The creative cliff illusion

Brian J. Lucas[a,1] and Loran F. Nordgren[b,1]

[a]Industrial & Labor Relations School, Cornell University, Ithaca, NY 14853; and [b]Kellogg School of Management, Northwestern University, Evanston, IL 60208

Edited by Susan T. Fiske, Princeton University, Princeton, NJ, and approved July 4, 2020 (received for review April 3, 2020)

Across eight studies, we tested whether people understand the time course of their own creativity. Prior literature finds that creativity tends to improve across an ideation session. Here we compared people's beliefs against their actual creative performance. Consistent with prior research, we found that people's creativity, on aggregate, remained constant or improved across an ideation session. However, people's beliefs did not match this reality. We consistently found that people expected their creativity to decline over time. We refer to this misprediction as the creative cliff illusion. Study 1 found initial evidence of this effect across an ideation task. We found further evidence in a sample with high domain-relevant knowledge (study 2), when creativity judgments were elicited retrospectively (study 3), and across a multiday study (study 5). We theorized the effect occurs because people mistakenly associate creativity (the novelty and usefulness of an idea) with idea production (the ability to generate an idea). Study 4 found evidence consistent with this mechanism. The creative cliff illusion was attenuated among those with high levels of everyday creative experience (study 6) and after a knowledge intervention that increased awareness of the effect (study 7). Demonstrating the impact of creativity beliefs on downstream performance, study 8 found that declining creativity beliefs negatively influenced task persistence and creative performance, suggesting that people underinvest in ideation. This research contributes to work on prediction in the creative domain and demonstrates the importance of understanding creativity beliefs for predicting creative performance.

creativity | idea generation | prediction | time

Creativity is the generation of ideas that are novel and useful (1–3). Research finds that, when generating solutions to a creative problem, people typically do not generate their most creative ideas first. Instead, creative ideas tend to emerge over time, such as over the course of an ideation session (4–8) or even over the course of a career (9, 10). One reason for this time course is because of the cognitive processes that underlie idea generation itself. New ideas are generated by integrating and recombining knowledge in working memory (11). When solving a new problem, the information that comes to mind first (i.e., is the most cognitively accessible) tends to draw on common and obvious cognitive associations (12), which tend to result in more common—and less creative—ideas (13). After working on the problem for a period of time, people begin to draw on less common associations and less obvious approaches and, ultimately, arrive at more creative ideas. This feature of idea generation is one reason why persistence is a consistent predictor of creative performance (1, 6, 14–16).

In the current research, we examine whether people's beliefs about creativity match their actual performance. We hypothesized that people believe their creativity will decline across an ideation session. That is, they expect their later-stage ideas to be less creative than ideas they generated earlier. We argue this occurs because people (wrongly) associate idea creativity (i.e., the novelty and usefulness of an idea) with their ability to generate ideas (i.e., productivity). We theorize that people do this because the ease or difficulty of producing an idea is a more psychologically salient performance indicator than the creativity of an idea, a subjective judgment that can be difficult for people to assess in real time (1, 17, 18). When generating creative ideas, productivity tends to decline over time (19). The first handful of ideas tend to come quickly. However, after this initial flow of ideas, the process tends to slow down, novel associations are slower to form, and subsequent ideas are less frequent. This increased difficulty of producing ideas is saliently experienced by idea generators, and we expect that they associate the productivity decline with a decline in creativity.

However, research demonstrates that the creativity of people's ideas does not follow the same negative trajectory as productivity. Whereas productivity tends to steadily decline across an ideation session, creativity tends to increase or remain consistent (4–6, 20). This misalignment between expectations and the reality of the creative process forms the creative cliff illusion hypothesis: People's creativity predictions diverge from actual performance such that, whereas people expect their creativity to decline across an ideation session, their creativity actually improves or remains consistent. In other words, people expect their creativity to decay over time more rapidly than it actually does.

We tested our predictions across eight studies. Studies 1 through 7 collected creativity predictions as well as actual performance across an ideation session. This allowed us to test the hypothesis that predicted and actual creativity diverge. Studies 3 and 4 provided evidence of our proposed mechanism that people's creativity beliefs are informed by (the inappropriate) use of a productivity heuristic. Study 5 tested our hypotheses across a longer timeframe (across 5 days). Studies 6 and 7 explored a possible moderator and an intervention designed to attenuate

Significance

Creativity research across the social sciences seeks to elucidate factors that enhance and stifle creativity. We demonstrate that people systematically misunderstand their own creativity across an ideation session. Eight studies found that people expect their creativity to decline across an ideation session when it, in fact, tends to improve or persist (we call this misprediction the creative cliff illusion). These beliefs are consequential because they lead people to undervalue ideation: They exhibit less task persistence and lower creative performance. This research documents a fundamental disconnect between people's beliefs and the reality of how creativity emerges over time. It demonstrates the value of understanding creativity beliefs and has implications for facilitating creativity in individuals and their organizations and institutions.

Author contributions: B.J.L. and L.F.N. designed research; B.J.L. performed research; B.J.L. analyzed data; and B.J.L. and L.F.N. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

Data deposition: All data and study materials are available on the Open Science Framework: https://osf.io/uncjr/?view_only=c5f1a56705c14cf8a7eb335d52c867f3.

[1]To whom correspondence may be addressed. Email: brianlucas@cornell.edu.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2005620117/-/DCSupplemental.

First published August 3, 2020.

the effect. Finally, people's beliefs about creativity are important because they shape how, and to what extent, they invest effort into the creative process (6, 21). Study 8 tested whether beliefs about declining creativity influence task persistence and subsequent creative performance.

All studies were approved by the Institutional Review Board of Northwestern University, the University of Chicago, or Cornell University, and all participants provided informed consent.

Studies 1 through 7 used a similar procedure. We first asked participants to predict how creative they would be across an ideation session, and then asked them to complete the session. This allowed us to compare participants' predictions against their actual creativity. The creative cliff illusion hypothesis predicts that people will expect their creativity to decline across the ideation session. In our studies, we used variations of a classic idea generation paradigm in which participants are given a creative problem and are asked to generate multiple solutions (2, 22). Given that our main hypothesis involves participants' predictions about their own creativity across an idea generation session, it was important to select a task length that captures the amount of time people naturally spend generating ideas, so as to not impose a session length that is unnaturally short or long in duration. To this end, we conducted a pretest in which 99 participants worked on the idea generation task used in studies 1 through 3 and 6 and 7. No time limit was specified, and they were told to continue until they ran out of ideas. On average, participants chose to stop after 3.46 min (median = 2.25 min; range = 0.33 min to 18.78 min). Based on the results, we chose 5 min as an appropriate task length that captures the range of time people naturally spend generating ideas.

Study 1

Study 1 provided an initial test of our hypothesis. Participants were 121 adults from Amazon Mechanical Turk (AMT). Ten failed an attention check, and one did not complete the survey, leaving 110 for analysis (M_{age} = 32.29, SD_{age} = 9.89; 56 men, 54 women). Participants were told they would complete an idea generation task in which they would generate ideas about how a charity organization could increase donations from its local community. Participants first made five creativity predictions about how creative their responses would be during each minute of the task (−50 = not at all creative, +50 = extremely creative). Creative ideas were defined as ideas that are both novel and useful. Participants then completed the actual idea generation task. To incentivize performance, each idea generated earned participants a raffle ticket into a $50 lottery; across studies, we used similar incentives. A separate group of AMT participants rated the creativity of participants' ideas (−50 = not at all creative, +50 = extremely creative), and an average creativity score was computed for each minute of the task (see *SI Appendix, Supplementary Text* for additional details about the creativity rating procedure we used in studies 1 through 7).

Prior to analysis, predicted and actual creativity scores were standardized to facilitate comparison. To compare the trajectory of people's predictions against the trajectory of their actual performance, we conducted a 2(performance: predicted, actual) × 5(time period: 1 to 5) repeated measures ANOVA. This analysis revealed a significant interaction ($F_{(4,436)} = 21.27$, $P < 0.001$, $\eta^2 = 0.16$), indicating that predicted creativity across the task was significantly different from actual creativity (Fig. 1). People predicted creativity would decline across the task (linear trend: $F_{(1,109)} = 26.46$, $P < 0.001$, $n^2 = 0.20$; quadratic trend: $F_{(1,109)} = 26.86$, $P < 0.001$, $n^2 = 0.20$). However, consistent with prior literature, creativity actually increased (linear trend: $F_{(1,109)} = 11.10$, $P = 0.001$, $n^2 = 0.09$).

Study 1 provides initial evidence for the creative cliff illusion. Whereas participants predicted their creativity would decline across the idea generation session, their creativity actually increased.

Study 2

One limitation of the first study is that the sample may not have had domain knowledge relevant to the idea generation task, which can be an important determinant of creativity (23). In study 2, we specifically targeted participants with relevant domain knowledge. We again used the charity donation task but recruited 165 working adults from Prolific Academic who had prior experience working for a charity organization. Thirty-five

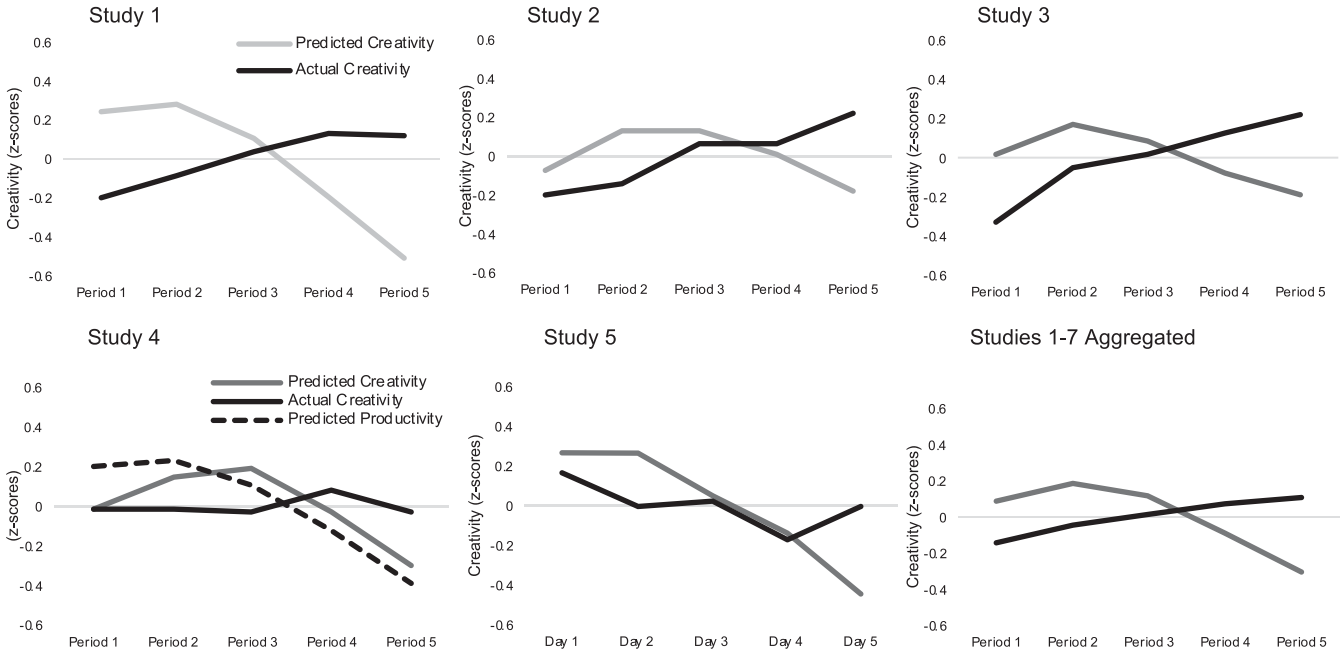

Fig. 1. Predicted and actual creativity across the ideation session in studies 1 through 5 and aggregated across all studies.

failed an attention check, leaving 131 for analysis (M_{age} = 31.42, SD_{age} = 10.12; 80 men, 51 women). The protocol followed study 1 (for additional study details, see *SI Appendix*).

Consistent with study 1, participants' predictions diverged from their actual performance. A 2(performance: predicted, actual) × 5(time period: 1 to 5) repeated measures ANOVA revealed a significant interaction ($F_{(4,520)} = 8.12$, $P < 0.001$, $\eta^2 = 0.06$) (Fig. 1). Whereas participants predicted their creativity would peak early and then decline (quadratic trend: $F_{(1,130)} = 19.49$, $P < 0.001$, $\eta^2 = 0.13$; linear trend: $F_{(1,130)} = 0.77$, $P = 0.381$, $\eta^2 = 0.01$), creativity actually increased across the session (linear trend: $F_{(1,130)} = 21.64$, $P < 0.001$, $\eta^2 = 0.14$). Studies 1 and 2 provide consistent evidence that people's creativity predictions diverge from actual performance, such that they predict their creativity will decline when it is in fact increasing.

Study 3

In the first two studies, participants made predictions about their creative performance on a future task. In study 3, we asked participants to estimate their creative performance on a task they just completed. This design allowed us to test the robustness of the creative cliff illusion—to test whether the effect is limited to predictions about creative performance or extends to assessments of past performance. The rationale underlying our primary hypothesis is that people confuse a decline in idea productivity with a decline in idea creativity. If this is the case, having experienced the task should not correct or reduce the misprediction.

We recruited 191 working adults from AMT who reported having worked for a charity organization. Sixty failed an attention check and comprehension check, leaving 128 for analysis (M_{age} = 35.02, SD_{age} = 10.44; 79 men, 49 women). The protocol followed that of study 1.

A 2(performance: predicted, actual) × 5(time period: 1 to 5) repeated measures ANOVA revealed a significant interaction ($F_{(4,508)} = 13.63$, $P < 0.001$, $\eta^2 = 0.10$) (Fig. 1). Whereas participants predicted their creativity would decline across the task (linear trend: $F_{(1,127)} = 3.77$, $P = 0.055$, $\eta^2 = 0.03$; quadratic trend: $F_{(1,127)} = 12.46$, $P = 0.001$, $\eta^2 = 0.09$), creativity actually increased (linear trend: $F_{(1,127)} = 41.25$, $P < 0.001$, $\eta^2 = 0.25$). Study 3 demonstrates the fundamental difficulty of predicting one's own creative performance. Even after experiencing the task, participants still mispredicted the trajectory of their creativity.

Study 4

Study 4 builds on the previous studies in two ways. First, we extended the timeframe of the task. To test whether the observed effects extend beyond 5-min sessions, we extended the task to 20 min. Second, we looked for evidence of our proposed mechanism. We asked participants to predict both their creativity and their productivity across the task. We argue that the creative cliff illusion occurs because people predict creativity will decline similarly to productivity. If this is the case, then we would expect predicted productivity to be associated with predicted creativity. Furthermore, we would expect predicted productivity to not be associated with actual creativity, producing a divergence between creativity predictions and actual performance. Study 4 is preregistered at aspredicted.org (https://aspredicted.org/j6ux5.pdf).

We invited 151 students to the University of Chicago behavioral laboratory. Two failed an attention check, leaving 149 for analysis (M_{age} = 23.35, SD_{age} = 8.94; 68 men, 81 women). Participants worked on an idea generation task for 20 min in which they generated ideas for products the bookstore could sell that would help roommates to get along better (24). All participants were University of Chicago students that reported familiarity with the bookstore, and 85% reported being customers. To incentivize performance, participants were told they would earn one raffle ticket into a $50 lottery for every idea they generated that was rated above average in creativity. Prior to engaging in the task, participants predicted their creativity at five equally spaced time intervals (i.e., every 4 min). Participants also made five predictions about expected productivity during each time period, that is, how many ideas they expected to generate at each time period. Actual creativity was rated by three university students who were familiar with the university bookstore and student housing (see more coding details in *SI Appendix*).* Ratings on the first 20% of responses established reliability (α = 0.89).

As in studies 1 through 3, a 2(performance: predicted, actual) × 5(time period: 1 to 5) repeated measures ANOVA revealed a significant interaction ($F_{(4,592)} = 5.75$, $P < 0.001$, $\eta^2 = 0.04$) (Fig. 1). Whereas people predicted their creativity would decline across the task (linear trend: $F_{(1,148)} = 5.40$, $P = 0.021$, $\eta^2 = 0.04$; quadratic trend: $F_{(1,148)} = 26.77$, $P < 0.001$, $\eta^2 = 0.15$), creativity did not significantly change (linear trend: $F_{(1,148)} = 0.09$, $P = 0.762$, $\eta^2 = 0.001$). Next, we tested our mechanism prediction. We used mixed model regression that controlled for the linear and quadratic terms for time and included participant as a random effect. The first model revealed that expected productivity significantly predicted creativity predictions ($b = 0.65$, $SE = 0.03$, $t = 21.24$, $P < 0.001$, $CI_{95\%}$[0.59, 0.71]). The second model revealed that expected productivity did not, however, predict actual creativity ($b = 0.05$, $SE = 0.04$, $t = 1.25$, $P = 0.210$, $CI_{95\%}$[−0.03, 0.12]). This analysis sheds light on how expected productivity influences the disconnect between predicted and actual creativity: Expected productivity influences creativity predictions but not actual creativity.

Study 5

We tested our hypotheses in a paradigm that incorporated two notable features of creative work. First, ideas are sometimes generated across multiple ideation sessions. To this end, we extended the timeframe of the paradigm to span across 5 days (d). Second, participants generated ideas about their own creative tasks. We asked participants to identify a creative challenge they are currently working through in their own lives and to use this study as an opportunity to facilitate idea generation and problem solving.

We recruited 123 adults from a listserve of students, alumni, and local community members managed by Cornell University. Nine did not complete the study, leaving 114 for analysis (M_{age} = 24.54, SD_{age} = 7.38; 29 men, 85 women). The study took place across 5 d. On day 1, participants reported a creative challenge they are currently working on in their own lives; some participants completed the session in person at a behavioral laboratory and others via an online survey. Creative challenges were described to participants as "challenges that you face in your daily life for which the solution or best course of action is not immediately obvious." Participants were told that, in response to creative challenges, people "generate many different ideas over periods of weeks, months, or even longer" (see *SI Appendix* for more details about participants' creative challenges). Next, participants spent 10 min generating ideas related to their creative challenge. We asked them to follow a procedure where they report one idea per minute (i.e., 10 ideas reported). Participants were then told that, on each of the next 4 d (i.e., days 2 to 5), they would engage in an additional 5-min ideation session to brainstorm about their creative challenge. Participants then predicted

*As a supplemental analysis, we collected creativity ratings from AMT workers using the independent-rater protocol used in our previous studies (i.e., no discussion or interaction across raters). Analyses with the AMT worker creativity ratings yielded results consistent with the main analysis (performance × time period interaction: F(4,592) = 8.39, P < 0.001, η2 = 0.05); see SI Appendix for more details.

how creative their ideas would be across days 2 to 5 (−50 = much less creative than today's ideas, 0 = about the same as today's ideas, +50 = much more creative than today's ideas). Note that participants did not make a day 1 prediction and that the days 2 to 5 predictions were made in relation to day 1; for analysis, we coded day 1 as zero. Finally, participants completed demographic information to end the day 1 session. On each of days 2 to 5, participants were emailed a link to an online survey where they completed that day's ideation session. As in study 4, creativity was rated by three coders who were students and staff from the participants' university ($\alpha = 0.71$; see more coding details in *SI Appendix*).†

A 2(performance: predicted, actual) × 5(day: 1 to 5) repeated measures ANOVA revealed a significant interaction ($F_{(4,452)} = 9.35$, $P < 0.001$, $\eta^2 = 0.08$) (Fig. 1). Consistent with prior studies, people predicted their creativity would decline across the study (linear trend: $F_{(1,113)} = 32.85$, $P < 0.001$, $\eta^2 = 0.23$; quadratic trend: $F_{(1,113)} = 6.08$, $P = 0.015$, $\eta^2 = 0.05$). Inconsistent with prior literature, we found that actual creativity declined across the study as well (linear trend: $F_{(1,113)} = 5.77$, $P = 0.018$, $\eta^2 = 0.05$; quadratic trend: $F_{(1,113)} = 4.45$, $P = 0.037$, $\eta^2 = 0.04$). However, in line with our hypothesis, the significant performance × day interaction indicates that people's creativity predictions declined at a significantly steeper rate. That is, people predicted their creativity would decline more rapidly than it actually did.

Study 5 found evidence consistent with the creative cliff illusion across a multiday study and with creative challenges from participants' own lives. Given the variety and subjective nature of the creative challenges that participants brought to the study, we also asked participants to self-rate the creativity of their own ideas. Supplemental analyses with this measure revealed results consistent with the main analysis (performance × day interaction: $F_{(4,452)} = 6.57$, $P < 0.001$, $\eta^2 = 0.06$; see *SI Appendix* for more details).

Study 6

Study 6 explored a possible moderator of the creative cliff illusion: everyday creative experience. As people engage in creative tasks within their professional and personal lives, they pick up creativity-relevant skills and strategies that help them to work through creative problems and generate creative ideas (23). These include strategies for thinking more broadly, making unusual associations, and even the simple belief that one is a creative individual (25). We reasoned that everyday creative experience may also give people self-insight into how their creativity emerges across an ideation session. Study 6 measured everyday creative experience and tested whether it moderates the creative cliff illusion.

We recruited 163 adults from AMT, and 10 failed an attention check, leaving 153 for analysis ($M_{age} = 33.90$, $SD_{age} = 10.96$; 66 men, 87 women). The protocol followed that of study 1. In addition, we measured our proposed everyday creative experience moderator with the question, "Generally speaking, how frequently are you required to be creative in your everyday life?" (three-point scale; 1 = not at all [low], 2 = occasionally [moderate], 3 = frequently [high]). We worded the question broadly, similar to questions on the General Social Survey, so as to capture any type of prior experience with any type of creative work.

To examine whether everyday creative experience moderates the creative cliff illusion, we conducted a 2(performance: predicted, actual) × 5(task period) × 3(everyday creative experience: low, moderate, high) mixed-factor ANOVA with the first two factors within participants. This analysis revealed a significant three-way interaction ($F_{(8,600)} = 2.14$, $P = 0.031$, $\eta^2 = 0.03$). Next, we looked at the 2(performance: predicted, actual) × 5(task period) two-way interactions at each level of everyday creative experience (Fig. 2). For those that reported low ($n = 27$) and moderate ($n = 95$) everyday creative experience, the performance × task period interactions were significant ($F_{(4,104)} = 5.12$, $P < 0.001$, $\eta^2 = 0.18$; $F_{(4,376)} = 18.48$, $P < 0.001$, $\eta^2 = 0.16$). However, for those that reported high levels of everyday creative experience ($n = 31$), the performance × task period interaction was nonsignificant, ($F_{(4,120)} = 0.96$, $P = 0.433$, $\eta^2 = 0.03$). Study 6 found that the beliefs of those with frequent everyday creative experiences were more aligned with the reality of how creativity unfolds across an ideation session.

Study 7

Study 7 tested whether a knowledge intervention can attenuate the creative cliff illusion through awareness of the effect. This study is preregistered at aspredicted.org (https://aspredicted.org/y7p4p.pdf).

We recruited 300 adults from AMT. Fifty-one failed an attention check, and 105 did not complete the creativity tasks or

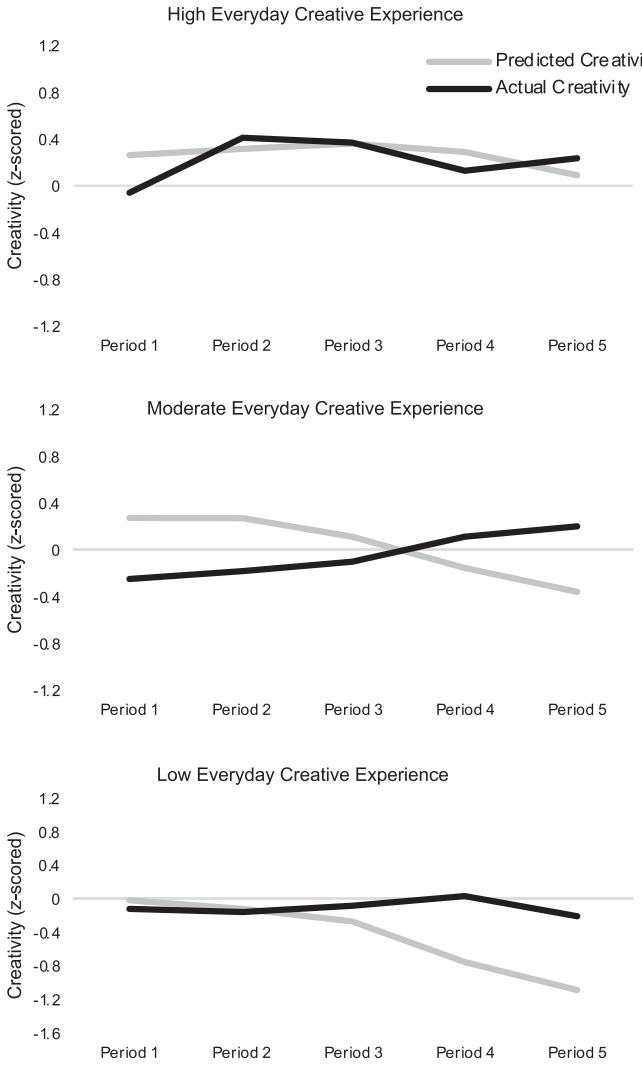

Fig. 2. Predicted and actual creativity across an idea generation task, by everyday creative experience (study 6).

†As in study 4, the coders received instructions as a group and discussed their understanding of the coding task, creating potential interdependence across raters. Given this, we also collected creativity ratings from AMT workers following the protocol of previous studies. We note that analyses with the AMT worker creativity ratings yielded results consistent with the main analysis (performance × time period interaction: $F_{(4,452)} = 9.04$, $P < 0.001$, $\eta^2 = 0.07$); see *SI Appendix* for more details.

provided nonsensical responses (e.g., "good good good"), leaving 144 for analysis (M_{age} = 37.19, SD_{age} = 11.77; 61 men, 83 women).‡ To begin the study, participants were randomly assigned to complete either the charity donations or the bookstore idea generation task. Similar to our previous studies, participants predicted their creativity across a 5-min idea session and then generated ideas for 5 min. The purpose of this task was to ensure a baseline level of familiarity with the study paradigm. Next, participants were told that they would complete a similar idea generation exercise for the main task but on a different topic (those who completed the bookstore task first were given the charity donation task and vice versa). Participants in the control condition went straight into the main task (control condition). In the knowledge intervention condition, participants were first told about the creative cliff illusion and shown a brief description of the results of study 1 prior to the main task (intervention condition). As expected, task order (bookstore, charity donations) did not moderate any analyses, so we collapsed this factor in the main analysis.

As a test of replication, we first analyzed the baseline task using a 2(performance: predicted, actual) × 5(task period) mixed-factor ANOVA with both factors within participants. Consistent with prior studies, there was a significant performance × task period interaction ($F_{(4,572)} = 4.19$, $P = 0.002$, $\eta^2 = 0.03$), such that, whereas people predicted creativity would increase and then decline across the task (linear trend: $F_{(1,143)} = 2.04$, $P = 0.155$, $\eta^2 = 0.01$; quadratic trend: $F_{(1,143)} = 25.70$, $P < 0.001$, $\eta^2 = 0.15$), creativity actually increased (linear trend: $F_{(1,143)} = 5.08$, $P = 0.026$, $\eta^2 = 0.03$). Next, we analyzed the main (i.e., postintervention) task. A 2(performance: predicted, actual) × 5(task period) × 2(intervention: control, intervention) mixed-factor ANOVA with the first two factors within participants revealed a significant three-way interaction ($F_{(4,568)} = 3.98$, $P = 0.003$, $\eta^2 = 0.03$). In the control condition, there was a significant performance × task period interaction ($F_{(4,288)} = 11.01$, $P < 0.001$, $\eta^2 = 0.13$), such that, whereas people predicted creativity would decline across the task (linear trend: $F_{(1,72)} = 12.57$, $P = 0.001$, $\eta^2 = 0.15$), creativity actually increased (linear trend: $F_{(1,72)} = 6.16$, $P = 0.015$, $\eta^2 = 0.08$) (Fig. 3, *Top*). However, in the intervention condition, this pattern was attenuated. The performance × task period interaction was nonsignificant ($F_{(4,280)} = 0.61$, $P = 0.656$, $\eta^2 = 0.01$), such that people predicted creativity would increase across the task (linear trend: $F_{(1,70)} = 6.05$, $P = 0.016$, $\eta^2 = 0.08$; quadratic trend: $F_{(1,70)} = 6.43$, $P = 0.013$, $\eta^2 = 0.08$), and creativity actually increased (linear trend: $F_{(1,70)} = 19.43$, $P < 0.001$, $\eta^2 = 0.22$) (Fig. 3, *Bottom*). This study demonstrates that a knowledge intervention can attenuate the creative cliff illusion by better aligning people's creativity predictions with actual performance.

Study 8

Studies 1 through 7 established evidence for the creative cliff illusion as well as a mechanism and boundary conditions. The goal of study 8 was to look at the consequences of people's creativity beliefs on actual creative performance. We predicted that the belief that creativity declines over time would negatively predict persistence on a creative task and that this would lead to fewer ideas generated and fewer highly creative ideas generated (ideas rated in the top 25% on creativity). For study 8 we partnered with Second City, an improv comedy school in Chicago, IL, to launch a creativity competition. We made the competition available to Second City alumni via their internal listserve. We left the competition open for approximately 8 wk, until we stopped receiving responses. We received submissions from 91 alumni (M_{age} = 33.95, SD_{age} = 11.79; 43 men, 45 women, one other, two unreported), who averaged 2.25 y of comedy training (SD = 2.28) and 5.61 y of comedy industry experience (SD = 11.79).

The study was advertised as a Cartoon Caption Competition. In these competitions, participants are shown a cartoon image and asked to generate funny captions for the cartoon. Captions typically involve narrative commentary or dialogue between the subjects in the cartoon. Participants were given 15 min and were told to generate as many creative captions as they could. They were also told that, if they finished generating ideas before time was up, they could move on, at any time, by clicking the arrow at the bottom of the page. To incentivize performance, we included substantial monetary prizes for competition winners (first = $150, second = $100, and third = $50) as well as recognition among the Second City executive team. We further incentivized creative idea generation such that each caption rated in the top 25% of all submissions would receive a $1 prize (referred to as highly creative ideas in the analyses). Creativity was rated by three professional comedians with a combined 66 y of comedy industry experience and 40 y of training between them. Each response was rated for novelty and funniness (a proxy for usefulness in this domain) using 100-point scales (0 = not at all, 100 = extremely). The two dimensions were averaged to create a creativity score for each participant and creativity scores were averaged across judges (α = 0.71).

To measure the belief that creativity declines over time, we created a three-item declining creativity beliefs scale. Participants indicated their agreement with the following items on a scale from 1 (strongly disagree) to 7 (strongly agree): "People tend to generate their best ideas first", "A person's best idea is usually among the first few ideas generated", and "Ideas generated earlier are often better than ideas generated later" (α = 0.84). We counterbalanced the presentation order of the caption competition task and the creativity belief scale across participants. Presentation order did not significantly moderate any of the main analyses; however, we note that controlling for presentation order, unexpectedly, increased the strength of some of our hypothesized relationships (see *SI Appendix* for analyses).

Descriptive statistics and correlations appear in Table 1. We predicted that declining creativity beliefs would negatively influence task persistence and that task persistence positively influences creative performance. We tested our hypotheses with a simple path model for each performance outcome whereby

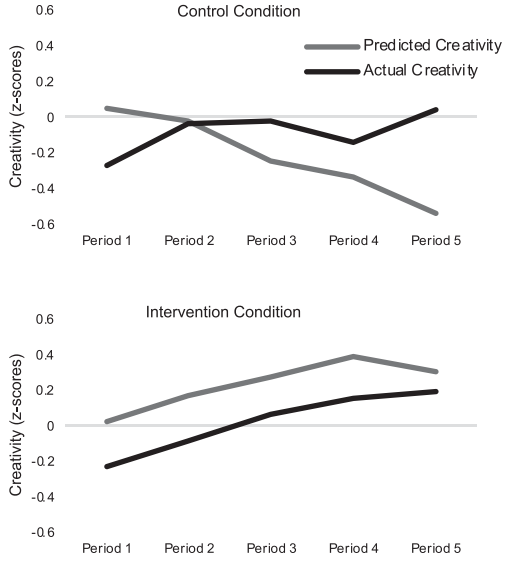

Fig. 3. Predicted and actual creativity across an idea generation task, in the control (*Top*) and intervention (*Bottom*) conditions (study 7).

‡This study was launched in mid-2019 during a high period of the so-called "bot epidemic" on the AMT platform. This may account for the prevalence of incomplete and nonsensical responses. Incidentally, excluding participants that provide incoherent responses to open-ended questions was one recommended practice for promoting data quality.

Table 1. Correlations between study variables, study 8

	M	SD	Declining creativity beliefs	Task persistence	Productivity	Number of highly creative ideas
Declining creativity beliefs	3.12	1.08				
Task persistence (minutes)	9.06	6.07	**−0.19†**			
Productivity	8.52	8.27	−0.14	0.67***		
Number of highly creative ideas	2.14	2.18	**−0.21***	0.68***	0.77***	
Average creativity	38.04	11.14	−0.09	0.14	−0.05	**0.27*** **

Bold text indicates a significant or marginally significant finding; †$P \leq 0.10$, *$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$.

declining creativity beliefs → task persistence → performance. First, declining creativity beliefs were a marginally significant negative predictor of task persistence ($\beta = -0.19$, $t = -1.80$, $P = 0.075$, $CI_{95\%}[-2.21, 0.11]$). In the first model, task persistence positively predicted productivity ($\beta = 0.67$, $t = 8.40$, $P < 0.001$, $CI_{95\%}[0.70, 1.13]$); in the second model, task persistence positively predicted the number of highly creative ideas generated ($\beta = 0.61$, $t = 7.27$, $P < 0.001$, $CI_{95\%}[0.17, 0.29]$); and in the third model, task persistence was a nonsignificant predictor of average creativity ($\beta = 0.09$, $t = 0.87$, $P = 0.388$, $CI_{95\%}[-0.22, 0.56]$). When all of the performance outcomes were analyzed concurrently, task persistence significantly predicted productivity ($\beta = 0.35$, $t = 4.41$, $P < 0.001$, $CI_{95\%}[0.26, 0.70]$), marginally predicted highly creative ideas ($\beta = 0.16$, $t = 1.71$, $P = 0.090$, $CI_{95\%}[-0.01, 0.13]$), and nonsignificantly predicted average creativity ($\beta = 0.21$, $t = 1.49$, $P = 0.139$, $CI_{95\%}[-0.13, 0.90]$). For every one scale point increase in declining creativity belief endorsement, participants spent 1.05 fewer minutes persisting on the task, generated 12% fewer ideas, and generated 18% fewer highly creative ideas. Supplemental analyses found that controlling for participants' training, comedy industry experience, and desire to win the competition—a proxy for overall motivation—did not significantly change the interpretation of the results (*SI Appendix*, Tables S1 and S2).

The current research revealed a fundamental disconnect between people's beliefs and the reality of the creative process. A combined analysis across all studies revealed that, consistent with prior research, creativity significantly increased across an ideation session (linear: $F_{(1,928)} = 50.14$, $P < 0.001$, $\eta^2 = 0.05$]). However, beliefs did not match reality: People consistently expected their creativity to decline (linear: $F_{(1,928)} = 63.86$, $P < 0.001$, $\eta^2 = 0.06$; quadratic: $F_{(1,928)} = 121.28$, $P < 0.001$, $\eta^2 = 0.12$; performance × time interaction: $F_{(4,3712)} = 68.25$, $P < 0.001$, $\eta^2 = 0.07$) (Fig. 1). We found evidence of this creative cliff illusion across samples with high domain-relevant knowledge (studies 2 through 5), when creativity judgments were elicited retrospectively (study 3), and in a multiday study (study 5). We found that the effect occurs because people mistakenly associate the trajectory of their creativity with that of productivity (study 4) and that it is attenuated among people with high levels of everyday creative experience (study 6) and through awareness of the effect (study 7). Given that some creativity and problem-solving is expected in the majority of the jobs in today's economy (26), these studies are useful for understanding who is more or less susceptible to the creative cliff illusion and how to attenuate its influence. Finally, we found evidence that declining creativity beliefs influence actual task persistence and creative performance. Supplemental analyses ruled out alternative hypotheses that creativity predictions are associated with expected idea novelty or usefulness (*SI Appendix*, Tables S3 and S4). We also found that the creative cliff illusion is robust to alternative measures of creativity (when dropping participants with missing values across the session, the number of creative ideas generated, the most creative idea generated; *SI Appendix*, Tables S5 and S6) and that creativity predictions for the self and for others follow a similar trajectory (*SI Appendix*, *Supplemental Study S1*).

Creativity research across the social sciences seeks to elucidate factors that enhance and stifle creativity. A half-century of research has investigated the processes and contextual factors that influence creative performance (1–3). More recently, research has begun to study people's lay beliefs about these factors, the accuracy of those beliefs, and implications for creative performance. For example, research finds that people are limited in their ability to accurately predict their productivity or to forecast the success of their ideas (6, 18). Here, we demonstrate that people systematically misunderstand their own ability to generate creative ideas across an ideation session. We contribute to this growing literature on prediction in the creative domain (18, 21, 27, 28). A practical implication of this research is that people may miss out on their own creative ideas because declining creativity beliefs lead them to halt idea generation while there are still creative ideas left in the tank. Furthermore, putting fewer creative ideas on the table at the idea generation stage could limit creative potential at later stages of the creative process, such as idea selection and implementation (25, 29). Whether one's goal is to maximize creative output or to generate just a few creative ideas, declining creativity beliefs systematically bias the decision of whether to continue investing in ideation by leading people to think their next ideas will be less creative than they actually are. This suggests that people should be wary of and persevere through their initial intuition to stop ideating. Groups and organizations could institutionalize this through rhetoric or with practices such as implementing longer brainstorming sessions, idea quotas, or longer deliberation periods for creative problems. Future research is needed to test the creative cliff illusion across a broader range of contexts and industries and to investigate its impact on later stages of the creative process such as idea selection. Understanding how people believe their creativity emerges over time is critical for understanding their willingness to invest in ideation and their creative performance.

Data Availability. All data and study materials are available on the Open Science Framework: https://osf.io/uncjr/.

ACKNOWLEDGMENTS. Funding for this research was provided by the Polsky Center for Entrepreneurship & Innovation at the University of Chicago.

1. T. M. Amabile, *Creativity in Context*, (Westview Press, Boulder, CO, 1996).
2. R. J. Sternberg, *Handbook of Creativity*, (Cambridge University Press, Cambridge, MA, 1999).
3. M. D. Mumford, *Handbook of Organizational Creativity*, (Academic, London, United Kingdom, 2012).
4. P. R. Christensen, J. P. Guilford, R. C. Wilson, Relations of creative responses to working time and instructions. *J. Exp. Psychol.* **53**, 82–88 (1957).
5. N. W. Kohn, P. B. Paulus, Y. H. Choi, Building on the ideas of others: An examination of the idea combination process. *J. Exp. Soc. Psychol.* **47**, 554–561 (2011).

6. B. J. Lucas, L. F. Nordgren, People underestimate the value of persistence for creative performance. *J. Pers. Soc. Psychol.* **109**, 232–243 (2015).
7. S. J. Parnes, Effects of extended effort in creative problem-solving. *J. Educ. Psychol.* **52**, 117–122 (1961).
8. M. Basadur, R. Thompson, Usefulness of the ideation principle of extended effort in real world professional and managerial creative problem-solving. *J. Creat. Behav.* **20**, 23–34 (1986).
9. D. K. Simonton, Creative productivity: A predictive and explanatory model of career trajectories and landmarks. *Psychol. Rev.* **104**, 66–89 (1997).
10. D. K. Simonton, Creativity as blind variation and selective retention: Is the creative process Darwinian? *Psychol. Inq.* **10**, 309–328 (1999).
11. S. M. Smith, T. B. Ward, R. A. Finke, *The Creative Cognition Approach*, (MIT Press, Cambridge, MA, 1995).
12. S. A. Mednick, The associative basis of the creative process. *Psychol. Rev.* **69**, 220–232 (1962).
13. T. B. Ward, Structured imagination: The role of category structure in exemplar generation. *Cognit. Psychol.* **27**, 1–40 (1994).
14. M. Csikszentmihalyi, *Creativity: Flow and the Psychology of Discovery and Invention*, (Harper Collins, New York, NY, 1996).
15. C. K. W. De Dreu, M. Baas, B. A. Nijstad, Hedonic tone and activation level in the mood-creativity link: Toward a dual pathway to creativity model. *J. Pers. Soc. Psychol.* **94**, 739–756 (2008).
16. D. K. Simonton, Scientific creativity as constrained stochastic behavior: The integration of product, person, and process perspectives. *Psychol. Bull.* **129**, 475–494 (2003).
17. J. Metcalfe, D. Wiebe, Intuition in insight and noninsight problem solving. *Mem. Cognit.* **15**, 238–246 (1987).
18. J. M. Berg, Balancing on the creative highwire: Forecasting the success of novel ideas in organizations. *Adm. Sci. Q.* **61**, 433–468 (2016).
19. B. A. Nijstad, W. Stroebe, H. F. M. Lodewijkx, Persistence of brainstorming groups: How do people know when to stop? *J. Exp. Soc. Psychol.* **35**, 165–185 (1999).
20. R. E. Beaty, P. J. Silvia, Why do ideas get more creative across time? An executive interpretation of the serial order effect in divergent thinking tasks. *Psychol. Aesthet. Crea.* **6**, 309–319 (2012).
21. P. Tierney, S. M. Farmer, Creative self-efficacy: Its potential antecedents and relationship to creative performance. *Acad. Manage. J.* **45**, 1137–1148 (2002).
22. J. P. Guilford, *The Nature of Human Intelligence*, (McGraw-Hill, New York, 1967).
23. T. M. Amabile, "A model of creativity and innovation in organizations" in *Research in Organizational Behavior*, B. M. Staw, L. L. Cummings, Eds. (JAI Press, Greenwich, CT, 1988), Vol. 10, pp. 123–167.
24. J. Berg, The primal mark: How the beginning shapes the end in the development of creative ideas. *Organ. Behav. Hum. Dec.* **125**, 1–17 (2014).
25. T. M. Amabile, M. G. Pratt, The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Res. Organ. Behav.* **36**, 157–183 (2016).
26. B. Wigert, J. Robison, Fostering creativity at work: Do your managers push or crush innovation? https://dx.doi.org/https://www.gallup.com/workplace/245498/fostering-creativity-work-managers-push-crush-innovation.aspx. Accessed 23 February 2020.
27. R. J. Sternberg, T. I. Lubart, An investment theory of creativity and its development. *Hum. Development* **34**, 1–31 (1991).
28. P. J. Silvia, Discernment and creativity: How well can people identify their most creative ideas? *Psychol. Aesthet. Crea.* **2**, 139–146 (2008).
29. J. E. Perry-Smith, P. V. Mannucci, From creativity to innovation: The social network drivers of the four phases of the idea journey. *Acad. Manage. Rev.* **42**, 53–79 (2017).