



Development of Creative Process Assessment Scale (CPAS)

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ABSTRACT

Creativity can be described as a process, and a model with eight phases is presented here: 1. problem discovery, 2. information search, intake and valuation, 3. concept combination, 4. idea generation, 5. development of a solution approach, 6. idea evaluation, 7. adaption and realization, and 8. communication and implementation. To measure these phases, a 24-item Creative Process Assessment Scale (CPAS) was developed, tested on 2324 participants, and validated with several instruments. This confirmed good reliability for the total score (Omega total: 0.95, Cronbach's alpha: 0.93, retest reliability: 0.87). Bifactor models were computed (with a general factor and either eight or seven specific factors). Combining phases 4 and 5 as core creativity showed the best fit. Validity analyses confirmed the phase model: Correlation patterns to personality traits showed the highest correlations between phase 4 and openness, between phase 7 and conscientiousness, between phase 8 and extraversion and risk-taking, and between phase 2 and the need for cognition. The CPAS correlated highly with creative self-efficacy as well as with domains of creativity and medium with scales measuring creative activity, achievement and behavior. The CPAS is thus a reliable and valid instrument to assess the creative process.

Introduction

Creativity is vital for society. It enables, for example, innovations and inventions, solving problems, new architecture, culture, music, and arts. One of the first to attempt to describe the process of creativity systematically was Wallas (1926). He referred to a speech by Helmholtz (1896) in which he recognized three phases of creativity (preparation, incubation, and illumination) and added a fourth, verification. According to Sadler-Smith (2015), Wallas' model even has a fifth phase: intimation (fringe consciousness) lies between incubation and illumination. There are other models that describe the creative process. Table 1 lists relevant examples. These models differ in complexity and number of phases. Lubart (2001) argued that "theories of the creative process need to specify in much greater detail how the subprocesses can be sequenced to yield creative productions" (p. 305).

A few years ago, we formulated an 8-phase model of creativity (Schuler & Görlich, 2007). The phases can be described as follows: 1. *Problem discovery*: The creative process begins with the search, identification, and definition of a problem. There are creative tasks where the problem is already given. Moreover, many creative achievements are not just the result of solving a given problem, but of identifying a problem that others have recognized as such. 2. *Information search, intake and valuation*: Creative problem-solving often requires information search and evaluation. This can be activated from one's own knowledge but often also requires the acquisition and memorization of new

information. 3. *Concept combination*: New ideas often arise from a combination of already existing concepts. Such a combination is perceived as original when analogies are perceived between distant, not obviously similar things or ideas, which make a connection possible. 4. *Idea generation*: This is the phase of many ideas and flashes of inspiration. This might be perceived as a "eureka experience". People differ in how easily they come up with new ideas and in how much they enjoy thinking up new things. 5. *Development of a solution approach*: Ideas need to be developed further; it is also often useful to play with variations of an idea. It's about expanding spontaneous ideas. 6. *Idea evaluation*: This is followed by an evaluation of the idea(s), for example, whether they can contribute to the solution of a problem or turn it into new products. It is also about how far an idea can be improved. 7. *Adaptation and realization*: This is about the practical realization of ideas into products or work. If difficulties arise, modifications have to be made. Until an idea can be realized and implemented in concrete terms, it often has to be fine-tuned. 8. *Communication and implementation*: This is about persuasion, about presenting new work, products, or ideas in such a way that they become a success, but also about winning others over to unconventional ideas.

This model describes the process in an ideal-typical manner (i.e., focusing on its characteristics). It is not always necessary to pass through all phases; sometimes, there are also loopbacks (Schuler & Görlich, 2007). Compared to Wallas' model (Wallas, 1926), the first three phases can be summarized as the preparation phase, and phases 6 and 7 refer to the verification phase. Phases 4 and 5 together can be described

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Table 1

Phase models of the creative or innovation process.

Authors (Year)	Phases of the creative or innovation process
Wallas (1926)	1. preparation, 2. incubation, 3. illumination, 4. verification
Osborn (1953)	1. fact-finding, 2. idea-finding, 3. idea evaluation
Parnes (1967; Osborn-Parnes 5-stage CPS model)	1. fact-finding, 2. problem-finding, 3. idea-finding, 4. solution-finding, 5. acceptance-finding
Busse & Mansfield (1980)	1. problem selection, 2. effort at solution, 3. setting constraints, 4. transformation, 5. verification and elaboration
Schmidt-Tiedemann (1982)	1. exploration, 2. innovation, 3. diffusion
Amabile (1983)	1. problem or task presentation, 2. preparation, 3. response generation, 4. response validation, 5. outcome
Mumford et al. (1994)	1. problem discovery, 2. problem definition, 3. problem construction
Basadur (1994)	1. problem-finding, 2. problem-solving, 3. solution implementation
Shneiderman (2000)	1. collect, 2. relate, 3. create, 4. donate
Mace & Ward (2002)	1. artwork conception, 2. idea development, 3. making the artwork, 4. finishing the artwork, 5. resolution
Basadur & Gelade (2005)	1. generating, 2. conceptualizing, 3. optimizing, 4. implementing
Kilgour (2006)	1. definition, 2. combination, 3. idea generation
Schuler & Görlich (2007)	1. problem discovery, 2. information search, intake and valuation, 3. concept combination, 4. idea generation, 5. development of a solution approach, 6. idea evaluation, 7. adaption and realization, 8. communication and implementation
Zhang & Bartol (2010a,b)	1. problem identification, 2. information-searching and encoding, 3. idea generation
Botella et al. (2011)	1. preparation, 2. concentration, 3. incubation, 4. ideation, 5. insights, 6. verification, 7. planning, 8. production, 9. validation
Cropley & Cropley (2012)	1. preparation, 2. activation, 3. generation, 4. illumination, 5. verification, 6. communication, 7. validation
Botella et al. (2013)	1. general idea or 'vision', 2. documentation/reflection, 3. first sketches, 4. testing forms or ideas, 5. provisional object/ draft, 6. final work/series
Sadler-Smith (2015)	1. preparation, 2. incubation, 3. intimation, 4. illumination, 5. verification
Fouad et al. (2018)	1. generation of ideas, 2. concept development, 3. development of the prototype, 4. production and marketing
Zaverzhenets & Lobacz (2021)	1. opportunity identification, 2. ideation and idea management, 3. concept development, 4. development, 5. testing and validating, 6. launch

as core creativity (Schuler et al., 2013). The fact that these phases are not always sequential has recently been discussed (Sawyer, 2021).

Aims of the study and initial hypothesis for the scale development

The aim of this study was to develop and validate a scale that can assess creativity-related personal traits and map them onto the 8-phase creative process model. The chosen format is a self-reported assessment with three items representing each phase of the creative process. The underlying hypothesis is that the various phases of the creative process have distinct requirements for the persons involved. Such assessment could thus help to optimize a team's composition for specific creative tasks. Conversely, it can help to identify process-related strengths and weaknesses of individuals and to optimally allocate tasks and measures of personnel development. A further aim was to test correlations between elements of creativity and personality traits.

Development of Creative Process Assessment Scale (CPAS)

The development of the questionnaire started initially in two parallel versions with over 100 items. The initial item set was tested in three consecutive rounds of preliminary studies (each with different groups of participants, ~500 in total) for comprehensibility, factor loading, item mean, and corrected item-total correlation. The number of items was reduced in each round to eventually three items for each of the eight phases of the creative process.

The 24 items of the final version of the Creative Process Assessment Scale (CPAS) are listed in Table 3; the English and German versions of the CPAS are in the supplementary information S1 and S2. The item sequence is arranged according to the phases, with one item per phase, and this is repeated three times. The scale was developed in German. The author and a fluently English-speaking researcher independently translated the scale into English, and consensus was subsequently reached on minor discrepancies. Another fluent English speaker translated the English scale back into German. In terms of content, all items corresponded to the original German version. The final English version was presented to a native English speaker, who assessed the comprehensibility of the items and had the opportunity to make comments. Thus, small linguistic changes were still made. Response options are on a 7-step scale, from 1 = does not apply at all to 7 = applies completely. A 7-point scale was chosen because creativity is a positively associated

construct and therefore average self-assessments above the mean of a given scale were expected. However, in order to allow for sufficient variance, a 7-point scale was used, as this still provides 3 scale points above the scale's mean. The score was calculated as the mean value of the 3 items belonging to a given process phase. The total score is the mean of all 24 items. Item characteristics, reliability and validity are described in the Results.

Hypotheses

The phases were expected to differ in terms of their correlation patterns with respect to different constructs.

Hypotheses related to openness to experience, conscientiousness and extraversion

With regard to the robust five-factor model of personality (Big Five: extraversion, openness to experience, agreeableness, conscientiousness; emotional stability (vs. neuroticism); Goldberg, 1993) openness to experience is expected to correlate positively with the creative process. Previous studies have shown positive correlations between creativity and openness to experience (Batey et al., 2010, 2010; Hirsh & Peterson, 2008; Yao & Li, 2020) and extraversion (Furnham & Bachtari, 2008; Furnham et al., 2008; Sung & Choi, 2009). With regard to the phase model, phase 4 was expected to correlate most strongly with openness, followed by phase 5 (which together represent core creativity), while extraversion should correlate highest with phase 8 and conscientiousness with phase 7.

Hypothesis 1a. Openness to experience correlates positively with phase 4 (idea generation).

Hypothesis 1b. Openness to experience correlates positively with phase 5 (development of a solution approach).

Hypothesis 1c. Conscientiousness correlates positively with phase 7 (adaption and realization).

Hypothesis 1d. Extraversion correlates positively with phase 8 (communication and implementation).

Hypotheses related to need for cognition

Need for cognition (NFC), as a tendency to engage in and enjoy thinking (Cacioppo & Petty, 1982; Cohen et al., 1955) is positively

associated with creativity or innovative behavior (Chen et al., 2006; Dollinger, 2003; Madrid & Patterson, 2016; Wu et al., 2014). The first three phases, in particular, are expected to correlate with the construct NFC and the highest with phase 2 (information search, intake and valuation).

Hypothesis 2a. NFC correlates positively with phase 1 (problem discovery).

Hypothesis 2b. NFC correlates positively with phase 2 (information search, intake and valuation).

Hypothesis 2c. NFC correlates positively with phase 3 (concept combination).

Hypothesis related to risk-taking

Risk-taking is positively associated with creativity (Dewett, 2007; Eisenman, 1987; Merrifield et al., 1961). Here, the highest correlation with phase 8 (communication and implementation) is to be expected, as especially persuasion and the implementation of an idea into innovations requires risk-taking (García-Granero et al., 2015).

Hypothesis 3. Risk-taking correlates positively with phase 8 (communication and implementation).

Hypothesis related to life satisfaction

Well-being is positively correlated with creativity: meta-analytically an effect of $r = 0.14$ was found (Acar et al., 2021). Three components of subjective well-being were recognized: positive affect, negative affect, and life satisfaction (Diener et al., 1985). Thus, a positive correlation is expected for life satisfaction across all phases.

Hypothesis 4. Life satisfaction correlates positively with the CPAS total.

Hypotheses related to interpersonal trust and agreeableness for discriminant validity

For discriminant validation, the constructs interpersonal trust and agreeableness are used. Here, the research situation is ambiguous. Feist (1998) found meta-analytically that creative scientists and artists are more hostile. On the other hand, Feist & Barron (2003) found, that several positive interpersonal traits (e.g. likeability) predicted creative achievement. Other studies showed no correlation between creativity and agreeableness (Silvia et al., 2011; Sung & Choi, 2009). So, only weak correlations are expected.

Hypothesis 5a. Correlation of interpersonal trust with the CPAS total is $< |.10|$.

Hypothesis 5b. Correlation of agreeableness with the CPAS total is $< |.10|$.

Hypotheses related to creative self

Karwowski (2012) differentiated the creative self into creative self-efficacy (CSE) and creative personal identity (CPI). Both concepts are correlated (e.g. $r = 0.71$; Karwowski, 2012 or 0.69 ; Karwowski et al., 2018) and related to self-reported originality: to CSE with $r = 0.55$ and to CPI with $r = 0.47$ (Karwowski et al., 2018). In this context positive correlations are expected for CSE as well as CPI.

Hypothesis 6a. CSE correlates positively with the CPAS total.

Hypothesis 6b. CPI correlates positively with the CPAS total.

Hypotheses related to creative activities, achievements and behavior

Positive correlations with CPAS total are expected for scales (see method section for scale details) measuring creative activities and achievements (ICAA; Jauk et al., 2014; CAQ; Carson et al., 2005), and creative behavior (CBI, Hocevar, 1979; BICB, Batey, 2007).

Hypothesis 7a. The sum of ICAA activities correlates positively with the CPAS total.

Hypothesis 7b. The sum of ICAA achievements correlates positively with the CPAS total.

Hypothesis 7c. CAQ correlates positively with the CPAS total.

Hypothesis 7d. CBI correlates positively with the CPAS total.

Hypothesis 7e. BICB correlates positively with the CPAS total.

Hypothesis related to domains of creativity

Kaufman Domains of Creativity Scale (K-DOCS, Kaufman, 2012) assesses self-perceptions of creative ability and is more focused on self-beliefs in creative domains than the scales ICAA, CAQ, CBI or BICB. The K-DOCS is of course correlated to CAQ (McKay et al., 2017) and CBI (Miroshnik et al., 2022). Thus, positive correlations with the CPAS are also expected. Since the creative process is not domain-specific, the hypothesis refers to the total K-DOCS value.

Hypothesis 8. K-DOCS total correlates positively with the CPAS total.

Hypothesis related to fluency

Fluency is an aspect of divergent thinking. "A fluent individual gives a large number of ideas." (Runco & Acar, 2012, p. 67). This corresponds to the idea generation phase of the creative process. A medium-high correlation was found with fluency for the creative self (Karwowski et al., 2018), also the ICAA (Diedrich et al., 2018; Jauk et al., 2014) correlated with fluency (in a range of $.22$ to 0.32). Fluency tasks correlated with $r = 0.20$ to self-related creativity and with $r = 0.24$ to the Biographical Inventory of Creative Behaviours (BICB; Furnham et al., 2008).

Hypothesis 9. Fluency correlates positively with phase 4 (idea generation).

Hypothesis related to business-relevant criteria

It was expected that more business-relevant criteria correlate with the creative process. These are business ideas, suggestions for improvement, patents, and registered trademarks.

Hypothesis 10. The mean value of business-relevant criteria correlates positively with the CPAS total.

Methods

Measurements

The rationale for the scale selections was to evaluate the construct and criterion validities of the new measurement as thoroughly as possible. Naturally, these comparative scales had to include earlier creativity scales, measuring creative activities, achievements (ICAA, CAQ), and behaviors (BICB, and CBI). These instruments are actually quite complementary: ICAA includes the dimension sports; CAQ includes humor and architecture. BICB is a checklist (in contrast to the rating scales of other tests), and refers to activities of the last 12 months. CBI does not make this restriction. The K-DOCS was used to measure and distinguish 5 different domains of creativity (incl. self/everyday that is not included in other scales). The rationale of employing this wide range of tests was (I) to explore as many facets and dimensions of creativity as possible, (II) to integrate prior knowledge of creativity testing as completely as possible, and (III) to benchmark the new measurement as thoroughly as possible against previous scales. This follows the concept that researchers should "use as many measurement tools as is feasible, given the limits on time and resources, including several self-report measurements of creative actions and thinking styles" (Silvia et al., 2012, p. 13).

According to the author's knowledge, no German translation was available for BICB, K-DOCS and SSCS. Therefore translations were made

in the course of this study. The procedure was as follows: two persons (the author and a fluent English speaker) translated the scale independently of each other, and another fluent English speaker translated the scale back into German. In case of discrepancies, a consensus was negotiated, and comprehensibility was pre-tested.

Big Five

The personality factors extraversion, neuroticism, agreeableness, openness, and conscientiousness (Big Five; Goldberg, 1993) were assessed with the BFI-10 (Rammstedt & John, 2007). Response options range on a 5-step scale from 1 = disagree strongly to 5 = agree strongly, each factor is measured via 2 items. Retest-reliability (6 to 8 weeks) for extraversion was $r_{tt} = 0.83$, for agreeableness was $r_{tt} = 0.68$, for openness was $r_{tt} = 0.72$, for conscientiousness was $r_{tt} = 0.77$, and for neuroticism was $r_{tt} = 0.74$.

Need for cognition

Need for cognition (NFC), as the desire to engage in and enjoy thinking (Cacioppo & Petty, 1982; Cohen et al., 1955), was measured via a 5-item short version (NFC-K-2; Beißert et al., 2019), whose items go back to the original scale by Cacioppo & Petty (1982); these were translated (Bless et al., 1994) and put into a short version (Beißert et al., 2019). Response options range on a 7-step scale from 1 = does not apply at all to 7 = fully applies; the mean of the 5 items is the total score. For the used NFC-K-2 version, Cronbach's alpha was = 0.69 (Beißert et al., 2019), in this current study Cronbach's alpha was 0.71.

Risk-taking

The construct risk-taking was assessed via a single item scale (Beierlein et al., 2014). On a 7-step scale from 1 = not at all willing to take risks to 7 = very willing to take risks, people state how willing they are in general to take risks. Retest reliability (after 6 weeks) was $r_{tt} = 0.74$.

Life satisfaction

Life satisfaction was measured via a single item scale (Beierlein et al., 2015). Participants were asked to report how satisfied they currently are with their lives (all aspects being considered). Response options on a 5-point Likert scale from 1 = not at all satisfied to 7 = completely satisfied; retest reliability (6 weeks): $r_{tt} = 0.67$.

Interpersonal trust

For the determination of discriminant validity, the construct interpersonal trust was used. It dates back to Rotter (1971) and was measured via the Interpersonal Trust Short Scale (KUSIV3; Beierlein et al., 2014). Response options on a 5-step scale are from 1 = do not agree at all to 5 = agree completely; the mean of the 3 items is the total score. The reported retest reliability (interval of 6 to 10 weeks) was $r_{tt} = 0.57$ and $\omega = 0.85$; Cronbach's alpha was 0.78 (calculated in the present study).

Creative self

The Short Scale of Creative Self (SSCS, Karwowski, 2012, 2014; Karwowski et al., 2018) measures creative self-efficacy (CSE) and creative personal identity (CPI). Response options range from 1 = definitely not to 5 = definitely yes. For the evaluation of creative self-concept, the average of all 11 items was taken, for CSE, the average of all six, and for CPI, the mean of all 5 items. Karwowski (2012) reported Cronbach's alpha for CSE 0.81 and for CPI 0.90. In this study, Cronbach's alpha was 0.80 for CSE, 0.91 for CPI, and 0.90 for SSCS total.

Creative activities and achievements

The Inventory of Creative Activities and Achievements (ICAA; Diedrich et al., 2018; Jauk et al., 2014; here the German version was used) assesses creative activity (CAct) and creative achievement (CAch) across the eight domains literature, music, arts and crafts, creative cooking, sports, visual arts, performing arts, and science and engineering.

The CAct scale asks how frequently six activities per domain were performed in the past 10 years. Answers are given on a 5-point Likert-type scale (0 = never; 1 = 1–2 times; 2 = 3–5 times; 3 = 6–10 times; 4 = more than 10 times). Averaging across the six items yielded a domain-specific CAct score; a domain-general score was computed by summing across the eight domains. The CAch scale measures creative achievement on 11 different levels of attainment per domain (ranging from I have never been engaged in this domain to I have already sold some work in this domain); multiple answers are possible. Each level of attainment is equivalent to an increasing value from 0 to 10. Summing across all marked levels of attainment yielded a domain-specific CAch score; a domain-general CAch score was obtained by summing across the eight domains. In this study, Cronbach's alpha for creative activity were: for literature 0.59, for music 0.84, for arts and crafts 0.85, for creative cooking 0.82, for sports 0.76, for visual arts 0.80, for performing arts 0.72, for science and engineering 0.72, and for CAct total 0.90. No reliabilities were found for CAch for the individual domains; for the sum value, CAch, Guttman's Lambda was 0.71 (Diedrich et al., 2018).

The Creative Achievement Questionnaire (CAQ; Carson et al., 2005; German version: Form et al., 2017) includes 10 domains of creativity: visual arts, music, creative writing, dance, drama, architecture, humor, scientific discovery, invention, culinary art (cooking). Each domain includes 8 ranked questions (score weighted from 0 (no achievement) to 7). For scoring, the sum of the 8 items from each domain was built and a total score was calculated as the sum of all items. The retest reliability (interval of 2 to 17 weeks, mean 7 weeks) was $r_{tt} = 0.81$.

Creative behavior

The Creative Behavior Inventory (CBI; Hocevar, 1979) was used in the revised version by Dollinger (2003) in a German translation (Form et al., 2017). The scale consists of 28 items, a list of activities and accomplishments that are commonly considered to be creative. The answer options in the German version (Form et al., 2017) are: 0 = Never, 1 = 1–2 times, 2 = 3–4 times, 2 = 5–6 times, 3 = More than 6 times. The sum of all items forms the total value. Cronbach's alpha was 0.89 (Dollinger, 2003), 0.85 (Form et al., 2017) and in this current study 0.88.

The Biographical Inventory of Creative Behaviours (BICB; Batey, 2007) is a checklist of 34 creative activities that people may have engaged in during the past 12 months, each item checked was coded 1, if unchecked 0. The sum of all checked items is the total score. Cronbach's alpha reported by Batey (2007) was 0.74; in the present data it was 0.69.

Domains of creativity

Kaufman Domains of Creativity Scale (K-DOCS; Kaufman, 2012) was used to measure the domains self/everyday, scholarly, performance, mechanical/science and artistic. Participants were asked to compare their creativity with other people of similar age and experience. Response options for the 50 items were from 1 = being much less creative to 5 = being much more creative. Cronbach's alpha was between 0.83 and 0.87, and the retest reliability after 2 weeks between 0.76 and 0.86 (Kaufman, 2012). In this study, Cronbach's alpha was 0.74 for self/everyday, 0.87 for scholarly, 0.88 for performance, 0.86 for mechanical/scientific, 0.85 for artistic, and 0.90 for K-DOCS total.

Fluency

Fluency was measured by two alternative tasks (modelled on Guilford, 1967). Three minutes were allowed for each task. The instruction was: Please name as many different, even unusual, uses for an umbrella (task 1)/ a book (task 2) as possible. All named uses were added up and the mean value of both tasks was formed. The correlation of both tasks was 0.76, Spearman-Brown corrected reliability was 0.86 (Brown, 1910; Spearman, 1910).

Table 2
Sample characteristics of the total sample.

	N	Percent
<i>Gender</i>		
Female	1460	62.8%
Male	842	36.2%
Diverse	5	0.2%
Not specified	17	0.7%
<i>Mother tongue</i>		
German	2160	92.9%
Non-German	109	4.7%
Not specified	55	2.4%
<i>Highest school-leaving qualification¹</i>		
No secondary school-leaving qualification (kein Schulabschluss)	10	0.4%
Lower secondary school-leaving qualification (Hauptschulabschluss)	63	2.7%
Intermediate school-leaving qualification (mittlerer Schulabschluss, Realschulabschluss)	381	16.4%
Vocational baccalaureate (Fachabitur)	361	15.6%
A-level/high school diploma (Abitur)	1491	64.2%
Not specified	18	0.8%
<i>Current occupation</i>		
Pupil	74	3.2%
Vocational student	111	4.8%
University student	815	35.1%
Employed	1262	54.3%
Retired	89	3.8%
Housewife/-men/parental leave	91	3.9%
Unemployed	57	2.5%
Not specified	20	0.9%

Note. ¹Certifies the successful completion of a given school form, e.g., corresponding to high school. German terms are given in parentheses. Lower secondary school-leaving qualification (Hauptschulabschluss): 9 years of school education, minimum requirement for an apprenticeship; intermediate school-leaving qualification (mittlerer Schulabschluss, Realschulabschluss): 10 years of school education, standard requirement for an apprenticeship; vocational baccalaureate (Fachabitur): 12 years of school education, mostly specialist, standard requirement for admission to a university of applied sciences, A-level/high school diploma (Abitur): 12 to 13 years of school education, mostly general, standard requirement for admission to a university.

N = 2324.

Additional biographical criteria

Additional biographical criteria were collected as individual items. Participants were asked if they already had a business idea, suggestions for improvement, patents, or registered trademarks. The four items were coded as 1 = yes and 0 = no. The mean of the four items was also computed.

Demographics

Furthermore, demographic questions were asked about age, gender, school-leaving qualification, and current occupation (professional, educational, or other).

Procedure

Data were collected in German via the online platform LimeSurvey. The sample was a convenience sample: Essentially, the author and psychology students invited as many acquaintances as possible to participate, and requested to forward the invitation to others. The validation instruments were used in subsamples. The data for determining the retest reliability were collected with an average interval of 12 weeks ($M = 12.36$; $SD = 1.28$; range from 10 to 15 weeks) between the two measurements.

Sample

2324 participants completed the Creative Process Assessment Scale (CPAS). Age ranged from 18 to 91 years ($M = 33.55$; $SD = 14.58$). The description of the total sample can be found in Table 2. Not all participants completed all validation scales. Supplementary Table S1 shows the demographics for the participants for the different validation scales and the retest.

Statistical procedures

Data were analyzed using IBM SPSS Statistics (version 25) as well as the programming language R (version 4.0.5) and development interface R-Studio (version 1.4.1106) for macOS. Confirmatory factor analyses (CFA) were computed as bifactor models. Reliability of the CPAS: Omega total (McDonald, 1978; Revelle & Zinbarg, 2009), Omega hierarchical (McDonald, 1999; Zinbarg et al., 2005) and Omega specific were derived from the CFA. Omega total (Reise et al., 2013), Omega hierarchical and Omega specifics were also calculated for each subscale (Reise et al., 2013; Schermelleh-Engel & Gåde, 2020). Additionally, internal consistencies using Cronbach's alpha (Cronbach, 1951) and retest reliabilities were calculated. Mean value comparisons were performed by *t*-tests for dependent samples. Correlation analyses were calculated as Pearson correlations (*r*); the effect sizes were evaluated according to Cohen (1988); the correlations were additionally double attenuation-corrected (Muchinsky, 1996). Dichotomous variables were dummy-coded. Significance tests of hypotheses 5a and 5a were performed according to Eid et al. (2017). Correlation differences were tested for significance using the method of Olkin (1967).

Ethics

Participation was voluntary and anonymous; all participants gave written informed consent. Individual codes that participants generated themselves and knew only themselves were used to determine retest reliability, so anonymity was ensured also for this sample. The study was approved by the ethics committee of the PFH Private University of Applied Sciences Göttingen.

Table 3
Item analysis for the phases of the creative process.

Item	M	SD	Corrected item-total correlation	Alpha if item deleted
<i>Phase 1: Problem discovery</i>				
1. I like to get to the bottom of things and often discover new problems. (P11)	5.15	1.41	.520	.659
9. I am good at finding information that can be important for solving a problem. (P12)	4.46	1.44	.552	.620
17. I often discover problems that others don't see. (P13)	4.64	1.41	.553	.619
<i>Phase 2: Information search, intake, valuation</i>				
2. I am good at finding information that can be important for solving a problem. (P21)	5.32	1.18	.533	.565
10. I can easily memorize information that is important to me for a question. (P22)	5.17	1.29	.451	.669
18. My knowledge often contributes to solving problems. (P23)	4.83	1.28	.536	.557
<i>Phase 3: Concept combination</i>				
3. I often make connections between very different matters. (P31)	5.02	1.36	.598	.689
11. I often notice that very different things actually have some aspects in common. (P32)	5.03	1.29	.599	.687
19. I recognize connections between different principles effortlessly. (P33)	4.54	1.31	.602	.684
<i>Phase 4: Idea generation</i>				
4. I have a lot of ideas. (P41)	5.12	1.44	.677	.684
12. I like to think of something original. (P42)	4.92	1.53	.664	.694
20. I often have flashes of inspiration. (P43)	4.41	1.55	.579	.786
<i>Phase 5: Development of a solution approach</i>				
5. I like to further develop new ideas. (P51)	5.18	1.36	.555	.598
13. I often think about how I can expand a spontaneous idea. (P52)	4.42	1.59	.566	.576
21. I like to play through many variations of an idea. (P53)	4.78	1.50	.478	.685
<i>Phases 4/5: Core creativity</i>				
4. I have a lot of ideas. (P41)	5.12	1.44	.702	.825
12. I like to think of something original. (P42)	4.92	1.53	.716	.821
20. I often have flashes of inspiration. (P43)	4.41	1.55	.630	.838
5. I like to further develop new ideas. (P51)	5.18	1.36	.626	.839
13. I often think about how I can expand a spontaneous idea. (P52)	4.42	1.59	.675	.829
21. I like to play through many variations of an idea. (P53)	4.78	1.50	.544	.853
<i>Phase 6: Idea evaluation</i>				
6. It is easy for me to evaluate the quality of ideas. (P61)	4.83	1.29	.589	.685
14. I can judge well whether an idea has potential. (P62)	4.75	1.31	.652	.612
22. I easily grasp whether an idea can be improved. (P63)	4.80	1.25	.542	.737
<i>Phase 7: Adaptation and realization</i>				
7. If difficulties arise in turning an idea into a product or output, I modify it until it works. (P71)	4.70	1.50	.682	.792
15. I am very well suited to fine-tuning new concepts until they prove themselves. (P72)	4.27	1.51	.717	.758
23. I tinker with the implementation of an idea until it can be realized. (P73)	4.27	1.55	.701	.774
<i>Phase 8: Communication and implementation</i>				
8. It comes easily to me to convince others of my ideas. (P81)	4.86	1.34	.669	.742
16. I can win others over, even for unconventional ideas. (P82)	4.14	1.49	.687	.720
24. I can present new works, products or ideas in such a way that they become a success. (P83)	4.38	1.47	.641	.768

Note. N = 2324.

Results

Factor analysis

The confirmatory factor analysis was tested on a bifactor model with one general and 8 specific factors. The fit statistic was: $\chi^2 = 2454$, $df = 228$, $p < .001$, $\chi^2/df = 10.76$; CFI = 0.894; TLI = 0.872; SRMR = 0.055; RMSEA = 0.065 (90% CI: 0.063; 0.067). The details of the model are shown in supplementary Fig. S1. Combining phases 4 und 5 (as core creativity) improved statistics of the fit: $\chi^2 = 1802$, $df = 228$, $p < .001$, $\chi^2/df = 7.91$; CFI = 0.924; TLI = 0.908; SRMR = 0.046; RMSEA = 0.055 (90% CI: 0.052; 0.057). An acceptable model fit can thus be assumed. The details of the model are shown in Fig. 1.

In both models, all items contributed to the general factor, but they also loaded on specific factors, the creativity phases. Some items contribute more to the specific factors, others less; the latter are already represented in the general factor (e.g., items P23, P53, or P63). Depending on the choice of model, the loading pattern changes, for example, the factor loading for P53 increases when combining phases 4 and 5, whereas the factor loadings of the items P23 and P63 decrease.

Item analysis, descriptive statistics, reliability and stability

Item analyses were calculated for the items of each phase (cf. Table 3). There are high corrected item-total correlations (range from 0.45 to 0.69). The mean values of the items were between 4.14 and 5.32

(range 1 to 7). No scale showed an improvement in Cronbach's alpha when an item was omitted.

The descriptive statistics of the phases of the creative process are shown in Table 4. The mean value ranged for the 8 phases between 4.41 (phase 7) and 5.11 (phase 2) with a mean of 4.75 and a standard deviation of 0.88 for the CPAS total score. Due to the skewness and kurtosis, a normal distribution can be assumed.

The reliability values can be found in Table 5. The Omega total for the creativity process score was 0.95, Cronbach's alpha was 0.93 and the test-retest reliability was 0.87. For the individual phases, Omega total ranged from 0.71 to 0.84, Cronbach's alpha from 0.69 to 0.84 and the test-retest reliability from 0.72 to 0.80. Only one value (Cronbach's alpha, phase 2) was lower than 0.7, namely 0.69. The other values were within an acceptable range.

The mean values showed no significant differences between the two measurement times (for the CPAS total value: T1: M = 4.64, SD = 0.86; T2: M = 4.65, SD = 0.85; $t = -0.23$; $p = .817$; for details on the phases see Supplementary Table S2).

Testing of hypotheses

Hypotheses related to openness to experience, conscientiousness and extraversion

The highest correlations were found between phase 4 (idea generation) and openness to experience ($r = 0.54$, $p < .001$), between phase 5 (development of a solution approach) and openness to experience

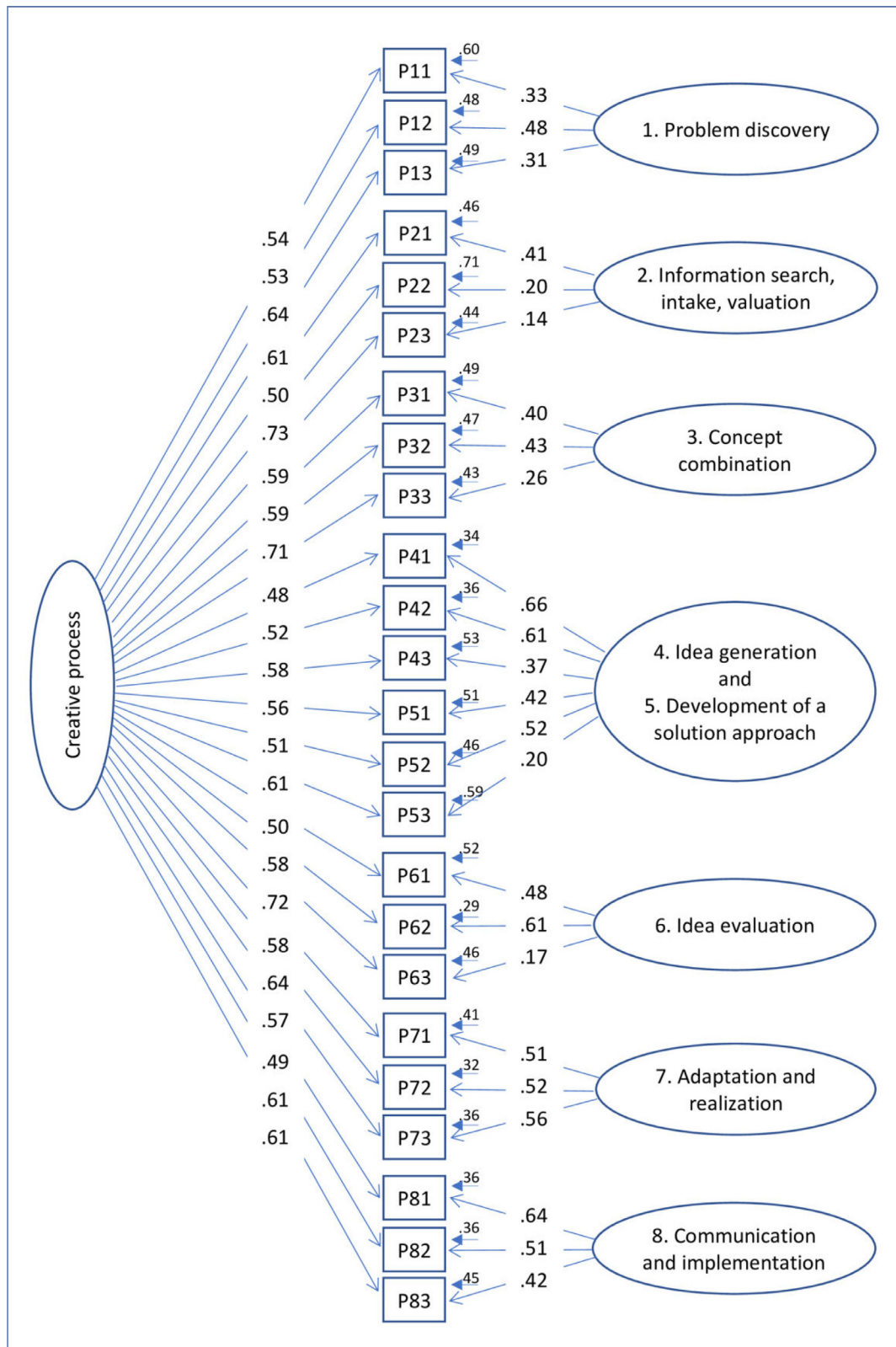


Fig. 1. Bifactor model creative process assessment: phases 4 and 5 together as core creativity.

Note. $N = 2324$, P11 to P87 are items of the phases of the creative process (item wording see Table 3), bifactor model with standardized parameter estimates; $\chi^2 = 1803$, $df = 228$, $p < .001$, $\chi^2/df = 7.91$; $CFI = 0.924$; $TLI = 0.908$; $SRMR = 0.046$; $RMSEA = 0.055$ (90% CI: 0.052; 0.057).

Table 4
Descriptive statistic and intercorrelation of the 8 phases of CPAS.

	Phases of the creative process													
	M	SD	Skewness	Kurtosis	1	2	3	4	5	4/5	6	7	8	
Phase 1	4.75	1.14	-0.33	-0.17										
Phase 2	5.11	0.98	-0.45	0.06	.591**									
Phase 3	4.87	1.09	-0.23	-0.30	.632**	.667**								
Phase 4	4.82	1.27	-0.29	-0.56	.440**	.412**	.507**							
Phase 5	4.80	1.18	-0.32	-0.35	.493**	.454**	.487**	.742**						
Phases 4/5	4.81	1.14	-0.32	-0.38	.499**	.463**	.533**	.938**	.928**					
Phase 6	4.79	1.06	-0.36	0.01	.462**	.585**	.515**	.430**	.525**	.510**				
Phase 7	4.41	1.32	-0.15	-0.61	.454**	.507**	.428**	.484**	.632**	.560**	.522**			
Phase 8	4.46	1.22	-0.20	-0.37	.420**	.506**	.482**	.494**	.517**	.541**	.546**	.501**		
CPAS total	4.75	0.88	-0.28	0.00	.733**	.761**	.766**	.755**	.809**	.837**	.746**	.758**	.740**	

Note. Phases of the creative process: 1. Problem discovery, 2. Information search, intake, valuation, 3. Concept combination, 4. Idea generation, 5. Development of a solution approach, 6. Idea evaluation, 7. Adaptation and realization, 8. Communication and implementation; CPAS total: Creativity Process Assessment Scale; Phases 4/5: Core creativity.

* $p < .05$. ** $p < .01$, two-tailed.

$N = 2324$.

Table 5
Reliability of CPAS.

	Omega total	Omega hierarchical	Omega specific	Cronbach's alpha	Retest reliability
Phase 1	.728	.505	.223	.721	.769
Phase 2	.707	.608	.099	.690	.744
Phase 3	.773	.580	.193	.767	.778
Phase 4	.807	.389	.418	.796	.798
Phase 5	.735	.486	.249	.712	.735
Phases 4/5	.866	.501	.366	.858	.807
Phase 6	.793	.528	.265	.762	.718
Phase 7	.839	.471	.368	.838	.748
Phase 8	.821	.450	.371	.813	.799
CPAS total	.951	.869	.082	.932	.865

Note. Phases of the creative process: 1. Problem discovery, 2. Information search, intake, valuation, 3. Concept combination, 4. Idea generation, 5. Development of a solution approach, 6. Idea evaluation, 7. Adaptation and realization, 8. Communication and implementation; CPAS total: Creativity Process Assessment Scale; Phases 4/5: Core creativity. N Omega and Cronbach's alpha = 2324; N retest reliability = 93; average time interval: 12 weeks; Omega calculation from bifactor model.

($r = 0.44, p < .001$), between phase 7 (adaptation and realization) and conscientiousness ($r = 0.35, p < .001$) and between phase 8 (communication and implementation) and extraversion ($r = .38, p < .001$). This supported hypotheses 1a, 1b, 1c and 1d. The correlations can be found in Table 6. The double attenuation corrected values showed the correlation between the constructs even more clearly, as these values are adjusted for measurement error. Accordingly, the corrected correlation (r_{corr}) between phase 4 and openness was 0.71, between phase 7 and conscientiousness 0.43 and between phase 8 and extraversion 0.46.

Hypotheses related to need for cognition

NFC correlated most strongly with the first three process phases, especially with phase 2 (information search, intake, valuation, $r = 0.40, p < .001, r_{corr} = 0.56$), with phase 1 (problem discovery, $r = 0.34, p < .001, r_{corr} = 0.48$) and phase 3 (concept combination, $r = 0.37, p < .001, r_{corr} = 0.50$), which supported hypotheses 2a, 2b and 2c.

Hypothesis related to risk-taking

Risk-taking correlated significantly ($r = 0.29, p < .001, r_{corr} = 0.37$) with phase 8 (communication and implementation), as expected in hypothesis 3.

Hypothesis related to life satisfaction

Life satisfaction correlated significantly positively with all phases; the correlation with the total value of the creative process assessment (CPAS total) was $r = 0.20 (p < .001, r_{corr} = 0.25)$, which supported hypothesis 4.

Hypotheses related to interpersonal trust and agreeableness

For discriminate validation, low correlations with interpersonal trust and agreeableness were expected. Correlations to the CPAS total of 0.09 ($r_{corr} = 0.11$) and $-0.04 (r_{corr} = -0.05)$ were found. Although $r = 0.09$ is smaller than 0.1, this difference is not significant ($p = .183$), i.e., hypothesis 5a is inferentially not supported. The correlation after double attenuation correction is also slightly above 0.10. The correlation of -0.04 , on the other hand, is significantly smaller than $|0.1| (p = .010)$, supporting hypothesis 5b.

Hypotheses related to creative self

The CPAS correlated particularly highly with the creative self (SSCS total values $r = 0.67, p < .001, r_{corr} = 0.73$). The highest correlation was found with phase 4 (idea generation, $r = 0.71, p < .001, r_{corr} = 0.83$). With creative self-efficacy (CSE), the correlation was $r = 0.72 (p < .001, r_{corr} = 0.83)$ and with creative personal identity (CPI) $r = 0.53 (p < .001, r_{corr} = 0.57)$. This supported Hypotheses 6a and 6b.

Hypotheses related to creative activities, achievements and behavior

Significantly positive correlations with a medium effect according to Cohen (1988) were found between the CPAS total and the ICAA creative activity score ($r = 0.36, p < .001, r_{corr} = 0.39$, supporting hypothesis 7a), the ICAA creative achievement score ($r = 0.33, p < .001, r_{corr} = 0.40$, supporting hypothesis 7b), the CAQ ($r = 0.31, p < .001, r_{corr} = 0.35$, supporting hypothesis 7c); the CBI ($r = 0.36, p < .001, r_{corr} = 0.40$, supporting hypothesis 7d) and the BICB ($r = 0.37, p < .001, r_{corr} = 0.46$, supporting hypothesis 7e). The correlations can be found in Table 7. For more details of the correlations to the domains of ICAA and CAQ see Supplementary Table S3.

Table 6
Correlation of CPAS with different constructs.

	<i>M</i>	<i>SD</i>	<i>N</i>	Phases of the creative process								CPAS total	
				1	2	3	4	5	4/5	6	7		8
Extraversion	3.43	1.01	1247	.065* (.084)	.113** (.148)	.155** (.194)	.190** (.232)	.163** (.209)	.189** (.223)	.129** (.159)	.062* (.074)	.376** (.455)	.210** (.236)
Agreeableness	3.24	0.79	1247	-.105** (-.149)	-.056* (-.081)	-.040 (-.055)	.013 (.018)	.011 (.016)	.013 (.018)	-.069* (-.094)	.008 (.011)	-.037 (-.050)	-.042 (-.052)
Openness	3.66	1.01	1247	.169** (.233)	.124** (.174)	.222** (.298)	.541** (.710)	.443** (.609)	.528** (.669)	.212** (.281)	.250** (.322)	.249** (.324)	.377** (.456)
Conscientious-ness	3.61	0.85	1247	.175** (.234)	.236** (.320)	.099** (.128)	.097** (.123)	.161** (.214)	.136** (.167)	.206** (.264)	.347** (.432)	.137** (.172)	.244** (.285)
Neuroticism	2.94	0.95	1247	-.199** (-.271)	-.258** (-.357)	-.212** (-.280)	-.140** (-.181)	-.171** (-.232)	-.166** (-.207)	-.236** (-.308)	-.189** (-.240)	-.260** (-.334)	-.274** (-.327)
Need for cognition	4.81	1.04	1147	.342** (.476)	.398** (.562)	.371** (.501)	.209** (.276)	.263** (.364)	.251** (.320)	.243** (.324)	.275** (.356)	.228** (.299)	.381** (.464)
Risk-taking	4.17	1.42	1124	.167** (.228)	.189** (.261)	.208** (.275)	.231** (.299)	.222** (.301)	.243** (.304)	.156** (.204)	.144** (.183)	.289** (.371)	.270** (.322)
Life satisfaction	5.06	1.30	1119	.117** (.168)	.198** (.288)	.161** (.224)	.080** (.109)	.100** (.143)	.096** (.126)	.180** (.247)	.164** (.219)	.201** (.271)	.199** (.249)
Interpersonal trust	3.50	0.77	1149	.017 (.023)	.102** (.137)	.112** (.144)	.080** (.101)	.061* (.081)	.076** (.092)	.075* (.095)	.035 (.043)	.087** (.109)	.093** (.108)
Creative self-efficacy (CSE)	3.76	0.64	1319	.472** (.618)	.550** (.731)	.539** (.685)	.637** (.793)	.587** (.766)	.654** (.786)	.500** (.628)	.530** (.647)	.551** (.680)	.721** (.827)
Creat. personal identity (CPI)	3.68	0.96	1319	.273** (.335)	.246** (.307)	.334** (.398)	.661** (.771)	.577** (.706)	.662** (.746)	.296** (.348)	.391** (.447)	.357** (.413)	.528** (.568)
SSCS total	3.72	0.72	1319	.396** (.489)	.417** (.523)	.465** (.557)	.711** (.834)	.636** (.782)	.720** (.816)	.423** (.501)	.496** (.571)	.485** (.564)	.672** (.726)

Note. Phases of the creative process: 1. Problem discovery, 2. Information search, intake, valuation, 3. Concept combination, 4. Idea generation, 5. Development of a solution approach, 6. Idea evaluation, 7. Adaptation and realization, 8. Communication and implementation; CPAS total: Creativity Process Assessment Scale; Phases 4/5: Core creativity; SSCS: Short Scale of Creative Self.

Numbers in brackets are correlations with double attenuation correction, based on the respective reliabilities. The latter include Omega total for the creative process phases and CPAS total (see Table 5), as well as the following: $r_{it,Extraversion} = 0.83$, $r_{it,Agreeableness} = 0.68$, $r_{it,Openness} = 0.72$, $r_{it,Conscientiousness} = 0.77$, $r_{it,Neuroticism} = 0.74$, $\alpha_{NFC} = 0.71$, $r_{it,Risk-taking} = 0.74$, $r_{it,Life,satisfaction} = 0.67$, $\alpha_{Interpersonal,trust} = .78$, $\alpha_{CSE} = 0.80$, $\alpha_{CPI} = 0.91$, $\alpha_{SSCS,total} = 0.90$.

* $p < .05$. ** $p < .01$, two-tailed.

Table 7
Correlation of CPAS with creative activity, achievements, behavior, fluency and business-relevant criteria.

	<i>M</i>	<i>SD</i>	<i>N</i>	Phases of the creative process								CPAS total	
				1	2	3	4	5	4/5	6	7		8
CAct	9.01	4.31	516	.175** (.216)	.198** (.248)	.282** (.338)	.391** (.459)	.324** (.398)	.382** (.433)	.262** (.310)	.219** (.252)	.339** (.394)	.364** (.393)
CAch	44.07	40.72	516	.155** (.216)	.165** (.233)	.228** (.308)	.365** (.482)	.326** (.451)	.368** (.469)	.246** (.328)	.189** (.245)	.299** (.392)	.328** (.399)
CAQ	8.32	8.37	888	.194** (.253)	.202** (.267)	.288** (.364)	.310** (.383)	.268** (.347)	.311** (.371)	.199** (.248)	.208** (.252)	.217** (.266)	.308** (.351)
CBI	27.75	16.67	769	.199** (.249)	.212** (.269)	.269** (.326)	.411** (.488)	.339** (.422)	.403** (.462)	.227** (.272)	.261** (.304)	.292** (.344)	.364** (.398)
BICB	5.22	3.32	410	.163** (.230)	.192** (.275)	.241** (.330)	.401** (.537)	.368** (.517)	.412** (.533)	.260** (.351)	.228** (.300)	.331** (.440)	.369** (.456)
K-DOCS self/everyday	3.62	0.47	1050	.289** (.394)	.307** (.424)	.321** (.424)	.344** (.445)	.334** (.453)	.363** (.453)	.335** (.437)	.312** (.396)	.414** (.531)	.436** (.520)
K-DOCS scholarly	3.16	0.67	1050	.343** (.431)	.390** (.497)	.424** (.517)	.277** (.331)	.260** (.325)	.288** (.332)	.305** (.367)	.211** (.247)	.293** (.347)	.403** (.443)
K-DOCS performance	2.51	0.88	1050	.058 (.072)	.067* (.085)	.164** (.199)	.305** (.362)	.155** (.193)	.248** (.284)	.140** (.168)	.066* (.077)	.186** (.219)	.190** (.205)
K-DOCS mechanical/ scientific	2.57	0.87	1050	.321** (.406)	.303** (.389)	.284** (.348)	.150** (.180)	.205** (.258)	.189** (.219)	.241** (.292)	.308** (.363)	.163** (.194)	.319** (.353)
K-DOCS artistic	3.16	0.77	1050	.149** (.189)	.189** (.244)	.220** (.271)	.359** (.433)	.306** (.387)	.357** (.416)	.246** (.300)	.231** (.274)	.201** (.241)	.314** (.349)
K-DOCS total	3.01	0.45	1050	.357** (.441)	.385** (.483)	.438** (.525)	.451** (.529)	.388** (.477)	.450** (.510)	.389** (.460)	.349** (.402)	.375** (.436)	.511** (.552)
Fluency	7.11	3.56	1750	.115** (.145)	.115** (.147)	.163** (.200)	.162** (.194)	.139** (.175)	.162** (.188)	.101** (.122)	.069** (.081)	.127** (.151)	.163** (.180)
Business idea ^a	0.34	0.47	2014	.213** (.298)	.206** (.293)	.211** (.287)	.271** (.361)	.236** (.329)	.272** (.349)	.212** (.285)	.151** (.197)	.226** (.298)	.285** (.349)
Suggestions for improvement ^b	0.39	0.49	2017	.205** (.287)	.217** (.308)	.162** (.220)	.145** (.193)	.165** (.230)	.165** (.212)	.140** (.188)	.131** (.171)	.175** (.232)	.218** (.267)
Patents ^c	0.03	0.18	1939	.118** (.165)	.118** (.168)	.131** (.178)	.087** (.116)	.120** (.167)	.110** (.141)	.139** (.187)	.115** (.150)	.120** (.158)	.155** (.190)
Registered trademarks ^d	0.02	0.15	2009	.099** (.139)	.129** (.183)	.122** (.166)	.128** (.170)	.141** (.197)	.144** (.185)	.127** (.170)	.108** (.141)	.120** (.158)	.160** (.196)
Mean (from a to d)	0.20	0.22	2021	.276** (.362)	.286** (.380)	.254** (.323)	.271** (.337)	.271** (.353)	.290** (.348)	.248** (.311)	.201** (.245)	.270** (.333)	.340** (.390)

Note. Phases of the creative process: 1. Problem discovery, 2. Information search, intake, valuation, 3. Concept combination, 4. Idea generation, 5. Development of a solution approach, 6. Idea evaluation, 7. Adaptation and realization, 8. Communication and implementation; CPAS total: Creativity Process Assessment Scale; CAct (Creative activity) and CAch (creative achievement) are sum scores across creative domains of the Inventory of Creative Activities and Achievements (ICAA), CAQ is the sum score of Creative Achievement Questionnaire; correlations to the individual domains of ICAA and CAQ can be found in Supplementary Table S3; CBI: Creative Behavior Inventory; BICB: Biographical Inventory of Creative Behaviours; K-DOCS: Kaufman Domains of Creativity Scale.

Numbers in brackets are correlations with double attenuation correction, based on the respective reliabilities. The latter include Omega total for the creative process phases and CPAS total (see Table 5), as well as the following: $\alpha_{CAct} = 0.90$, $\lambda_{CAch} = 0.71$, $r_{it,CAQ} = 0.81$, $\alpha_{CBI} = 0.88$, $\alpha_{BICB} = 0.69$, $\alpha_{self/everyday} = 0.74$, $\alpha_{scholarly} = .87$, $\alpha_{performance} = 0.88$, $\alpha_{mechanical/scientific} = 0.86$, $\alpha_{artistic} = 0.85$, $\alpha_{K-DOCS,total} = 0.90$, reliability_{fluency} = 0.86, for a to d the reliability was estimated at 0.7 and for the mean of a to d at 0.8.

* $p < .05$. ** $p < .01$, two-tailed.

Hypothesis related to domains of creativity

An overall correlation of 0.51 ($p < .001$, $r_{corr} = 0.55$) was found between the domains of creativity (K-DOCS) and the CPAS total (supporting hypothesis 8), with some differences with regard to the phases and domains. The highest correlations were found between the domain self/everyday and phase 8 (communication and implementation, $r = 0.41$, $p < .001$, $r_{corr} = 0.53$), between the domain scholarly and phase 3 (concept combination, $r = 0.42$, $p < .001$, $r_{corr} = 0.52$), between the domain performance as well as artistic and phase 4 (idea generation, $r = 0.31$, $p < .001$, $r_{corr} = 0.36$ and $r = 0.36$, $p < .001$, $r_{corr} = 0.43$) and between the domain mechanical/science and phase 1 (problem discovery $r = 0.32$, $p < .001$, $r_{corr} = 0.41$) and phase 7 (adaptation and realization, $r = 0.31$, $p < .001$, $r_{corr} = 0.36$).

Hypothesis related to fluency

Fluency correlated significantly with phase 4 (idea generation, $r = 0.16$, $p < .001$, $r_{corr} = 0.19$), supporting hypothesis 9. The same correlation was found with phase 3 (concept combination) and the CPAS total.

Hypothesis related to business-relevant criteria

Medium correlations are found with more business-relevant external criteria: the CPAS total correlated with business ideas at $r = 0.29$ ($p < .001$, $r_{corr} = 0.35$), with suggestions for improvement at 0.22 ($p < .001$, $r_{corr} = 0.27$), with patents and registered trademarks at 0.16 ($p < .001$, $r_{corr} = 0.19$ resp. $r_{corr} = 0.20$) and with the mean value of the 4 criteria at 0.34 ($p < .001$, $r_{corr} = 0.39$, supporting hypothesis 10).

Discussion

The aim of this study was to develop a scale (CPAS) for assessing creativity-related traits and relating them to a multi-stage creative process. The scale was validated with a large sample of 2324 participants. The total value of CPAS (with 24 items) reached very good reliabilities with an Omega total of 0.95, a Cronbach's alpha of 0.93, and test-retest reliability of 0.87. Since Cronbach's alpha depends on the number of items, it was challenging to achieve acceptable alphas for the individual phases with just three items each. Nevertheless, Cronbach's alphas were larger than 0.70 for seven of the eight phases. Only phase 2 (information search, intake, and valuation) had a slightly lower alpha of 0.69, perhaps because the items were rather heterogeneous. They cover not only "information search" but also "information absorption", which relates to retentiveness, and knowledge required for problem-solving. The total Omega values for all individual phases were above 0.70. The descriptive statistics of the CPAS were nearly normally distributed with $M = 4.75$, $SD = 0.88$, skewness = -0.28 and kurtosis = 0.00 with a mean above the mean of the scale. Since this was expected, it made sense to use a 7-step scale in order to differentiate in the upper scale range as well.

The test-retest reliabilities indicate a stable construct; the individual phases also correlated highly between the two measurement points (between 0.72 and 0.80). The mean values show no significant differences. Thus, the instrument may be useful for monitoring creativity training programs, allowing to attribute improvements to the training success with little distortion due to repeated measurement.

The fit of the bifactor model improved when phases 4 and 5 were combined and thus assumed to represent the core creativity.

Nevertheless, describing the creative process through 8 phases also appears adequate. Indeed, phases 4 and 5 differ in their correlation patterns. Phase 4, for example, correlated significantly stronger with openness to experience ($r_{phase\ 4} = 0.54$ vs. $r_{phase\ 5} = 0.44$; Olkin's $z = 5.72$, $p < .001$) and with the K-DOCS domain performance ($r_{phase\ 4} = 0.31$ vs. $r_{phase\ 5} = 0.16$; Olkin's $z = 7.01$, $p < .001$), while phase 5 correlated significantly higher with conscientiousness ($r_{phase\ 4} = 0.10$ vs. $r_{phase\ 5} = 0.16$; Olkin's $z = 3.23$, $p = .001$) and with the

K-DOCS domain mechanical/scientific ($r_{phase\ 4} = 0.15$ vs. $r_{phase\ 5} = 0.21$; Olkin's $z = 2.53$, $p = .011$).

Conscientiousness is particularly relevant for phase 7; it helps with adaptation and realization. The fact that extraversion and risk-taking correlated highest with phase 8 is an indication of the validity of the communication and implementation phase. At the same time, phases 6 through 8 also correlated with openness and the other creativity scales, indicating that these phases are also part of creativity. Life satisfaction was positively associated with all phases of the creative process. It correlated to 0.20 with the CPAS total score, which is consistent with recent, meta-analytic results (Acar et al., 2021). Discriminant validity of the CPAS was ensured by its low correlation with agreeableness: The correlation of $|r| = 0.04$ with the CPAS total was significantly smaller than 0.10, which is considered a threshold value for a small effect. Since it is possible to offend someone when exposing problems (phase 1) or evaluating ideas (phase 6), the slightly negative correlations with agreeableness are perhaps not surprising. This fits with the results of Feist (1998). Correlations of almost zero ($r = 0.01$), on the other hand, were found for phase 4 (idea generation), phase 5 (development of a solution approach) and phase 7 (adaptation and realization) and are consistent with the results of previous studies (Silvia et al., 2011; Sung & Choi, 2009). The differentiation into phases allows for a better understanding of the relationship between creativity and agreeableness, which was inconclusive in previously studies.

For interpersonal trust, there were only non-significant correlations with phase 1 (problem discovery) and phase 7 (adaptation and realization). The other phases correlated weakly positively with interpersonal trust, hence also with the total value. Since 0.09 is not significantly smaller than 0.1, the corresponding hypothesis is not supported, but descriptively, a small effect according to Cohen (1988) can be assumed. That even small correlations became significant, is due to the large sample size.

Construct and criterion validity were given by correlations with other creativity scales. Overall, the correlations with scales that measure little C (Runco & Richards, 1998) were somewhat higher than with scales for big C (Kaufman & Beghetto, 2009). The correlation with creative self-efficacy was particularly high. A high effect size (according to Cohen 1988) was also found with the K-DOCS total value. The correlations of the creative process with creative activity, creative achievement and creative behavior (ICAA, CAQ, CBI and BICB) correspond to a medium effect size - comparable to correlations between K-DOCS and CAQ (McKay et al., 2017).

The correlation of fluency to phase 4 (idea generation) was significant at $r = 0.16$; a similar correlation was found with phase 3 (concept combination). In terms of content, this was fitting because the participants had been asked to think of unusual uses for objects. For this purpose, the concept combination makes sense in order to abstract new possible uses. The relatively low correlation may be due to the fact that the test situation was not standardized and the participants could continue with the survey before the 3 min allotted for this item had elapsed.

Many instruments on creative activities, performance and behavior take little account of business-related creativity, so corresponding items were additionally included (e.g. business idea or suggestions for improvement). There were positive correlations with small to medium effect sizes. The fact that these are not higher may be due to the fact that these items were only surveyed dichotomously and also that the sample was very heterogeneous (various occupations, pupils, students).

The phase model and the CPAS can be used to identify individual creative strengths and optimize team compositions for a given creative project. Indeed, it might be helpful to bring together individuals with strengths for different phases of the creative process. Some people are particularly good at discovering problems, others at finding and memorizing information or contributing relevant knowledge. Some might be strong in generating ideas or evaluating them, while others are better at implementing them. An appropriate alignment of individual strengths

is key for a team's performance, and ideally, team members should contribute what they are particularly good at.

If only core creativity is to be measured, the items of phases 4 and 5 can be used together as a short scale. The reliability of this core creative scale was high with omega total = 0.87, Cronbach's alpha = 0.86 and a retest reliability = 0.81. Validity was given with high correlations to openness ($r = 0.53, p < .001, r_{corr} = 0.67$), to creative self-efficacy ($r = 0.65, p < .001, r_{corr} = 0.79$) and to creative personal identity ($r = 0.66, p < .001, r_{corr} = 0.75$), and medium correlation to domains of creativity (KDOCS total: $r = 0.45, p < .001, r_{corr} = 0.51$), creative activity (CACT: $r = 0.38, p < .001, r_{corr} = 0.43$), creative achievements (CACh: $r = 0.37, p < .001, r_{corr} = 0.47$; CAQ: $r = 0.31, p < .001, r_{corr} = 0.37$), and creative behavior (CBI: $r = 0.40, p < .001, r_{corr} = 0.46$; BICB: $r = 0.41, p < .001, r_{corr} = 0.53$).

Deliberately separating the phases during the creative process can also be helpful. The team or individual can first discover problems, then seek, add, and validate information, combine concepts and pass them on to the idea generation phase, come up with variations of initial ideas, compare and evaluate them. The next phase is the adaption and realization. Here, ideas often need to be pragmatically adapted and testing loops have to be run. The last phase is communication and implementation, which includes convincing people as well as securing funding and resources. An ability test based on the 8 phases has been realized in the DBK-PG (Schuler et al., 2013). With the CPAS, a short self-assessment tool is now available. The CPAS can also guide a selection or development interview. In this way, the self-report can be better validated, and impression management can be reduced or detected.

Limitations

The tests for reliability and validity have so far only been carried out for the German version. It is possible that some participants were not as motivated to name different uses in an anonymous online survey, which could be a possible reason for some low correlations. Socially desirable self-deception (Paulhus, 1984) may have also occurred in the self-reports. This may have led to the fluid measurement tasks being taken less seriously. Often, the allotted time (3 min) for alternative tasks to measure fluency was not fully used. It would be useful to check this again under controlled conditions. The sample of convenience may have meant that the variance in creative achievement was relatively small. This should be further investigated in the future through the acquisition of Big-C samples and specific occupations.

Declaration of Competing Interest

No conflict of interest exists.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.yjoc.2023.100042.

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