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Targeted intervention to increase creative capacity and performance: A randomized controlled pilot study

Eliza Kienitz[a,b], Eve-Marie Quintin[a], Manish Saggar[a], Nicholas T. Bott[a,b], Adam Royalty[c], Daniel Wei-Chen Hong[d], Ning Liu[a], Yin-hsuan Chien[e,f], Grace Hawthorne[c], Allan L. Reiss[a,*]

[a] *Center for Interdisciplinary Brain Sciences Research, Department of Psychiatry and Behavioral Sciences, Stanford University, 401 Quarry Road MC 5795, Stanford, CA 94305, United States*
[b] *Pacific Graduate School of Psychology-Stanford University Psy.D. Consortium, 1791 Arastradero Road, Palo Alto, CA 94304, United States*
[c] *Hasso Plattner Institute of Design at Stanford, 416 Escondido Mall, Building 550, Room 169, Stanford, CA 94305, United States*
[d] *Institute of Biomedical Engineering, National Taiwan University, No. 1, Sec. 1, Jen-Ai Road, Taipei 100, Taiwan*
[e] *Department of Pediatrics, Taipei City Hospital Zhong-Xing Branch, No. 145, Zhengzhou Road, Datong District, Taipei City 103, Taiwan*
[f] *Graduate Institute of Biomedical Electronics and Bioinformatics, National Taiwan University, Room 410 BL Building, No. 1, Roosevelt Road, Sec 4, Taipei 10617, Taiwan*

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ABSTRACT

Creativity is generally regarded as the ability to synthesize novel connections to create meaningful outcomes. Previous studies in adults have mainly focused on creativity as a static construct. In this study, we tested the hypothesis that creativity is a fluid construct within normal adults that can be enhanced with a targeted intervention. We also explored the relationship between baseline personality characteristics and level of creativity enhancement. A 5-week creativity capacity building program (CCBP) was conducted in parallel with a 5-week language capacity building training program (LCBP) designed as a control intervention. Creativity was measured, before and after training using a standardized assessment of creativity: the Torrance Test of Creative Thinking-Figural (TTCT-F). Personality was measured before training using the NEO Five-Factor Inventory (NEO-FFI). Results revealed greater increase for CCBP than LCBP on two primary factors of the TTCT-F: Resistance to Premature Closure and Elaboration. Analysis of NEO-Openness and Extraversion factors revealed more improvement on the TTCT-F scores after intervention for individuals with high Extraversion (E) scores, but this did not differ between groups. Altogether, our results indicate that creativity is a fluid construct, functioning independently of personality traits, which can be enhanced through targeted creativity intervention.

1. Introduction

Creativity has long been a psychological construct of great intrigue to researchers, given the value that our societies have placed on creative achievements over time. Contemporary American culture places a high value on the concept of creativity and the ability of an individual to engage in creative processes (Kern, 2010). Individuals who express higher creative

* Corresponding author. Tel.: +1 650 498 4538.
E-mail address: areiss1@stanford.edu (A.L. Reiss).

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capacity may be more desirable to employers (Jin Nam, Anderson, & Villette, 2009; Pace & Brannick, 2010), express greater confidence (Bungay & Vella-Burrows, 2013), and are seen as possessing a special trait (Garcia-Ros, Talaya, & Perez-Gonzalez, 2012). Beyond the obvious external outputs of creative individuals, creativity is also linked to psychological well-being. For example, individuals with higher creative capacity show greater psychological resilience in the face of tragedy, such as Hurricane Katrina and within Holocaust survivors (Coholic, Eys, & Lougheed, 2012; Greene, Hantman, Sharabi, & Cohen, 2012; Lynch, Sloane, Sinclair, & Bassett, 2013; Metzl, 2009). Creative thinking has also been linked to flexibility and adaptation to daily-life demands (Csikszentmihalyi, 1996; Reiter-Palmon, Mumford, & Threlfall, 1998) and entrepreneurial success (Amabile, 1997; Kern, 2010). Given this link between creativity and performance as well as other psychological strengths, finding new ways to foster individual creative capacity represents an important area of research. The main focus of our work is to examine whether targeted creativity training, as compared to parallel control training, can enhance creative capacity at the individual level.

1.1. Models of creativity

The dynamic and complex nature of creativity and creative expression has made it challenging to experimentally assess creative capacity in a constrained laboratory environment (Guilford, 1988; Kettner, Guilford, & Christensen, 1959). In the extant literature focused on individual creativity, the construct is commonly defined as a behavior, thought, or output that is both novel and useful (Feist, 1998; Guilford, 1950; Hennessey & Amabile, 2010). In order to conduct research on such an illusive construct, various models of creativity have been purported (Guilford, 1988; Lubart, 2001; Megalakaki, Craft, & Cremin, 2012; Scott, Leritz, & Mumford, 2004). Generally, these models seek to deconstruct the creative process itself, in the hope of identifying and measuring the components that result in creative output. Broadly, researchers have identified and studied four components of a creative process: cognitive, affective, environmental, and motivational (Amabile, Barsade, Mueller, & Staw, 2005; Feist, 1998; Megalakaki et al., 2012; Scott et al., 2004).

Models of creativity have evolved over time. While initial models focused on a set staged process (Csikszentmihalyi & Getzels, 1971; Lubart, 2001; Scott et al., 2004) later models have expanded to view an integrated or dynamic approach (Hennessey & Amabile, 2010; Lubart, 2001). The dynamic understanding describes an integrated process involving individual elements such as neurological, cognitive, affective, and motivational factors as well as environmental factors (Hennessey & Amabile, 2010; Rubenson & Runco, 1992; Scott et al., 2004). Additionally, social and interpersonal factors have been shown to affect creative outcomes (Byron & Khazanchi, 2012). As such, some previous studies have focused on classrooms or workplaces as both prime venues for individual creative enhancement as well as situations in which creative processes may be implemented to change the overall environment (Craft, 2008; Cremin, Burnard, & Craft, 2006; Fasko, 2001; Treffinger, Solomon, & Woythal, 2012). Although research into creativity as a social practice often focuses on a wide variety of individual and inter-personal factors, similarities also exist within study designs, assessment strategies, and models. For example, divergent thinking, operationalized as the capacity to generate multiple alternate solutions, remains of primary interest in assessing outcomes of a creative process whether at the individual or group level (Claxton, Pannells, & Rhoads, 2005; Schmidt, Soper, & Facca; 2012; Treffinger, 1971; Treffinger et al., 2012). Understanding the influence of social interactions and group factors may prove to be an additional axis along which creative capacity enhancement occurs at an individual level as well. For the purposes of our study we attempt to create a nearly identical learning environment for our intervention and control group so as to mitigate the potential effects of social factors in training. However, our hypotheses and measurement strategies focus on several levels of the creative construct within an individual.

Several studies have investigated underlying personality or characterological factors – attempting to define the creative individual (Cropley, 1990; Feldhusen & Goh, 1995; Feist & Barron, 2003). Results from these studies indicate that the personality traits of Openness and Extraversion, based on the Five-Factor personality model (Costa & McCrae, 1992; Norman, 1963), are related to creative expression (Batey & Furnham, 2006; Cropley, 1990; Furnham & Bachtiar, 2008). The influence of these individual personality traits suggest that the underlying cognitive processes of individuals with greater openness and extraversion allows for greater synthesis of connections, motivation for creation and ability to form novel ideas (Ivcevic & Mayer, 2007; Richards, Kinney, Benet, & Merzel, 1988). However, a strong association with personality traits also implies that creativity may be a product of stable attributes that are relatively resistant to modification (Batey & Furnham, 2006; Ivcevic & Mayer, 2007). Using the Five-factor model of personality, we also investigate whether the fluidity of creative capacity is dependent upon stable personality traits.

1.2. Assessments of individual creative capacity

Central to the measurement of creative expression is the process of divergent thinking (Guilford, 1950; Kim, 2011; Scott et al., 2004). Divergent thinking abilities can be understood as the generation of multiple or alternative solutions to a given stimuli or problem. Researchers have operationalized divergent thinking into components, such as, originality of ideas, number of relevant ideas (fluency), number of categories utilized (flexibility), level of elaboration for each idea, etc. (Csikszentmihalyi & Getzels, 1971; Kettner et al., 1959; Scott et al., 2004; Torrance, 1999). Early prototypical work of Guilford et al. (1967), who developed the Alternate Uses Test (AUT) to assess divergent thinking, spurred a large number of such assessments that are rigorously tested and standardized. For example, the Torrance Test of Creative Thinking (TTCT), figural version, is one of the widely used standardized measure of divergent thinking. In this test, participants are given a

set of incomplete figures and are asked to complete them in a set amount of time such that the final figure should portray a unique and interesting story (Torrance, 1981). Further, trained evaluators, who are blind to the study protocol, conditions, and participants, are recommended to assess and score the TTCT-F responses on various aspects of divergent thinking. In the current work, we used TTCT-F (versions A and B) as a measure to assess individual creative capacity. For an unbiased and standardized evaluation, figural responses were sent to the Scholastics Testing Service, Inc (http://ststesting.com).

1.3. Enhancing creative capacity using targeted training

Given the high value of creative abilities, many researchers, educators, and workplaces hope to find ways to increase or promote creativity. Further, creative capacity is known to decline in early childhood (Claxton et al., 2005). To combat this decline in creative capacity, studies focused on creativity promotion have primarily focused on children and adolescents in a classroom setting. For example, within the classroom, strategies that include curriculum development, pedagogical training for instructors, and specific creative training have been successfully employed (Cliatt, Shaw, & Sherwood, 1980; Craft, 2012; Ekvall & Ryhammar, 1999; Galton, 2010; Gerrard, Poteat, & Ironsmith, 1996; Reese, Parnes, Treffinger, & Kaltsounis, 1976). A contemporary meta-analysis of studies focused on enhancing creativity suggests that the construct may be more flexible and adaptable in adults than previously assumed (Scott, Leritz, & Mumford, 2004). Enhancing creativity within individual professional domains such as engineering (Ayob, Majid, Hussain, & Mustaffa, 2012; Charyton & Merrill, 2009) and management (Choi, Anderson, & Veillette, 2009; Fontenot, 1993; Herrmann, 2013) has recently been explored. These studies employed strategies that included workplace environment changes, process improvements, and domain-specific training for creative capacity enhancement (Ayob, Majid, Hussain, & Mustaffa, 2012; Charyton & Merrill, 2009; Choi et al., 2009; Fontenot, 1993). Across these studies, targeted training programs have been the most effective and common strategy for increasing creative capacity.

Although effective, previous trainings in adults focused mainly in domain specific groups and were mostly done in the constraints of workplace environments. It is unclear whether domain-general targeted training done outside of workplace or scholastic settings would provide creative capacity enhancement in an adult population. To this end, we developed a randomized control experiment, where adults from a range of vocational and educational backgrounds participated and half of them were pseudo-randomly assigned to either a creative capacity building program (CCBP) or a parallel control of language capacity building program (LCBP) for 5-weeks. Our CCBP training was based on applied design-thinking and creative skills and included rapid prototyping and fast-paced exercises (see Section 2 and Hawthorne et al., 2013). Overall, we tested two hypotheses about the nature and development of creativity. First, we examined whether domain-general targeted-training would significantly increase creative capacity as compared to control training. Second, we examined whether individuals with greater openness and extraversion personality traits would show increased creative enhancement following training as compared to individuals with low openness and extraversion.

2. Methods

2.1. Participants

Thirty-six participants enrolled in the study and 28 participants completed the CCBP and LCBP interventions as well as the time 1 (T1) and time 2 (T2) assessments of the TTCT-F. Of the initial 36 participants, 2 withdrew their participation before their first CCBP or LCBP session, 1 participant was excluded due to lack of class participation, 1 participant was excluded due to use of prescription antidepressants, and 4 participants completed the training program but not the assessments due to time constraints. Overall, the average age of the participants was 29. The group included 16 women and 12 men. Additionally, the participants came from both academic and work-based settings around the San Francisco Bay Area; 7 students and 21 professionals. Details are presented in Table 3.

The University Institutional Review Board, Human Subjects Division, approved all the experimental protocol and procedures. Written informed consent was obtained for every participant in the study. The overall study was conducted in a parallel group, crossover design such that people who were initially enrolled in the LCBP were then enrolled in the CCBP (Hawthorne et al., 2013). In the current paper, we report results from comparison of the initial parallel group intervention (i.e., before crossover).

2.2. Study design

Data for the study were collected as part of a larger experimental protocol examining the cognitive and neural correlates of creativity in normal healthy adults for which results focused on the executive function domain are also reported elsewhere (Hawthorne et al., 2013). The study included two groups, assessed at two time points. Following baseline assessments at Time 1 (T1), participants were randomly assigned to receive either a creativity capacity building program (CCBP) or a control intervention (language capacity building training program (LCBP)). We assessed creative output at T1 with the Torrance Test of Creative Thinking Figural (TTCT-F) (Torrance, 1999) version A and with version B at Time 2 (T2). We assessed personality

Table 1
Creative capacity building program elements.

Element	Description
See	Reduce perceptual bias so that one can see multiple perspectives to a given problem and identify opportunities
Start	Induce bias toward action (or reduce bias against taking an action) by using rapid prototyping and fast-paced exercises
Build	Enhance manual dexterity by building 3D prototypes to communicate ideas using limited everyday materials
Feel	Sharpen affective processes to better empathize with others to better understand user's needs and requirements
Communicate	Enhance listening and communication skills – better connecting leads to better empathy and design
Inspire	Seek active inspiration from everyday incidents and situations to nurture original idea generation
Synthesize	Combining disparate constructs to transform independent set of ideas into a new direction
Navigate	Reduce the fear of failure in situations where the outcome is uncertain by becoming aware of and embracing uncontrollable variables

Table 2
TTCT-F sub-score definitions.

	Definition
Fluency	The total number or relevant responses.
Originality	The unusualness or infrequency of the responses.
Abstractness of Titles	The ability to capture the essence of the information involved, know what is important, enabling the viewer to see the picture more deeply and richly.
Elaboration	The number of types of responses to a stimulus as well as the imagination and use of detail in a response.
Resistance to Premature Closure	The ability to demonstrate an openness of mind that allows for original ideas to form, taking into consideration all available information.

Adapted from Torrance Tests of Creative Thinking Interpretive Manual, 2008 (p. 2).

with the NEO Five Factor Inventory, 3rd edition (NEO-FFI-3, Costa & McCrae, 1992) at T1. Assessments occurred one week before (T1) and one week after (T2) the intervention (CCBP or LCBP).

2.3. Creativity training intervention and control intervention

The interventions are described in detail elsewhere (Hawthorne et al., 2013). Briefly, both interventions were conducted in an interactive weekly 2-hour group session. There were 5 sessions for each group. The CCBP was an abbreviated version of a highly popular class offered at the Stanford Design Institute called "Creative Gym." Creative Gym classes immerse students in a learning environment based in experimentation. Students rapidly cycle through a series of phases: observe, brainstorm, synthesize, prototype, and implement; repeating as necessary. The class is based on a primary goal of producing reliably innovative results in any field. The class includes many hands-on exercises based on the eight elements enumerated in Table 1. The Creative Capacity Building Group focuses on applied creativity, spontaneity, uncertainty and "failing fast", reduction of bias, and rapid prototyping.

As a control intervention, we trained half of the participants in a language capacity building program (LCBP). This intervention also included many hands-on exercises to learn basic Chinese vocabulary, Chinese character writing, and learning basic phrases (e.g., How are you?) and was thus intended to represent a similar experience to the CCBP class while reducing the opportunity to produce creative outcomes and reflect upon a creative process.

2.4. Procedures

Recruitment for the study was performed via flyers, emails, message boards, and word of mouth. Individuals were primarily recruited on or around the University campus and around the Bay Area. This paper is part of a larger umbrella study on creative capacity enhancement, thus, the criteria for participating in the study were: (1) Ability to commit to the full duration of the study, (2) Non-Mandarin speaking, (3) Not concurrently enrolled in the Design Institute curriculum, (4) no contraindications for MRI (e.g., metal implants or pacemakers), (5) right-handed, and (6) no self-reported history of past or current psychiatric or neurological condition.

2.5. Measures

2.5.1. Torrance Test of Creative Thinking, Figural versions A and B

The Torrance Test of Creative Thinking, Figural (TTCT-F) is a paper–pencil based valid and reliable assessment measure of the divergent thinking aspects of creativity (Torrance, 1981). The measure takes approximately 30 min to complete and has two equivalent versions (A and B). We administered all three subtests of the TTCT-Figural assessment: Picture Construction, Picture Completion, and Parallel Lines. For each task, participants produce as many figural drawings as possible in a predetermined period of time (~10 min). For example, stimuli include parallel lines in boxes on the page with instructions that direct participants to create as many different and novel pictures with the parallel lines that they can in 10 min. The three tasks are included in the scoring procedure that yields five sub-scale scores (Fluency, Originality, Abstractness of Titles,

Table 3
Participant sample.

Variable	Total ($N = 28$)	Creative capacity building program ($N = 15$)	Language capacity building program ($N = 13$)
Age			
Mean	29.21	28.8	29.69
(SD)	(5.63)	(4.72)	(6.30)
Range	23–40	23–37	23–40
IQ			
Mean	121	120	123
(SD)	10	(11)	(8)
Range	95–142	95–142	110–135
Ethnicity			
Asian (%)	17.9	13.33	23.1
Caucasian (%)	71.4	73.33	69.2
Multiple/other (%)	10.7	13.33	7.7
Female (%)	57.1	60	53.8

Elaboration, and Resistance to Premature Closure) and a total score (see Table 2). Standard score, national percentages, and raw scores are calculated for each sub-scale and for the average total score. We used the standard scores in these analyses, as they are the only valid and reliable metrics that can be equated between versions and across groups. The TTCT-Figural has a mean score of 100 and a SD of 20, as opposed to many psychological assessments that have a mean score of 100 and a SD of 15. TTCT-F tests were scored by Scholastics Testing Service, Inc (http://ststesting.com/). Raters were not aware of the experimental design.

2.5.2. NEO-FFI Personality Inventory

The NEO-FFI-3 is a 60 item self-report measure adapted from the longer NEO-PI-R and is a valid and reliable assessment measure of personality (Costa & McCrae, 1992). The measure takes approximately 15 min to complete. Participants were administered the NEO-FFI-3 one-week before (T1) the first CCBP and LCBP sessions. The five factors of the NEO-FFI are: Openness, Extraversion, Agreeableness, Conscientiousness, and Neuroticism.

2.5.3. Baseline measures

Our baseline measures (T1) include age, sex, socioecomonic status, ethnicity, professional status, and general intellectual functioning. We administered the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II, Psychological Corporation, 2011) to obtain an intellectual quotient score (IQ) for each participant.

2.6. Statistical analysis

Analyses were performed with SPSS version 20. All available data were used for the analysis for the 28 participants who completed both T1 and T2 assessments. Independent Sample *T*-Tests were used to examine group differences at Time 1 on age, IQ, demographic variables, NEO-FFI and TTCT-F scores. Two-Sample Kolmogrov–Smirnov *Z* tests were used to ascertain that T1 data distribution did not differ between groups and were sampled from the same population. No differences were found between groups on initial levels of Openness or Extraversion on the NEO-FFI and TTCT-F scores at T1. ANCOVAs were used to determine if there was a significant relationship between group assignment and TTCT-F scores at T2 utilizing TTCT-F scores at T1 as a covariate. Regressions were performed to assess the relationship between personality factors and TTCT-F scores within group. For each group, we entered Openness and Extraversion as predictors of TTCT-F change scores (TTCT-F scores at T1 subtracted from TTCT-F scores at T2).

3. Results

3.1. Sample characteristics

Participants included in these analyses were 28 individuals who completed both T1 and T2 assessments ($N = 28$; 16 F, 12 M). All participants had at least a college level education and had an average IQ of 121 (SD = 10). Of the participants 20 were Caucasian (71.4%), 5 were Asian (17.9%), and 3 were reported as multiple or other (10.7%). Groups had no difference in age or IQ at baseline (CCBP mean age = 28.8 SD = 4.72 and IQ mean = 120 SD = 11; LCBP mean age = 29.69 SD = 6.3 and IQ mean = 123 SD = 8) (see Table 3).

3.2. TTCT-Figural Average Standard Score

Our first set of analyses examined the hypothesis that participants in the CCBP would have significantly higher scores on the TTCT-Figural assessment at T2 than participants in the LCBP. The difference between groups approached significance

Table 4
Groups difference from T1 to T2 on TTCT-Figural scores.

TTCT-Figural score	Time 1		Time 2		ANCOVA		Cohen's *d*
					F	*p*	
TTCT Average Standard Score					3.63	.07	.56
CCBP	M	111	M	124			
n = 15	SD	9.3	SD	13.1			
	Range	93–129	Range	98–147			
LCBP	M	107	M	116			
n = 13	SD	10.5	SD	9.4			
	Range	86–127	Range	97–131			
TTCT Resistance to Premature Closure Standard Score					7.0	.01	.93
CCBP	M	104	M	126			
n = 15	SD	16.4	SD	13.0			
	Range	84–135	Range	101–147			
LCBP	M	100	M	111			
n = 13	SD	13.5	SD	16.7			
	Range	78–120	Range	87–147			
TTCT Elaboration Standard Score					4.64	.04	.55
CCBP	M	130	M	134			
n = 15	SD	17.4	SD	13.7			
	Range	97–160	Range	106–154			
LCBP	M	134	M	127			
n = 13	SD	16.3	SD	15.3			
	Range	107–151	Range	106–154			
TTCT Abstraction Standard Score					3.85	.06	.74
CCBP	M	119	M	123			
n = 15	SD	11.3	SD	13.1			
	Range	105–138	Range	98–147			
LCBP	M	111	M	113			
n = 13	SD	11.5	SD	9.6			
	Range	88–126	Range	98–130			
TTCT Fluency Standard Score					.03	.88	.05
CCBP	M	107	M	125			
n = 15	SD	11.4	SD	15.8			
	Range	86–130	Range	95–151			
LCBP	M	100	M	120			
n = 13	SD	17.2	SD	17.2			
	Range	59–119	Range	89–153			
TTCT Originality Standard Score					.96	.34	.21
CCBP	M	95	M	113			
n = 15	SD	17.3	SD	18			
	Range	67–135	Range	90–141			
LCBP	M	92	M	107			
n = 13	SD	18.5	SD	17.6			
	Range	62–126	Range	82–138			

($F(1,28) = 3.63$, $p = .068$) where the ANCOVA model utilized TTCT-F Average Standard Score at T2 as the dependent variable, Group Assignment as the independent variable, and TTCT-F Average Standard Score at T1 as the covariate. Although the difference between groups did not reach the a priori significance threshold, a moderate effect size was observed for this model (Cohen's $d = .562$) (see Table 4).

3.3. TTCT-Figural Sub Scores

For our second set of analyses, we used the same procedure but with TTCT-F sub-scores instead of the total score to assess whether specific components of creativity were modified by the CCBP (versus LCBP) intervention. Participation in CCBP was associated with significantly increased creative output on two of five sub-scores relative to the LCBP group: Elaboration ($F(1,28) = 4.64$, $p = .041$) and Resistance to Premature Closure ($F(1,28) = 7.0$, $p = .014$) (Table 4). Group assignment effect on Elaboration had a moderate effect size (Cohen's $d = .551$), while group assignment effect on Resistance to Premature Closure scores showed a large effect (Cohen's $d = .932$). The same analyses were performed for the other three sub-scores of the TTCT-F. Abstractness of Titles showed a trend toward significance for participants in the CCBP relative to the LCBP ($F(1,28) = 3.851$ $p = .061$) with a moderate effect size (Cohen's $d = .739$).

Table 5
NEO-FFI-3 predictors of ΔTTCT-Resistance to Premature Closure.

Regression Model				Predictors	*B*	SE *B*	*t*	*p*	Comparison of correlation coefficients (CCBP versus LCBP)
R^2	*F*	*df*	*p*						
CCBP group									
.45	4.85	14	.03	Extraversion*	2.41	.86	2.79	.02	Fisher's $z = .94$, $p = .17$
				Openness	−1.17	.99	−1.18	.26	
LCBP group									
.20	1.27	12	.32	Extraversion	1.21	.97	1.25	.24	
				Openness	−1.99	1.73	−1.15	.78	

* Significant, $p < 0.05$.

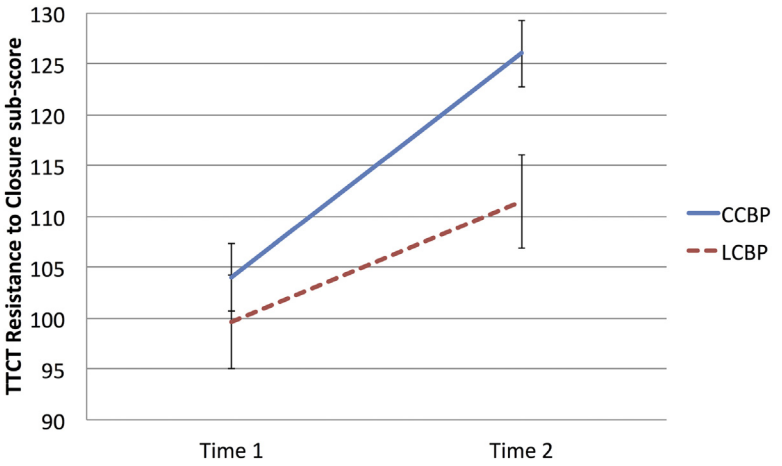

Fig. 1. TTCT resistance to premature closures cores between groups from T1 to T2.

3.4. NEO-FFI Personality Inventory

The third set of analyses examined whether Openness and Extraversion scores on the NEO-FFI-3 were associated with change in TTCT-F scores for the two groups. Linear regression analyses were performed within group with NEO scores at T1 as the predictor variables (Openness and Extraversion) and TTCT-F change scores (ΔTTCT-F: TTCT-F scores at T1 subtracted from TTCT-F scores at T2) as the dependent variables. Separate analyses were performed for each change score of the TTCT-F (ΔResistance to Premature Closure, ΔElaboration, ΔAbstractness of Titles, ΔFluency, and ΔOriginality) as well as the total score (ΔAverage Standard Score). Although Openness was not a significant predictor of any of the ΔTTCT-F scores, Extraversion was found to be a significant predictor of ΔResistance to Premature Closure for the CCBP group (Table 5). Post hoc correlation coefficients corresponding to the relationship between ΔResistance to Premature Closure and Extraversion were not significantly different between groups. None of the other regression models reached significance for either group (all *p* values > 05).

4. Discussion

The results of this study provides conclusive evidence to support our first hypothesis that domain-general targeted training, conducted outside of workplace or scholastic settings, could provide creative capacity enhancement in an adult population. These findings support previous studies that have advanced our understanding of creative fluidity and its various components and correlates (Basadur, Runco, & Vega, 2000; Scott, Leritz, & Mumford, 2004). In particular, the results presented here suggest that creativity, which we measured with the Torrance Test of Creative Thinking Figural (TTCT-F), can be enhanced through a focused training program. Participation in the CCBP led to creative capacity enhancement in the areas of Elaboration and Resistance to premature closure, as compared to participation in LCBP. As depicted in Fig. 1, however, relatively small improvement in the resistance to premature closure score is also evident in the LCBP group at T2. Although LCBP was not designed to enhance creativity, it is possible that the longitudinal increase depicted in LCBP could be attributed to general task learning (Anderson, 1987).

4.1. Enhancement in creative capacity

Although the average TTCT-F scores between groups was not significant, a moderate effect size is seen between groups and the direction was in line with creative capacity enhancement in CCBP, compared to LCBP. Two of the five sub-scales of TTCT-F showed significant enhancement in the CCBP as compared to the LCBP. Elaboration score on the TTCT-F represents the details and imagination of responses to stimuli (Torrance, 2008). Our results on the TTCT-F Elaboration score suggest that participants in the CCBP generated more imaginative and detailed responses than participants in the LCBP. Resistance to premature closure represents the ability of an individual to maintain an open mind to allow new and unique ideas to form (Torrance, 2008). A greater increase on the TTCT-F Resistance to Premature Closure score for participants in the CCBP indicates that they considered more options in response to the presented stimuli, allowing them to synthesize more original connections than participants in the LCBP. We claim that these two results reflect the kind of activities that participants were engaged in during CCBP training. The CCBP curriculum included rapid prototyping and improvisational activities with various constraints (e.g., time, materials, topic, etc.) and external prompts. Repeated exposure to these activities over the course of the intervention was intended to enhance the students' bias toward action, increase resilience when experiencing failure, and increase one's ability to synthesize novel connections (Hawthorne et al., 2013).

4.2. Creativity enhancement and personality

Strategies aimed to enhance creativity in the CCBP are closely related to definitions of personality in the sense of requiring open-mindedness, ability to draw from diverse and new experiences, and integrating novel ideas or other's ideas into one's own experience. Generally, personality traits such as Openness and Extraversion are thought to be positively correlated with creative expression due to the hypothesized increase of novel experiences and connections that are hypothesized to be associated with those traits (Batey & Furnham, 2006; Cropley, 1990; Furnham & Bachtiar, 2008). Our study differs from previous investigations of personality and creativity because we used an intervention to analyze creative capacity growth rather than correlations between personality traits and creative output measured simultaneously.

Overall, our results indicate that the intervention had larger effects on change in TTCT-F scores over time than personality. Personality traits were not associated with scores on measures of creativity at T1 in our sample. However, when looking at change scores it appeared that some facets of creativity might be more associated with personality than others. Specifically, the personality trait of Extraversion was associated with greater change in Resistance to Premature Closure scores. Although this finding was significant in the CCBP group only, both groups showed a positive relation between Extraversion and Resistance to Premature Closure. Though a group by extraversion interaction analysis failed to reach significance (Table 5), one might speculate that individuals with higher trait Extraversion are more likely to benefit from CCBP, perhaps through enhancing persistence and increasing the use of any and all relevant information in the creation of ideas and images. Although extraversion was not associated with change on other TTCT-F scores, a larger sample size may have provided more power to observe personality trait effects. Contrary to our hypotheses, Openness was not associated with change on any of the TTCT-F scores between T1 or T2. Openness is the personality trait most associated with intelligence and creativity in studies considering creativity as a static construct (DeYoung et al., 2010; Feist & Barron, 2003). However, the objective measurement of creativity through the TTCT-F at multiple time points indicates that the intervention improved creative performance regardless of underlying personality factors.

4.3. Limitations

Although the design and results of our study are novel and provide new momentum to the field of creativity research there are limitations; in particular, the sample size was small ($n = 28$). However, the moderate and large effect sizes observed in our results (Average Standard Score Cohen's $d = .562$; Elaboration Cohen's $d = .551$; Resistance to Premature Closure Cohen's $d = .932$; Abstractness of Titles Cohen's $d = .739$) suggest that a larger sample size may help refine our understanding of the impact of the creativity training. Our sample had an average IQ of 121, which is close to 1.5 SD above the norm (Mean = 100). This high IQ sample may not be representative of the population at large. While our study employs a training strategy based around measures assessing cognitive based change, it also incorporates affective, motivational, and confidence building elements. Future studies should incorporate additional assessments that align with the dynamic layers of the construct of creativity (Hennessey & Amabile, 2010). Additionally, as mentioned previously, we recruited participants with the explicit draw of creativity training. Although we made every attempt to randomize and standardize multiple aspects of our treatment conditions, expectation bias may have played a role in the participants' efforts and output.

Finally, some debate exists within the literature on the ability of the TTCT-F to fully measure creativity. The inter-rater reliability in scoring TTCT-F responses can also affect the results (Torrance, 1990). In an effort to extinguish this problem, we sent our TTCT-F protocols to Scholastics Testing Service, Inc. for unbiased and standardized evaluation. Another factor that can affect TTCT-F performance is the testing environment (Torrance, 1987). Higher scores result from fun and lively environments. We created similar testing environments across CCBP and LCBP, providing a fun and exploratory atmosphere in both groups throughout the study. Some have described the TTCT as a measure of divergent thinking, which is related to creativity but does not capture all aspects of this construct (Feldhusen & Goh, 1995; Kaufman, Plucker, & Russel, 2012). It is possible that participants in the CCBP group acquired skills that are valuable for becoming a creative individual but

that were not captured by the TTCT. Given the dynamic understanding of creativity as a construct, it becomes clear that the TTCT can only assess a limited aspect and, thus, future studies should include several creative assessment strategies (Zeng, Proctor, & Salvendy, 2011). As part of the umbrella study, results of which are currently being analyzed, four measures of creativity were employed: Torrance Test of Creative Thinking – Figural, Creative Achievement Questionnaire, Spontaneous Improvisation and Creative thinking game, and a newly developed Design Test of Creative Thinking. In future work, we plan to include all four measures of creative capacity to fully understand the implications of the CCBP intervention.

5. Conclusion

Findings from this study suggest that more research is needed to determine the dynamic nature of changes in creativity within individuals. Larger and more diverse samples could help uncover the flexibility and plasticity of some of the fundamental cognitive, personality, and environmentally oriented constructs that underlie the creative process. Our findings suggest that specific personality traits may not be required for target-training based individual creative capacity enhancement. These findings pave the way for new research to uncover the possibility of enhancing domain-general creative potential in adults, which was previously limited to children and young adults in classroom settings.

Conflicts of interest

None declared.

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