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The Creative Self and Creative Thinking: An Exploration of Predictive Effects Using Bayes Factor Analyses

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The present research explored the relationship between the creative self and creative performance. Based on prior research purporting that perceptions of the self can predict behavior, the authors predicted that beliefs about the creative self would predict creative performance. Participants completed two scales on beliefs about their creativity (creative self-efficacy; fixed and growth mindsets about creativity), and then completed two types of creativity tasks: three divergent thinking tasks and one creative-problem-solving scenario. Model comparisons based on constellations of predictors were performed using Bayesian analyses (Bayes factors and Bayesian regression). Results show that creative self-efficacy predicted fluency in divergent thinking but did not relate to originality ratings of ideas generated during divergent thinking. Endorsing a fixed mindset about creativity was related to decreased performance in creative problem solving, with no mediation by creative self-efficacy. However, creative self-efficacy remained correlated with growth mindset. Implications for further research on the creative self are discussed.

Keywords:

mindsets, self-efficacy, creative thinking, Bayesian statistics

A consistent stream of studies has examined ways that social– cognitive factors such as—implicit theories, mindsets, self-efficacy, —predict performance in academic settings (e.g., for a review and meta-analysis, see Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013; see also Dweck, 1986, 1999, 2006). With the exception of creative self-efficacy (e.g., Beghetto, 2006; Tierney & Farmer, 2002, 2011), comparatively less research has focused on how beliefs about creative abilities predict creative performance, particularly regarding implicit theories and mindsets. This line of research contrasts with a relatively rich database of studies in which interventions designed to support intrinsic motivation tend to support creativity (for a review and meta-analysis, see Byron & Khazanchi, 2012). Such work suggests that contexts that promote autonomy and self-efficacy are important for creativity. The question remains, however, whether other cognitive and motivational factors aside from creative self-efficacy, namely, implicit theories and mindsets, are related to creativity. This study was designed to address that question.

Assessing Creative Thinking and Problem Solving

Although there are many perspectives on how to frame the study of creativity, the construct is often defined as the ability to produce new, useful, and high-quality ideas and products (Runco & Jaeger, 2012). In laboratory studies, creativity is often assessed by providing participants with open-ended problems, and then analyzing the solutions to those problems with one of many coding or rating systems designed to distinguish among varying levels of creativity across responses. In the current study, two different types of problems were used to elicit responses: divergent thinking (DT) problems (e.g., alternative uses for a brick), which require participants to provide as many responses as possible in a limited time (e.g., 3 min), and a creative problem solving (CPS) scenario, which poses a specific problem to participants, who must generate a single solution to this problem. As such, creativity was operationalized in terms of the degree of creativity demonstrated by participants while engaging in creative thinking.

Interestingly, much of the existing work on the creative self has not employed assessments of creativity focusing on creative production but rather other or self-evaluations (e.g., Beghetto, Kaufman, & Baxter, 2011). This contrasts with studies examining how intrinsic and extrinsic motivating factors influence creativity (e.g., Amabile, 1982; Eisenberger, Armeli, & Pretz, 1998; Eisenberger & Rhoades, 2001), all of which used procedures that would also qualify as creative thinking exercises. Thus, if research on the creative self is to mirror research relating self variables like implicit theories of intelligence to academic performance (e.g., Bodill & Roberts, 2013; Grant & Dweck, 2003; Romero, Master, Paunesku, Dweck, & Gross, 2014), there is a need for research mapping creative-self variables to creative thinking. This study addresses that need by operationalizing creativity via creative thinking. In addition, the study used multiple measures of creative thinking to more broadly examine potential links between self concept variables and creative thinking.

Creative Thinking and the Creative Self

A central question in the burgeoning area of research on the “creative self” is whether creative thinking—as measured via DT and CPS— depends on the various constellations of concepts that have been recently collected together as reflecting the “creative self” (Karwowski & Kaufman, 2017). These creative-self concepts include creative self-efficacy (e.g., Beghetto, 2006; Reiter-Palmon, Robinson-Morral, Kaufman, & Santo, 2012; Tierney & Farmer, 2002, 2011), creative identity (Jaussi, Randel, & Dionne, 2007), and mindsets and implicit theories (e.g., Hass, 2014; Hass, Katz Buonincontro, & Reiter-Palmon, 2016; Karwowski, 2014; Lee, Kim, Ryu, & Song, 2015). The probing of a relationship between self-concepts and creative thinking is rooted in agentic theories of the self: For example, mindsets (also known *as implicit beliefs* or *self-expectations*) can affect behaviors like goal setting and achievement of goals (e.g., Bandura, 2008). Given the large body of research on the impact of self-concepts like mindsets on educational outcomes (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Burnette et al., 2013), research on the relationship between the creative self-concept and creative performance would be important for fostering creativity in learning environments. The current study brings the field forward by specifically asking whether self concepts like mindsets about creativity and creative self-efficacy relate to performance on two different kinds of creative thinking tasks. More importantly, statistical methods were employed that allow for more robust analysis of the likelihood of a null relationship in addition to the likelihood of a predictive relationship among those variables. The next two sections review research on creative self-efficacy and creative mindsets.

Creative Self-Efficacy

Self-efficacy is an extensively researched topic both inside and outside of creativity research. Bandura (1977, 2008) described self-efficacy as playing an important role in determining the quality of performance. In Bandura's (1977) theory, self-efficacy in any context describes the belief in one's ability to perform in that context. Self-efficacy beliefs are conceived of as cognitive structures developed via interaction with the world. Not surprisingly, *creative self-efficacy*, or the belief in the ability to be creative or generate new ideas (Beghetto, 2006), has been found to be predict creative performance at work, as rated by supervisors (Gong, Huang, & Farh, 2009; Jaiswal & Dhar, 2015; Jaussi & Randel, 2014; Tierney & Farmer, 2002). Other work has evaluated the relationship between creative self-efficacy and teacher ratings (Beghetto, 2006; Beghetto et al., 2011; Karwowski, Gralewski, & Szumski, 2015). Creative self-efficacy has also been found to predict self-reported creative behaviors (Lemons, 2010, but see Pretz & McCollum, 2014) and is often correlated with the "growth" creative mindset (Hass et al., 2016; Karwowski, 2014).

The link between creative self-efficacy and creative performance—as measured via problem solving and idea generation—is tenuous. Puente-Diaz and Arroyo (2016) found that creative self-efficacy did not predict DT. As this study was performed with a group of elementary students (mean age 10.54 years), there may be developmental differences in young students' conception of their creative self-efficacy, which might impact how they perform on a DT test in a different way than comparatively older college students. It might be that creative self-efficacy is more malleable in younger students, before they mature as adolescents and develop comparatively stronger academic goals and interests. Pretz and McCollum (2014) measured creative thinking via a DT task and via two writing tasks (a picture caption and an essay), and measured creative self-efficacy in two ways. First, they used Beghetto's (2006) three-item Creative Self-Efficacy scale, which is a "domain general" scale of creative self-efficacy, as the items do not ask participants to judge their creative abilities in a particular domain. Second, participants rated their perceived level of creativity on all three creativity tasks after performing them. The latter is a measure of more “local” or “domain-specific” creative-self efficacy. Correlational analysis showed that global creative self efficacy did not relate to the fluency of DT responses (i.e., total number), nor did it relate to the statistical infrequency of DT responses or to ratings given to those selected by participants as their “top two” best responses. However, global creative self efficacy and the “local” self-ratings did relate, suggesting that people are consistent in what Pretz and McCollum called “creative metacognitions.” Local self-efficacy was correlated with each of the three creativity measures.

The results presented by Pretz and McCollum (2014) can be contextualized when considering results reported by Reiter-Palmon et al. (2012). The latter set of authors found that creative self-efficacy was highly correlated with other self-reports of creativity but not as strongly with creative achievement. Pretz and McCollum also measured creative achievement and found that global creative self-efficacy was a significant predictor of creative achievement but only when the personality trait Openness to Experience was not accounted for. In a related vein, Beghetto and colleagues (2011) reported that although creative self-efficacy was a significant predictor of teacher ratings of creativity, the effect size was small.

If the effect size linking creative self-efficacy to creative performance or creative thinking tasks is small, then it is not surprising to find conflicting results across studies with very different sample sizes. It is important to note that the way in which Pretz and McCollum (2014) measured local self-efficacy deviated from the way that the global construct is measured. First, Pretz and McCollum asked participants to report how creative they were on each task after it was finished using two items: “My responses to that task were creative” and “My responses were more creative than the average person my age” (p. 230). Their global self-efficacy measure comprised of the items from Beghetto (2006; e.g., “I have a lot of good ideas” and “I have a good imagination”). So there is reason to believe that perhaps the phrasing of the items, or the fact that they were assessed immediately after task performance, led to the different pattern of relationships among global, local, and performance measures. That said, the fact that the global and local measures were correlated suggests that they were measuring the same construct. Nevertheless, it is surprising that many prior studies showed some evidence of a link between global self efficacy and creativity, whereas theirs did not. In sum, studies on the relationship between creative self-efficacy and creative performance provide a mixed picture, which may be related to a variety of reasons (age of participants, creativity task, domain, rater and context [academic, workplace]).

Thus, one of the purposes of this study was to more robustly examine the global-self-efficacy/creativity link. This was accomplished using a Bayesian statistical approach, which allows for the examination of multiple different regression models without inflating experiment-wise error rates. Indeed, many studies on creative self-efficacy, as with other studies, are often comprised of 10 or more individual statistical tests, and in the classic null hypothesis significance test scheme, these multiple comparisons may lead to spurious results. We are not at all saying that this was a limitation of previous studies but rather are attempting to more precisely ascertain the size of the creative self-efficacy relationship.

Rather than utilize local self-efficacy measures, we opted to examine global self-efficacy and its relation to two tasks, both of which can be considered somewhat domain general. The two creative thinking tasks used were DT and CPS. Though Pretz and McCollum (2014) found no relationship between global self efficacy and DT, they only administered one DT prompt (brainstorming ideas for how to use a $1 million donation to their college), which is not among the prompts commonly used by other researchers. Third, creative self-efficacy was examined alongside two constructs—fixed and growth mindsets—that have gained increasing popularity in the literature on the creative self (e.g., Karwowski, 2014; Karwowski & Kaufman, 2017). Though this may be seen as an incremental gain, an important part of the progress of science is investigating the degree to which the same effect can be detected across different samples and different tasks.

Creative Mindsets

There is a long history of work on creativity and motivation (for reviews, see Amabile, 1996; Byron & Khazanchi, 2012) focused on whether or not the promise of a reward increases or decreases participants' creativity in the immediate context. This relates to a larger question of whether self-determination and autonomy promote creativity (see Deci & Ryan, 1987). Although the current study did not address self-determination or goal orientation directly, Dweck and Leggett (1988) argued that there is a direct connection between goal orientation and a person's beliefs about the nature of their own abilities. Several studies conducted by Dweck and colleagues showed that self-motivation shapes orientations toward tasks: Children who adopt a helpless learning orientation versus a mastery learning orientation perceive their own successes as external as opposed to intrinsic; also, children endorsing a learned helplessness orientation attribute poor performance to their own incompetence (Goetz & Dweck, 1980).

Building on this evidence, Dweck and Leggett (1988) coined the term "self-cognitions," and then "mindset" (Dweck, 2006), to explain how self-perceptions relate to goals and to performance. Fixed mindset, formerly referred to as *entity theory* (e.g., Dweck, 1986, 1999), represents a person's belief that important traits (e.g., personality, intelligence) are not malleable, and that no matter how much one develops these traits, they will not change. Growth mindset, formerly referred to as *incremental theory* (e.g., Dweck, 1986, 1999), represents a person's belief that traits like personality and intelligence can change, perhaps through effort and practice. Dweck has written extensively on the topic and showed that people endorsing a fixed mindset tend to be motivated more by performance goals (e.g., "trying not to look stupid" or "trying to impress everyone") as opposed to adopting learning goals (e.g., "trying to learn for the sake of learning"; Hattie, 2008). There are obvious parallels between self-determination theory and mindsets theory, such that in both cases, more positive outcomes seem to result from autonomy. There is some support for self-determination theory in the creativity literature (e.g., Amabile, 1982), but a recent meta-analysis (Byron & Khazanchi, 2012) showed that learnedindustrious theory, which highlights the fact that positive outcomes can be attributed to extrinsic motivating factors, can account for other results in the creativity literature (e.g., Eisenberger & Rhoades, 2001).

Although a discussion of the merits of these theories of motivation are out of the scope of this article, it is important to point out that research on mindsets is linked to research on motivation and goal orientation, which, in turn, are linked to educational outcomes. New research shows that, indeed, mindsets do relate to goal orientation with regard to creative tasks (Puente-Diaz & CavazosArroyo, 2017). In addition, the mindsets tend to correlate strongly with other creative self-report measures, such as self-efficacy (Hass et al., 2016; Karwowski, 2014) and self-esteem (Pretz & Nelson, 2017). Specifically, growth mindset tends to positively correlate with creative self-efficacy, such that the more one believes that creativity is a malleable ability, the more likely one is to also develop high creative self-efficacy.

Despite positive relations among the growth mindset and other self-report variables, attempts to link growth mindsets directly to high creative thinking and performance abilities have yielded mixed results. For example Karwowski (2014) showed that fixed, but not growth, mindsets predicted performance on insight problems, and that fixed mindset may moderate the growth–insight relationship. Similarly, O'Connor, Nemeth, and Akutsu (2013) found that fixed mindset was negatively related to creativity on DT tasks. More recently, Royston and Reiter-Palmon (2017) found that effect of mindsets on CPS was fully mediated by creative self-efficacy. Lastly, in a classroom study measuring the correspondence of creativity beliefs to performance on course assignments requiring creative thinking, students endorsing fixed mindsets about creativity were less likely to perform well on a real-world problem-solving task compared with students endorsing growth mindsets, but mindsets did not predict performance on all tasks (Katz-Buonincontro, Hass, & Friedman, 2017). Thus, the evidence linking mindsets directly to creative thinking measures is far weaker than one might expect given the interrelations among mindsets and other self-reported creative behaviors.

The Present Study

The present study was constructed to address the inconsistency of findings linking mindsets and self-efficacy to measures of creative thinking and problem solving. Rather than testing mediation or moderation models, the analysis focused first on using Bayesian methods for evaluating the strength of the evidence for predictive relationships between creative self-variables and two commonly utilized creative thinking measures: DT and CPS. Although some studies on creative self-efficacy have utilized multiple measures of creative thinking and problem solving (e.g., Pretz & McCollum, 2014; Pretz & Nelson, 2017), no single study has used Bayesian analysis to determine the strength of association among these variables. Bayesian statistical inference differs from classic null-hypothesis significance testing (NHST) in many ways, but the most fundamental for this study is that the particular Bayesian approach used currently—Bayes factor (BF) model selection—provides a means for selecting among many potential explanatory models, including a “null model” without inflating the false discovery rate (e.g., Raftery, 1995). This allowed for a fully bottom-up approach to model testing in this study in order to let the data drive the evidence for or against a specific model. That is, rather than run a number of regressions, and choose among them using a statistic like ΔR^2 , which depends on p values—which can lead to inference errors—in this study, model comparison was performed in such a way as to keep false discovery rates low.

Admittedly, there are many means of controlling false discovery rates, for example the Akaike information criterion (AIC), which is used to compare models with different numbers of parameters. However, what makes BF analysis unique, and informative, is that it is one of the only means for showing direct support for a null hypothesis (e.g., Rouder & Morey, 2012). This is an especially important type of analysis to use for constructs like self-efficacy and mindset, because the concept of *growth mindset* has been adopted widely in the field of education and, in some cases, has been misinterpreted (DeWitt, 2017). Several interventions for promoting growth mindset have very low effect sizes, likely due to the fact that the proper conditions conducive to growth mindset are ignored, as well as because it is difficult to intervene at the right time when a child is anxious, has recently failed at a task, or is in the midst of experiencing a significant intellectual challenge (DeWitt, 2017).

The sizes of the associations between self-variables and creative thinking measures are not well known and are likely small. In general, with a fixed sample size (N), statistical power is reduced when the size of an effect is small (e.g., Cohen, 1992; Hogg & Craig, 1978). In Cohen’s (1992) brief article on power, he relayed informal effect size ranges for correlations, and all studies that have investigated correlations between self-efficacy and creative thinking, and between mindsets and creative thinking, have found small to medium effects. *Power* is the probability that a false null hypothesis will be rejected or, more directly, the probability that an effect will be detected if it is, *in actuality*, a *real effect*. As a microscope needs more power to see small particles, a statistical test needs more power to detect small or weak statistical relations. If a study does not detect an effect (i.e., the null cannot be rejected) in the NHST approach, the researcher cannot conclude that the null hypothesis is true but can only conclude that there was not enough evidence to reject it. Thus, the major contribution of this study is to, for the first time, actually attempt to provide evidence against and for the null hypothesis.

In actuality, there are several potential null hypotheses in this study, as each predictor considered in isolation and in combination with other predictors constitutes a statistical hypothesis in the context of regression. For example, between models, one can ask whether creative self-efficacy predicts or does not predict fluency on DT tasks, or whether a model with two predictors— creative self-efficacy and fixed mindset— improves predictions over that model. In NHST, this would likely be answered using an *F* test for evaluating the significance of the change in R^2 as a result of adding the fixed mindset variable. However, it is less straightforward to compare a number of models in terms of how well they outperform a default "null model," as ΔR^2 is reserved for testing changes in predictive power and AIC (for example) is used to compare models with one another. Further, in none of those cases can the null hypothesis truly be concluded to have evidence behind it, and so BF analysis provides a means for more precise examination of the truth of the null hypotheses that may have been obscured by previous analyses (for an alternative view using frequentist methods, see Anderson & Maxwell, 2016; Lakens, 2017). The computation of BFs will be explained more fully in a later section of the article.

With Bayesian analysis in hand, the following questions were addressed in the present study: First, what is the weight of the evidence (for or against a null hypothesis) with regard to relationships between the beliefs about creativity (creative self-efficacy and fixed and growth mindsets about creativity) and creative thinking? Second, are the relationships between self-constructs and creative thinking consistent across different creativity measures (DT and CPS)? As such, BF model comparison was first conducted to examine which, if any, constellation of predictors provided substantial evidence against a default null model—the intercept-only model. To the extent that evidence was in favor of particular predictor constellations, Bayesian regression was performed in order to examine the effect sizes of the particular predictors. This was done separately for dependent variables culled from the two different creative thinking tasks administered to participants. As this was a bottom-up investigation of these statistical relationships, there was no outward prediction as to which, if any, predictors would emerge as significant.

Method

Participants

One hundred thirteen participants (54 females) were recruited from the psychology participation pool at a large state university in the United States. The average age of participants was 19.39 years (SD = 1.95). Data from two participants were omitted. One participant did not complete all of the tasks, and the other participant did not follow directions on the DT tasks. Sixty-five percent of the participants identified as White/Caucasian, 14% as African American, 11% as Hispanic/Latino, 5% as Asian American, 3% as other, and 1% as Native American.

Materials and Measures

Creative self-efficacy. Creative self-efficacy (Beghetto, 2006; Tierney & Farmer, 2002) was measured with six items (e.g., "I have a lot of good ideas"). Participants rated their agreement with each statement on a 5-point Likert scale (1 = *strongly disagree*; 5 =

strongly agree). Prior studies using these items reported internal consistency (Cronbach's alpha) greater than .80. Participants' scores on this variable were comprised of the average of their responses on these six items.

Creative mindsets. Fixed mindset (Karwowski, 2014) was measured with five items (e.g., "You are either creative or you are not— even trying very hard you cannot change much"). Growth mindset (Karwowski, 2014) was measured with four items (e.g., "Everyone can create something great at some point if he or she is given appropriate conditions"). Again, participants used a 5-point Likert scale to respond to each statement (1 = *strongly disagree*; 5 = *strongly agree*). Prior studies using these scales reported internal consistency in the range of .80 for fixed mindset, and growth mindset was usually in the range of .60. As with creative self-efficacy, mindset scores represented averages of the items used to measure each one.

Divergent thinking. DT was measured across two different items: consequences of no longer needing sleep and consequences of gravity ceasing to exist (e.g., Torrance, 1966). Response arrays were scored for fluency (total number of responses) and for creativity. Three independent trained raters provided creativity ratings for each unique response following the procedures described by Silvia and colleagues (2008, Appendix). Unique responses were assembled into a single array for scoring so that raters were not aware of the source of each response. The fluency scores across the two tasks were averaged for each participant, as were the averages of the creativity ratings earned across the two tasks.

Creative problem solving. CPS was assessed by presenting participants with an ill-defined, ambiguous, everyday problem that would be familiar to college students. Participants were asked to generate one solution to the problem presented, which depicted a college student working as a research assistant but finding that she was not enjoying the work, working more than she planned on, and was working with a difficult supervisor. Past research has used similar problems successfully to measure creativity (Reiter-Palmon, Mumford, O'Connor Boes, & Runco, 1997; Reiter-Palmon et al., 2012). Three independent trained raters provided originality ratings for each of the responses, and three additional independent trained raters provided quality ratings. These raters were not the same as those who scored the DT items. Thus, there were two scores assigned to each participant's CPS solution.

Procedure

All items were presented to participants online via the Qualtrics platform. Previous studies examining DT items (Hass, 2015) and self-assessment items (Zongrone et al., 2015) showed that online administration does not distort the data collection process. After providing electronic consent, participants completed demographic questions. Then, they were presented with three blocks of items. First, the creative self-efficacy items and mindsets items were presented, with the order of the presentation of the two sets of items randomized. Then, DT problems were presented, also in a random order. Participants could not advance to the next problem until 2 min had elapsed. Finally, the CPS scenario was presented. Similarly, participants could not submit their response until 3 min had elapsed. Most participants completed the entire set of measures in 30 min.

Table 1
Means, Standard Deviations, and Pairwise Spearman Correlations Among All Variables

Scores	*M*	*SD*	1	2	3	5	6	8	9	10	11
1. Fixed mindset (BACS)	2.88	.76	(.77)								
2. Growth mindset (BACS)	4.91	.64	−.36	(.56)							
3. Creative self-efficacy (BACS)	3.95	.54	.03	.24	(.74)						
5. Fluency (DT; gravity)	6.01	3.33	−.05	−.07	.21	(n/a)					
6. Fluency (DT; sleep)	6.67	3.41	.00	−.01	.24	.46	(n/a)				
8. Originality (DT; gravity)	1.19	.52	.07	.02	.03	.14	.11	(.56)			
9. Originality (DT; sleep)	2.11	.54	−.06	−.01	.00	.15	−.06	.32	(.57)		
10. Quality (CPS)	2.77	.96	−.20	.13	.04	.39	.13	.12	.24	(.88)	
11. Originality (CPS)	2.96	.85	−.25	.17	.13	.39	.09	.21	.34	.79	(.89)

Note. BACS subscales represent averages across subscale items. DT creativity scores represent the average originality rating per item, and CPS originality and quality scores represent rater averages for each participant. Numbers on the diagonal are alpha reliabilities (for BACS subscales) and intraclass correlations (for originality and quality scores). Information on statistical significance is omitted due to the focus on Bayesian regression. BACS = Beliefs about Creativity Scale; DT = Divergent Thinking; CPS = creative problem solving.

Results

All analyses were performed using the R statistical programing language (R Core Team, 2016). The data set and statistical algorithms are https://osf.io/fy9tv/. All variables were checked for distributional assumptions of normality by inspecting histograms and quantile-quantile (qq-plots). As usual, fluency scores were positively skewed and kurtotic, so they were subject to natural logarithm transform, which eliminated the skew.

Table 1 contains the means and standard deviations of each of the measures, along with Spearman correlations among subscales and creativity assessments as well as reliability estimates (Cronbach's alpha). The fluency variables in the table are the raw scores, which is why Spearman's rho was used to capture correlations. As can be seen, the reliability of the growth mindset items was suboptimal (α = .56), whereas creative self-efficacy and fixed mindset were acceptable (αs = .74) but lower than those used by previous studies. The ensuing analyses made use of composite fluency and DT creativity variables, but the fluency and creativity scores from the two tasks are presented separately in Table 1. Though the primary approach to hypothesis testing in this article is Bayesian, it is important to note that fixed mindset and creative self-efficacy did not show a particularly strong correlation. This is consistent with prior analysis (Hass et al., 2016).

Bayes Factor Analysis

For the BF analysis, all variables were mean centered, except for fluency, as it was previously log transformed. BFs were calculated using the *BayesFactor* package (Morey & Rouder, 2015) in the R statistical programming environment (R Core Team, 2016). For those unfamiliar with BFs, the next section gives an overview of how to interpret the results of the analysis.

A BF is similar to a likelihood ratio, in that it is a ratio of the likelihood of one model (i.e., set of parameters) to the likelihood of another model. Unlike frequentist likelihood ratios, the numerator and denominator of a BF represent the probability of the data given a particular model. That is, rather than consider the probability of an infinite collection of data sets and some model parameters, the BF directly compares the probability of the particular data set at hand given the two models compared (for a more detailed treatment, see Rouder & Morey, 2012) in terms of a ratio.

The BF has many desirable properties. First, the ratio itself can be interpreted in a straightforward manner as the amount of evidence in favor of the model in the numerator. For example, if the numerator represents a regression model predicting originality as a function of two predictors (e.g., creative self-efficacy and fixed mindset), and the denominator represents a "null" regression model— one in which only the intercept (grand mean) predicts originality—and the BF is equal to 20, then the data are 20 times more probable given the two-predictor model compared with a model with no predictors. In addition, the value of the ratio is not subject to a significance test but is instead interpreted in terms of how well the model represented in the numerator outperforms the model represented in the denominator. BFs between 1 and 3 represent weak support for the numerator model compared with the denominator model, BFs between 3 and 20 represent positive support, BFs between 20 and 150 represent strong support, and BFs greater than 150 represent very strong report (Raftery, 1995). For each of the dependent variables in this study—DT fluency, DT creativity, CPS originality, and CPS quality—there were seven unique combinations of predictors: each predictor considered alone ($n = 3$), each unique pair of predictors (n 3), and the combination of all three predictors (n 1).

For each BF ratio, one of the predictor models was represented in the numerator, and the denominator was always comprised of the intercept-only model, which specifies that the best predictor of each dependent variable is just its mean. As such, the null hypothesis in the model comparison phase was that the predictive relationship was zero. In cases in which the BF for a particular model reached or exceeded 3, Bayesian regression was performed to estimate the coefficients for that particular model.

Table 2
Bayes Factors for the Seven Unique Constellations of Predictors of the Average Creativity Rating Across the Two Divergent Thinking Consequences Tasks

Model (predictors)	BF
CSE	.23
Growth mindset	.22
Fixed mindset	.20
CSE + Growth Mindset	.08
CSE + Fixed Mindset	.07
Fixed Mindset + Growth Mindset	.06
Fixed Mindset + Growth Mindset + CSE	.03

Note. BFs are listed in order from largest to smallest. BF = Bayes factor; CSE = creative self-efficacy.

Divergent thinking creativity. Table 2 gives the BFs for each of the seven unique predictor combinations for the DT creativity outcome. As can be seen, all evidence favors the null hypotheses (all BFs 1.0), and this evidence grows as more predictors are added to the equation. As such, the weight of the evidence is for DT creativity not to be related to any of the three predictors examined presently. Indeed, according to this analysis, adding predictors progressively strengthened the evidence in favor of the intercept-only model.

Divergent thinking fluency. Table 2 provides the BFs for the unique predictor combinations for the DT fluency outcome (log transformed). As can be seen, there is positive evidence for a model with creative self-efficacy scores predicting log fluency (BF 4.21); however, there was only weak support for the other predictor constellations compared with the intercept-only model. Table 3 summarizes estimates of the regression weight for creative self-efficacy along with error variance and the g-prior across 10,000 iterations of posterior distribution sampling. The empirical mean of the estimates for creative self-efficacy was .18, and the 95% Bayesian credible interval indicated that, with .95 probability, the true coefficient was between 0.04 and 0.32 (see Table 4). These coefficients are not directly interpretable as effect sizes because fluency was log transformed, whereas creative self-efficacy was mean centered. However, this indicates that the true creative self-efficacy coefficient is not zero, though the credible interval indicates that there is still a good degree of uncertainty about the size of the effect. Figure 1 makes it clear that although increases in creative self-efficacy were associated with larger log-fluency scores, very few people's creative self-efficacy scores were low, and a few high creative self-efficacy scores were associated with lower than average log-fluency scores.

Creative problem solving. Table 5 provides the BFs for the models predicting CPS originality. There was moderate to convincing evidence that a model containing all three predictors is better than a null model for CPS originality scores. To explore the unique predictive contributions of the variables, Bayesian regression was run for three models: one with fixed mindset as a predictor, one with fixed mindset and creative self-efficacy as predictors, and one with all three predictors. Table 6 provides the mean and

95% credible interval for each coefficient across 10,000 samples from the posterior distribution. In all three models, the coefficient for fixed mindset was negative and the 95% credible intervals did not contain zero, indicating, with .95 probability, that the true coefficient is not zero. As with the model for DT fluency, the interval is wide, indicating some uncertainty about the size of this effect. Notably, all the credible intervals for the other coefficients contained zero, indicating that no relationship is a plausible conclusion for those variables. The relationship between fixed mindset and CPS originality scores is illustrated in Figure 2. As can be seen, there is still substantial variance to be explained in CPS originality scores, and the results above indicate that neither growth mindset nor creative self-efficacy improve predictions beyond what fixed mindset already supplies.

Regarding CPS quality, Table 7 provides the BFs for the various predictor constellations. The weight of the evidence is less convincing regarding an association between fixed mindset and CPS quality, and when predictors in addition to fixed mindset are added, the weight of the evidence swings toward the null hypothesis. Though the fixed mindset model did not indicate much more than anecdotal evidence for an effect, Bayesian regression was run for the purposes of comparison with the CPS originality results (indeed, Table 1 shows that CPS originality and quality scores are highly correlated). Although the magnitude of the mean fixedmindset coefficient was similar to the originality model ($b_{mean\,=}$ 0.26), the 95% credible interval was wider and contained zero: 95% CI [0.49, 0.03]. As such, despite the correlation between CPS originality and CPS quality, fixed mindset may not directly predict CPS quality.

Discussion

This study used a Bayesian procedure for model selection— BFs—to more properly contextualize the reality of null effects in models in which constellations of creative-self variables predicted several different creative thinking outcomes. Results confirmed the mixed trends previously identified across studies of all three constructs. In addition, the relationships between creative self-concept variables and creative thinking were not consistent across different measures of the latter. Specifically, creative self-efficacy only predicted the average fluency of participants across the two DT tasks. Creative self-efficacy did not significantly predict ratings of creativity of DT ideas, nor did it significantly predict the originality or quality of CPS solutions. Fixed mindset was a significant predictor, in the negative direction, of CPS originality but did not significantly predict any of the other creativity measures. Growth mindset, although highly correlated with fixed mindset (see Table 1), did not show significant relationships with any of the creative thinking variables. This adds to prior research on the topic because the lack of statistical power cannot be the reason for the present results.

Table 3
Bayes Factors for the Seven Unique Constellations of Predictors of the Average Fluency Score (Log-Transformed) Across the Two Divergent Thinking Consequences Tasks

Model (predictors)	BF
CSE	4.21
CSE + Growth Mindset	1.54
CSE + Fixed Mindset	1.40
CSE + Fixed Mindset + Growth Mindset	.82
Fixed mindset	.23
Growth mindset	.20
Fixed Mindset + Growth Mindset	.07

Note. BFs are listed in order from largest to smallest. BF = Bayes factor; CSE = creative self-efficacy.

In addition, unlike prior studies that have purported to show direct benefits of growth mindset on creative thinking, the present study found that, in fact, it is fixed mindset that has the primary relationship with CPS skills. However, the same cannot be said for either fluency or creativity as measured via DT tasks. Thus, the results point to a wide range of potential effect sizes for the fixed-mindset/CPS relationship and to a likely small relationship between creative self-efficacy and DT fluency. The evidence for these effects across analyses was far from strong or convincing, again fortifying previous conclusions that, at least when the constructs are measured as they were in the current study, effect sizes are likely small.

Implications for Creative Self-Efficacy

In the introduction to this article, the size of the relationship between creative self-efficacy and creative thinking was posited to be somewhat small. Our results are consistent with those presented by Pretz and McCollum (2014), who showed that "global" (i.e., domain general) creative self-efficacy, measured with the same tool used as presently, did not relate to any of their creative thinking measures. However, the one inconsistency was that the present study found a significant relationship between creative self-efficacy and DT fluency. There are several potential reasons for this. First, Pretz and McCollum did not use Bayesian estimation techniques, and given that their sample size was smaller than the current study, their analyses may have been underpowered. They found that the zero-order correlation between global creative self-efficacy and DT fluency was .197, which did not reach significance. Though they did not include global creative self-efficacy in a regression model, using the .197 zero correlation as an estimate of the partial correlation, they would require 200 participants to detect the effect at 80% power.[1] That does not invalidate their results, however, as their hypothesis was that local creative self-ratings would provide a better predictor of creativity across multiple measures, which was confirmed. It is important to note that Pretz and McCollum used a single novel prompt for DT ("Think of ideas for using a $1 million donation to their college"), whereas participants in the present study completed two DT tasks with more general prompts. It may be that with two attempts to engage in creative DT, and by using prompts that pull on general knowledge, creative self-efficacy better explained some of the variance in fluency in the current study. Fluency scores on single DT tasks are often skewed, as mentioned in the Results section of this article, which can affect the magnitude of the Pearson correlation coefficient. Pretz and McCollum did not provide information about whether their fluency scores were skewed, which could explain the discrepancy between their findings and those presented here. Though linear modeling is relatively robust to some skewness, it is unclear whether the skewness affected the previous results. The natural log transformation used in the current analysis sufficiently normalized the fluency scores and revealed a small but significant relationship between the two.

[1.] This was computed using G Power, a free program for conducting power analyses.

Table 4
Parameter Estimates From the Posterior Distribution of the Model With Creative Self-Efficacy Predicting the Log-Fluency Scores

Parameter	Empirical mean	*SD*	95% credible interval
CSE coefficient	.18	.07	[.04, .32]
σ^2	.18	.02	[.14, .23]
g	.33	.25	[.02, 3.69]

Note. Estimates are from 10,000 iterations of posterior distribution sampling. Sigma squared (σ^2) and g are parameters used in the Bayesian estimation procedure. CSE = creative self-efficacy.

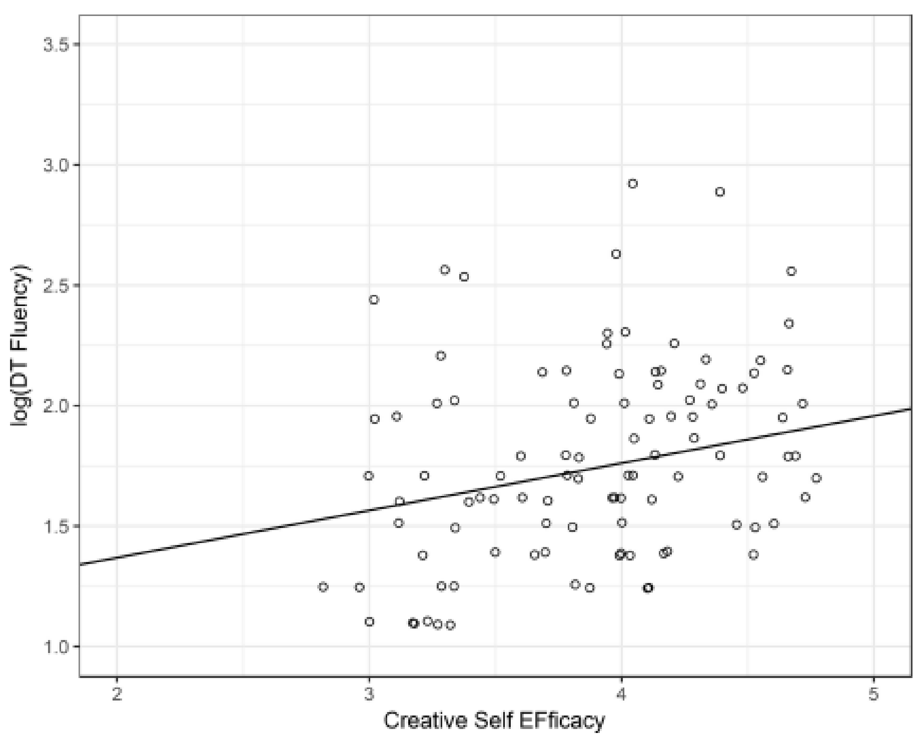

Figure 1. Scatterplot of the relationship between creative self-efficacy and divergent thinking fluency (log-transformed). Regression line was fit with ordinary linear regression.

The present study's results are interesting in light of PuenteDiaz and Arroyo's (2017) study, which found that creative self efficacy did not predict DT. On one hand, the present study is consistent with their finding that creative self-efficacy was not significantly related to DT scores. On the other hand, the present study, as mentioned above, did find a relationship between creative self-efficacy and fluency in DT. Further reasoning for the reality of the link—potentially small— between fluency and creative self efficacy comes from reflection on the nature of self-report creativity indices. The most highly cited studies in this area (Tierney & Farmer, 2002, 2011) did not measure creative thinking, but rather managerial evaluations, of employee creativity. Tierney and Farmer (2002) described these evaluations as essentially probing managers' perceptions of employees' abilities to produce many novel ideas or solutions to problems at work (see Tierney, Farmer, & Graen, 1999). That is, it may be that both intrapersonal and interpersonal creative self-efficacy assessments are driven mainly by the quantity of ideas a person can produce and not necessarily related to idea quality. It further suggests that people may not be able to properly assess the quality of their ideas, because, if so, one would expect creative self-efficacy to relate to all the performance measures included in the current study and to have a more consistent relationship to creative measures across studies. The notion that people may not be able to accurately judge the creative quality of their own ideas is consistent with the characterization of some aspects of the creative process as blind—that is, a person is not always able to predict which ideas are good and which are bad (cf. Reiter-Palmon & Arreola, 2015; Simonton, 2003; Weisberg & Hass, 2007). Thus, one advantage to the local self-efficacy measure that Pretz and McCollum (2014) used was that both the specificity and proximity of the actual DT assessment may enhance participants' abilities to accurately judge the quantity and quality of their ideas.

Finally, Beghetto and Karwowski (2017; see also Pretz & McCollum, 2014; Pretz & Nelson, 2017) offered suggestions for studying creative self-efficacy that could offer insight into these results. Creative self-efficacy, they posited, has distinct dimensions: People might orient themselves toward engaging in future tasks, not the task at hand to be completed in the experiment. Because creative self-efficacy is highly specific, the view of one's self as creative might be fluid and fluctuate depending on the nature of the task. Therefore, in this experiment, participants might have rated their own creativity in a global or general understanding of themselves. This means there was a possible mismatch between how they rated themselves and how they perceived the creative task. Indeed, Figure 2 shows that the range of creative self-efficacy scores was restricted. For future measurement, experimenters might further tailor creative self-efficacy items to address nature of the experimental task, such that "I'm good at coming up with ideas" would be "I'm good at coming up with ideas... (when thinking of new uses of a brick)/(when discussing how to solve a problem with a friend)." It is important to note that these conclusions are precisely why Pretz and McCollum (2014) conducted their study, and future work should focus on more precise and specific self efficacy measurements.

Table 5

Bayes Factors for the Seven Unique Constellations of Predictors of the CPS Originality Scores

Model (predictors)	BF
Fixed mindset	10.26
Fixed Mindset + CSE	9.98
Fixed Mindset + Growth Mindset	5.90
Fixed Mindset + Growth Mindset + CSE	4.23
Growth mindset	1.67
Growth Mindset + CSE	.70
CSE	.55

Note. Bayes factors are listed from largest to smallest. BF = Bayes factor; CPS = creative problem solving; CSE = creative self-efficacy.

Table 6

Parameter Estimates From the Posterior Distribution of Three Different Regression Models for Predicting CPS Originality Scores

Regression model	Parameter	Empirical mean	*SD*	95% credible interval
Fixed mindset model	Fixed mindset coefficient	–.28	.10	[–.48, –.09]
	σ^2	.68	.09	[.52, .89]
	g	.64	3.75	[.03, 3.72]
Fixed Mindset + CSE	Fixed mindset coefficient	–.29	.10	[–.49, –.09]
	CSE coefficient	.22	.14	[–.05, .50]
	σ^2	.66	.09	[.51, .87]
	g	.22	1.44	[.02, 1.04]
All three predictors	Fixed mindset coefficient	–.25	.10	[–.46, –.04]
	CSE coefficient	.18	.14	[–.10, .47]
	Growth mindset coefficient	.10	.13	[–.14, .35]
	σ^2	.67	.09	[.50, .87]
	g	.12	.24	[.02, .50]

Note. Estimates are from 10,000 iterations of posterior distribution sampling. For Bayes factors, see Table 5. Sigma squared (σ^2) and g are parameters used for Bayesian estimation. CPS = creative problem solving; CSE = creative self-efficacy.

On a final note, Pretz and Nelson (2017) found that the pattern of relationships between creative performance and creative self-efficacy was more coherent when self-efficacy was measured with respect to domains (using the Kaufman Domains of Creativity Scale; Kaufman, 2012). However, and Pretz and Nelson posited that the link between what they call “creative metacognitions” and creative performance may only be strong when measured with respect to an individual’s domain, in a population, such as employees of a specific company, who would have ample opportunities to receive feedback on creative performance. Thus, an alternative interpretation of our results is that general creative self-efficacy is too broad of a construct to be linked strongly to general creative thinking tasks, especially when individuals have not experienced direct feedback about performance on such tasks. This conclusion is consistent with the observation, raised previously, that researchers such as Tierney and Farmer (e.g., Tierney & Farmer, 2002) found stronger links between creative self-efficacy ratings and supervisory ratings, because supervisors would have had occasion to observe the idea generation capacities of their employees and those employees would likely have received some kind of environmental feedback about their abilities.

Table 7
Bayes Factors for the Seven Unique Constellations of Predictors of the CPS Quality Scores

Model (predictors)	BF
Fixed mindset	2.56
Fixed Mindset + Growth Mindset	.88
Fixed Mindset + CSE	.88
Growth mindset	.51
Fixed Mindset + Growth Mindset + CSE	.33
CSE	.24
Growth Mindset + CSE	.15

Note. Bayes factors are listed from largest to smallest. BF = Bayes factor; CPS = creative problem solving; CSE = creative self-efficacy.

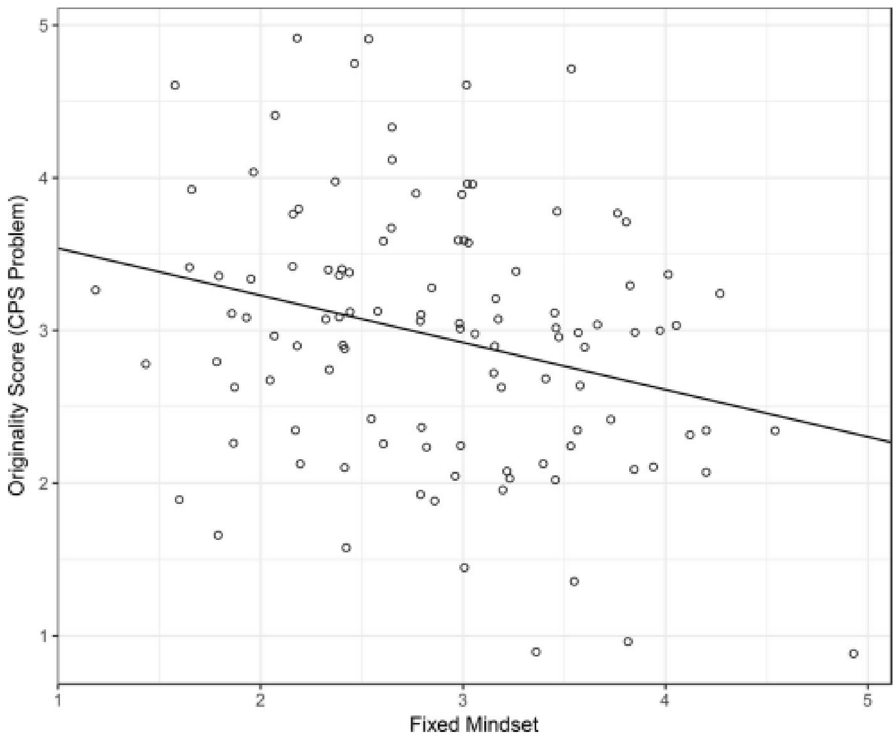

Figure 2. Scatterplot of the relationship between fixed mindset and creative problem solving originality. Regression line was fit using ordinary linear regression.

Implications for Creative Mindsets

Scant research exists on creative mindsets and creative thinking, except for the published studies mentioned previously. The reason to measure creative mindsets is that a growth mindset is argued to be an antecedent of achievement or mastery goal orientation (e.g., Dweck & Leggett, 1988; Puente-Diaz & Arroyo-Cavazos, 2017). Though we found evidence to suggest that fixed creative mindset negatively relates to CPS originality, again, the pattern of results linking fixed creative mindset (or growth, for that matter) to all of the current creative thinking measures was mixed. As previously mentioned, there is likely a more complicated relationship lurking among all of the self variables measured in this study, including a potential mediating relationship played by creative self-efficacy (Royston & Reiter-Palmon, 2017). However, our results do not support such a mediating relationship, as creative self-efficacy and fixed creative mindset did not relate to the same outcome variables, as is required for most tests of mediation (e.g., Preacher & Hayes, 2008).

Again, the use of Bayesian techniques allows for some more definitive conclusions about mindsets and creative thinking that do not hinge on statistical power. First, even though the weight of the evidence for a negative relationship between fixed creative mindset and CPS originality was the strongest out of all of the effects presently examined, the results of the Bayesian regression (see Table 6) illustrate a wide range of potential effect sizes, including effects near zero. This was true regardless of whether fixed mindset was the single predictor of CPS originality or not. More importantly, none of the analyses showed any evidence to favor growth mindset as an important correlate of any of the creative thinking outcomes measured. Thus, the weight of the evidence seems to be in the favor of a null effect with regard to growth creative mindset and creative thinking.

The current results are in conflict with the popular notion that fostering a growth mindset should positively affect outcomes like creative thinking. Instead, it seems that, if anything, it may be that interventions designed to ameliorate fixed mindset might be more effective than those designed to foster a growth mindset. Indeed, the observation of helpless self-cognitions following failure is what led Dweck (1999) to posit that mindsets might be important to academic achievement. In this view, it may be more effective to “diagnose” whether someone holds a fixed mindset (i.e., believes that one is helpless to change or get better) about creativity and, if so, work to challenge those thoughts. As mentioned previously, Dweck’s appendix, illustrates the use of only fixed mindset items to measure beliefs about intelligence and personality. Although the two mindsets are correlated (e.g., Hass et al., 2016; Karwowski, 2014), it is possible for someone to hold both sets of beliefs. For example, a budding songwriter may believe that no amount of practice will enable him or her to reach the level of output achieved by John Lennon but also may believe that via practice, his or her songwriting will continue to improve. These are all important issues that will require much more effort to fully untangle. It is also possible that the creative thinking (DT) and creative solving (CPE) performance measures do not tap into the same aspect of creativity that is signified in the beliefs about creativity scales, implying a mismatch that warrants further investigation.

Limitations

Although the theoretical conclusions raised in the previous two sections are important to ponder, there are reliability issues with the scales used in this article, especially the growth mindset scale. If a scale is not reliable, then it is likely to fluctuate across different administrations, which could either mask or amplify any relationships between that scale and other scales. This cannot be ameliorated by the Bayesian techniques used for statistical analyses, and the substantial noise seen in both Figures

1 and 2 speak to the potential measurement error lurking in the composite variables formed from these scales. As such, there is a need for larger studies, using latent variable models to control measurement error, in order to fully understand the relationships probed currently. Latent variable models were not used presently, as the focus was on Bayesian estimation, and the sample size was deemed too small to adequately estimate parameters the indirect effects using structural equation modeling (e.g., Wolf, Harrington, Clark, & Miller, 2013).

Additionally, though it is common to speak of effect sizes in regression analyses, we have no clear case for temporal precedence in any of our models; thus, it remains an open question as to the causal relations among these variables. Indeed, a basic tenet of Bandura's (e.g., Bandura, 1977) social learning theories is that there is a reciprocal determinism between a person's behavior and the learning environment. As such, it may be fruitful to employ non-recursive structural equation models, especially in longitudinal designs, to more fully understand the unfolding of these processes throughout development. Again, this will require very large samples to enable the accurate estimation of structural equation modeling parameters and to provide adequate statistical power.

Also, though we chose to use global self-efficacy measures, we are limited by the fact that our results cannot be taken as evidence for or against those relayed by Pretz and McCollum (2014). However, as we argued, the tasks that we used to measure creative thinking involve generating ideas and using one's imagination, which are precisely what the global self-efficacy items assess (see Beghetto, 2006). Yet it is still very possible that when participants respond to the global items, they base their self-reports on experiences that differ from what the creative thinking tasks used presently represent. It is therefore essential that all those interested in further studying creative self-efficacy determine a way for self-reports to be based on a consistent context across participants, following from Pretz and McCollum.

Finally, some may still view this study as providing only a small contribution to new knowledge on the topic of the creative self. However, because reproducibility has taken center stage in psychological science, studies like this provide a key way of testing the reliability of statistical effects across conceptual replications. Indeed, Anderson and Maxwell (2016) listed four goals of replication studies that go beyond significance testing. This study met two of those goals: investigation of null effects (using Bayesian analyses) and examination of effect sizes. Armed with our conclusions, future studies of creative self-efficacy and mindsets linked to creative thinking will no doubt be more precise and better able to put forth generalizable conclusions.

Conclusion

The present study examined the degree to which creative self constructs related to well-worn laboratory measures of creative thinking. The data suggest that there is likely a small to mediumsized negative relationship between fixed mindset and CPS ability. However, no such relationship seems to exist between creative mindset and DT abilities. Furthermore, creative self-efficacy seems to be related to awareness of the fluency of one's creative ideas but not necessarily the quality or originality of creative ideas. It is assumed, as others have found, that such effects are likely small but not insignificant. In conclusion, the study has contributed to the groundswell of interest in improving the measurement of creative-self constructs and provides concrete next steps in this research agenda. This study points toward a mismatch between a person's intrapersonal sense of their creativity and objective perceptions of that person's creativity, which implies a need for highly focused research to unpack the association of these relationships in a precise manner relative to the task, context, and developmental issues.

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