about creativity were mostly investigated as individual process. A lack of correlation would only indicate that this personal factor is less important in group setting than in individual creativity for this particular creative outcome.
What are the moderators of the relationships between personal factors and creativity outcomes in group setting?	Moderators: - Familiarity - Skill diversity - Group demography - Constraint - Type of task - Creative phase - Number of participants - Time - Leadership	Meta-analysis: we will systematically collect all the data available in databases and ask for unpublished studies on twitter and researchgate. We will report the sample size for every relationship.	We will add to the model the moderator.	We will report the moderator in all level and the combined effect. A moderator that moderates the effect is one whose 95% confidence intervals don't include 0 and the other level (such as the control group) do.	A moderator whose 95%CI do not include 0 and the control group includes 0 will be interpreted as a meaningful moderator of the relationship.	Most of our moderators' hypotheses are exploratory hypotheses (Coursey et al., 2018). Thus, an absence of evidence will only be seen as a hypothesis not to investigate further.

Does publication status influence the outcome of the relationship	Publication status influences the status of the relationship.	Meta-analysis: we will systematically collect all the data available in databases and ask for unpublished studies on twitter and researchgate. We will report the sample size for every relationship.	We will add to the model the moderator.	We will report the moderator in all levels and the combined effect. If there is a discrepancy between published articles and not published articles (one condition finds an effect and not the other), the hypothesis will be confirmed.	If there is a discrepancy between published articles and not published articles (one condition finds an effect and not the other), we will interpret this as an influence of the publication status, leading to a possibility of publication bias.	The purpose of this moderator is to flag possible publication bias and no theory is involved.

Exploratory Analyses

We expected to include more variables that are not listed in the pre-registered coding sheet as possible moderators as we examine the literature. [note stage 1 : These additional moderator analyses will be considered as exploratory and will most likely be conducted if tests of homogeneity reveal significant heterogeneity among the studies included in our meta-analysis.]

Publication Bias

To address possible publication bias, we corrected for sampling error and measurement error, as indicated in guidelines for psychometric meta-analyses (Schmidt & Hunter, 2015). Reliability was corrected using internal consistency artifact distributions (alpha or composite reliability) compiled from studies included in the present meta-analyses. A summary of weighted mean internal consistency can be found in supplementary.

We also conducted a sensitivity analysis (Mathur & VanderWeele, 2020) with the use of cumulative meta-analysis.

Results

Meta-analytic results are shown in Table 3. [relevant construct1] and [relevant construct2] were [no/lowly/moderately/highly] correlated = XX with [not-consistently/consistently/consistently strong] relations across sample (80% credibility interval ranged XX to XX). [Add all the important relationships in-text]. These results [support/don't support] the hypothesis [name of the direct hypothesis.es or explanation about it].

Table 4
Summary of Meta-Analysis findings

Personality trait	Creativity outcome	***k***	***N***	$\underline{r}$	*SD*r	*SD*res	$\underline{\rho}$	SDrc	SD	**95% CI**	**80% CR**
Openness	Number of ideas										
	Originality										
	Usefulness										
Conscientiousness	Number of ideas										
	Originality										
	Usefulness										
Extraversion	Number of ideas										
	Originality										
	Usefulness										
Agreeability	Number of ideas										
	Originality										
	Usefulness										

Neuroticism	Number of ideas
	Originality
	Usefulness
Social anxiety	Number of ideas
	Originality
	Usefulness
Emotional intelligence	Number of ideas
	Originality
	Usefulness
Cognitive style	Number of ideas
	Originality
	Usefulness
Need for Structure	Number of ideas
	Originality

	Usefulness									
Self-efficacy	Number of ideas									
	Originality									
	Usefulness									
Motivation	Number of ideas									
	Originality									
	Usefulness									
Need for Cognition	Number of ideas									
	Originality									
	Usefulness									

Note: k = number of studies contributing to meta-analysis; *N* = total sample size; $\underline{r}$ = mean observed correlation; SDr = observed standard deviation of r; SDres = residual standard deviation of r; $\underline{\rho}$ = mean true-score correlation; SDrc = observed standard deviation of corrected correlations (rc); SD = residual standard deviation of $\underline{\rho}$; CI = confidence interval around $\underline{\rho}$; CR = credibility interval around $\underline{\rho}$. Correlations corrected using artifact distributions.

Moderator Analyses

We examined 10 possible theoretical and methodological moderators according to a pre-registered criteria and coding sheet.

Note stage 1: our preregistered moderators are Familiarity, skill diversity, Group demography, Constraint, Task type, Creative phase, Number of participants, Time, Leadership, and publication status. We will update the relevant and possible moderators with our meaningful moderators.

[Relevant Moderator 1].

[Moderator1] [moderates/or not] the relation between [subconstruct1] and [subconstruct2]. In [condition 1 of moderator 1], [Construct1] and [construct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than for [condition 2 of moderator 1], $\underline{\rho}$ = XX, 95%IC [XX, XX]. [Add other conditions if needed]. These results [support/don't support] the hypothesis [name of the direct hypothesis/es or explanation about it].

[Possible Moderator 2].

[Moderator1] [moderates/or not] the relation between [subconstruct1] and [subconstruct2]. In [condition 1 of moderator 1], [Construct1] and [construct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than for [condition 2 of moderator 1], $\underline{\rho}$ = XX, 95%IC [XX, XX]. [Add other conditions if needed]. These results [support/don't support] the hypothesis [name of the direct hypothesis/es or explanation about it]. Results of relationships with [moderator 2] can be found in table 4.

Table 5

Summary of Meta-Analysis findings for [moderator2]

Personality trait	Creativity outcome	***k***	***N***	$\underline{r}$	*SD*r	*SD*res	$\underline{\rho}$	SDrc	SD	**95% CI**	**80% CR**
Openness	Number of ideas										
	Originality										
	Usefulness										
Conscientiousness	Number of ideas										
	Originality										
	Usefulness										
Extraversion	Number of ideas										
	Originality										
	Usefulness										
Agreeability	Number of ideas										
	Originality										
	Usefulness										
Neuroticism	Number of ideas										

	Originality	
	Usefulness	
Social anxiety	Number of ideas	
	Originality	
	Usefulness	
Emotional intelligence	Number of ideas	
	Originality	
	Usefulness	
Cognitive style	Number of ideas	
	Originality	
	Usefulness	
Need for Structure	Number of ideas	
	Originality	
	Usefulness	

Self-efficacy	Number of ideas									
	Originality									
	Usefulness									
Motivation	Number of ideas									
	Originality									
	Usefulness									
Need for Cognition	Number of ideas									
	Originality									
	Usefulness									

Note: k = number of studies contributing to meta-analysis; *N* = total sample size; $\underline{r}$ = mean observed correlation; SDr = observed standard deviation of r; SDres = residual standard deviation of r; $\underline{\rho}$ = mean true-score correlation; SDrc = observed standard deviation of corrected correlations (rc); SD = residual standard deviation of $\underline{\rho}$; CI = confidence interval around $\underline{\rho}$; CR = credibility interval around $\underline{\rho}$. Correlations corrected using artifact distributions.

Creativity

[This is a section for inter-correlation between number of ideas generated, usefulness and originality.]

[Subconstruct1] and [Subconstruct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than [with other subconstruct] = XX, 95%IC [XX, XX]. [We will explain further if the IC is different from zero or different from one correlation to one another].

Personal Factors

[This is a section for inter-correlation between personality traits, emotional traits, and cognitive traits.]

[Subconstruct1] and [Subconstruct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than [with other subconstruct] = XX, 95%IC [XX, XX]. [We will explain further if the IC is different from zero or different from one correlation to one another].

Personality Traits

[This is a section for inter-correlation openness, extraversion, introversion, conscientiousness, agreeability, neuroticism.]

[Subconstruct1] and [Subconstruct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than [with other subconstruct] = XX, 95%IC [XX, XX]. [We will explain further if the IC is different from zero or different from one correlation to one another].

Emotional Traits

[This is a section for inter-correlation between emotional intelligence and social anxiety.]

Emotional intelligence and social anxiety were [weakly/strongly] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX]. [We will explain further if the IC is different from zero].

Cognitive Traits

[This is a section for inter-correlation between cognitive style, creative self-efficacy, Need for Closure, and Need for Cognition.]

[Subconstruct1] and [Subconstruct2] were [More/less/equally] correlated, $\underline{\rho}$ = XX, 95%IC [XX, XX] than [with other subconstruct] = XX, 95%IC [XX, XX]. [We will explain further if the IC is different from zero or different from one correlation to one another].

Other Inter-Relations

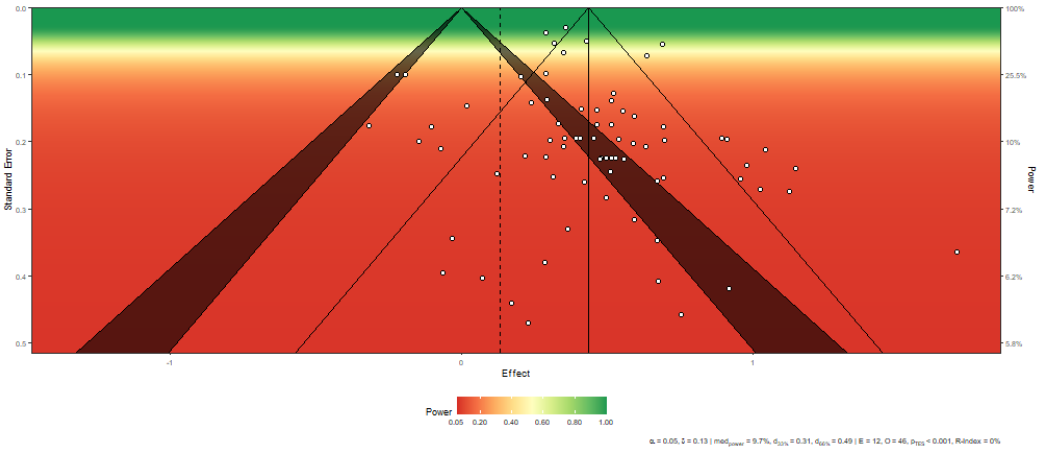
[in this section, we will discuss further some meaningful relationships between personal factors, for example between neuroticism and social anxiety]. A summary table can be found in supplementary for all inter-correlations.

Power Analysis

We created a sunset plot in Figure 2 to show the statistical power of studies included in the meta-analysis. The average power is XX% and the replicability index XX% which means that we have less than XX% of chance to reject H0 when there is a true effect, and no chance at all to replicate one study (see Motyl et al., 2017 for R-index). [We will produce other power analyses based on one correlation if we find some interesting correlations to investigate].

Figure 2

Power test of all studies (Example to replace in stage 2)



Discussion

Personal Factors Related to Creativity in Group Setting

We [found support / did not find support] for a meaningful relationship between personal factors and creativity outcomes. The present meta-analysis found a [minimal to small / small / small to medium / medium / medium to large / strong / large strong]. [we will explain major overall correlations].

[We will 1) Describe the results of credibility intervals and cumulative analysis, 2) Describe the magnitude of effect adjusted, 3) discuss the relationships based on the artifact distribution and reliability coefficients].

Moderator Analyses Findings

Methodological Moderators

Type of construct and subcontruct

[We will describe and evaluate the evidence or lack of evidence for the effect of different constructs. If meaningful difference exists, we will explain the possible reasons for such meaningful difference.]

Theoretical Moderators

[We will review and discuss the moderators we analysed in results, and explain the contributions they provide to theory following the literature review of Coursey et al. (2018).]

Limitations

[We will describe different kinds of limitations transparently. If applicable, we may consider discussing limitations such as lack of statistical information provided by studies, approximation of effect sizes, lack of standardization of methodology (Elson, 2019), statistical power/sample size, problems in reliability, insufficient studies for some moderator categories, challenges of coding, cultural homogeneity, USA-centric, constraints of generality, in terms of theory, population, methods and temporal specificity.]

Future Research Directions

[We will suggest possible future research directions and theoretical and methodological ways for improvement. Here are some suggestions to consider: 1) Improvement in transparency of information and data, to enhance accuracy of approximation of effect sizes and facilitate coding, 2) Call for high-powered reproducible, replicable and transparent pre-registered replication-extension of findings (LeBel et al., 2018, 2019), perhaps with different measures and scenarios, especially if there are discrepancies between classic findings and meta-analytical findings, 3) Call for further investigation of boundary conditions, 4) Call for studies in non-WEIRD samples, cross-cultural studies, and ideally multi-national multi-lab studies (see Apicella et al., 2020; Cheon et al., 2020; Henrich et al., 2010; Muthukrishna et al., 2020). 5) Call for investigation of possible individual differences in the phenomenon, 6) Discuss other uncertainties and unknowns of the effect. Highlight the research gaps (Siddaway et al., 2019). For example, we may purpose unexplored moderators, possible domains that the phenomenon can be applied in, or discuss possible ways to

investigate theories/mechanisms that may explain the phenomenon, 7) Suggest ways to improve the theories/theory that explain the phenomenon, and/or suggest ways to test and compare competing theories, if applicable, 8) Call for adversarial collaboration, to help resolve the disagreements, controversies and discrepancies in findings and/or theories (notable examples: Bateman et al., 2005; Mellers et al., 2001).

Interpretations and Implications

[1) If possible and if the evidence is sufficient, we will evaluate and extend theories, 2) we will describe the possible practical implications of the meta-analysis in the improvement of creativity process, 3) we will discuss the recent theoretical and/or practical research progress of the relationship.]

Conclusion

To conclude, our registered meta-analysis [found support / failed to find support] for [correlation], with a [minimal to small / small / small to medium / medium / medium to large / large] effect size. [Summarize the moderator analyses findings, with directions of findings] [Briefly describe the limitations] [Summarize possible future research directions and implications].

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