Journal of Experimental Psychology: General

Manuscript version of

Creativity Anxiety: Evidence for Anxiety That Is Specific to Creative Thinking, From STEM to the Arts

Richard J. Daker, Robert A. Cortes, Ian M. Lyons, Adam E. Green

Funded by:

- Georgetown University
- National Science Foundation

Revision of XGE-2018-1544 as invited by the action editor, Jessica D. Payne.

Creativity Anxiety: Evidence for Anxiety that is Specific to Creative Thinking, from STEM to the Arts

Richard J. Daker, Robert A. Cortes, Ian M. Lyons* & Adam E. Green*

Georgetown University, Department of Psychology

* Indicates dual-senior authorship and corresponding authors

Funding

This research was supported by a grant to A.E.G. from the National Science Foundation (DRL-1420481). R.A.C. was additionally supported by a National Science Foundation Graduate Research Fellowship and the Patrick Healy Graduate Fellowship from Georgetown University.

Word Count: 7,645

Abstract

Creative thinking drives progress not only in the arts but even, and perhaps especially, in STEM fields and projects to become even more valuable than technical skills at which artificial intelligence will outpace human cognition. Fostering creative thinkers has become a primary focus of educators. Educationally-relevant anxieties, like math anxiety, have been shown to substantially impact specific forms of achievement and engagement, both in school and in career pursuits. Identifying these anxieties has led to promising interventions to enable affected individuals to reach their potential. Somewhat surprisingly, however, the possibility of anxiety specific to creative thinking is unexplored to our knowledge. Here, across multiple samples, we tested the viability of creativity anxiety as a construct. We first created a new measure, the Creativity Anxiety Scale (CAS), demonstrating validity, internal reliability, and specificity. Applying the CAS revealed that creativity-specific anxiety predicted individual differences in creative achievement and attitudes toward creativity over and above effects of general anxiety. Moreover, across diverse content domains, from science to arts, anxiety was greater for situations that required creativity than similar situations that did not. Notably, this effect was especially pronounced in women. These findings suggest that creativity anxiety may have wide-reaching impacts, and distinguish creativity anxiety from anxiety about noncreative aspects of performance. Establishing creativity anxiety as a novel construct, and the CAS as a valid measurement instrument, opens a new avenue of research that promises to deepen basic understanding of creative cognition and inform development of interventions to enable greater achievement of creative potential.

Key Words: Creativity, Anxiety, Creativity Anxiety, Individual Differences, Attitudes

INTRODUCTION

Even among people who are very technically skilled at what they do, it is common to find individuals who recoil when they are asked to generate a new idea of their own. This apparent anxiety at the prospect of having to be creative may be associated with the colloquial refrain, "I'm not a *creative* person," frequently used to turn aside requests for creative input or justify avoidance of creative pursuits. While this phrase is sometimes spoken lightheartedly, avoidance of creative endeavors has become an increasing impediment to advancement in the modern innovation economy. Creative abilities are highly prized across a wide range of fields (World Economic Forum, 2016) and the ability to maximize one's creative potential is only likely to become a more essential determinant of success as creativity increasingly emerges as the human ability least achievable by artificial intelligence (Dartnall, 2013; Jennings, 2010). The capacity to innovate drives progress in science, engineering, and industry, manifesting in creative generation of new hypotheses, new products, and new solutions. Relatedly, fostering creative thinkers is a primary goal of educators from kindergarten through graduate school, and the ability to think creatively consistently predicts academic achievement (Gajda, Karwowski, & Beghetto, 2017). Thus, characteristics that keep people from realizing their creative potential are likely to have substantial impacts on achievement and opportunity.

Here we propose that anxiety about creative thinking may be a previously overlooked limiting factor for achievement. Despite the importance of creativity both in the workplace and in education, no research that we are aware of has investigated the viability of anxiety that is specific to creativity. While creativity-specific anxiety has not yet been empirically investigated, there are theoretical reasons to expect that some individuals may be anxious about having to be creative. Ambiguity and uncertainty – common aspects of the sort of open-ended thinking that

often characterizes creativity (e.g., Sternberg, 2007) – have been consistently shown to elicit anxiety (Kirschner et al., 2016; for review, see Hirsh, Mar, & Peterson, 2012). Relatedly, some researchers have suggested that worries about increased risk of failure when venturing away from established approaches can serve as a deterrent to creative thinking (Amabile & Khaire, 2008; Gurteen, 1998; Badawy, 1986; Bilton & Leary, 2002). More broadly, research in clinical populations has shown that simply being exposed to new and unfamiliar situations or activities can elicit anxiety (for review, see Henderson, Pine, & Fox, 2015). Because being creative requires exploring new possibilities and producing novel ideas and behaviors (Runco & Jaeger, 2012), the inherent novelty associated with creative thinking may be particularly anxiety-inducing for some individuals.

Furthermore, there is precedent elsewhere in the literature for both the existence and impacts of non-general anxiety toward specific elements of education- and work-related cognition. For instance, substantial work has established that the construct of math anxiety is distinct from general anxiety and even anxiety toward other academic domains (Dowker et al., 2016; Pizzie & Kraemer, 2018). Math anxiety is associated with underperformance in and avoidance of math and careers that involve math (e.g., Hembree, 1990; Dowker et al., 2016). Encouragingly, the identification and characterization of math anxiety has led to intervention strategies that show success in enabling students to more fully reach their potential in mathematics (Jamieson et al., 2010; Park, Ramirez, & Beilock, 2014). Establishing and understanding anxiety about creativity may thus prove theoretically and practically fruitful in a similar manner.

The primary objective of the present research was therefore to conduct a first investigation into the construct of creativity-specific anxiety through the development of a new

Creativity Anxiety Scale (CAS), intended to detect this putative anxiety (i.e., to assess whether individuals do, in fact, experience creativity-specific anxiety). In particular, we devised creativity anxiety (CA) items to measure anxiety about situations that require creative generation (i.e., generating new ideas/solutions).

"Creativity" can be challenging to define, but here we adopted what Runco and Jaeger (2012) refer to as the "standard definition" of creativity: a form of cognition that results in the generation of novel and valuable output, broadly construed. Importantly, this widely-accepted definition does not make reference to any of the specific content domains often thought of as "creative", like art or music, but rather refers to a form of generative cognition that can take place in any domain. In line with this "standard definition" of creativity, we sought to test for creativity anxiety, not as an anxiety toward particular content domains, but as an anxiety toward a *way of thinking* (i.e., thinking creatively).

Notably, when presented with a situation that requires creativity, it is possible that anxiety could result not only from the need to be creative, but also from demands of the situation that are technical or content-related rather than creative. As an example, if a student is asked to diagram a new way of conceptualizing the organization of the solar system, the need to be creative might be anxiety-inducing, but so might the need to draw precisely or to correctly recall the names of planets. To isolate CA from anxiety about the particular noncreative demands of presented situations, we devised non-creativity anxiety control (NAC) items that mirror the contexts presented in CA items but remove the creative demands. These items emphasize following instructions or established procedures in an exact and methodical manner. Thus, while CA items measure anxiety about having to be creative, NAC items measure anxiety about having to perform noncreative aspects of the tasks presented in the CA items. Inclusion of these NAC

items increases the precision of models relating CA to other individual and group differences (i.e., it enables clearer identification of effects specific to anxiety toward creativity) and enables direct tests of whether individuals experience *more* anxiety toward situations that require creativity than toward similar but noncreative situations. Moreover, if CA is a viable construct, we anticipate that it should manifest (and be distinct from anxiety about relevant noncreative demands) across various content domains – from canonically "creative" domains like art and music to those typically considered less creative like math and science. If so, this would suggest that any negative effects of CA could impact performance in many areas, including STEM domains. Most fundamentally, exploring distinctions between creative cognition and engagement in certain content domains, especially artistic domains, has potential to inform greater nuance in basic conceptualizations of creativity (i.e., distinguishing creativity as what you do vs. creativity as how you think).

From an applied standpoint, identifying a potential barrier to creative engagement and achievement like CA would be a key first step toward developing intervention strategies to enable affected individuals to reach their creative potential. A scale that measures CA would also enable creativity researchers to newly account for the influence of anxiety on creative performance, and provide a new tool to educators seeking to identify the academic strengths and/or needs of their students. Given evidence of gender differences in other forms of anxiety (Wigfield & Meece, 1988; Hembree, 1990; Devine et al., 2012), a key exploratory question for the present research was whether women and men differ in CA. Gender differences in math anxiety, for instance, are thought to partially explain gender differences in pursuing college majors and careers that involve math (Beilock & Maloney, 2015; Chipman, Krantz, & Silver, 1992). The extant literature relating gender to creative ability is highly heterogeneous, with

inconsistent evidence as to whether and in what ways gender differences in creative ability may manifest (see, e.g., Furnham & Nederstrom, 2010; Tegano & Moran, 1989; for review, see Baer & Kauffman, 2008). While this research has not established consistent gender differences, the several reports of differences (though marked by inconsistencies in constructs and measurement) suggest that gender is worthy of further empirical consideration in creativity research. If gender differences exist in a putative CA, this could impact the degree to which individuals of different genders engage with or avoid situations – or even career paths – that involve creative thinking.

Across two separate two-part studies, we created and validated the Creativity Anxiety Scale to investigate the viability and characteristics of a putative creativity-specific anxiety. We measured individual differences in CA and their impacts on creative achievement and attitudes (distinguishing effects of CA scores from NAC scores and from general trait anxiety), assessed whether participants, on average, reported higher levels of anxiety toward creative generation than toward similar but noncreative situations (and whether any such difference is moderated by gender), and examined generalizability by testing whether anxiety toward being creative manifests across diverse content domains.

Study 1a

Study 1a focused on the creation and validation of the Creativity Anxiety Scale. In addition, mean differences in CA and NAC scores were investigated.

Methods

Participants

Participants were 430 adults recruited through Amazon's Mechanical Turk (MTurk). Data collected on MTurk have been shown to be similar in quality to data collected in-lab in college samples if appropriate quality assurance steps are taken (Paolacci, Chandler, & Ipeirotis, 2010; Buhrmester, Kwang, & Gosling, 2011). One hundred and fourteen participants were excluded from analysis because of failure to adequately explain instructions in their own words, duplicate IP addresses, or failed attention checks (i.e., items intended to ensure that participants were devoting appropriate attention to the task, such as an item that simply asked participants to "Please select 'Very much'" as their response). Thus, the quality-controlled sample totaled 316 participants (150 female, age: $M = 34.56$, $SD = 11.21$).

Procedure

All procedures and materials were reviewed and approved by the Georgetown University Institutional Review Board and all participants gave informed consent prior to the beginning of the study and received $5 in compensation. The study primarily consisted of a questionnaire containing a superset of items for scale development (12 each of CA and NAC items; see Table 1) presented in a randomized order. In addition, participants completed a number of questionnaires and cognitive tasks as part of a separate study, along with basic demographic questions. With the exception of the demographic questionnaire, which always came at the end of the study, all questionnaires and tasks were presented in a randomized order.

Stimuli and Materials

Creativity Anxiety Scale Item Generation

In the development version of the Creativity Anxiety Scale (as in the final version) participants read descriptions of a series of situations and reported how anxious each situation made them feel. We aimed to create two types of items: creativity anxiety (CA) items, intended to measure anxiety toward situations that require being creative, and non-creativity anxiety control (NAC) items, intended to measure anxiety toward the noncreative demands of the situations presented in the CA items. As a first step, we generated 12 CA items. We next generated 12 NAC items, 9 of which were "paired" with a CA item. Paired NAC items were devised to approximate the contextual elements of one of the CA items – although all CA items were intended to be as general/context-free as possible, some elements of context are inevitable. For example, the CA item "Having to come up with a creative solution to a problem," was paired with the NAC item, "Having to solve a problem in the exact way you were taught to do so." These two items involve a similar situational context – having to solve a problem – but probe creative vs. noncreative ways of approaching the problem. The remaining 3 NAC items did not correspond closely to a CA item. This was done in case the similarities between the paired CA and NAC items biased participants to respond too similarly (i.e., in case the influence of context overrode influences of creative demand). Thus, a total of 24 items were created: 12 CA items and 12 NAC items (9 NAC items that were paired to a CA item and 3 that were not; Table S1).

All 24 items were presented in a randomized order. Participants were given the following instructions: "In this section, you will be presented with various situations and experiences that may cause tension, apprehension, or anxiety. For each situation, please choose the response that best describes how much it would make you feel anxious. Keep in mind there are no right or

wrong answers. We are interested in your honest opinions." Response options were 'not at all', 'a little', 'a fair amount', 'much', and 'very much'. Items were scored on a 5-point scale from 0 (not at all) to 4 (very much).

External Validity Surveys

Extant self-report measures likely to be related to putative creativity anxiety were included to assess the external validity of our measure. The main surveys of interest were: The Creative Achievement Questionnaire (Carson, Peterson, & Higgins, 2005), Tolerance for Ambiguity (Budner, 1962), Creative Self-Efficacy (Tierney and Farmer, 2002), and the Trait Anxiety Inventory (Spielberger, et al., 1970).

Creative Achievement Questionnaire (CAQ_log)

The Creative Achievement Questionnaire (CAQ; Carson, Peterson, & Higgins, 2005) consists of 80 total questions, 8 in each of the following domains: Visual Arts, Music, Dance, Architecture, Creative Writing, Humor, Invention, Science, Drama, and Culinary Arts. The set of 8 items in each domain starts with an item that asks whether the respondent has any training in the domain. Questions then progressively ask about higher and higher levels of achievement and distinction in the domain. Using music as an example domain, item 1 is "I have no training or recognized talent in this area" (binary Yes/No), item 2 is "I play one or more musical instruments proficiently" (binary Yes/No), and item 8 is "My compositions have been critiqued in a national publication" (enter number of times this applies).

A total CAQ score was calculated by summing scores across all domains. Following previous work (Prabhakaran, Green, & Gray, 2014), these total scores were log-transformed to

more closely approximate a normal distribution. Two outliers with log-transformed CAQ scores greater than 3 SDs above the mean were dropped from analysis; as such, N = 314 for analyses involving CAQ. We predicted that individuals higher in CA would have lower CAQ scores.

Tolerance for Ambiguity (TolAmb)

Tolerance for Ambiguity (TolAmb) is a scale that measures attitudes about ambiguous stimuli or events (Budner, 1962). The scale asks participants to rate the degree to which they agree or disagree with 16 ambiguity-relevant statements on a 1-7 scale (strongly disagree to strongly agree). Examples: "A good job is one where what is to be done and how it is to be done are always clear," "People who insist upon a yes or no answer just don't know how complicated things really are" (reverse-coded). Possible scores range from 16 to 112. Higher scores indicate *less* tolerance for ambiguity. Because creative endeavors are typically open-ended, we predicted that individuals with higher levels of CA would have lower TolAmb scores.

Creative Self-Efficacy (CSE)

The Creative Self-Efficacy (CSE) scale was used to measure participants' beliefs about their ability to be creative (Tierney and Farmer, 2002). This 3-item scale asks participants to indicate their level of agreement with statements on a scale from 0 ("Strongly disagree") to 7 ("Strongly agree"). Example: "I have a knack for further developing the ideas of others". Possible scores range from 0 to 21, where higher scores indicate greater creative self-efficacy. Due to an error, 108 of the retained participants were not presented with the CSE scale. As a result, all analyses that include the Creative Self-Efficacy Scale were conducted in a sample of 208 participants

instead of the full retained sample of N = 316. We predicted that individuals with higher levels of CA would be lower in CSE.

Trait Anxiety (TAI)

Trait anxiety was measured using the 'trait' subscale of the State-Trait Anxiety Inventory (TAI; Spielberger et al., 1970). This 20-item scale instructs participants to respond to statements on a scale from 1 (Almost never) to 4 (Almost always) based on how they generally feel [examples: "I worry too much over something that doesn't really matter"; "I am 'calm, cool, and collected'" (reverse-scored)]. Possible scores range from 20 to 80, where higher scores indicate greater anxiety. The TAI was included as a control measure to increase the specificity of regression models involving CA (i.e., to distinguish effects of creativity-specific anxiety from effects of general trait anxiety).

Exploratory Single-Item Measure of Self-Creativity Overlap

In addition to the previously validated measures employed for validation of the CAS, participants completed a modified version of the widely-used Inclusion of Other in the Self scale developed by Aron, Aron, and Smollan (1992). This scale was initially developed to measure the extent to which individuals incorporate others into their sense of self, but has been frequently modified to address how much people incorporate abstract entities like nature (Schultz, 2001), sports (Blanchard et al., 1998), and math (Necka et al., 2015) into their sense of self. The self-creativity overlap measure participants completed was not primarily intended for validation of the CAS, but to assess the extent to which individuals incorporate creativity into their sense of self. This measure presents a series of seven Venn diagrams that begins with no overlap and progressively

increases the degree of overlap to almost complete overlap. Participants were given the instructions to select the diagram that indicates "how much your sense of yourself overlaps with the bolded person, topic, or activity," and above the series of Venn diagrams was the phrase, "Your relationship with **Creativity.**" Higher levels of math anxiety have been shown to be related to lower levels of self-math overlap (Necka et al., 2015). We included this measure as an exploratory initial test of the prediction that CA would be negatively associated with self-creativity overlap.

Results

Factor Analysis

We first aimed to assess whether responses on the CA and NAC items successfully measured separable underlying constructs. To this end, we entered all 24 items into an exploratory factor analysis using maximum likelihood extraction. We chose this method of extraction instead of orthogonal extraction to allow for the possibility that the responses on the two sets of items (CA and NAC) may be correlated. For the same reason, we used the promax rotation method (delta=0) to generate rotated solutions. The same methods of extraction and rotation were used for all factor analysis results reported across all studies. Note that the final sample of 316 participants resulted in a subject-to-item ratio of over 13:1, above the 10:1 subject-to-item ratio shown to be acceptable for exploratory factor analysis (Costello & Osborne, 2005).

Table 1

Factor	Eigenvalue	% Variance
1	10.12	42.17
2	5.11	21.31
3	1.01	4.22
4	.68	2.82
5	.65	2.71

Note. Table 1 shows eigenvalues and percent of variance explained for the top five factors yielded by maximum likelihood extraction in participant responses to CAS items. Two factors (those above the dashed line) were retained.

Extraction yielded 3 factors with eigenvalues above 1 (Table 1). However, the third factor accounted for only 4.22% of the variance in responding. As such, two factors were retained. The rotated solution showed that these two factors corresponded very clearly to *a priori* categories: Factor 1 loaded highly only on CA items and Factor 2 loaded highly only on NAC items (Table 2). Note that in all cases CA and paired NAC items loaded on separate factors, suggesting that the presence or absence of a need to be creative in a given situation drove differences in responding to the two types of items.

The results of our factor analysis indicate that the items we generated successfully measured creativity anxiety as separate from anxiety about the noncreative demands of the situations presented in the CA items.

Table 2

Item	Factor 1	Factor 2
CA1	0.84	
CA2	0.88	
CA3	0.79	
CA4	0.89	
CA5	0.73	
CA6	0.72	
CA7	0.85	
CA8	0.78	
CA9	0.68	
$CA10_{np}$	0.79	
$CA11_{np}$	0.59	
$CA12_{np}$	0.84	
NAC1		0.78
NAC2		0.83
NAC3		0.80
NAC4		0.84
NAC5		0.83
NAC6		0.83
NAC7		0.87
NAC8		0.78
NAC9		0.70
$NAC10_{np}$		0.81
$NAC11_{np}$		0.56
$NAC12_{np}$	0.39	0.38

Note. Table 2 shows rotated factor loadings for the 2-factor solution for all 24 items. Loadings with an absolute value below .3 are suppressed. CA and NAC items with the same number were paired unless denoted with "$_{np}$" (see Methods). The table shows that Factors 1 and 2 closely correspond to CA and NAC items, respectively.

Creativity Anxiety Scale

To compose the final Creativity Anxiety Scale, we selected 8 items from each factor. In selecting the set of items for the final scale, CA items with paired NAC items were given preference over CA items that did not have a paired NAC items in order to increase the interpretability of NAC items as a control measure. The content of CA items and paired NAC items were designed to be

similar aside from the presence or absence of a need to be creative, minimizing the risk that confounding factors not related to creativity might drive differential responding on items. After removing CA items that did not have paired NAC items from consideration, we selected the 8 CA items that had the highest factor loadings on the CA factor (Factor 1) and their 8 paired NAC items. This yielded our final Creativity Anxiety Scale (CAS), shown in Table 3.

Table 3

Item Pair #	Creativity Anxiety Items	Non-creativity Anxiety Control Items
1	**Having to come up with a creative solution to a problem**	**Having to solve a problem in the exact way you were taught to do so**
2	**Having to come up with a unique way of doing something**	**Having to precisely follow an established method of doing something**
3	**Having to think about something from a novel perspective**	**Having to think about something according to a fixed system**
4	**Having to think in an open-ended and creative way**	**Having to think in a precise and methodical way**
5	**Having to solve a problem for which the solution is open-ended**	**Working in a situation where there is an established correct and incorrect way of doing things**
6	**Having to improvise**	**Having to carefully follow instructions**
7	**Having to think 'outside the box'**	**Having to think 'by the book'**
8	**Focusing on novelty over precision when doing something**	**Focusing on precision over novelty when doing something**

Note. Table 3 shows the final items of the Creativity Anxiety Scale.

Reliability, Interrelatedness, and Selectivity

Internal reliability, computed as Cronbach's α, was high for both item types: CA: α=.96; NAC: α=.94.

The CA and NAC components were significantly correlated with one another, which was anticipated because each CA item is paired with a NAC item that probes anxiety about a similar situation. However, the correlation between CA and NAC score was modest (r = .28, p = 5E-7),

as was the partial correlation controlling for TAI score (r = .19, p = 7E-4). The low collinearity between CA and NAC is critical for the intended utility of our scale. These two scores can be entered separately into a multiple regression analysis to assess unique contributions to a given outcome measure without concern of violating collinearity assumptions (e.g., to measure the effects of CA scores controlling for NAC scores).

Finally, Figure 1 shows the item-wise correlation matrix for all 16 items of the final scale. Items within each item type (CA and NAC) were considerably more related to one another than to items from the other item type (all ps <= 2E-16). This suggests that individual items showed good selectivity for items within their own item type.

Figure 1

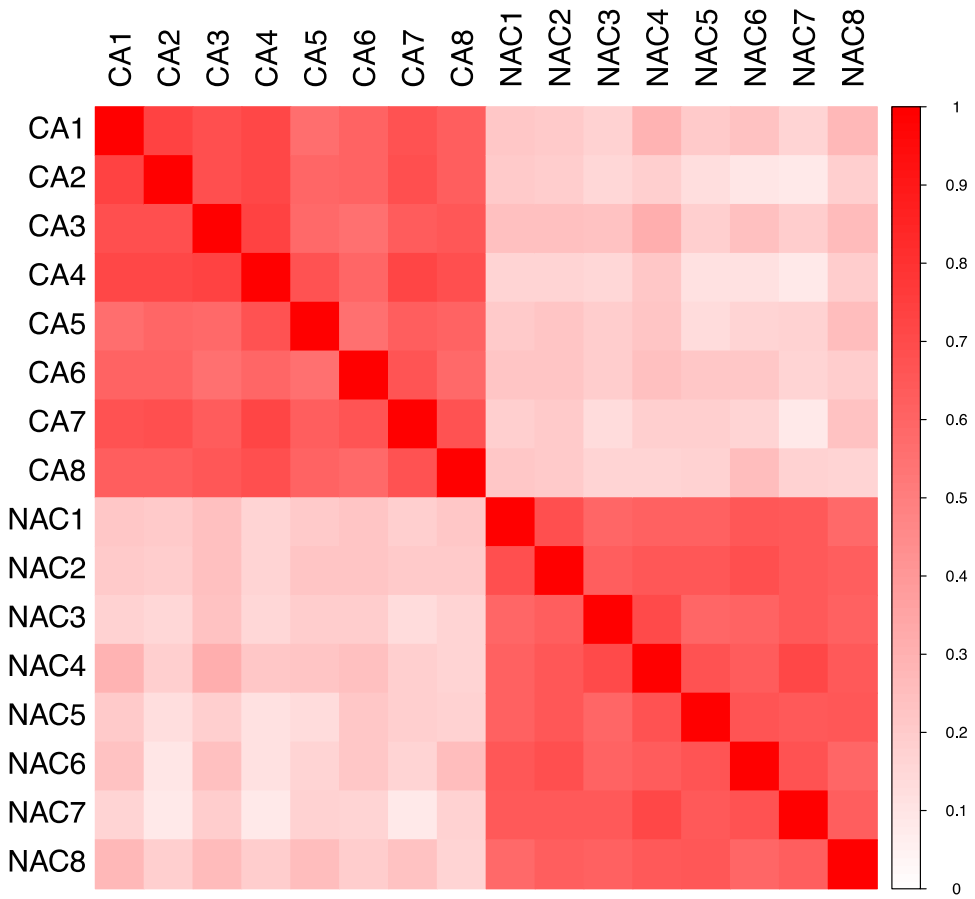

Figure 1 shows correlations among individual items of the final CAS. Higher correlations within item types and lower correlations between item types demonstrates good selectivity between the two item types.

External Validity

Descriptive statistics for all variables are shown in Table 4. CA and NAC scores were computed by summing self-ratings (scored 0 to 4; 8 items each) across items for each participant. Possible scores for CA and NAC therefore range from 0 to 32. In order to test the external validity of our CA measure, we ran multiple regression models with previously established scales as the dependent variable and CA, NAC, and TAI scores as the independent variables. This allowed us to assess the unique variance in each scale that was explained by CA.

Table 4

Measure	*N*	Mean	SD
CA	316	12.62	7.78
NAC	316	10.03	7.47
CAQ_log	314	0.81	0.52
TolAmb	316	60.09	10.54
CSE	208	15.00	3.90
TAI	316	40.22	12.98

Note. Descriptive statistics for CA, NAC, and external validity measures are shown. See Methods for explanation for varying *N*s. Abbreviations: CA – creativity anxiety; NAC – non-creativity anxiety control; CAQ_log – log-transformed Creative Achievement Questionnaire score; TolAmb – tolerance for ambiguity; CSE – creative self-efficacy; TAI – general trait anxiety.

We hypothesized that, controlling for NAC control items and TAI, CA would negatively predict CAQ_log, positively predict TolAmb (where higher TolAmb scores reflect less tolerance for ambiguity), and negatively predict CSE. Results from multiple regression analyses (shown in Table 5) supported all three hypotheses, suggesting the CAS is an externally valid measure of creativity anxiety and is distinct from general trait anxiety. The strong negative relationship between CA and CSE also provides evidence that feeling higher levels of anxiety about creativity is associated with appraising oneself as less capable of creative thinking.

Note that, while moderately positively correlated themselves, CA and NAC scores predicted the external validity measures in opposite directions. This suggests that the distinction between anxiety toward having to be creative and toward the associated noncreative demands is an especially important one when predicting these measures.

(a) DV: CAQ_log, df = 312 (b) DV: TolAmb, df = 312 (c) DV: CSE, df = 204

Predictor	*b*	*se*	*t*	*p*	*b*	*se*	*t*	*p*	*b*	*se*	*t*	*p*
CA	-.012	.004	-2.86	.005	.464	.079	5.88	1E-8	-.218	.034	-6.33	2E-9
NAC	.012	.004	2.95	.003	-.136	.080	-1.70	.091	.094	.037	2.60	.010
TAI	-8E-4	.002	-.33	.745	.030	.048	.63	.528	-.030	.021	-1.44	.153

Table 5

Note. Multiple regression models predicting external validity measures. CA predicted unique variance in each external validity measure, and all coefficients were in the predicted direction. In each case, the coefficient of CA significantly differed from that of NAC (all *p*s < .001) and from general trait anxiety (TAI; all *p*s < .05). Note that higher TolAmb scores reflect *less* tolerance for ambiguity.

Relationship Between Creativity Anxiety and Self-Creativity Overlap

We assessed the relationship between CA and the single-item Venn diagram measure used as an initial measure of self-creativity overlap, controlling for NAC and TAI scores. Consistent with previous work showing that math anxiety and self-math overlap are negatively related (Necka et al., 2015), multiple regression results showed that CA negatively predicted self-creativity overlap (CA: B = -.090, $t(313)$ = -6.65, p = 1E-10; NAC: B = .050, $t(313)$ = 3.36, p = 9E-4; TAI: B = .000, $t(313)$ = .06, p =.95). This suggests a negative relationship between the extent to which individuals are anxious about being creative and the extent to which they incorporate creativity into their sense of self. This relationship appears generally consistent with the relationship between CA and CSE.

Comparing CA and NAC Scores

Differences between mean CA and NAC ratings

The items of the CAS were created in pairs so that CA and NAC scores could be directly compared to one another with minimal confounding (see Table 3). We hypothesized that, on average, participants would report greater levels of anxiety about situations that require creativity than similar ones that do not. A paired-samples t-test supported this hypothesis ($t(315)$ = 5.03, p = 8E-7, d = .34). This suggests that people are on average more anxious about situations in

which they have to be creative than about situations with similar noncreative demands in which they do not.

The Modulating Role of Gender

As an exploratory analysis, we next assessed whether the observed difference between CA and NAC scores was modulated by gender. Gender differences in other forms of anxiety have been hypothesized to explain gender differences in performance and engagement in other domains (Beilock & Maloney, 2015; Chipman, Krantz, & Silver, 1992). Thus, if gender affects responding on the CAS, this might have implications for engagement in endeavors that require creative thinking. A 2 (Gender) x 2 (Item Type) mixed-factorial ANOVA showed no significant main effect of gender ($F(1,314) = 0.167$, $p = 0.683$, $\eta^2 = .0005$) but showed a significant main effect of item type such that CA scores were significantly greater than NAC scores ($F(1,314) = 25.61$, $p = 7E\text{-}7$, $\eta^2 = .075$); however, these effects were qualified by a significant gender by item type interaction ($F(1,314) = 5.35$, $p = 0.021$, $\eta^2 = .017$). The difference between CA and NAC scores was significantly greater in women than it was in men (women: mean CA = 13.39, mean NAC = 9.56, paired-samples $t(149) = 4.633$, $p = 8E\text{-}6$, Cohen's $d = 0.49$; men: mean CA = 11.93, mean NAC = 10.46, paired-samples $t(165) = 2.349$, $p = 0.02$, Cohen's $d = 0.20$; see Figure 3). These results suggest that the magnitude of the difference between CA and NAC is significantly greater for women than for men.

Figure 2

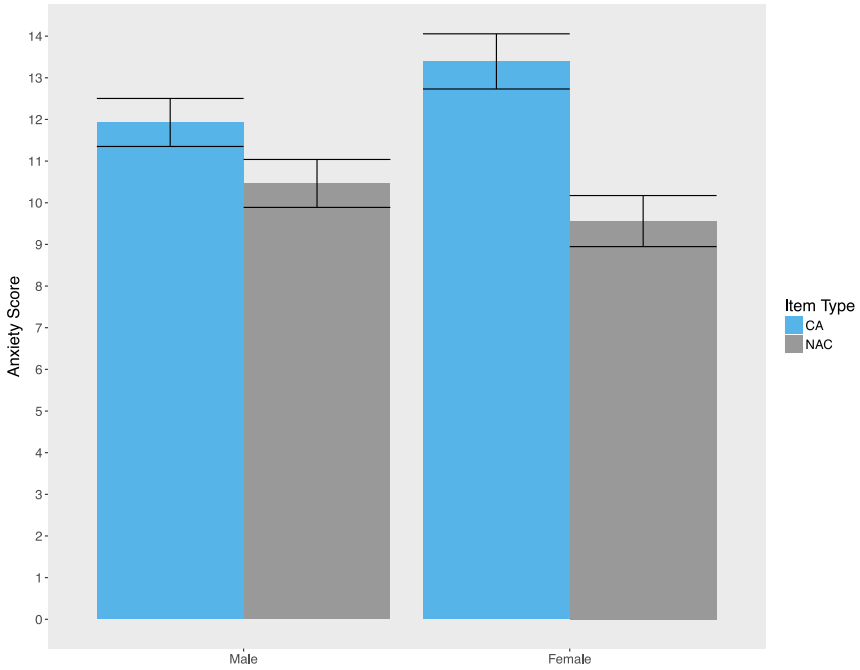

Figure 2 shows mean CAS scores, broken down by item type and gender are shown. Error bars reflect standard errors of the mean. For both male and female participants, average CA scores were significantly greater than NAC scores (both *p*s < .05). A Gender × Item Type interaction was found ($p = .02$) such that the difference between CA and NAC scores was significantly greater among female participants.

Study 1b

Study 1b explored generalizability by investigating whether CA (as separate from NAC) would manifest within several content domains, from domains conventionally viewed as highly creative, like art and music, to domains conventionally viewed as less creative, like math and science.

Methods

Participants

The participants in Study 1b were the same 208 participants who received the full survey battery in Study 1a (including the Creative Self-Efficacy Scale).

Procedure

In addition to completing the CAS and the external validity measures described in Study 1a, participants completed items from the CAS in the context of different domains to assess whether creativity anxiety manifests across a variety of content domains (see immediately below). All survey measures were presented in a randomized order.

Stimuli and Materials

Creativity Anxiety Scale Items Across Domains

Four pairs of items (item pairs 2, 4, 7, and 8; see Table 3) from the original CAS were asked across content domains. Participants were instructed to consider the situations described in the CAS items within each of 10 domains and to indicate their level of anxiety about each situation in each domain (see Figure 3). The particular CAS item pairs included were selected because they were deemed to be applicable to all content domains. Choices ranged from "None at all" (0) to "Very Much" (4).

The presented domains were the same as those used in the Creative Achievement Questionnaire (Carson, Peterson, & Higgins, 2005), except that we chose to substitute mathematics for architecture because we deemed that our participants were much more likely to be familiar with math, and because we had an interest in empirically exploring the intersection of math and creativity anxiety. Therefore, the 10 domains presented were: Visual Arts, Music, Dance, Math, Creative Writing, Humor, Invention, Science, Drama, and Culinary Arts. This

allowed for a diversity of domains in which people can behave in both creative ways (i.e. generating something new) and noncreative ways (not generating anything new). Participants completed 4 item pairs (each with one CA item and one NAC item) across 10 domains for a total of 80 responses per participant.

Figure 3

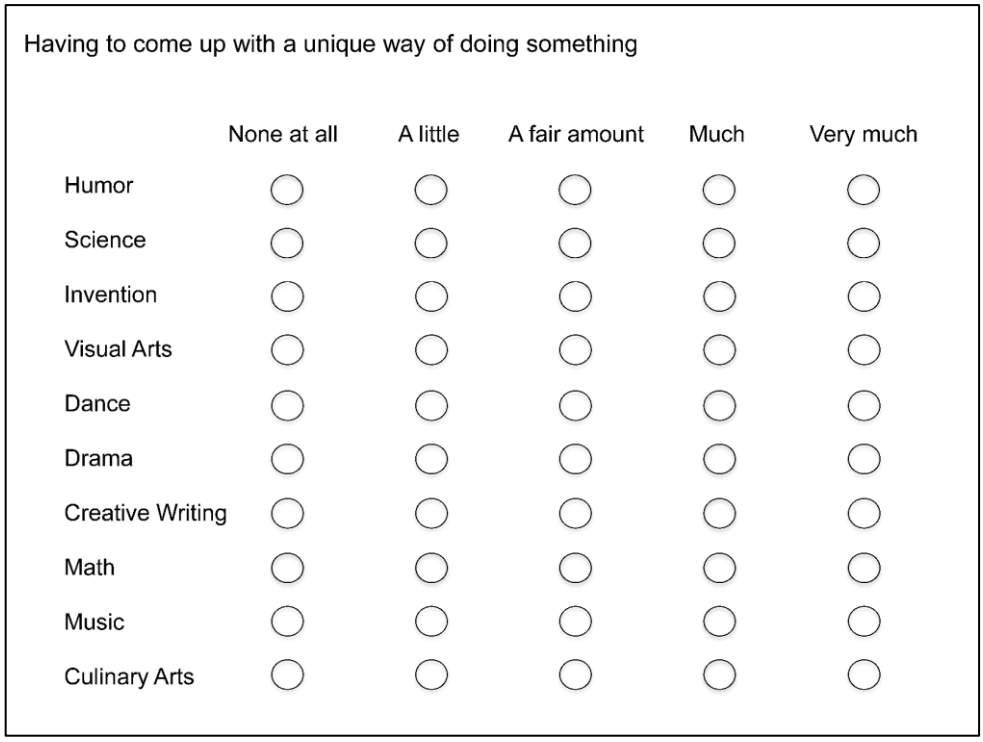

Figure 3 gives an example of a CA item presented across domains. Items from the CAS were presented across multiple content domains to test the generalizability of CA.

Results

Within-Domain Factor Analyses

In order to assess whether CA manifests as separate from anxiety about noncreative performance within different content domains, we conducted 10 different exploratory factor analyses, one for each of the domains included. Each domain factor analysis included 8 items – 4 CA items and 4 NAC items. If creativity anxiety manifests across the diverse set of presented domains, as we hypothesized, separate CA and NAC factors should be derived within each domain. If, on the

other hand, creativity anxiety were tied to specific domains, we would not expect separate CA and NAC factors to be derived within domains.

Exploratory factor analyses yielded 2 eigenvalues above 1 for 6 out of the 10 domains, excluding Visual Arts, Drama, Music, and Culinary Arts (Table 2). However, for each of these domains, the factor with the second-highest eigenvalue accounted for more than 10% of variance. As such, for each of the 10 domain factor analyses, we produced 2 factors. Across all 10 domains, one factor was comprised of exclusively CA items, and the other factor was comprised of exclusively NAC items (all factor loadings > .64; see Figure 4 below; for additional detail, see Table S3). These results indicate that the prospect of creative vs noncreative cognition does lead to differential levels of anxiety across ten diverse content domains, suggesting that CA may manifest across a wide array of pursuits.

Figure 4

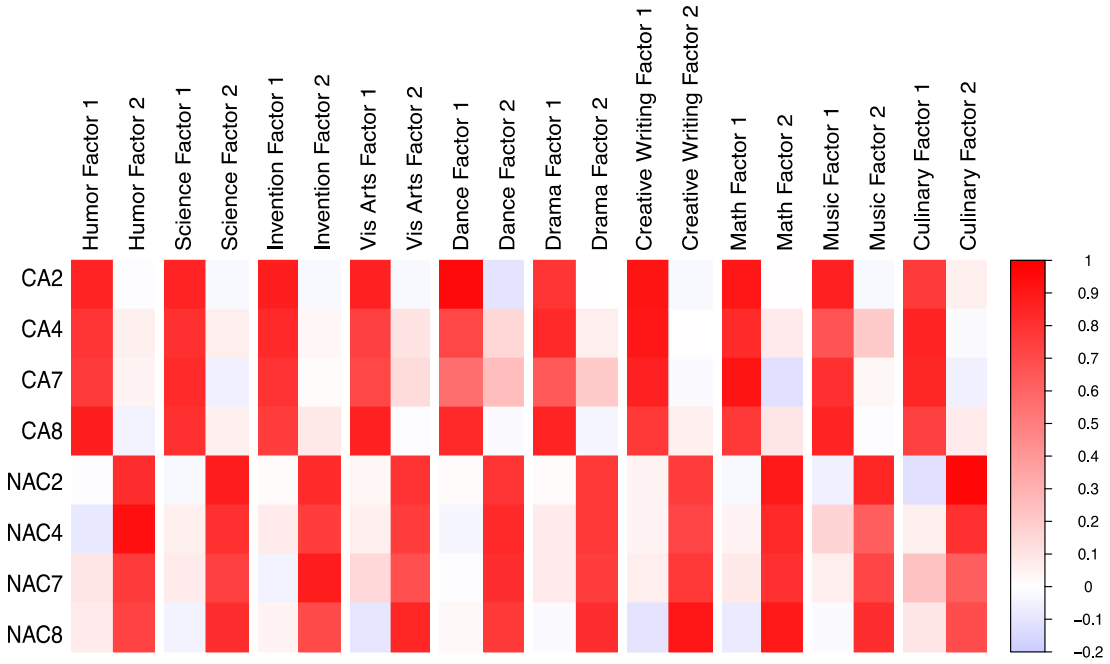

Figure 4 shows a heat-map of factor loadings for the 2-factor solution over CAS items within each of 10 domains. Alternating red bars within each domain demonstrate consistent differentiation (high selectivity) for CA vs. NAC items even within specific domains.

Mean Difference Analysis

In order to compare CA and NAC scores across the domains included in the modified CAS, we computed a CA and NAC score for each domain by summing the individual responses (0-4) across each of the 4 items of each anxiety type. Possible scores therefore ranged from 0-16 for each item type.

Means for CA and NAC scores in each domain and results of paired t-tests assessing the difference between them are shown in Table 9 (see Table S4 for additional detail). CA significantly exceeded NAC scores in each domain with the exception of Creative Writing (possibly because the word "Creative" in the name of the domain unintentionally elicited anxiety toward creativity, resulting in higher NAC scores). This shows that, on average, people are more anxious about being creative than about the noncreative demands of performance across a variety of domains.

Figure 5

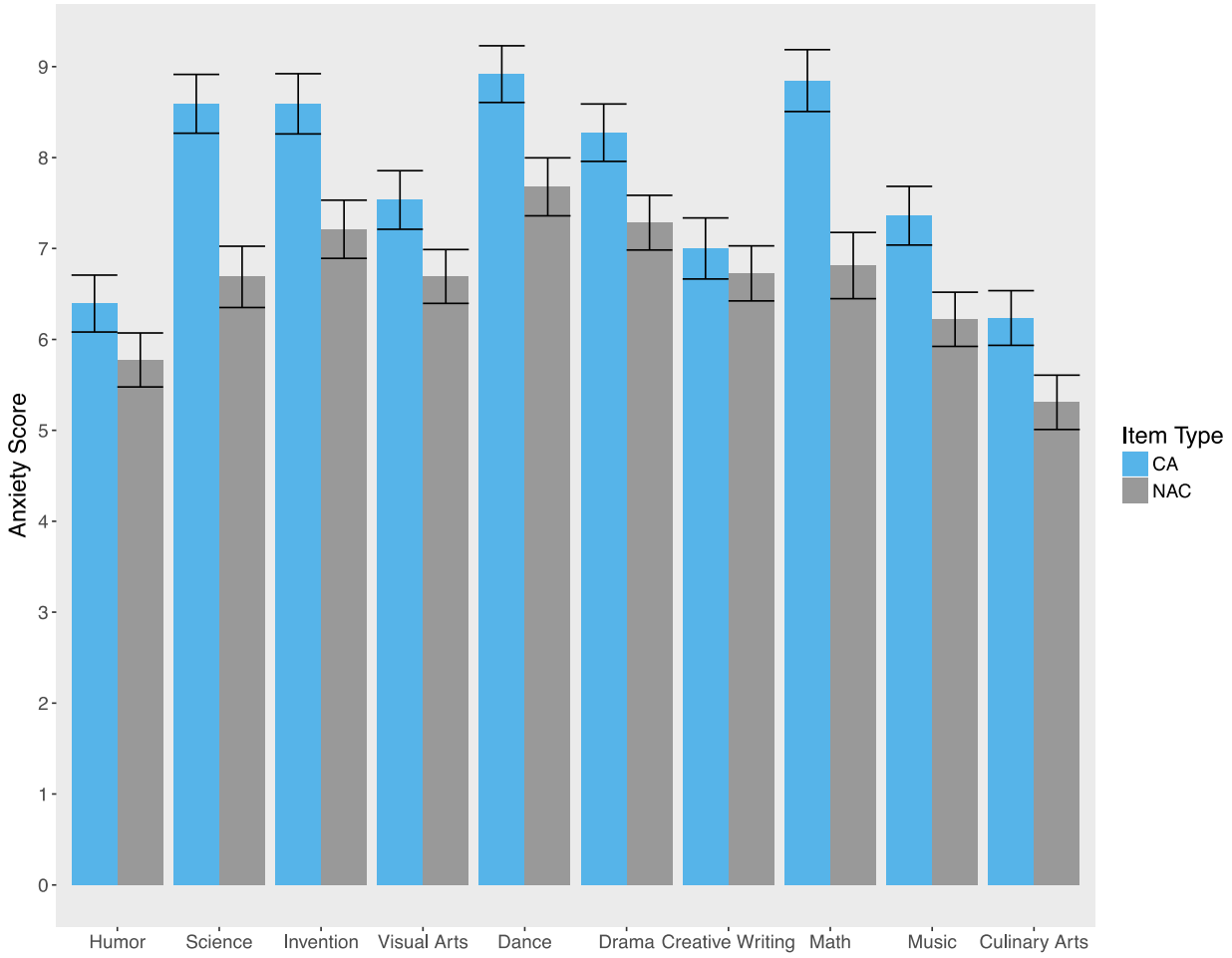

Figure 5 shows mean CAS scores broken down by item type and domain are shown. Error bars reflect standard error of the mean. CA scores were significantly greater than NAC scores at $p < .05$ in each domain except Creative Writing (see Supplementary Materials for additional detail). Note that the probability of finding a significant difference at $p < .05$ for 9 out of 10 comparisons by chance is 2E-11.

Study 2a

Studies 2a and 2b sought to replicate the findings of Studies 1a and 1b in an in-lab sample of undergraduates. Study 2a focused on the factor structure of the CAS and mean differences in CA and NAC scores.

Methods

Participants

Participants were 235 undergraduate students at Georgetown University (153 female, mean age: $M = 20.71$, $SD = 4.47$) who took part in the research for cash or course credit. Ten participants were dropped from analysis for failure to correctly respond to attention checks, resulting in a final sample of 225.

Procedure

Participants completed the final 16-item CAS on laboratory computers as part of survey batteries in four unrelated experiments. Though the unrelated content of these experiments varied, crucially for present purposes, the order of all tasks and surveys was randomized across participants in each of these experiments.

Stimuli and Materials

Creativity Anxiety Scale

All participants completed the 16-item CAS described in Study 1a.

Results

Factor Analysis

We entered all 16 items of the CAS into an exploratory factor analysis as in Study 1. Note that the final sample of 225 participants resulted in a subject-to-item ratio of 14:1. Extraction again yielded only 2 factors with eigenvalues above 1 (Table 6). The rotated solution again showed that these two factors corresponded very clearly to *a priori* categories: Factor 1 loaded highly only on CA items and Factor 2 loaded highly only on NAC items (Table 7). The results of this factor analysis thus closely replicate the results obtained in Study 1.

Table 6

Factor	Eigenvalue	% Variance
1	5.98	37.37
2	4.40	27.53
3	.78	4.89
4	.65	4.08
5	.52	3.27

Note. Eigenvalues and percent of variance explained for the top five factors yielded by maximum likelihood extraction in participant responses to CAS items are shown. As in Study 1a, the two factors above the dashed line were retained.

Table 7

Item	Factor 1	Factor 2
CA1	0.82	
CA2	0.83	
CA3	0.71	
CA4	0.89	
CA5	0.71	
CA6	0.70	
CA7	0.84	
CA8	0.75	
NAC1		0.75
NAC2		0.80
NAC3		0.78
NAC4		0.75
NAC5		0.72
NAC6		0.81
NAC7		0.80
NAC8		0.68

Note. Table 7 shows rotated factor loadings for the 2-factor solution for all 16 items. Loadings with an absolute value below .3 are suppressed. CA and NAC items with the same number were paired. Original items 9, 10, 11, and 12 of both item types were dropped in the creation of the final CAS and were therefore not administered to this sample. Factors 1 and 2 closely correspond to CA and NAC items, respectively, thus closely replicating findings from Study 1a.

Reliability, Interrelatedness, and Selectivity

Internal reliability, using Cronbach's α, was again high for both item types: CA: α=.92; NAC: α=.91. CA and NAC were again correlated with each other (r = .16, p = .019).

Figure 6 shows the item-wise correlation matrix for all 16 items of the scale. Items within each item type were again considerably more related to one another than to items from the other item type (all ps <= 2E-16). This again suggests that individual items showed good selectivity for items within their own item type.

Taken together, these results closely replicate those of Study 1, providing additional evidence that the CAS is a reliable, selective measure of creativity anxiety.

Figure 6

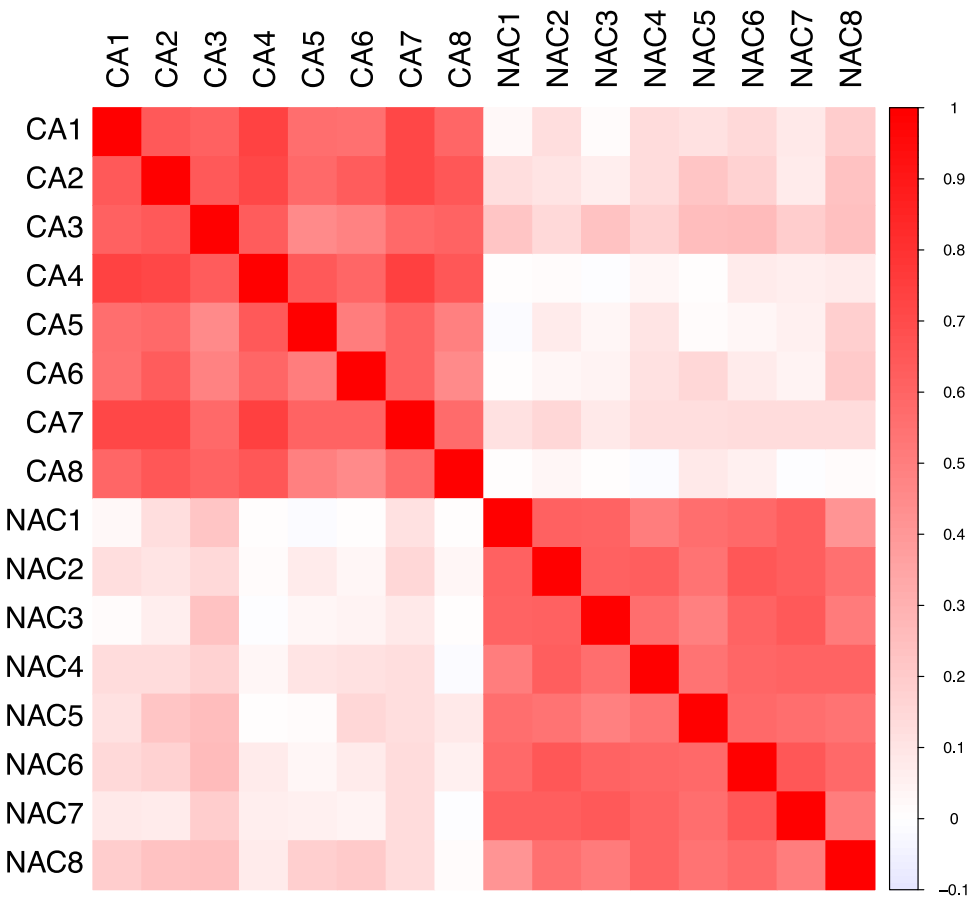

Figure 6 shows correlations among individual items. Results again demonstrate high selectivity between the subscales.

Comparing CA and NAC Scores

Differences between mean CA and NAC ratings

Participants reported greater CA scores than NAC scores (mean CA = 11.18, mean NAC = 7.14, paired-samples $t(224) = 7.49$, $p = 2E\text{-}12$, $d = .65$). This replicates the finding from Study 1a that participants were, on average, more anxious about situations in which they have to be creative than situations in which they do not.

The Modulating Role of Gender

It was found in Study 1a that gender modulated the difference between CA and NAC scores. We assessed whether this replicated in the in-lab sample by conducting a 2 (Gender) x 2 (Item Type) mixed-factorial ANOVA. Results showed a significant main effect of gender ($F(1, 223) = 3.96$, $p = 0.048$, $\eta^2 = .017$) and a significant main effect of item type($F(1, 223) = 57.53$, $p = 9E\text{-}13$, $\eta^2 = .205$). These results were again qualified by a significant gender by item type interaction ($F(1, 223) = 6.92$, $p = 0.009$, $\eta^2 = .030$). The difference between CA and NAC scores was significantly greater in women than it was in men (women: mean CA = 12.09, mean NAC = 7.08, paired-samples $t(152) = 7.42$, adjusted $p = 8E\text{-}12$, Cohen's $d = 0.81$; men: mean CA = 9.25, mean NAC = 8.25, paired-samples $t(71) = 2.35$, $p = 0.021$, Cohen's $d = 0.33$; see Figure 7). These results replicate findings from Study 1a showing that the magnitude of the difference between CA and NAC scores was higher among women than men.

Figure 7

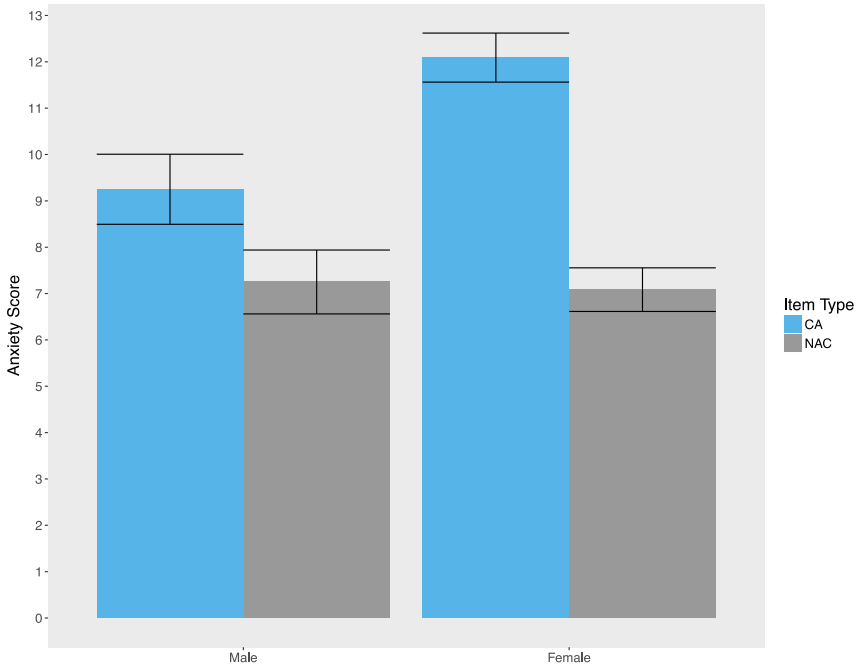

Figure 7 shows mean CAS scores, broken down by item-type and gender. Error bars reflect standard errors of the mean. For both male and female participants, average CA scores were significantly greater than NAC scores (both *p*s < .05). There was a significant Gender × Item-type interaction ($p = .009$), such that the difference between CA and NAC scores was significantly greater among female participants (which closely replicates Study 1a).

Study 2b

Study 2b sought in-lab replication of the findings from Study 1b that, in multiple content domains, CA manifests as separate from NAC and CA exceeds NAC scores.

Methods

Participants

Of the 235 participants who completed the CAS in Study 2a, 122 also completed the CAS across domains.

Stimuli and Materials

Creativity Anxiety Scale Items Across Domains

Participants completed 8 CAS items across domains as described in Study 1b. The same 8 items from the CAS (4 CA, 4 NAC) were presented across the same 10 domains.

Results

Within-Domain Factor Analyses

We again conducted 10 different exploratory factor analyses, one for each of the domains included. Each domain factor analysis included 8 items – 4 CA and 4 NAC.

Exploratory factor analyses yielded exactly 2 eigenvalues above 1 for all domains (see Table S5). As such, for each domain factor analysis, we again produced 2 factors. Across all 10 domains, one factor was comprised of exclusively CA items, and the other factor was comprised of exclusively NAC items (all factor loadings > .5; see Figure 8 below; see Table S6 for additional detail). These results replicate those obtained in Study 1b and provide further indication that CA is not tied to specific content domains but rather can manifest across a variety of domains.

Figure 8

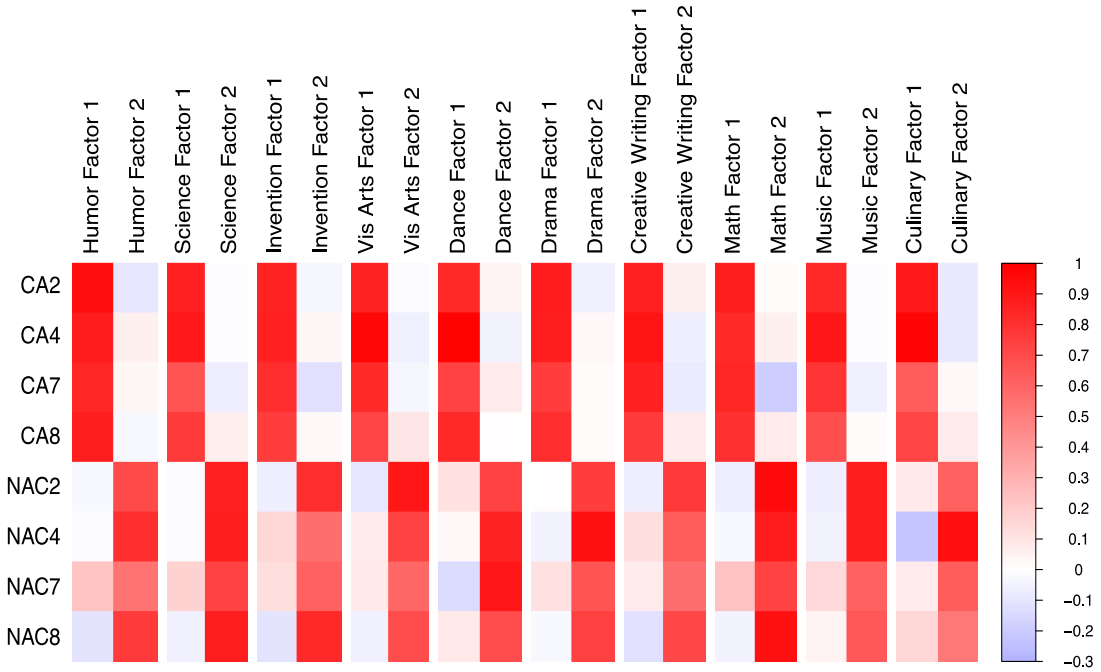

Figure 8 shows a heat-map of factor loadings of the 2-factor solution over CAS items within each of 10 domains. Results again demonstrated a consistent selectivity between CA and NAC items within domains.

Mean Difference Analysis

Mean CA and NAC scores in each domain, and results of paired t-tests assessing the difference between them, are shown in Figure 9 (see Table S7 for additional detail). CA scores were higher than NAC scores in each domain (all *p*s < .05), closely replicating findings in Study 1b.

Taken together, the results of Studies 2a and 2b are highly consistent with those of Studies 1a and 1b.

Figure 9

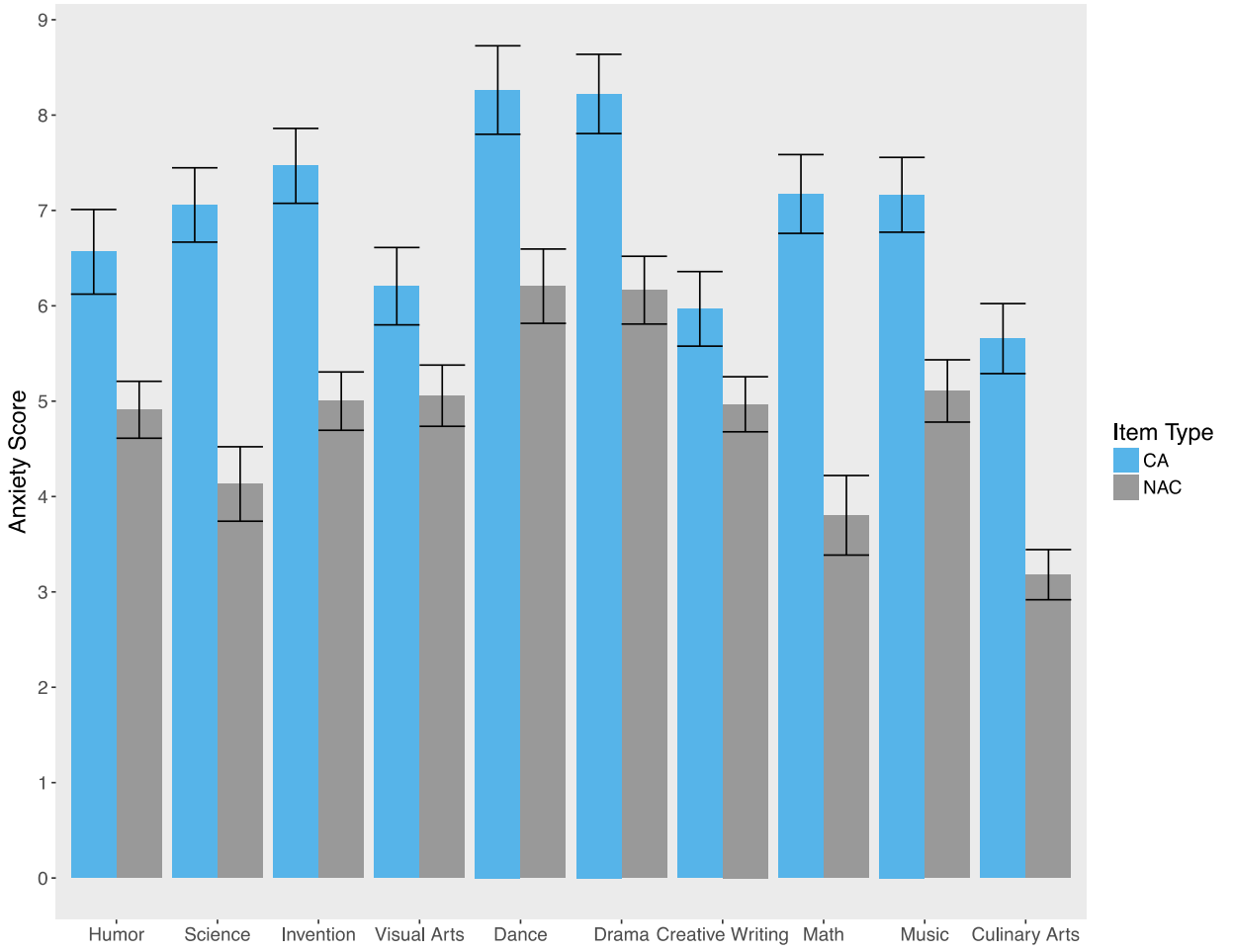

Figure 9 shows mean CAS scores broken down by item type and domain. Error bars reflect standard errors of the mean. CA scores were significantly greater than NAC scores at $p < .05$ in each domain (see Supplementary Materials for additional detail). Note that the probability of finding a significant difference at $p < .05$ for 10 out of 10 comparisons by chance is 1E-15.

GENERAL DISCUSSION

The present study provides new evidence of anxiety that is specific to thinking creatively. To measure CA, we developed the Creativity Anxiety Scale, the validity, reliability, and specificity of which we confirmed through online and in-lab experiments (Studies 1a and 2a). CA uniquely predicted creative attitudes and achievement over and above anxiety about noncreative demands of the presented situations and, notably, over and above general trait anxiety. Data also indicated that, on average (and especially among women), anxiety was greater for situations that require

creativity than noncreative situations with similar demands. Studies 1b and 2b showed that these results generalized across 10 content domains, including domains that are popularly thought of as creative (e.g., visual arts, dance) and domains that are not (e.g., science, mathematics), suggesting that the CAS captures a generalizable anxiety about a way of thinking rather than anxiety about a specific kind of activity or content. Initial data also suggest that people with higher CA think of themselves as less capable of creativity and consider creativity to compose less of their identity.

The present findings suggest that CA could have an important impact on what kinds of careers and majors people pursue. Previously characterized anxieties, like math anxiety, are related to avoidance of the target of the anxiety (Hembree, 1990). It is likely that individuals who are anxious about being creative would avoid career paths that require innovation. Notably, the difference between CA and NAC scores was significantly larger in women than men. Such differences could relate to gender disparities in the innovation economy such as those described in a U.S. Department of Commerce report entitled, *Women in STEM: A Gender Gap in Innovation* (Beede et al., 2011). Coinciding with each step of the progression toward a career in STEM is a sizable increase in demands for creative output, especially in fields like computer science and engineering. Hence, gender differences in CA may play a role in the "leaky pipeline" in STEM – the tendency for women to opt out of STEM career paths at higher rates than their male counterparts at each step along the educational and professional pathway.

In Studies 1b and 2b, we assessed whether having to be creative in various content domains is associated with higher CA relative to anxiety about noncreative demands in the same domains. In almost all cases (19 out of 20 across both studies), domain-specific CA scores were higher than NAC scores, suggesting that any negative effects of CA may have impacts across a

wide range of pursuits. Even in domains traditionally considered creative, data indicated that anxiety was significantly affected by the presence/absence of the need to think creatively. Thus, through the lens of anxiety, these results help to distinguish technically competent (or even expert) participation in canonically creative activities from actual creative thinking in the sense of innovative generativity. These are often conflated in colloquial usage of the term, "creative," to refer to a set of domains, like visual arts or music. Yet some people who are generally comfortable being creative may be anxious about playing the violin because of its technical, noncreative demands. Conversely, it is also quite likely that even some highly accomplished violinists (one person known to the authors considers himself an example) approach their craft as a technical pursuit more than a creative one, and indeed do not consider themselves particularly creative. This ostensible paradox of the "uncreative artist," points to the utility of the present research, beyond anxiety, to empirically inform a nuanced conceptualization of creativity (i.e., distinguishing the conceptualization of creativity based on what a person does from the conceptualization of creativity as how a person thinks).

A valuable outcome of this work is the development of a new instrument for measuring creativity anxiety. At 16 items total, the CAS is relatively quick to administer. All results replicated and showed high consistency across laboratory and online samples, demonstrating that the CAS is suitable for in-person and remote testing. Foreseeable uses include basic and applied research. The CAS adds to the methodological toolkit of researchers interested in cognition-emotion dynamics, and those seeking to account for potential confounding effects of CA on performance of creativity tasks. The CAS also has potential educational and professional training applications; identifying the needs of individual students may help teachers encourage more creative engagement in high-need students. Measurement of math anxiety has bolstered

understanding of math cognition and led to promising interventions to boost math achievement such as cognitive reappraisal and expressive writing (Jamieson et al., 2010; Park, Ramirez, & Beilock, 2014). Likewise, characterizing CA as a new construct and developing an instrument to measure it promises to inform understanding of creativity, and enable tailored applications of established (and perhaps novel) anxiety interventions. This new avenue of research has potential to bolster creative achievement and engagement at a time when creative thinking is at a premium in the global innovation economy (World Economic Forum, 2016).

As previously noted, for the purposes of the present work we used the "standard definition" of creativity as generative cognition that results in novel and valuable output (Runco & Jaeger, 2012). It is important to acknowledge that creativity is not thought of by specialists as a unitary cognitive process, but rather a collaboration of multiple processes (Campbell, 1960; Basadur, 1995; Brophy, 1998; Runco, 2007; Allen & Thomas, 2011; Sowden, Pringle, & Gabora, 2015; Goldschmidt, 2016; Barr, 2018). The two major component processes of creative cognition that have received the most research attention are divergent thinking, which involves sampling a broad search space of possible alternative outputs, and convergent thinking, which constrains the generation of outputs by selecting a limited number of possible alternatives based on evaluation of their usefulness/value in relation to a goal (Guilford, 1967; Mednick, 1962). As we and others have noted (e.g., Cortes et al., 2019; Weinberger et al., 2016; Weinberger et al., 2017; Sowden, Pringle, & Gabora, 2015; Allen & Thomas, 2011; Barr, 2018), divergence and convergence are highly interrelated processes, and any measure of creativity (by the "standard definition") includes both. Convergence without any divergence is unlikely to yield novelty, and divergence without any convergence (if this is possible at all), implies randomness that is unlikely to yield usefulness/value (Cropley, 2006). The CA items in the present study were

devised to emphasize divergent thinking based on the expectation that anxiety toward creativity would be at least partially driven by the uncertainty, ambiguity, and novelty manifested in the divergent aspects of creative generation. However, they do not assume an absence of demand for creative convergence; indeed both divergence and convergence are assumed to be necessary in all CA item scenarios. While NAC items described activities that might be characterized as convergent, these items did not involve convergent *creativity*. Instances of convergent thinking are commonplace in daily life (e.g., driving to work by a familiar route), and it is likely that the great majority are not instances of convergent creativity. The explicitly non-generative goals, and externally constrained/directed activities described in the NAC items were devised to control for anxiety toward the noncreative demands of technically carrying out the tasks described in the CA items.

Future research should examine whether and in what contexts CAS ratings predict *objective* performance on additional measures of creative ability, including performance in domains not traditionally viewed as highly creative (e.g., math, computer science). Prospective and longitudinal designs might examine the extent to which individuals high in CA avoid situations, and even careers in which they anticipate strong demands for creative thinking.

Context

As creativity increasingly emerges as the human ability least achievable by artificial intelligence (Dartnall, 2013; Jennings, 2010), the already historically high value placed on creative thinking will continue to grow (World Economic Forum, 2016), and the ability to maximize one's creative potential is only likely to become a more essential determinant of opportunity and attainment. Relatedly, fostering creative thinkers is a primary goal of educators from

kindergarten through graduate school, and the ability to think creatively is a consistent predictor of academic achievement (Gajda, Karwowski, & Beghetto, 2017). Thus, characteristics that keep people from realizing their creative potential are likely to have substantial impacts on achievement and opportunity. Educationally-relevant anxieties, like math anxiety, have been shown to substantially impact specific forms of achievement and engagement. Somewhat surprisingly, however, the possibility of creativity-specific anxiety is unexplored. By combining the authors' collective interests in the (formerly separate) research on educationally-relevant anxieties and on processes that underlie creative cognition, we sought to explore whether anxiety specific to creativity was a viable construct. The findings in this initial paper on the subject suggest that creativity anxiety is indeed viable and that it may have wide-reaching impacts even across areas not traditionally considered creative. Gender differences observed in the present study intriguingly suggest that creativity anxiety may help explain the so called "leaky STEM pipeline" along which women drop out of STEM pursuits at each stage of career advancement. We hope this work and the creation of the Creativity Anxiety Scale will encourage researchers and educators to further explore the role that creativity anxiety may play in shaping creative cognition and decisions to approach or avoid creativity in a variety of contexts. As with math anxiety, we anticipate that this work can provide an empirical launchpad for the development of interventions to enable greater achievement of creative potential.

REFERENCES

Allen, A. P., & Thomas, K. E. (2011). A dual process account of creative thinking. *Creativity Research Journal*, *23*(2), 109-118.

Amabile, T. A., & Khaire, M. (2008). *Creativity and the role of the leader*. Cambridge, MA: Harvard Business School Publishing.

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of personality and social psychology*, *63*(4), 596.

Badawy, M. K. (1986). How to prevent creativity mismanagement. *Research Management*, *29*(4), 28-35.

Baer, J., & Kaufman, J. C. (2008). Gender differences in creativity. *The Journal of Creative Behavior*, *42*(2), 75-105.

Barr, N. (2018). Intuition, reason, and creativity: an integrative dual-process perspective. In *The New Reflectionism in Cognitive Psychology* (pp. 99-124). Routledge.

Basadur, M. (1995). Optimal ideation-evaluation ratios. *Creativity Research Journal*, *8*(1), 63-75.

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). Women in STEM: A gender gap to innovation. Economics and Statistics Administration Issue Brief No. 04-11.

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 4-12.

Bilton, C., & Leary, R. (2002). What can managers do for creativity? Brokering creativity in the creative industries. *International journal of cultural policy*, *8*(1), 49-64.

Blanchard, C., Perreault, S., and Vallerand, R. J. (1998). Participation in team sport: a self-expansion perspective. *Int. J. Sport Psychol.* 29, 289–302.

Brophy, D. R. (1998). Understanding, measuring, and enhancing individual creative problem-solving efforts. *Creativity Research Journal*, *11*(2), 123-150.

Budner, S. (1962). Intolerance of ambiguity as a personality variable 1. *Journal of personality*, *30*(1), 29-50.

Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data?. *Perspectives on psychological science*, *6*(1), 3-5.

Campbell, D. T. (1960). Blind variation and selective retentions in creative thought as in other knowledge processes. *Psychological review*, *67*(6), 380.

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the creative achievement questionnaire. *Creativity Research Journal*, *17*(1), 37-50.

Chipman, S. F., Krantz, D. H., & Silver, R. (1992). Mathematics anxiety and science careers among able college women. *Psychological science*, *3*(5), 292-296.

Cortes, R. A., Weinberger, A. B., Daker, R. J., & Green, A. E. (2019). Re-examining prominent measures of divergent and convergent creativity. *Current Opinion in Behavioral Sciences*, *27*, 90-93.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research & evaluation*, *10*(7), 1-9.

Cropley, A. (2006). In praise of convergent thinking. *Creativity research journal*, *18*(3), 391-404.

Dartnall, T. (Ed.). (2013). *Artificial intelligence and creativity: An interdisciplinary approach* (Vol. 17). Springer Science & Business Media.

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and brain functions*, *8*(1), 33.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: what have we learned in 60 years?. *Frontiers in psychology*, *7*, 508.

Furnham, A., & Nederstrom, M. (2010). Ability, demographic and personality predictors of creativity. *Personality and Individual Differences*, *48*(8), 957-961.

Gajda, A., Karwowski, M., & Beghetto, R. A. (2017). Creativity and academic achievement: A meta-analysis. *Journal of Educational Psychology*, *109*(2), 269.

Goldschmidt, G. (2016). Linkographic evidence for concurrent divergent and convergent thinking in creative design. *Creativity research journal*, *28*(2), 115-122.

Gray, J. A., & McNaughton, N. (1983). Comparison between the behavioural effects of septal and hippocampal lesions: a review. *Neuroscience & Biobehavioral Reviews*, *7*(2), 119-188.

Guilford, JP: *The nature of human intelligence*. McGraw-Hill; 1967.

Gurteen, D. (1998). Knowledge, creativity and innovation. *Journal of knowledge Management*, *2*(1), 5-13.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for research in mathematics education*, 33-46.

Henderson, H. A., Pine, D. S., & Fox, N. A. (2015). Behavioral inhibition and developmental risk: a dual-processing perspective. *Neuropsychopharmacology*, *40*(1), 207.

Jamieson, J. P., Mendes, W. B., Blackstock, E., & Schmader, T. (2010). Turning the knots in your stomach into bows: Reappraising arousal improves performance on the GRE. *Journal of Experimental Social Psychology*, *46*(1), 208-212.

Jennings, K. E. (2010). Developing creativity: Artificial barriers in artificial intelligence. *Minds and Machines*, *20*(4), 489-501.

Kashdan, T. B., & Hofmann, S. G. (2008). The high-novelty–seeking, impulsive subtype of generalized social anxiety disorder. *Depression and Anxiety*, *25*(6), 535-541.

McNaughton, N., & Gray, J. A. (2000). Anxiolytic action on the behavioural inhibition system implies multiple types of arousal contribute to anxiety. *Journal of affective disorders*, *61*(3), 161-176.

Mednick, S. (1962). The associative basis of the creative process. *Psychological review*, *69*(3), 220.

Muris, P., van Brakel, A. M., Arntz, A., & Schouten, E. (2011). Behavioral inhibition as a risk factor for the development of childhood anxiety disorders: a longitudinal study. *Journal of Child and Family Studies*, *20*(2), 157-170.

Necka, E. A., Sokolowski, H. M., & Lyons, I. M. (2015). The role of self-math overlap in understanding math anxiety and the relation between math anxiety and performance. *Frontiers in psychology*, *6*, 1543.

Paolacci, G., Chandler, J., & Ipeirotis, P. G. (2010). Running experiments on amazon mechanical turk.

Park, D., Ramirez, G., & Beilock, S. L. (2014). The role of expressive writing in math anxiety. *Journal of Experimental Psychology: Applied*, *20*(2), 103.

Peñas-Lledó, E., Jiménez-Murcia, S., Granero, R., Penelo, E., Agüera, Z., Alvarez-Moya, E., & Fernández-Aranda, F. (2010). Specific eating disorder clusters based on social anxiety and novelty seeking. *Journal of anxiety disorders*, *24*(7), 767-773.

Pizzie, R. G., & Kraemer, D. J. (2018). The Academic Anxiety Inventory: Evidence for dissociable patterns of anxiety related to math and other sources of academic stress. *Frontiers in psychology*, *9*.

Prabhakaran, R., Green, A. E., & Gray, J. R. (2014). Thin slices of creativity: Using single-word utterances to assess creative cognition. *Behavior research methods*, *46*(3), 641-659.

Reeb-Sutherland, B. C., Vanderwert, R. E., Degnan, K. A., Marshall, P. J., Pérez-Edgar, K., Chronis-Tuscano, A., ... & Fox, N. A. (2009). Attention to novelty in behaviorally inhibited adolescents moderates risk for anxiety. *Journal of Child Psychology and Psychiatry*, *50*(11), 1365-1372.

Runco, MA: *Creativity: Theories and themes: Research, development, and practice.* Academic Press; 2007.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, *24*(1), 92-96.

Schultz, P. W. (2001). The structure of environmental concern: concern for self, other people, and the biosphere. *J. Environ. Psychol.* 21, 327–339. doi: 10.1006/jevp.2001.0227

Sowden, P. T., Pringle, A., & Gabora, L. (2015). The shifting sands of creative thinking: Connections to dual-process theory. *Thinking & Reasoning*, *21*(1), 40-60.

Spielberger CD, Gorsuch RL, Lushene RE. 1970. Manual for the state- trait anxiety inventory. Palo Alto (CA): Consulting Psychologists Press.

Sternberg, R. (2007). Creativity as a habit. In *Creativity: A handbook for teachers* (pp. 3-25).

Tegano, D. W., & Moran III, J. D. (1989). Sex differences in the original thinking of preschool and elementary school children. *Creativity Research Journal*, *2*(1-2), 102-110.

Tierney, P., & Farmer, S. M. (2002). Creative self-efficacy: Its potential antecedents and relationship to creative performance. *Academy of Management journal*, *45*(6), 1137-1148.

Weinberger, A. B., Green, A. E., & Chrysikou, E. G. (2017). Using transcranial direct current stimulation to enhance creative cognition: interactions between task, polarity, and stimulation site. *Frontiers in human neuroscience*, *11*, 246.

Weinberger, A. B., Iyer, H., & Green, A. E. (2016). Conscious augmentation of creative state enhances "real" creativity in open-ended analogical reasoning. *PloS one*, *11*(3), e0150773.

Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of educational Psychology*, *80*(2), 210.

World Economic Forum. (2016, January). The future of jobs: Employment, skills and workforce strategy for the fourth industrial revolution. In *World Economic Forum*.