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STRUCTURE OF CREATIVITY: AN INVESTIGATION ON A LATENT STRUCTURE OF THIRTEEN MEASURES OF CREATIVITY

Teemu Toivainen (a)*, Nicholas G. Shakeshaft (b), Yulia Kovas (c)
*Corresponding author

(a) Goldsmiths, University of London, 8 Lewisham Way, London SE14 6NW, United Kingdom
(b) King's College London, Strand, London WC2R 2LS, United Kingdom
(c) King's College London, Strand, London WC2R 2LS, United Kingdom

Abstract

The assessment of creativity in education is important because it allows educators to recognize and nurture students' creative potential. Many measures tap into Individual differences, such as cognitive tests; estimates of one's own individual characteristics (self-reported creativity); and inventories of previous creative behaviours. Such measures can estimate creativity in general or in specifically defined domains (e.g., in science and art). However, previous research has indicated poor construct validity which indicates that inter-relationships between different measures are inconclusive. The present study investigated latent component structure among thirteen creativity measures (three cognitive tasks, two behavioural inventories and eight self-reported questionnaires) in a sample of 188 English speaking adults. The results suggested a multidimensional structure of creativity, comprising six components explaining 74% of the variance of individual differences in this construct. Measures of previous creative behaviours (creative activity and creative achievement measures) were not strongly associated with any general creativity measures (self-reported or cognitive tests); but were associated with self-reported domain-specific visual and verbal creativity. Furthermore, out of five self-reported creativity domains (scientific, social, visual, verbal and sports), only social creativity was associated with any general creativity measures; it was associated with two cognitive creativity measures. General creativity measures (cognitive tests and self-reports), as well as behavioural inventories, loaded on three separate components. The results support a view of creativity as a multidimensional construct which needs to be considered when making inferences based on performance in specific creativity measures.

Keywords: Creativity, Measurement, Individual Differences, Structure, Construct Validity

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1. Introduction

Creativity assessment, based on psychometric measures, can broadly be sorted into three categories of creative cognition, creative traits, and creative activity and achievements (Kaufman et al., 2008). The measures include cognitive tests, self-reports and behavioural inventories. Most measures can also be used to estimate creativity in a broad sense or in a more targeted manner, at specific areas of creativity. For example, 'How creative are you?' in comparison to 'How creative are you in music?'.

Previous research on inter-relationships among different creativity measures has reported poor underlying construct validity. For example, one study reported a differential relationship of creative cognition with creative activity and achievement in science: a cognitive creativity task (a divergent thinking task) had a positive correlation with scientific creative activities ($r = .22$) but a negative correlation with scientific creative achievements ($r = -.21$; Agnoli et al., 2016). Creative activities refer to more common, everyday behaviours, such as thinking over a scientific problem; and creative achievements to socially recognised achievements, such as winning awards. In another study, the correlations between different measures of creativity, a cognitive task, self-reported measure, and behavioural inventory, varied from $r = .14$ to $.31$ - indicating weak inter-relationships (Batey et al., 2010).

The poor construct validity of creativity construct based on cognitive tests, self-reports, and behavioural inventories can be partly explained by differences in the level of measurement. For example, cognitive tests aim to estimate a rudimental cognitive ability, whereas self-reports rely on a compilation of factors. For example, depending how self-reported questions are formulated, the participants may be thinking specific behaviours in comparison to broader assessment of one's own thinking style. A previous study reported a weak correlation of $r = .22$ between a divergent thinking task, a measure of idea fluency, and self-reported creativity (Batey et al., 2010). Similar findings, with small correlations between cognitive tests and self-reports, have been reported in intelligence research among student samples (Paulhus et al., 1998). This may indicate that the self-evaluation of one's own cognitive skills is difficult and perhaps biased by several reasons, such as basing an evaluation of specific situations. For example, people who are interested in scientific topics may show poor estimation of their own intelligence when compared to their actual performance in standardised batteries of intelligence tests. Such people may, for example, especially underestimate their fluid intelligence as this tends to be associated with novel and creative thinking, rather than learned information. Similar dissonance is likely to happen when trying to evaluate one's own creative cognition.

Despite the weak inter-correlations between creativity measures, findings, based on a single measure, are often generalised as appropriate proxies for creativity. This approach is sometimes taken even if a test measure assesses a very specific ability, such as one's ability to come up with alternative uses for an object – a divergent thinking task. Some researchers have proposed that cognitive creativity tasks, such as measures of divergent thinking and associative ability, are relevant to creative behaviours across different areas (e.g., Mednick, 1962; Runco et al., 2011). Others argue that creative thinking does not rely on any specific cognitive processes that would only apply to creativity, only general factors combining creativity at different areas are intelligence and motivation (Kaufman & Baer, 2004).

The weak, even negligible, inter-relationships between different creativity measures may be due for several reasons. The associations may reflect sample-specific reasons and not be generalisable. However,

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it is also possible that they are tapping into different aspects of a latent, multidimensional creativity construct that are only loosely connected. Furthermore, another explanation could be that different creativity measures tap into separate constructs, not on a latent creativity construct. It could be that such a construct does not exist.

To investigate the structure of creativity and the relationship of domain-specific and domain-general abilities in creativity, this research investigates the latent structure of creativity in 3 ways: (1) by exploring the underlying component structure among 13 creativity measures; (2) by investigating whether creative activities or creative achievements are more strongly associated with domain-general (self-reported and cognitive) creativity measures vs. domain-specific measures (self-reported creativity in science, social, visual, verbal and sports domains) with; (3) by investigating whether domain-general creativity measures are associated with domain-specific measures of self-reported creativity in scientific, social, visual, verbal and sports domains. Specifically, the research questions for the present study are:

i. What is the component structure among 13 creativity measures?
ii. Are creative activity and creative achievement inventories associated with any general creativity measures or with self-reported creativity in science, visual, verbal, social and sports domains?
iii. Are self-reported creativity measures in science, visual, verbal, social and sports domains associated with six domain-general creativity measures?

2. Methods

2.1. Sample

In total, 188 participants took part in the study. However, the sample size for one of the measures was lower (n = 157) due to attrition. The participants ranged in age from 18 to 57 (m_{age} = 23.79; SD= 8.66). The sample included 135 women (m_{age} = 22.28; SD = 7.01) and 53 men (m_{age} = 27.62; SD = 7.01). Participants were recruited online, through social media, and through the 1st year psychology undergraduate student's participation scheme at Goldsmiths, University of London, the United Kingdom. A description of the study with a link and a personal password were emailed to participants.

The data collection was completed on-line using personal computers. Participation was open to everyone who was 18 years or older and fluent in English. Most participants were undergraduate students in the UK. Due to the length of the battery (approximately 60 minutes), the participants could interrupt at any point and return at a later date by using their personal ID. Ethics were granted for this study by the ethics board at the Department of Psychology, Goldsmiths, University of London.

2.1.1. Measures

The study included a selection of diverse creativity measures, commonly used in creativity research. The aim was to select psychometric creativity measures, which are measuring creative activities, self-reported creativity and creative cognition. The measures were also aimed to capture both domain-general and domain-specific aspects. The selection was based on literature research, conducted by the first author. The selection of the measures was not based on any systematic selection method.

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The thirteen measures included;

two behavioural inventories:

1) the Creative Behaviour Inventory (CBI; Dollinger, 2011; Hocevar, 1979),

2) the Creative Achievement Questionnaire (Carson et al., 2005);

eight self-reported creativity measures:

3) Creative Self-Efficacy (CSE; Beghetto, 2006),

4) Runco Ideational Behaviour Scale (RIBS; Runco et al., 2001),

5) Use of Creative Cognition in Studying (UCCS: Rogaten & Moneta, 2015),

Short Self-Reported Creativity (SSRC; Hughes et al., 2013) in:

6) science,

7) social,

8) visual,

9) verbal, and

10) sports;

and three cognitive tasks:

11) the Remote Associates Test (RAT; Bowden & Jung-Beeman, 2003; Mednick, 1962),

12) the Alternative Uses Task (AUT; Guilford, 1967); and

13) the Figural Divergent Thinking Task (fDT; Runco, 1986).

2.1.2. Creative Behaviour Inventory

The Creative Behaviour Inventory (CBI) is an inventory of 28 items of everyday creativity activities (Dollinger, 2011). The CBI is a shortened form of Hocevar's (1979) creative achievement and activity scale, only retaining the activity measures. Participants are asked to indicate how often they engage with specific activities on a 4-point scale (1 = not at all, 2 = monthly, 3 = weekly, 4 = daily). Examples include: ‘made your own holiday decorations’ and ‘wrote a short story’. Previous research has shown a unifactorial structure underlying the items (Dollinger, 2011). The internal consistency for the scale was Cronbach’s alpha (α) = .87.

2.1.2.1. Creative Achievement Questionnaire

The Creative Achievement Questionnaire (CAQ) measures creative achievements in ten domains: visual arts, music, dance, architectural design, creative writing, humour, inventions, scientific discovery, theatre and film; and culinary arts (Carson et al., 2005). The CAQ measures socially recognised creative achievements and, by virtue of only considering rarer creative achievements, produces a highly skewed distribution in a normal population (Silvia et al., 2012). As people tend not to excel in more than one or two domains, within a normal population the total CAQ score is not informative, since the 10 domains do not form a single factor (Carson et al., 2005). For example, by creating a total sum, a person who would have received an international award for their creative achievement in one domain might be scored similarly with a person who had several low-level achievements in various domains. However, some studies have

used factor scores, based on a 2 or 3-factorial structure, as indications of latent factors underlying the 10 dimensions (Carson et al., 2005; de Manzano & Ullén, 2018).

The measurement scale for the CAQ is 0-7. If the highest score of 7 is chosen, participants are also asked to report the frequency of the item (e.g., receiving a national award). The frequency is used as a multiplier for the item score of 7. However, in this sample of the present study, no participant reported the value of 7 for any of the items.

The present study utilised a summed score among all 10 domains as very few high scores among the participants were observed. This resulted in extremely skewed scores in all 10 domains with a large proportion of 0 values. The heavily skewed data was likely due to participants' young age. The internal consistency for the scale was α =.41.

2.1.2.2. Creative Self-Efficacy (CSE)

Creative self-efficacy (CSE) refers to a person's belief of being creative (Ti Tierney & Farmer, 2011). In the present study, CSE was measured by 3 items on a five point scale (Beghetto, 2006). The items were (a) "I am good at coming up with new ideas," (b) "I have a lot of good ideas," and (c) "I have a good imagination". Each participant was assigned a summed total of the three items. The internal consistency for the scale in the present study was α = .82.

2.1.2.3. Use of Creative Cognition in Studying (UCCS)

The Use of Creative Cognition in Studying (UCCS) consists of 5 items about students' use of creative cognition in studying, measured with a five point scale (Rogaten & Moneta, 2015). The UCCS measures how frequently the participant engages in each behaviour during their study (or work), measured with items such as 'I find effective solutions by combining multiple ideas' and 'While working on something, I try to generate as many ideas as possible'. The measure was originally intended for university students. Items which referred to studying were adapted in the present study to also apply to work situations. Each participant was given a summed total of the five items. The internal consistency for the scale in the present study was α =.77.

2.1.2.4. Runco Ideational Behaviour Scale (RIBS)

The Runco Ideational Behaviour Scale (RIBS) is a self-reported measure of creative ideation consisting of 23 items (Runco et al., 2001). Participants are asked to evaluate on a 5-point scale "How well the following statements describe you?" Statements include items such as "I come up with a lot of ideas or solutions to problems" and "Friends ask me to help them think of ideas and solutions". The validation study of the RIBS established a two-factorial structure for the 23 items (Runco et al., 2001). The present study included the 17 items loading highly on the first factor, which measures self-evaluated creative thinking (Runco et al., 2001). The internal consistency for 17 items in the present study was α = .93.

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2.1.2.5. Short Self-Reported Creativity (SSRC)

The Short Self-Reported Creativity (SSRC) measure requires participants to rate their creativity in comparison to others in five domains: visual, verbal, scientific, social and sports (Hughes et al., 2013). For each of the five questions, participants use a scale of 1 to 7 in their self-evaluations. The 5 items are not treated as a unitary scale, which is also reflected in the low internal consistency of α =.41.

2.1.2.6. The Remote Associates Test (RAT)

The Remote Associates Test (RAT) is a measure of associative ability that is used as a measure of creative cognition (Bowden & Jung-Beeman, 2003; Mednick, 1962). In the RAT, participants are shown three words and asked to come up with a fourth that creates a compound word with the three stimuli words. For example, the three stimuli words “cake” “swiss” and “cottage” would form compound words with the word “cheese”. The score was the sum of correct responses, out of 30 items. The 30 items were selected to cover a range of items with different level of difficulty, based on the normative data of 144 items, reported in previous research (Bowden & Jung-Beeman, 2003; Mednick, 1962). The internal consistency for the scale in the present study was α =.62.

2.1.2.7. The Alternative Uses Task (AUT)

The verbal version of the Alternative Uses Task (AUT) is a measure of divergent thinking (Guilford, 1967). The measure included three trials during which the participants are shown a word of a common household object (e.g., a brick, a paperclip and a newspaper; Webb et al., 2017). The participants were instructed to come up with as many alternative uses for each item as they could think of within 2 minutes.

In the present study, the AUT total score was the mean value of the scores based on all three stimuli. The score for each individual stimulus was based on the total number of responses per item. For example, if a participant came up with 6 alternative uses for a brick, 9 for a paperclip and 12 for a newspaper, the total score for the task would be 9 (27 / 3 = 9). The present study only utilised the frequency score for the AUT task due to limitations in resources for evaluating the creative originality of individual responses. This was deemed sufficient since this study was an initial exploration of the relationships across the various creativity measures listed above. Also, previous research has shown that frequency score (the number of given responses) is highly correlated with the originality score of the responses (Batey et al., 2010). The internal consistency for the frequency scores of three conditions was α = .86.

2.1.2.8. The Figural Divergent Thinking Task (fDT)

Figural Divergent Thinking (fDT; Runco & Acar, 2012) is a similar measure to the AUT. In this task participants are shown unfinished drawings with only a few lines or curves and asked to come up with ideas what the image may represent. Participants were instructed to come up with as many responses as they can in 2 minutes. The fDT total score was calculated similarly to the AUT as a mean value of the scores based on each three stimuli. The score for each individual stimulus was based on the total number of responses per item. The internal validity for three items was α = .88.

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All creativity measures used in the study are summarised in the Table 1.

Table 1. The study measures (name, number of items, scale, Cronbach's alpha, example of items, and reference)

Name of the measure	Number of items	Scale per item/stimuli	Cronbach's alpha	Example items	Reference
Creative Behaviour Inventory (CBI)	28	1-4	.87	Made your own holiday decorations; Wrote a short story; Wrote the lyrics to a song	Dollinger (2011); Hocevar (1979)
Creative Achievement Questionnaire (CAQ)	10	0-7 (if 7 is selected, the score will be multiplied based on the frequency of the event)	.41[1]	Creative achievements in visual arts, music, dance, architecture, creative writing, humour, inventions, scientific discovery, theatre and film, and culinary arts. I have no training or recognized talent in this area; I have taken lessons in this area; People have commented on my talent in this area; My work has been critiqued in national publications.	Carson et al. (2005)
Creative self-efficacy (CSE)	3	1-5	.82	I am good at coming up with new ideas; I have a lot of good ideas; I have a good imagination	Beghetto (2006)
Use of Creative Cognition in Studying (UCCS)[2]	5	1-5	.77	I find effective solutions by combining multiple ideas; While working on something, I try to generate as many ideas as possible; I try to act out potential solutions to explore their effectiveness.	Rogaten and Moneta (2015)
The Runco Ideational Behaviour Scale (RIBS)	17	1-5	.93	I come up with a lot of ideas or solutions to problems; Friends ask me to help them think of ideas and solutions; It is important to be able to think of bizarre and wild possibilities.	Runco et al. (2001)
Short Self-Reported Creativity (SSRC)	5	1-7	.37[3]	In relation to others, how creative are you in visual, verbal, scientific, social and sports areas?	Hughes et al. (2013)
Remote Associates Test (RAT)	30	0-30	.62	In the RAT, participants are shown three words and asked to come up with a fourth that creates a compound words with the three stimuli words. For example, the three stimuli words "cake" "swiss" and "cottage" would form	Bowden and Jung-Beeman (2003)

				compound words with the word "cheese".	
Alternative Uses Task (AUT)	3 trials	0-30	.86, based on the total scores of 3 trials	The measure included three trials during which the participants are shown a word of a common household object (a brick, a paperclip and a newspaper). The participants were instructed to come up with as many alternative uses for the object as they can think of in 2 minutes.	Guilford (1967)
Figural Divergent Thinking Task (fDT)	3 trials	0-30	.88, based on the total scores of 3 trials	In this task participants are shown 3 unfinished drawings with only a few lines or curves and asked to come up with ideas what the image may represent. The participants are instructed to come up with as many responses as they can in 2 minutes. The score is the mean of the three items.	Guilford (1967); Runco and Acar (2012)

[1]CAQ is not designed to be used as a composite score (Carson et al., 2005); however, due to very low frequencies in each achievement domains, a composite was created to account for creative achievement in general
[2]The measure was originally intended for university students. Items which referred to studying were adapted in the present study to also apply to work situations.
[3]The items are not expected to form a unitary scale

3. Results

The descriptive statistics for the thirteen measures are presented in Table 2.

Table 2. Descriptive statistics of thirteen creativity measures

	N	Range	M	Sd	Skew	Kurtosis
CBI	185	28-112	48.25	12.21	0.67	0.53
CAQ total	188	0-70	6.22	4.33	1.11	1.65
CSE	167	1-15	11.26	2.16	-0.90	2.02
UCCS	172	5-25	17.42	2.86	-0.20	1.78
RIBS	176	1-5	3.36	0.70	-0.06	-0.29
SSRC science	169	1-7	3.93	1.59	-0.32	-0.69
SSRC social	169	1-7	5.28	1.44	-0.77	0.19
SSRC visual	169	1-7	4.30	1.66	-0.43	0.19
SSRC verbal	169	1-7	4.34	1.52	-0.40	-0.38
SSRC sports	169	1-7	3.44	1.82	0.19	-1.02
RAT	157	0-30	12.17	7.30	0.09	-0.99
AUT	169	0-30	11.79	5.68	0.84	0.69
fDT	169	0-30	9.10	4.48	0.69	0.31

Note. CBI = Creative Behaviour Inventory; CAQ total = total score for Creative Achievement Questionnaire; CSE = Creative Self-Efficacy; UCCS = Use of Creative Cognition in Studying; RIBS = Runco Ideational Behavior Scale; SSRC = Short Self-Rated Creativity; RAT = Remote Associates Test; AUT = Alternative Uses Task; fDT = Figural Divergent Thinking Task.

The bivariate correlation coefficients among the thirteen measures are presented in Table 3.

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Table 3. Correlations among thirteen creativity measures

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1.CBI	1												
2.CAQ total	.50**	1											
3.CSE	.19*	.27**	1										
4.UCCS	.25**	.19*	.47**	1									
5. RIBS	.36**	.36**	.62**	.57**	1								
6.SSRC science	.03	.09	-.02	.12	.14	1							
7.SSRC social	.15	.19*	.23**	.20**	.28**	-.04	1						
8.SSRC visual	.49**	.37**	.22**	.21**	.17*	-.01	.17*	1					
9.SSRC verbal	.33**	.28**	.24**	.21**	.36**	.12	.09	.26**	1				
10.SSRC sports	.01	.13	.17*	.02	.16*	.18*	.13	.09	.09	1			
11.RAT	.09	.12	.08	.10	.06	.13	-.01	.01	-.01	-.02	1		
12.AUT	.24**	.20**	.22**	.22**	.26**	.05	.24**	.17*	.31**	.07	-.12	1	
13.fDT	.35**	.30**	.24**	.24**	.28**	.11	.29**	.16*	.29**	.04	.02	.72**	1

Note. ** p < .01; * p < .05
CBI = Creative Behaviour Inventory; CAQ total = total score for Creative Achievement Questionnaire; CSE = Creative Self-Efficacy; UCCS = Use of Creative Cognition in Studying; RIBS = Runco Ideational Behaviour Scale; SSRC = Short Self-Rated Creativity; RAT = Remote Associates Test; AUT = Alternative Uses Task; fDT = Figural Divergent Thinking Task.

Principal Component Analysis (PCA) was used as a dimension reduction method to explore the correlations among observed variables using a smaller number of components. The scree plot for the rotated component solution, based on Varimax rotation, is presented in Figure 1. Varimax, which is an orthogonal rotation method, was used to maximise the differences between the components. No prior predictions of the number of components or their relationships were made.

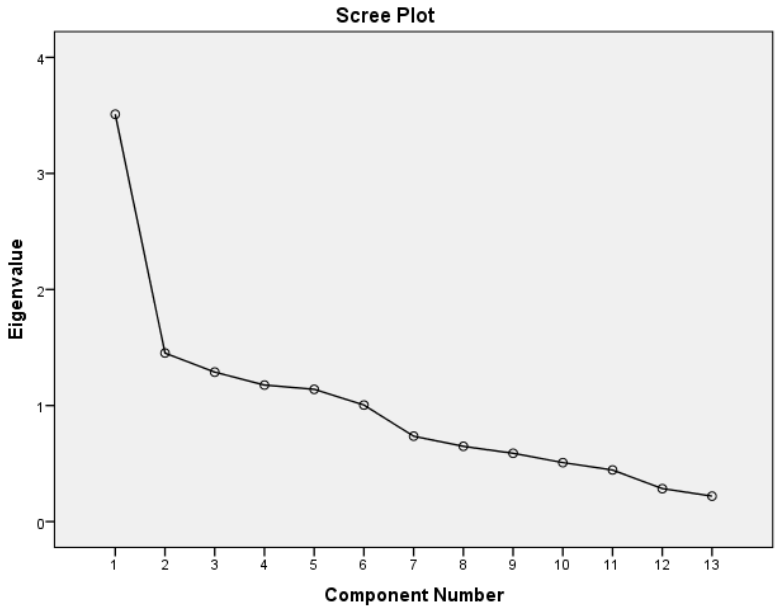

Figure 1. Scree plot for thirteen creativity measures

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Based on a rotated component solution, with a cut-off point of 1 Eigenvalue in a scree plot, six components emerged. The estimates for variance explained by each rotated component are presented in Table 4.

Table 4. The variance explained by rotated component solution among thirteen creativity measures

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3.51	26.99	26.99	3.51	26.99	26.99
2	1.45	11.17	38.17	1.45	11.17	38.17
3	1.28	9.90	48.07	1.28	9.90	48.07
4	1.17	9.04	57.12	1.17	9.04	57.12
5	1.14	8.76	65.89	1.14	8.76	65.89
6	1.00	7.72	73.62	1.00	7.72	73.62
7	.73	5.66	79.28			
8	.64	4.98	84.26			
9	.58	4.52	88.79			
10	.50	3.91	92.70			
11	.44	3.42	96.12			
12	.28	2.18	98.31			
13	.21	1.68	100.00			

In total, the six components, based on the rotated component solution, explained 73.62% of total variance in the outcome. The rotated component loadings, based on a Varimax rotation, are presented below in Table 5.

Table 5. Rotated component loadings of thirteen creativity measures (Varimax rotation)

	1 Visual and Verbal Creativity	**2 Self-reported Creative Cognition**	**3 Test-based Divergent Thinking**	**4 Sports Creativity**	**5 Scientific Creativity**	**6 Linguistic Associative Creativity**
1.CBI	**.79**	.13	.12	-.12	-.05	.10
2.CAQ total	**.65**	.17	.15	.13	-.03	.27
3.CSE	.14	**.81**	.08	.20	-.12	.01
4.UCCS	.07	**.81**	.12	-.18	.08	.08
5. RIBS	.28	**.83**	.10	.10	.03	-.01
6.SSRC science	-.04	.02	.13	.23	**.82**	.18
7.SSRC social	.09	.12	**.41**	**.42**	**-.56**	.13
8.SSRC visual	**.76**	.10	.05	.14	-.14	.05
9.SSRC verbal	**.61**	.16	.14	-.06	.31	-.27
10.SSRC sports	.05	.05	-.06	**.90**	.13	-.07
11.RAT	.08	.06	-.06	-.06	.11	**.91**
12.AUT	.14	.16	**.88**	-.01	.03	-.16
13.fDT	.17	.10	**.90**	-.03	.03	.07

Note. factor loadings >.40 are bolded.
CBI = Creative Behaviour Inventory; CAQ total = total score for Creative Achievement Questionnaire; CSE = Creative Self-Efficacy; UCCS = Use of Creative Cognition in Studying; RIBS = Runco Ideational Behaviour Scale; SSRC = Short Self-Rated Creativity; RAT = Remote Associates Test; AUT = Alternative Uses Task; fDT = Figural Divergent Thinking Task.

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Four measures loaded highly (>.40) on the first component. The measures were CBI (.79), CAQ (.65), SSRC in visual (.76) and SSRC in verbal (.61) domains. The second factor had high loadings of CSE (.81), UCCS (.81) and RIBS (.83). Verbal and figural versions of divergent thinking tasks loaded highly on the same factor (AUT, .88; fDT, .90). SSRC in social domain creativity loaded highly on three components: the third - with AUT and fDT (.41); the fourth - with SSRC in sports domain (.42); and the fifth -with scientific domain (-.56). The negative component loading indicates negative association of scientific SSRC measure with the latent factor score. The RAT loaded on the sixth component, separately from the other measures.

4. Discussion

This study investigated the underlying component structure and inter-relationships of thirteen domain-general and domain-specific creativity measures. Two were behavioural inventories (CBI and CAQ), eight were self-reports (CSE; UCCS; RIBS; and SSRC in science, visual, verbal, social and sports) and three were cognitive tests (RAT, AUT and fDT).

4.1. What is the component structure among 13 creativity measures?

Based on a rotated component solution, six components emerged, explaining 73.62% of the variance of individual differences in creativity. The first component, *Visual and Verbal Creativity*, explained 26.99% of the total variance and included four measures: CBI (.79), CAQ (.65), SSRC in visual (.76) and SSRC in verbal (.61) domains. The results showed that self-reported verbal and visual creativity loaded highly (.76 and .61, respectively) on the *Visual and Verbal Creativity* component with the creative achievement (CBI) and activity (CAQ) measures. This may indicate that creative achievement and activity measures emphasise behaviours, which are based on verbal and visual skills. For example, the CBI does not include items that would be specific for scientific, social or sports creativity, hence being unable to capture creativity in those areas. Additionally, visual and verbal activities are commonly recognised being creative and therefore identified easily by individuals when assessing their own creativity. For example, it could be that visual creativity is easier to recognise than sports or scientific creativity.

The second component, *Self-reported Creative Cognition*, explaining 11.17% of the total variance, had high loadings of CSE (.81), UCCS (.81) and RIBS (.83). All three self-reported scales measure individuals' beliefs in their own creative thinking with different emphasises. However, some of the items are very similar which explains the associations. Additionally, some researchers have made an argument that similar measurement method between creativity measures, such as CSE; UCCS; and RIBS, may increase the associations between them (Kandler et al., 2016). However, this was a speculative claim, and no elaboration was given how this could be tested empirically.

The third component, *Test-based Divergent Thinking*, explained 9.90% of the total variance. It had high loadings of verbal and figural versions of divergent thinking tasks (AUT, .88; fDT, .90). The high correlation between the measures is likely to reflect that idea fluency is based on similar cognitive processes, regardless of whether the stimuli is in a linguistic or in visual form.

The fourth (8.77%), fifth (8.76%) and sixth (7.72%) components each had a high loading from a single measure. The measures loading on the components were, respectively, self-reported creativity in

sports (.90; *Sports Creativity*), self-reported scientific creativity (.82; *Scientific Creativity*) and the performance in the Remote Associates Test (.91; *Linguistic Associative Creativity*). In addition, self-reported social creativity had weaker cross-loadings with sports creativity on the fourth component (.42) and with the scientific creativity on the fifth component (-.56). The negative relationship between social and scientific creativities could be due to many reasons, one being that those who excel in scientific creativity may be better working independently, which would reduce the number of opportunities to engage with their social creativity. Social creativity also had a weak loading on the third (*Test-based Divergent Thinking*) component (.42). It is plausible that social creativity is a more general attribute that is beneficial to other forms of creativity as well, from idea fluency to creative behaviours in sports.

Taken together, the latent structure of six components, among 13 individual level measures of creativity, indicates that creativity is not a unitary construct.

4.1.1. Are creative activity and creative achievement inventories associated with any general creativity measures or with self-reported creativity in science, visual, verbal, social and sports domains?

Evaluation of the results on the relationship between domain-general and domain-specific creativity measures (science, visual, verbal, social and sports) showed that only the self-reported social creativity (SSRC social) loaded highly on any of the six domain-general creativity measures (CSE, UCCS, RIBS, RAT, AUT and fDT). It had a moderate component loading (.41) on the same Test-based Divergent Thinking component with the VAU and fDT.

One possible explanation for the positive associations between social creativity and divergent thinking may also be linked to personality traits of Openness to Experience and Extraversion. Previous research has found that these personality traits were positively associated with divergent thinking (Furnham & Bachtiar, 2008). These personality traits also capture the frequency and enjoyment of social interactions which are relevant in the engagement in social creativity. Interestingly, none of the *Self-reported Creative Cognition* measures (CSE, UCCS and RIBS) loaded highly on the same factor with any self-reported creativity domains (science, social, visual, verbal and sports). This may indicate that Self-reported Creative Cognition measures are not biased towards any specific domain, or alternatively not tapping into the same latent construct.

4.1.2. Are self-reported creativity measures in science, visual, verbal, social and sports domains associated with six domain-general creativity measures?

Additionally, none of the domain-general creativity measures (CSE, UCCS, RIBS, RAT AUT and fDT) loaded highly with the behavioural inventory measures of creative activity (CBI) or creative achievement (CAQ). This raises a question of the ecological validity of domain-general creativity measures: are these measures beneficial to applied settings if they are not associated strongly with creativity dimensions of actual behaviours, captured as creative activities and achievements? Similarly, the self-evaluated measures of creativity in five different domains (science, visual, verbal, social and sports) did not load highly on the same components with any of the six domain-general creativity measures. It could be

that evaluating one's own creativity includes such a wide range of different behaviours that this reduces the reliability of the measurement and hides any effect, if there is one to be found.

Taken together, these findings provide interesting insights into the structure of creativity. As indicated with the previous research, creativity is a complex and multidimensional construct which is not easy to define and operationalise as clearly separated elements (e.g., Agnoli et al., 2016). For example, the lack of associations between self-reported verbal creativity with a verbal measure of creative cognition (RAT) indicates that when individuals are evaluating their verbal creativity, it is not based on their ability to create linguistic associations (or compound words). It could be that participants are thinking of more complex behaviours, such as those which are recognised as being creativity in various social contexts. This also highlights that different theoretical approaches to creativity, such as cognitive and sociocultural approaches, are not necessarily accommodating one another to a great extent. This separation between the different theoretical approaches to creativity can create difficulties in the interpretation of results. In a similar vein, the lack of association between Creative Self-Efficacy and the measures of creative cognition (AUT and RAT) implies that the evaluation of creative thinking is not based on the evaluation of these specific abilities of creative cognition. Again, the self-evaluation of creative self-efficacy may cover of large array of different cognitive processes.

4.1.3. Limitations

The present study had a number of limitations. One problem for creativity measurement, especially in relation to self-reported measures, is how to separate creativity from a skill which it is associated with (Kaufman & Baer, 2005). It may be that when reporting self-evaluated creativity, participants instead evaluate their level of skill, instead of their creativity in the domain. On the other hand, inventories of creative activities may only measure a frequency of activity, regardless of creative input. For example, attending a pottery class may assign a person scores in the inventory even if they only repeated the actions of the course tutor. This repetitive activity would be not considered being creative.

In addition, The Creative Achievement Questionnaire (CAQ) may not be a suitable measure to use in young samples due to the low variance in the scores. Many creative achievements may reasonably be expected in higher numbers only in older participants. Also, the CAQ in its current form is not up to date with more recent technological creative areas, such as coding and graphic design. Another limitation in the present study was that the language criterion was set for fluent English skills rather than being restricted to only native English speakers. It has been shown, for example, that, in the Remote Associates Test, native speakers have advantage in comparison to non-native speakers (Estrada et al., 1994). The sample size also poses a limitation in the present study. Recommended sample size for a robust PCA with 13 measures would be 200 or higher (Comrey et al., 2013). Additionally, the sample in the present study had a high proportion of students from Arts, Humanities and Psychology.

4.1.4. Future directions

More studies are needed to uncover the inter-relationships of creativity measures in different samples. Better understanding of the underlying structure among the measures will enhance research in this area. Similarly, more research is needed on other cognitive tasks. For example, the Remote Associates Test

has been extensively used in a verbal format, but much less work has been done with a newly developed visual version (Toivainen et al., 2019). Additionally, more research is needed that explores the relationship between psychological constructs, such as personality and intelligence, with different creativity measures in the same sample. Further research is also needed to find reliable ways to empirically separate the level of skill from creative output.

5. Conclusions

The non-unitary structure of creativity can propose difficulties for research. This should not be seen as a disadvantage. However, it has to be recognised. To address this issue, it is important is to be clear to which aspect of creativity we are referred to. As shown, creative cognition, evaluations one's creativity in certain situations or previous creative behaviours, are likely not to be indicators of same dimension of creativity construct. Alternatively, they could be indicators of completely different constructs.

Clarifying the structure of creativity and the extent to which different measures tap into its different facets, has implications also for education (Plucker, 2004). For example, in order to cultivate creativity, educational practises could focus on general creative process skills or certain domain-specific tasks, depending on our understanding of creativity (Plucker, 2004). Tailoring creative interventions or activities to the correct level and application will save time and resources.

To summarise, the findings of this study provide evidence for the variable relationships among different measures that are used interchangeably as proxies for creativity. The findings suggest that existing measures are likely to tap into different dimensions of creativity or even separate constructs. This could even mean that creativity is not a general construct but a sum of various factors which are used to associate with creativity.

Data Availability Statement

Data is available upon request.

Declaration of Conflicts Interests

The authors would like to declare that they have no conflict of interest to disclose.

Ethical Statement

Ethical approval for this study/case/case series was obtained from the ethics board at the Department of Psychology, Goldsmiths, University of London (TT1_2016).

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