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Curiosity made the cat more creative: Specific curiosity as a driver of creativity

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ABSTRACT

The present research examines the causal relationship between specific curiosity and creativity. To explicate this relationship, we introduce the concept of *idea linking*, a cognitive process that entails using aspects of early ideas as input for subsequent ideas in a sequential manner, such that one idea is a stepping stone to the next. Study 1 demonstrated the causal effect of specific curiosity on creativity. Study 2, a field study of artisans selling handmade goods online, found that experiencing specific curiosity predicts greater next-day creativity. Study 3 demonstrated idea linking as a mechanism for the effect of specific curiosity on creativity. Study 4 further established the impact of idea linking on creativity, finding that it boosted creativity beyond the well-established intervention of brainstorming. We discuss specific curiosity as a state that fuels creativity through idea linking and idea linking as a novel technique for creative idea generation.

1. Introduction

> The successful scientists often are not the most talented, but the ones who are just impelled by curiosity. They've *got* to know what the answer is. (Physicist Arthur Schawlow, as quoted in Amabile, 1997, p. 39).

Weick (1993, p. 641) argues that curiosity is what "organizations most need" in times of instability and change, because curiosity provides the raw materials to adapt creatively to changing conditions. The connection between curiosity and creativity has been extolled in entrepreneurship as well; as Wilkinson (2015, p. 48) concludes from her inductive study of successful entrepreneurs, "The creator's most important tool is curiosity." Curiosity and creativity represent two fundamental features of human nature: the drive to learn and explore (Kashdan & Silvia, 2009; Litman, Hutchins, & Russon, 2005) and the drive to create things that are new and valuable (Amabile, 1983, 1988; Oldham & Cummings, 1996; Woodman, Sawyer, & Griffin, 1993; Stein, 1974). Developing a deeper understanding of curiosity and creativity, including the relationship between them, contributes to our knowledge not only of essential psychological processes within organizations but also of human progress at large.

While some organizations have identified curiosity as a core value, a driver of innovation, and a source of competitive advantage, researchers have tended to focus on what have been theorized as desirable downstream effects of curiosity, such as creativity, rather than on curiosity itself (Harrison, 2016). Thus, in spite of the importance of curiosity and creativity separately and the promising connection between them, the two constructs have rarely been the focus of concurrent research. Further, the few studies that have jointly examined curiosity and creativity suggest a need for clarity with regard to this relationship and the processes that connect them. Scholars have theorized that both diversive curiosity, which reflects broad interest in exploring and learning, and specific curiosity, which entails a desire to solve a particular puzzle (Berlyne, 1960, 1966; Loewenstein, 1994; Litman & Spielberger, 2003; Litman & Jimerson, 2004; Litman et al., 2005; Harrison, Sluss, & Ashforth, 2011), may play a role in predicting individual creativity (Hardy, Ness, & Mecca, 2017; Harrison, 2011; Kashdan & Fincham, 2002; Amabile, 1988; Loewenstein, 1994). To date, however, this work has either focused exclusively on curiosity's diversive form (e.g., Harrison & Dossinger, 2017) or has yet to establish an empirical relationship between specific curiosity and creativity (e.g., Hardy et al., 2017). The question of whether – and through what process – specific curiosity supports individual creativity remains open.

Understanding the connection between specific curiosity and creativity is practically and theoretically important. From a practical

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perspective, because work often centers on tasks and goals that require individuals to solve complex, pressing problems, opportunities for individuals to experience specific curiosity likely abound in organizational settings. So, even though specific curiosity might be the less heralded form in previous theoretical attempts to elucidate the curiosity-creativity link, it might arise more frequently. Theoretically, while a great deal of research has looked at the creative benefits of various phenomenological or cognitive states that free individuals from constraints experienced at work (e.g., De Dreu, Giacomantonio, Shalvi, & Sligte, 2009; Galinsky, Magee, Gruenfeld, Whitson, & Liljenquist, 2008), our research flips this script by exploring the creative potential of moments in which individuals are constrained to thinking through a more narrow puzzle. Further, while prior research suggests that diversive curiosity is important for exploring one's environment (Hardy et al., 2017; Harrison & Dossinger, 2017; Harrison & Rouse, 2014), we theorize and demonstrate, through the novel mechanism of *idea linking*, that specific curiosity drives the within-individual cognitive exploration that supports creative idea generation. Thus, our research answers the call for additional theoretical work to explore the role of curiosity in organizational life in general (e.g., Harvey, Novicevic, Leonard, & Payne, 2007) and the link between curiosity and creativity specifically (Harrison, 2011; Kashdan & Fincham, 2002; Kashdan & Silvia, 2009; Schweizer, 2006; Unsworth, 2001). More generally, our development and measurement of idea linking brings clarity to the nuances of the creative process by illustrating one method by which individuals move from a less creative, initial idea to a more creative, final idea.

2. Specific curiosity, creativity, and idea linking

2.1. Specific curiosity and creativity

Specific curiosity motivates exploration in response to an unsolved puzzle due to the need to reduce uncertainty and create a sense of mastery (Litman & Jimerson, 2004; Litman, 2008). It may seem counterintuitive to suggest that specific curiosity, which drives individuals to seek the answer to a puzzle and therefore to engage in a somewhat narrow search (Loewenstein, 1994; Grossnickle, 2016), might benefit creativity, which relies on making associations between diverse and seemingly unrelated concepts (Martindale, 2001; Amabile, 1983, 1988). However, specific curiosity may provide an important source of fuel that supports creativity.

Specific curiosity drives individuals to seek out information that goes beyond what is needed to solve the puzzle that initiated the search (Loewenstein, 1994; Feldman & March, 1981; Strull, Lo, & Charles, 1984). Indeed, Berlyne (1954) theorized that specific curiosity would be a stronger motivator of information seeking than diversive curiosity due to the desire to solve the puzzle at hand. As a result, individuals discover details about the puzzle that they would not have otherwise. As an example, a Kandinsky masterpiece, *Painting with White Border*, was meant to address a very narrow itch: to paint the "extremely powerful impressions I had experienced in Moscow" (Ashton, 2015, p. 57). But finding the solution to the narrow problem required "slow progress" that "tormented" Kandinsky, "when it suddenly dawned on me what was missing – the white edge. Since this white edge proved the solution, I named the whole picture after it" (p. 57–59). Research on Galileo similarly shows that Galileo's narrow investigations often led to unexpected insights (Simonton, 2012).

While a puzzle might appear to drive convergence on a single solution, in actuality, there are often multiple ways to solve a puzzle, and puzzles often have aspects that require different or unexpected approaches (Getzels, 1975; Unsworth, 2001). Individuals experiencing specific curiosity tend to engage in a directed form of exploration (Arnone & Grabowsky, 1992; Spielberger & Starr, 1994), experimenting with multiple possibilities that might solve different aspects of the puzzle at hand (Loewenstein, 1994). Hence, while individuals experiencing specific curiosity have an idea of the type of solution they seek, the path to that destination – and certainly the destination itself – is unclear. This may propel individuals down multiple pathways as they seek to solve the puzzle, leading them to encounter ideas that are loosely related to the puzzle and to each other. We expect specific curiosity to benefit the idea generation stage of the creative process, because this stage involves exploring new mental pathways to develop original ideas (Amabile, 1983, 1988).

Hypothesis 1. The experience of specific curiosity increases creativity.

2.2. Idea linking as a mediating mechanism

Specific curiosity elicits an intense desire to find an explanation for a puzzling experience or phenomenon (Loewenstein, 1994; Litman, 2005). We propose that this desire may encourage individuals to use of aspects of early ideas as input for subsequent ideas in a sequential manner. First of all, an unsolved puzzle by its nature signifies a lack of information that would meet a need for a particular solution. As a result of this "information gap" (Loewenstein, 1994, p. 93), individuals experiencing specific curiosity are likely to engage in continued, directed exploration as they work towards a satisfactory solution. More importantly, in the process of searching for a final solution, individuals may move from idea to idea in a sequential manner, exploring ideas that may each satisfy different pieces of the puzzle. This is because puzzles are often multifaceted and difficult to solve (Getzels, 1975; Unsworth, 2001); the desire to solve a puzzle likely activates a cognitive process in which individuals are propelled to explore different possibilities. Moreover, they are likely unwilling to abandon any idea completely, as each may contribute to a plausible solution by addressing a particular element of the puzzle. Therefore, individuals may be inclined to retain aspects of earlier ideas that satisfy one piece of the puzzle and to incorporate new elements into subsequent ideas to solve a different piece of the puzzle. We refer to this process as *idea linking*, defined as using aspects of early ideas as input for subsequent ideas in a sequential manner, such that one idea is a stepping stone to the next.

Idea linking represents one mechanism through which individuals can overcome the tendency to focus on familiar and closely related concepts (Schwarz, et al., 1991; Tversky & Kahneman, 1973) that can become a roadblock to developing creative ideas (Wallach, 1970; Martindale & Greenough, 1973). Coming up with a creative idea requires the individual to depart from the familiar conceptual associations that more readily come to mind (Tversky & Hemenway, 1984; Berg, 2014). Idea linking may support this process, as each idea retains an aspect of the previous idea but nonetheless moves in a new direction to address a piece of the puzzle that was unaddressed by earlier ideas.

The Wright brothers' experimentation with building an airplane provides a compelling example of idea linking. They had long viewed flying as depending on momentum, and as owners of a bicycle shop, they initially thought of creating a flying bicycle. Through working with bicycles, though, they then theorized that flying was likely also a matter of balance. The journey to understand balance in the air led them to examine how birds turn their wings, which drove them to invent a kite that could perform "wing warping." Each idea provided a starting point for the next, so that the final idea (a glider based on birds) was evolutionarily distinct from the starting idea (a flying bicycle) (McCullough, 2016). With idea linking, early ideas are provisional but indispensable to the idea generation process, as each idea retains an aspect of the previous one while moving in a different direction. Therefore, in contrast with cognitive processes that rely on random associations to generate ideas, such as those involved in brainstorming techniques (Paulus, 1999), idea linking involves associations that rely on the individual's perspective and experience as a guide for how early elements of ideas may be retained and used. Idea linking is therefore related to the interpretive processes that are involved in conceptual combination (Finke, Ward, & Smith, 1992; Scott, Lonergan, & Mumford, 2005; Ward, 2001); although combined elements may or

may not be retained as the idea is further developed, the process of linking these elements is integral to the development of the final idea.

In sum, we argue that specific curiosity supports creativity by driving individuals to explore multiple, partially overlapping ideas as they strive to solve the puzzle before them. This exploration manifests in the cognitive process of idea linking, by which individuals develop ideas by linking them together in a sequential manner, using aspects of initial ideas as input into subsequent ideas. Put formally:

Hypothesis 2. Idea linking mediates the positive effect of specific curiosity on creativity.

2.3. Overview of studies

We examined our two hypotheses with four studies. Study 1 manipulated specific curiosity and measured creativity to establish the causal relationship. Study 2 examined the ecological validity of these results in the field, testing the relationship between the daily specific curiosity of online artisans and their creativity the following day. Study 3 tested idea linking as a mediator of the causal relationship between specific curiosity and creativity. Study 4 compared the effect of idea linking on creativity to that of the well-established brainstorming strategy.

3. Study 1: Specific curiosity drives creativity

3.1. Participants and design

Ninety-two adults (49 men, 43 women, M_{age} = 32.14, SD = 10.07) from Amazon Mechanical Turk (MTurk) were randomly assigned to a control or curiosity condition in a study "examining how people respond to entertainment." MTurk has been successfully used as a source for participants in experimental studies of creativity (e.g., Chua, 2013). MTurk study participants are typically more diverse than college student samples and therefore more demographically representative of the general U.S. population (Buhrmester, Kwang, & Gosling, 2011; Paolacci, Chandler, & Ipeirotis, 2010). All of our participants resided in the United States and had a prior MTurk approval rating of at least 85%.

3.2. Procedure

Participants began with a vignette task that manipulated specific curiosity. Then, they completed a creative idea generation task. Three participants (one in curiosity and two in control condition) did not follow the idea task instructions and were excluded from subsequent analyses.

Specific curiosity manipulation. Drawing on existing theory and research, we developed a manipulation that used a magic trick vignette and related questions to induce specific curiosity by creating a desire to solve a puzzle (Litman & Spielberger, 2003; Loewenstein, 1994).

Participants in all conditions read an adaptation of a news article about the *Vanishing Elephant* (Moore, 2007), one of magician Harry Houdini's famous magic tricks. In the curiosity condition, the passage was edited to make participants feel curious about how Houdini accomplished the illusion. The passage described a magic show in which Houdini made an elephant disappear and indicated that this trick, which was never solved, was one of the most mysterious Houdini performed. Participants were then asked to describe how they would feel if they were in the audience watching and how they thought Houdini achieved the trick. The program was designed to appear as if it was comparing participants' answers to the correct answer in a database, although this was simply a built-in time delay. After five seconds, a text box appeared, informing participants that their answer was close but not fully correct. This was intended to leave them curious about how the illusion was accomplished.

In the control condition, the vignette described the Vanishing Elephant as a standard trick for the industry and contained a description of how Houdini accomplished it. Similar to the curiosity condition, participants then described how they would feel if they were watching in the audience and how they thought Houdini accomplished the illusion. After a five-second delay, a text box informed them that their answer was correct and congratulated them for solving the trick. Thus, while participants in the curiosity condition were induced to remain curious about how the trick was accomplished, the control group received confirmation that they knew the nature of the trick. The full text of the manipulation appears in Appendix A.

After reading the magic trick vignette, participants in both conditions indicated the extent to which they felt curious using a nine-point scale (1 = "strongly disagree", 9 = "strongly agree"). To ensure that our manipulation did not elicit unintended states, participants also rated the extent to which they felt happy, sad, anxious, and angry.

Creativity task and measures. Next, participants were asked to generate additional ideas for magic tricks. The instructions read, "Imagine that you were Houdini and you were going to do a better trick than your Elephant trick. What might you do?" These responses were evaluated for creativity using multiple techniques.

Our primary measure of creativity draws on professional expertise in the domain of magic. Because domain experts are well versed in the trends and practices of their field, creativity is often assessed using expert evaluations (e.g., Amabile, 1982; Amabile, Conti, Coon, Lazenby, & Herron, 1996; Grant & Berry, 2011). In keeping with this logic, we recruited two professional magicians, each with over 20 years of experience, to evaluate the creativity of each response based on their professional experience and knowledge of the history of magic. The magicians were unaware of our hypotheses and manipulation. They rated each response as 1 if they believed that the magic trick was more creative than vanishing an elephant (0 if not). The magicians' evaluations incorporated judgments of the scale of the trick, how impossible the trick would seem, and whether responses achieved impossibility without seeming "too perfect." (Please see supplementary materials for a full description of their criteria.)

Several disagreements stemming from assumptions about the responses were resolved through discussion, while several differences of opinion about what makes magic tricks creative (e.g., whether tricks were "too perfect" and therefore unconvincing illusions) were unresolved. The magicians reached good interrater agreement (κ = 0.74), but in order to resolve the remaining differences, we recruited a third professional magician with over 40 years of experience to act as a tie-breaker. Like the first two magicians, this magician was instructed to evaluate the creativity of participants' magic trick ideas using a 1 or a 0. He evaluated only the 12 responses on which the first two magicians disagreed, and his ratings were used for these 12 responses.

To obtain a more robust evaluation of creativity by using different operationalizations (e.g., Gino & Ariely, 2012; Gino & Wiltermuth, 2014; Oldham & Cummings, 1996), we also had two research assistants blind to the hypotheses and manipulation code the responses for *non-fixation*, the degree to which participants' magic trick ideas moved beyond the core elements of the original Vanishing Elephant trick. We developed this measure based on the notion that creative ideas should demonstrate less fixation on existing parameters and associations (Duncker, 1945; e.g., Gino & Ariely, 2012; Gino & Wiltermuth, 2014; Maddux & Galinsky, 2009), which can cause cognitive interference that reduces creativity (Gilhooly, Fioratou, Anthony, & Wynn, 2007; Nusbaum & Silvia, 2011). Research assistants determined whether the magic trick ideas incorporated the central elements of the Vanishing Elephant trick: vanishing (including variants: disappearing, appearing, reappearing), elephants, and boxes. Ideas that incorporated a higher (lower) number of these elements exhibited a higher (lower) degree of fixation on the original trick, which indicates lower (higher) creativity. These scores (one point per element of the original trick) were then reverse-coded for our analyses, such that the fewer references to the

Vanishing Elephant, the higher the score for nonfixation, indicating higher creativity. Ideas that represented small tweaks to the original Vanishing Elephant trick (e.g., "Do a smoke cloud and a distraction while hiding the elephant") and/or incorporated all three elements of the original trick received a score of 0, ideas that incorporated two elements of the original trick received a score of 1, ideas that incorporated one element of the original trick received a score of 2, and ideas that did not incorporate any core elements of the original trick received a score of 3. (Please see supplementary materials for examples of this coding.)

When responses were ambiguous in terms of references to the original trick (e.g., "Change elephant to lion" could be interpreted as executing the original trick but replacing the elephant with a lion – higher fixation – or as a new magic trick entailing transforming an elephant into a lion – lower fixation) and research assistants disagreed, we determined that this ambiguity could not be resolved, and scores were averaged. Scores were averaged in two instances; the original scores were not more than one point apart.

Control variables. We controlled for intrinsic motivation (Deci, 1975; Deci & Ryan, 1985), which is often seen as similar to curiosity, by asking participants to indicate, using a nine-point scale (1 = "strongly disagree", 9 = "strongly agree"), the extent to which they knew how to perform magic tricks or watched magic shows. Because interest is core to intrinsic motivation, interest in magic may be considered a proxy for this construct given the nature of the task. We also controlled for creative personality, another known driver of creativity (Amabile, 1988; Oldham & Cummings, 1996; Zhou & George, 2001), by asking participants to indicate the extent to which their friends would describe them as having a creative personality (1 = "strongly disagree", 9 = "strongly agree").

3.3. Results

Manipulation check. Participants in the curiosity condition reported significantly higher curiosity than participants in the control condition ($F(1, 90) = 23.21$, $p < .01$). There were no significant differences between the two conditions on the other emotions measured (for happy, $F(1, 90) = 0.44$, $p = .51$; for sad, $F(1, 90) = 0.05$, $p = .82$; for anxious, $F(1, 90) = 0.87$, $p = .35$; for angry, $F(1, 90) = 0.02$, $p = .89$; see Table 1 for all means). Therefore, our manipulation successfully induced curiosity for participants in the curiosity condition but did not induce other states that might confound the results.

To assess whether our manipulation elicited specific curiosity in particular, two research assistants blind to the manipulation and hypotheses were trained in the definitions of specific and diversive curiosity and coded participants' descriptions of how they imagined that they would feel if they were an audience member. For specific curiosity, the judges looked for statements indicating curiosity about the puzzle of how the illusion was accomplished. For diversive curiosity, they looked for statements indicating curiosity about topics other than how the illusion was accomplished or any specific puzzles. Specific and diversive curiosity were each scored with a dichotomous variable, with a score of 1 reflecting that that type of curiosity was present in the response. Several initial questions about the coding scheme were resolved through discussion, and the judges reached total agreement. In the curiosity condition, 23 of 45 responses were coded as specific curiosity, and 0 responses were coded as diversive curiosity. The responses that were coded as neither were more vague, such as, "Awe and excitement," "Astounded, especially during those times," "I would feel astonished," and "Awed, flabbergasted, amazed." Such responses could be interpreted as relating to curiosity about the illusion but do not explicitly make this connection, and as such, they were not coded as either type of curiosity. Hence, our coding scheme was very conservative. The more frequent descriptions of specific curiosity, coupled with the significantly higher self-reported curiosity reported earlier, give us confidence that we had successfully manipulated specific curiosity.

Table 1
Mean manipulation check scores.

Condition	Curious	Happy	Sad	Anxious	Angry
Curiosity	7.18 (2.07)	5.69 (2.37)	2.13 (2.03)	3.13 (2.41)	1.69 (1.10)
Control	4.89 (2.45)	5.98 (1.81)	2.04 (1.74)	2.70 (2.02)	1.72 (1.33)

Note. Standard deviations are in parentheses.

Table 2
Creativity frequencies and nonfixation means by condition.

Condition	Creativity	Nonfixation
Curiosity ($n = 44$)	31/44 (70.5%)	2.16 (0.64)
Control ($n = 45$)	16/45 (36.0%)	1.62 (1.25)

Note. Percentages and standard deviations, respectively, are in parentheses.

Creativity. Hypothesis 1 predicted that experiencing curiosity leads to greater creativity. A chi-square analysis demonstrated that participants in the curiosity condition generated ideas that the professional magicians evaluated as creative significantly more often (71% of the time) than those in the control condition (36%; $\chi^2(1) = 10.87$, $p < .01$) (see Table 2). A binary logistic regression with magicians' creativity evaluations as the dependent variable and the predictor variables of curiosity, interest in magic, and creative personality revealed a significant model ($\chi^2(3) = 11.49$, $p < .01$) with curiosity as a significant predictor ($b = 1.49$, Wald = 9.85, $p < .01$).[1] Neither interest in magic nor creative personality were significant predictors of creative performance. Additionally, an ANCOVA revealed that participants in the curiosity condition generated magic ideas that were significantly less fixated on core aspects of the Vanishing Elephant trick than the ideas generated by control condition participants when controlling for interest in magic and creative personality ($M_{curiosity} = 2.16$, $SD = 0.64$ vs. $M_{control} = 1.62$, $SD = 1.25$, $F(1,85) = 7.10$, $p < .01$, $\eta_p^2 = 0.08$) (see Table 2).[2] These results support Hypothesis 1.

It may seem that individuals in the control condition developed less-creative ideas because they received more information about how the Vanishing Elephant trick was performed and felt that they should stay close to the original illusion in the ideas that they proposed. However, participants in both conditions were instructed to come up with a better – and therefore different – magic trick than the original Vanishing Elephant illusion. Still, because control condition participants received information about the presence of drapes or curtains as being essential to the Vanishing Elephant illusion, we looked for a difference in the number of ideas that involved drapes or curtains in each condition to rule out this alternative explanation. This difference was not significant (2 ideas in control condition, 0 in curiosity condition). Moreover, three other control condition participants explicitly stated that they would avoid using drapes or curtains so that their illusion would be better than the original one. Hence, we feel confident that control condition participants did not come up with less-creative ideas due to a perception that they should propose ideas that reflected the original Vanishing Elephant illusion.

3.4. Discussion

These results suggest that specific curiosity causes individuals to be more creative. Specific curiosity led participants to overcome fixation

[1] Results were similar when the control variables of interest in magic and creative personality were removed, with a significant model ($\chi^2(1) = 11.11$, $p < .01$) and curiosity as a significant predictor ($b = 1.46$, Wald = 10.39, $p < .01$).

[2] Results were similar when the control variables of interest in magic and creative personality were removed: $F(1,87) = 6.49$, $p = .01$, $\eta_p^2 = 0.07$.

on salient examples and generate ideas that were judged as more creative by experts. Controlling for intrinsic motivation helps to assuage potential concerns about the similarity between intrinsic motivation and specific curiosity and underscores the distinct role that specific curiosity plays in creative performance. While Study 1 allows for greater confidence in the causal relationship between specific curiosity and creativity, it did little to ensure external validity. As such, Study 2 assessed whether specific curiosity would motivate creativity in a field setting.

4. Study 2: Specific curiosity predicts next-day creativity among artisans

To test the ecological validity of the relationship between specific curiosity and creativity in the field, we turned to Artsy (a pseudonym), an e-commerce website through which artisans sell their own handmade goods.

4.1. Participants, design, and procedure

We initially enrolled 286 artisans in the study using primary recruiting and "snowball" or convenience sample methods (see Judge, Scott, & Ilies, 2006, for a complementary sampling procedure). We posted a link to enroll in a study exploring "the motivations behind craftwork" on Artsy's online forum and also sent participants a confirmation email after they enrolled that asked them to invite members of their Artsy communities to participate or post the invitation on their blogs. We entered participants in a raffle for a nominal gift and provided them with personality profiles when the study was completed. After removing participants who dropped out of the study, did not meet minimum survey completion criteria (at least seven of fourteen daily surveys completed), or for whom store-level data were not available, 124 qualified participants (43 percent of initial enrollment) remained. Of this baseline sample, 81 participants (65 percent) had complete data on our focal study measures of daily curiosity and next-day creativity; therefore, our final sample for analysis purposes consisted of 81 participants who completed 516 daily surveys. All participants were the sole contributors to their shops and were therefore responsible for designing and selling their goods. The handcrafted goods that artisans sold through their shops cover a wide range of categories: 44 percent sold jewelry, 19 percent sold paper goods, 12 percent sold art, 11 percent sold knit goods, 7 percent sold children's goods, and 6 percent sold candles. A comparison between our final sample of 81 participants and the 43 participants who were removed from the sample due to incomplete data indicated that the average daily specific curiosity in the final sample ($M = 2.44$, $SD = 0.64$) was not significantly different from the average daily specific curiosity for those removed from the sample ($M = 2.51$, $SD = 0.49$; t (1 2 2) $= 0.71$, $p = .48$).

We used an experience sampling methodology (ESM) to capture participants' experiences of curiosity and creativity over the data collection period. For two weeks, participants received a daily email instructing them to complete a web-based survey if they had worked on their shops on that day. They were asked to complete the survey immediately after they had finished their shop work. In addition to the self-reported daily survey data, we collected publicly available information about each participant's shop from Artsy's website.

Specific curiosity. We measured daily specific curiosity using a five-item scale developed by Litman and Spielberger (2003) and later refined by Litman (2008). We used a five-point scale (1 = "strongly disagree", 5 = "strongly agree") to gather information about the extent to which artisans agreed with statements regarding their experiences working on their shops that day. The instructions in the daily survey read: "The following questions refer to your experiences today as you have been involved in work related to your online store. Please answer the questions that best capture your thoughts and your feelings as you have worked on your online store." In keeping with these instructions, survey items used phrases like "today" and "during the day," which reminded participants to focus on daily experiences rather than general dispositions. Specific curiosity items included, "I was working hard on a frustrating problem today," and, "During the day, I was trying to solve a problem that has been bothering me." The mean (across days) reliability was $\alpha = 0.85$.

Creativity. The work that artisans do in designing and crafting their own products is intrinsically creative. Therefore, to measure whether participants were engaged in creativity, we used participants' daily diary entries in which they reported events that stood out as relevant to their work as artisans. Participants provided typed responses to the following prompt: "Use the space below to briefly describe one event from today that stands out in your mind as relevant to your craft business." This prompt was adapted from Amabile, Barsade, Mueller, and Staw (2005); because the prompt does not lead participants to report anything in particular, responses can be viewed as "veridical" accounts of daily work experiences and serve as a conservative measure of creativity (Amabile et al., 2005, p. 378). We used the Linguistic Inquiry and Word Count (LIWC) text analysis application (Pennebaker, Chung, Ireland, Gonzales, & Booth, 2007) to measure creativity-relevant language in the daily entries; we created a dictionary of creativity words for this measure which included words like "creative," "novel," and "unique." The LIWC analysis produces a numeric score for each verbatim entry that is bounded between 0 and 100 and reflects the percentage of the text that uses words indicating creativity. Higher LIWC creativity scores thus indicates more creative activity in a particular day. Following recommendations for reducing common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), we used the lagged LIWC creativity score for the verbatim entry provided on the next consecutive day (day $t + 1$) as our outcome measure.

Control variables. We controlled for current-day creativity (day t) using the same LIWC measure of creativity detailed above to further reduce concerns regarding common method bias. We also controlled for the number of words per daily entry at time $t + 1$ in order to account for the possibility that participants recounted more creative activity because they had more experiences at work that day that they deemed noteworthy. We included a measure of daily diversive curiosity as a control variable to account for any relationships between other forms of curiosity and our outcome. Daily diversive curiosity was measured using five items developed by Litman and Spielberger (2003) and later refined by Litman (2008). Using a five-point scale (1 = "strongly disagree", 5 = "strongly agree"), participants indicated the extent to which they agreed that the statements represented their experiences at work that day. Example items are, "Today, I have enjoyed exploring new ideas," and, "I have been fascinated with new information today." The mean (across days) reliability was $\alpha = 0.89$. Finally, in order to increase confidence that our creativity measure was not reflective of simply being more productive in general, we controlled for shop productivity, measured as the number of items listed as available for sale in each participant's shop at the start of the study period.

4.2. Analysis

We used the *meglm* command in Stata 14 (StataCorp, 2015) to test Hypothesis 1 using a multilevel generalized linear model (MGLM) with a log-link function. Because participants' daily responses were not independent, we employed a multilevel modeling approach with two levels of analysis to properly account for the nested nature of our data: Level 1 includes the day-level variables (daily curiosity, daily and next-day creativity, and word count of the next-day daily entry) which are nested within Level 2, the person-level (shop productivity). Further, because our dependent variable measure of creativity is bounded between 0 and 100 and positively skewed, we used a log-link function to more appropriately model relations between our predictor variables and a non-normally distributed outcome. We regressed the lagged measure of creativity onto our predictor and control variables, such that

Table 3
Descriptive statistics and within- and between-person correlations.

	M	*SD*	1	2	3	4	5
1. Creativity (t + 1)	2.26	4.32	–	0.09*	−0.05	−0.03	−0.02
2. Specific curiosity	2.43	0.82	−0.14	–	0.05	−0.13**	0.31**
3. Creativity (t)	2.18	4.46	0.67**	0.05	–	0.05	0.21**
4. Word count	38.13	42.19	−0.22*	0.05	−0.13	–	0.04
5. Diversive curiosity	3.15	0.87	−0.14	0.47**	0.00	0.18	–
6. Shop productivity	74.94	78.74	0.14	−0.24*	0.04	−0.11	−0.24*

Notes. Variables 1 and 4 were reported at day t + 1; variables 2, 3, and 5 were reported at day t; variable 6 was measured once at the beginning of the study. Correlations above the diagonal represent within-person mean-centered correlations; correlations below the diagonal represent between-person correlations (averaged within-person measures); Level 1n = 516; Level 2n = 81.
* $p < .05$.
** $p < .01$.

states of specific curiosity on day t were used to predict next-day creativity (t + 1). Variables at Level 1 were person-mean centered, and the Level 2 measure of shop productivity was grand-mean centered.

4.3. Results

Table 3 displays the descriptive statistics and bivariate correlations for all variables in our analysis. Between-individual correlations are presented below the diagonal and use the averaged day-level measures for the variables at Level 1. Within-individual correlations are presented above the diagonal; in order to accurately represent within-individual bivariate relationships independent of any between-individual relationships that may exist between these variables, these correlations are reported using the person-mean centered variables.

Using MGLM, we examined whether day-level specific curiosity predicted creativity the following day. Table 4 displays results of the regression analysis. In Model 1, we regressed next-day creativity onto the Level 1 and Level 2 control variables. In Model 2, we included day-level specific curiosity into the regression model; in support of Hypothesis 1, day-level specific curiosity was positively related to creativity the following day (b = 0.28, p = .02).

Supplementary analysis. We supplement our findings with a validity check on our creativity measure, which was based on the LIWC text analysis of participants' verbatim daily diary entries. To accomplish this, we averaged the next-day creativity scores for each participant and then examined the relationship between this person-level (Level 2) creativity variable and the number of "heart" ratings that shoppers gave to each participant's shop (n = 81). On the artisan website, a shopper can indicate their appreciation of a shop by clicking on a heart icon; the hearts accumulate, and the total number of hearts received is displayed on the shop's home page. Pilot interviews with artisans indicated that shoppers' heart ratings represent an external evaluation of participants' creativity.[3] More hearts given to a shop thus provides an approximation of greater overall creativity by the participant. Averaged next-day creativity was positively correlated with the number of store hearts received at the end of the two-week data collection period (r = 0.28, p = .01), which suggests that our creativity measure aligns with external evaluations of participants' work. The bivariate correlation between averaged participant specific curiosity and store hearts, however, was not statistically significant. The lack of relationship may be due to heart ratings partially reflecting evaluations of other shop characteristics (e.g., marketing copy and pricing information). Such evaluations are further removed from artisans' specific curiosity, and the likely influence of these other factors makes an association between shop-level hearts and averaged specific curiosity more difficult to observe than in a more controlled, experimental setting.

Table 4
Multilevel GLM results: effects of specific curiosity on next-day creativity.

	Model 1	Model 2
Variable	Coefficient (SE)	Coefficient (SE)
Constant	0.61 (0.14)***	0.57 (0.17)**
Level 1 predictors		
Specific curiosity		0.28 (0.12)*
Creativity (t)	−0.01 (0.01)	−0.02 (0.02)
Word count	−0.00 (0.00)	−0.00 (0.00)
Diversive curiosity	−0.13 (0.17)	−0.25 (0.23)
Level 2 predictors		
Shop productivity	−0.00 (0.00)	0.00 (0.00)
Log pseudolikelihood	−1475.88	−1471.55

Notes. Coefficients are unstandardized. Robust standard errors are in parentheses. Level 1 predictors were person-mean centered. Level 2 predictor was grand-mean centered. Level 1n = 516; Level 2n = 81.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

4.4. Discussion

These results provide further support for Hypothesis 1, that specific curiosity positively predicts creativity. The wide range of settings in which our participants – independent, online artisans – engage in their work, as well as our use of a different creativity measure that captures daily work experiences over time, strengthens the validity of our findings and complements the more controlled experimental setting of Study 1. However, we have yet to test Hypothesis 2 and idea linking as an explanatory mechanism of the relationship between specific curiosity and creativity. Therefore, in Study 3, we continue to build our evidence, through different samples and measures, that specific curiosity plays a key role in creative idea generation and further explicate the underlying cognitive process – idea linking – that explains this effect.

5. Study 3: Idea linking mediates the effect of specific curiosity on creativity

Study 3 tested Hypotheses 1 and 2 by manipulating specific curiosity with the magic trick vignette used in Study 1 and having participants generate magic trick ideas and describe their ideation process. We coded participants' descriptions for idea linking, demonstrating it as a driving mechanism between specific curiosity and creativity (Hypothesis 2).

[3] Pilot interviews with artisans prior to launching the study indicated that hearts reflected creativity: "I heart when I see something I haven't ever seen before," "I heart because I totally think a piece is awesome," "I only heart when I have a true interest in someone's item," "I have sent a heart to several people, mostly because it is something that I really like or that is unique," "I heart because I am wowed by something in the shop," "I heart products I find inspiring."

5.1. Participants and design

One hundred adults (57 men, 43 women, M_{age} = 33.71, SD = 10.81) from Amazon MTurk were randomly assigned to either a control or curiosity condition in an online study "examining how people respond to entertainment" and each received $1.00 for participation. The participants resided in the United States and had a prior approval rating of at least 90%.

5.2. Procedure

Participants first took part in the specific curiosity manipulation and idea generation task as those employed in Study 1. Then, they were instructed to describe their idea generation process, which allowed us to assess idea linking. Six participants (one in curiosity condition and five in the control condition) did not follow the creativity task instructions and were excluded from subsequent analyses.

Creativity task and measures. As was the case with Study 1, the two professional magicians each evaluated the creativity of participants' magic trick ideas (1 = creative, 0 = uncreative). Several disagreements were resolved through discussion, and the magicians reached good interrater agreement (κ = 0.71), but several other disagreements stemming from differences of opinion were unresolved. For these 14 cases, we again turned to our tiebreaker magician with over 40 years of experience.

To complement this holistic measure of creativity based on experts' evaluations, two research assistants blind to the hypotheses and manipulation read participants' magic trick ideas and coded them for the number of references to the original trick, which could range from zero to a maximum of three if ideas referenced all three elements of the Vanishing Elephant trick (vanishing, including variants: disappearing, appearing, reappearing; elephants; and boxes). These scores were then reverse-coded to create the measure of nonfixation that was used in our analysis (0 = high fixation, 3 = nonfixation). After reverse coding these values, responses with fewer references to the central aspects of Houdini's magic trick received higher scores on this measure, because they exhibited less fixation on the original trick. Scores were averaged when responses were ambiguous in terms of references to the original trick and research assistants disagreed; this took place in eight instances, and scores were never more than one point apart.

Idea linking. After completing the magic trick idea generation task, participants were asked to describe how they had generated their ideas. The instructions read, "In as much detail as possible, please describe how you came up with your idea(s) for the magic trick(s) that you would perform if you were Houdini."

Two research assistants blind to manipulation conditions and hypotheses were trained to evaluate idea linking, defined as using aspects of early ideas as input for subsequent ideas in a sequential manner, such that one idea is a stepping stone to the next. They were instructed to evaluate the number of sequential links between ideas that participants described. To illustrate, the following responses received a score of 0: "I have read about this trick," and, "It made logical sense." As another example, the following response received a score of 1: "I thought about what would be more visually impressive than making an elephant disappear. For me, there's only one thing more impressive than such a large animal vanishing, and that's to make such a large animal fly. I figure people would go absolutely bonkers for such a trick." As a final example, the following response received a score of 3: "I thought about how I would top making an elephant disappear. I then thought about what type of animal is bigger than an elephant. Maybe a whale, but it is impractical being a waterborn animal. Then I thought of a brontosaurus [sic], but it is extinct. Then I thought I could make the skeleton of one disappear from a museum." In some cases, if participants' idea process description was vague, it was necessary for the judges to refer to the magic trick ideas they came up with to see what ideas they considered and how they linked, if at all. After initial questions about the coding scheme were resolved, the research assistants reached full agreement on the idea linking evaluations.

Control variables. As in Study 1, we controlled for participants' interest in magic (a proxy for intrinsic motivation) and creative personality.

Table 5
Creativity frequencies and nonfixation means by condition.

Condition	Creativity	Nonfixation
Curiosity (n = 52)	15/42 (35.7%)	2.24 (0.70)
Control (n = 42)	31/52 (59.6%)	1.86 (1.00)

Note. Percentages and standard deviations, respectively, are in parentheses.

5.3. Results

Creativity. In support of Hypothesis 1 and replicating our findings from Studies 1 and 2, we found that experiencing specific curiosity fuels creativity. A chi-square test indicated that participants in the curiosity condition came up with ideas that the magicians deemed creative 60% of the time, which was significantly more than participants in the control condition, who came up with creative ideas 36% of the time (χ^2[1] = 5.31, p = .02, two-sided) (see Table 5). A logistic regression incorporating the control variables of magic interest and creativity personality again revealed a significant model (χ^2(3) = 12.10, p = .01) with specific curiosity as a significant predictor (b = 1.07, Wald = 5.62, p = .02).[4] The control variable of creative personality was a significant predictor of creativity (b = 0.28, Wald = 6.03, p = .01) in this analysis, but magic interest was not. An ANCOVA showed that participants in the curiosity condition also generated magic trick ideas that exhibited significantly less fixation on the original Vanishing Elephant trick than those in the control condition, when controlling for interest in magic and creative personality ($M_{curiosity}$ = 2.24, SD = 0.70 vs. $M_{control}$ = 1.86, SD = 1.00, F(1,90) = 5.47, p = .02, η_p^2 = 0.06) (see Table 5).[5]

Idea linking and mediation analyses. In support of Hypothesis 2, we found that idea linking mediates the effect of specific curiosity on creativity.[6] First, an ANCOVA revealed that participants in the curiosity condition shown significantly more idea linking in their idea development process when controlling for magic interest and creative identity ($M_{curiosity}$ = 1.51, SD = 1.08 vs. $M_{control}$ = 0.76, SD = 0.79, F(1,90) = 14.42, p < .01, η_p^2 = 0.14).[7] Bootstrap estimation (PROCESS Model 4: Hayes, 2017) was then used to test whether idea linking mediated the influence of curiosity on creativity. This procedure yielded a significant indirect effect of specific curiosity on creativity through idea linking for our holistic measure of creativity (B = 1.08, SE = 0.78, 95% CI = 0.37, 2.38) as well as nonfixation (B = 0.12, SE = 0.08, 95% CI = 0.002, 0.31).

[4] Results were similar when the control variables of interest in magic and creative personality were removed, with a significant model (χ^2(1) = 5.37, p = .02) and curiosity as a significant predictor (b = 0.98, Wald = 5.20, p = .02).

[5] Results were similar when the control variables of interest in magic and creative personality were removed: F(1,92) = 4.77, p = .03, η_p^2 = 0.05.

[6] An ANCOVA and ANOVA of the number of characters used by participants to describe how they came up with their ideas revealed no significant difference ($M_{curiosity}$ = 151.59, SD = 113.45 vs. $M_{control}$ = 144.40, SD = 110.68), whether controlling for magic interest and creative personality (p = .65) or not (p = .76). Thus, the difference in idea linking is not attributable to a mere difference in verbosity.

[7] Results were similar when the control variables of interest in magic and creative personality were removed: F(1,92) = 14.49, p < .01, η_p^2 = 0.14.

5.4. Discussion

These results support our hypotheses and show that participants who experienced specific curiosity came up with magic trick ideas that exhibited lower fixation and were judged as more creative by domain experts. Participants who experienced specific curiosity engaged in significantly more idea linking, using aspects of early ideas as input for later ideas in a sequential manner. Idea linking mediated the relationship between specific curiosity and creativity, whether measured with expert evaluations or through the measure of nonfixation.

These results indicate that specific curiosity drives individuals to use aspects of early ideas as a stepping stone to later ideas, rather than stopping at the first viable solution. To illustrate, one participant described first wondering, "What is cooler than a disappear [sic] elephant," which led them to think of Dumbo. They thought of making an elephant fly, which led them to think of making an elephant float, do flips, and defy gravity. Another described first questioning, "What is bigger than an elephant?" and thinking of a building; then thinking of three elephants, which would also be a "bigger" illusion; and finally thinking of disappearing an elephant *without* the box that was essential to Houdini's original illusion. For participants who engaged in idea linking, aspects of early ideas sparked additional cognitive exploration.

In the control condition, in contrast, participants exhibited less idea linking. For instance, one participant explained, "I just thought about something that would be easy to fool the audience with." Another proposed vanishing a smaller animal and explained, "Simple, there is less of a chance audience members will see a hidden animal if it is smaller which gives you more options to be able to hide said animal." A third simply modified the original trick by adding smoke and mirrors, arguing that this would be "the best way to conceal the hidden aspects of the trick as to not reveal the secrets behind it." These ideas were judged as uncreative by the professional magicians and exhibited moderate fixation on the original trick. In sum, in addition to reaffirming idea linking as the generative mechanism for the effect of specific curiosity on creativity, this study reveals idea linking as an effective creative idea generation strategy.

Because our idea linking measure relied on participants' self-reports of their idea generation process, there was a small chance that those in the curiosity condition, though similar in verbosity, were simply more focused on the process, whereas those in the control condition may have been more focused on the outcome, omitting from their descriptions the idea linking that they actually went through. Study 4 directly manipulated idea linking to exclude this possibility. Another goal for Study 4 was to pit idea linking against an existing creativity technique, brainstorming, to demonstrate its efficacy and novelty.

6. Study 4: Idea linking increases creativity compared to brainstorming

This final study sought to investigate whether the mechanism of idea linking provides additional benefits beyond existing creativity interventions and to better establish the relationship between idea linking and creativity, following recommendations by Spencer, Zanna, and Fong (2005) to develop a causal chain by manipulating the proposed mediator and evaluating its effect on the dependent variable (e.g., Gino & Wiltermuth, 2014). Study 4 manipulated idea linking and asked participants to generate ideas for a magic trick.

6.1. Participants and design

One hundred and eight undergraduate students (71 men, 37 women, $M_{age} = 21$, $SD = 0.77$) were randomly assigned to an idea linking, brainstorming, or no-instruction control condition in a study "exploring idea generation" in exchange for partial course credit.

6.2. Procedure

Depending on the condition, participants received idea linking training, brainstorming training, or no training before completing a creative idea generation task. Participants also filled out a short scale intended as a manipulation check. Participants who did not follow the creativity task instructions (six in idea linking condition, four in brainstorming control condition, and one in no-instruction control condition) were excluded from the analyses, resulting in a sample of 97 (30 in idea linking condition, 31 in brainstorming control condition, and 36 in no-instruction control condition).

Idea linking manipulation. Participants in all conditions were told, "Magicians often need to come up with new ideas for magic tricks. For instance, Houdini came up with the idea to vanish an elephant." In the idea linking condition, participants were then told, "One way to come up with new ideas involves moving from one idea to another before settling on a final idea, using one idea as a springboard to the next, rather than stopping at the first viable solution that comes to mind," and were provided with an example of this process (see Appendix B). This training was developed based on our conceptualization of idea linking and was intended to match closely the measurement of idea linking in Study 3. In the brainstorming control condition, participants were told, "One way to come up with new ideas is by brainstorming, or generating a large number of different ideas by saying whatever comes to mind and avoiding criticizing or evaluating the ideas, and then picking one," and were provided with an example of this process. This training was developed based on individual brainstorming research (which research shows to be more effective than group brainstorming [Kerr & Tindale, 2004; Mullen, Johnson, & Salas, 1991; Diehl & Stroebe, 1987]), which conceptualizes it as a process of an individual generating many different ideas while withholding judgment regarding quality. By encouraging the generation of many ideas, brainstorming has been shown to increase individual creativity (Paulus, Kohn, & Arditti, 2011). The full trainings are in Appendix B.

While brainstorming condition participants were instructed to generate ideas in a different way from idea linking participants, participants in both conditions were exposed to training that referenced the same set of magic trick examples, thus eliminating the possibility that examples incorporated in the training could affect results. Furthermore, participants in both conditions were exposed to the idea that using the particular technique on which they were trained should lead them to an idea that is different from the starting idea. As such, the brainstorming condition should serve as strong control condition with which to compare idea linking and examine its relative benefits.

Finally, in the no-instruction control condition, no special training was provided. This condition was intended to serve as a check that idea linking is not a process that organically occurs anytime individuals are generating ideas.

Creativity task and measures. Next, participants were asked to generate an idea for a magic trick. All participants were instructed, "Imagine that you were Houdini and you were going to do a better trick than your Vanishing Elephant trick. Assuming there are no constraints on what you could do, what might you do?" Participants in the idea linking and brainstorming conditions were instructed to apply the technique on which they had just received training, while participants in the no-instruction control condition were provided no additional instruction.

As with Studies 2 and 4, two professional magicians each evaluated the creativity of participants' magic trick ideas (1 = creative, 0 = uncreative). Several disagreements were resolved through discussion, and the magicians reached excellent interrater agreement ($\kappa = 0.94$), but several other disagreements stemming from differences of opinion were unresolved. For these two cases, we again relied on a third tiebreaker magician.

Idea linking manipulation check development. To further validate the idea linking construct and to develop a manipulation check for

the present experiment, we developed a scale to measure idea linking. We followed Hinkin's (1995, 1998) recommendations for establishing construct validity and reliability through the use of exploratory and confirmatory factor analysis. (Please see supplementary materials for a full description of the process, including evidence of convergent and discriminant validity through comparisons with related constructs.) The three-item scale is presented in Appendix C.

6.3. Results

Manipulation check. Participants in the idea linking condition reported significantly greater idea linking than participants in the brainstorming control condition ($M_{\text{brainstorming}} = 3.40$, $SD = 0.84$, $M_{\text{idealinking}} = 4.03$, $SD = 0.80$, $F(1, 59) = 9.24$, $p < .01$) and participants in the no-instruction control condition ($M_{\text{no-instruction}} = 3.46$, $SD = 1.17$, $F(1, 64) = 5.12$, $p = .03$). As evidenced by these results, we concluded that our manipulation successfully induced idea linking for participants in the idea linking condition and that idea linking is not a process that naturally occurs anytime individuals brainstorm or come up with ideas without instruction on the process.

Creativity. As a corollary to Hypothesis 2, we predicted that idea linking would be associated with greater creativity. A chi-square analysis demonstrated that participants in the idea linking condition generated ideas that the professional magicians evaluated as creative significantly more often (47% of the time) than those in the brainstorming control condition (10%; $\chi^2(1) = 10.38$, $p < .01$) or the no-instruction control condition (14%; $\chi^2(1) = 8.58$, $p < .01$). To supplement this, a binary logistic regression with magicians' creativity evaluations as the dependent variable revealed a significant model ($\chi^2(1) = 11.02$, $p < .01$) with the idea linking condition as a significant predictor as compared with the brainstorming control condition ($b = 2.10$, Wald = 8.77, $p < .01$). A second binary logistic regression with magicians' creativity evaluations as the dependent variable revealed a significant model ($\chi^2(1) = 8.77$, $p < .01$) with the idea linking condition as a significant predictor as compared with the no-instruction control condition ($b = 1.69$, Wald = 7.81, $p < .01$).

6.4. Discussion

This study makes several key contributions regarding the role of idea linking in creative idea generation. First of all, by demonstrating that idea linking can be manipulated through training, this study showcases the practical application of idea linking and provides a robust empirical tool that can be used in subsequent research. Second, through the inclusion of a control condition in which no idea generation instruction was provided, we demonstrate that idea linking is not simply a process that happens automatically when individuals engage in creative endeavors. Third, we show that idea linking boosts creativity beyond what is gained through the technique of individual brainstorming and provide evidence for its conceptual distinction from brainstorming. Brainstorming involves generating a number of different ideas and withholding judgment about which ideas are best. Idea linking also involves generating multiple ideas, but its conceptual distinction is the progression from one idea to the next, as elements of early ideas contribute to the generation of subsequent ideas. With idea linking, then, early ideas are indispensable in the idea generation process. We show that this process of using aspects of early ideas as input into subsequent idea generation helps individuals come up with more creative final ideas. Hence, it is not simply the process of detaching from early ideas, but that elements of early ideas seem to inspire subsequent ideas, that contributes to greater creativity.

7. General discussion

We began by arguing that the targeted exploration fueled by specific curiosity would lead to creativity. We further argued that this relationship would be mediated by idea linking, which we defined as using aspects of early ideas as input for subsequent ideas in a sequential manner, such that one idea is a stepping stone to the next. We expected this conceptual combination process to support creativity by enabling individuals to depart gradually from dominant and familiar conceptual associations that initially come to mind during open-ended idea generation.

Study 1 used an experimental design to manipulate specific curiosity and measure creativity and provided support for the causal relationship between specific curiosity and creativity. Study 2 used an experience sampling design and provided ecological validity for this relationship. Study 3 demonstrated that idea linking mediates the relationship between specific curiosity and creativity. Study 4 provided evidence that idea linking benefits creativity beyond existing creativity interventions, such as brainstorming. Additionally, through the development of a three-item scale that served as a manipulation check, Study 4 also provided evidence of the convergent and discriminant validity of idea linking (see supplementary materials). Specific curiosity drives individuals to engage in greater idea linking, and through this focused yet exploratory process, individuals who are experiencing specific curiosity tend to generate ideas that are more creative than those of individuals who are not experiencing specific curiosity.

7.1. Theoretical and practical implications

Our findings make an important contribution first of all to research on the antecedents of creativity by demonstrating the predictive link between specific curiosity and creativity. While prior theorizing (Amabile, 1988; Loewenstein, 1994; Kashdan & Fincham, 2002) has proposed that a positive relationship between curiosity and creativity likely exists, very little work has taken on this question empirically (cf. Hardy et al., 2017). This is perhaps because curiosity has often been treated as synonymous with intrinsic motivation (e.g., Amabile, 1988), which has held a prominent place in creativity research since Amabile's breakthrough work (e.g., Amabile, 1985). However, while intrinsic motivation is typically manipulated by varying the salience of extrinsic rewards (e.g., Amabile, 1988; see Cerasoli, Nicklin, & Ford, 2014, for a review and meta-analysis), studying curiosity allows a more nuanced exploration of how individuals engage with the topic that is the focus of their creative endeavors. It also allows us to explore how curiosity that is not generated by creativity tasks themselves may inadvertently be conducive to creative performance on these tasks. Indeed, scholars have recently begun taking curiosity more seriously as an independent predictor of creativity. However, this work has focused exclusively on trait curiosity (e.g., Hardy, et al., 2017; Harrison & Dossinger, 2017), despite urgings to explore state curiosity (Loewenstein, 1994). This is perhaps because curiosity is difficult to manipulate, given its variable nature (Loewenstein, 1994; Litman, 2005).

Through two experiments and a field study, we address this gap and establish a predictive relationship between specific curiosity and creativity both in controlled, experimental settings and in the real-world setting of online artisans. By focusing on state rather than trait specific curiosity, this work demonstrates that curiosity is indeed subject to contextual influences. Furthermore, by demonstrating one way that specific curiosity can be reliability manipulated, our work also makes an empirical contribution that can be used in future studies of state specific curiosity. Specific curiosity is important to understand, since the very nature of organizations, as sources of goals, tasks, and problems, provides a fertile seedbed for puzzles that elicit specific curiosity. This view adds further value to the link between specific curiosity and creativity: Individuals might solve a puzzling problem and, in the process, precipitate creativity.

We also introduce the mechanism of idea linking and provide evidence that this cognitive process mediates the relationship between specific curiosity and creativity. This contribution complements recent research indicating that diversive curiosity supports creativity via

information seeking (Hardy et al., 2017) by demonstrating that specific curiosity plays a critical role in the internal exploration that takes place during creative efforts. The present research suggests that experiencing specific curiosity motivates individuals to make a unique cognitive investment in idea generation, which manifests in greater idea linking. We provide evidence that idea linking benefits creative performance beyond the existing creativity intervention of brainstorming and that idea linking is not a process that happens automatically when people engage in creative tasks. Brainstorming encourages individuals to detach from early ideas by withholding judgment as they generate a large number of ideas and eventually select one to develop further. With idea linking, early ideas are provisional, but they are indispensable to the development of subsequent ideas, because aspects of early ideas serve as input into later ideas. Individuals move from partially overlapping ideas in a sequential manner, progressing towards a final idea that may be entirely different from the starting point. Through this process of linking various conceptual elements, individuals develop provisional ideas that may address different aspects of the puzzle at hand until they develop a "final" idea with which they are satisfied. As the examples discussed in Study 3 illustrate, idea linking seems to involve playing with aspects of early ideas with a spirit of improvisation, switching out different elements and perhaps disconfirming prior links until a satisfactory idea emerges.

More broadly, we show that even without the influence of external stimuli such as informational resources (Hardy, et al., 2017) and feedback (Harrison & Dossinger, 2017; Harrison & Rouse, 2014), curiosity drives processes that benefit creative performance. Specific curiosity can be a frustrating experience as individuals wrestle with the absence of the information that they desire (Loewenstein, 1994; Litman, 2005). However, when this frustration is directed towards a creative idea generation task, it seems to benefit creativity by driving individuals to experiment with the conceptual elements of their early ideas, turning a frustrating experience into a generative one. In other words, idea linking may enable individuals to funnel the dissatisfaction elicited by "unfilled" information gaps into a productive process with a creative outcome. Idea linking enables individuals to reap the benefits of the focused exploration catalyzed by specific curiosity, perhaps paradoxically, by simultaneously retaining aspects of earlier ideas while moving away from the starting point. As such, idea linking may be one manifestation of Amabile and Pratt's (2016) speculation that subsequent ideas, even in a single creative episode, can build from one another. While specific curiosity may be seen as distracting, we show that it can provide positive outcomes in the form of enhanced creative performance.

7.2. Limitations and future directions

As with any project, the current research has limitations, some of which open avenues for further research on idea linking and the connection between curiosity and creativity. First, in Study 3, the measurement of idea linking relied on participants' descriptions of how they came up with their ideas, and in Study 4, we used an idea linking scale as a manipulation check. Both of these methods are contingent upon the extent to which participants could accurately recall their idea generation process. While these methods have the advantage of not impinging on idea generation as it unfolds, future research could rely on in-the-moment recordings of the idea development process. Second, idea linking focuses on conscious thought processes; future research could examine whether specific curiosity influences nonconscious cognitive processes during creative endeavors as well. Researchers should also examine idea linking in naturalistic settings, which may reveal contextual factors that inform this process in important ways. For instance, environmental cues such as aspects of the physical environment or interpersonal interactions may serve as additional input into the idea linking process or may become a distraction, perhaps quelling idea linking even when specific curiosity is high.

Additionally, we did not explicitly control for the entire range of concepts that are conceptually similar to specific curiosity, such as intrinsic motivation. However, this concern is somewhat assuaged for a few reasons, beginning with the methodological decisions already mentioned. In Study 1 and 3, we measured and controlled for interest in magic, and because interest is a central feature of intrinsic motivation, controlling for this variable in our analyses demonstrates that intrinsic motivation does not account for our findings regarding specific curiosity as a driver of creativity. While future research on specific curiosity should control for intrinsic motivation more directly, this research contributes to our understanding of antecedents to creativity by providing empirical evidence that curiosity and intrinsic motivation are not one and the same. While a great deal of research has shown that intrinsic motivation drives creativity by supporting cognitive flexibility, positive affect, persistence, and risk taking (Shalley, Zhou, & Oldham, 2004), the present research indicates that specific curiosity drives individuals to engage in the cognitive process of idea linking, which is one mechanism for the conceptual combination that underpins creative idea generation. Of course, much work remains to be done to unpack the relationship between specific curiosity and creativity, such as whether it influences creativity through additional cognitive or affective mechanisms.

On a conceptual level, because of its more focused and targeted nature, specific curiosity often shares a level of bandwidth with creativity that makes it a theoretically relevant construct for studying creativity. Indeed, most process models of creativity begin with *problem formation* or *problem finding* (Amabile, 1988; Lubart, 2001). Creativity in context is not about coming up with ideas for anything but about generating potential solutions for a specific problem. Similarly, specific curiosity drives the exploration of information in relation to a specific problem. As such, the constructs are related by their theoretical breadth, which is in this case more narrow (Judge & Kammeyer-Mueller, 2012). Because we have examined states of specific curiosity that are primed experimentally, our findings are less likely to be explained by the simultaneous activation of other psychological states. Additionally, the use of randomized experiments and measuring curiosity that naturally fluctuates within individuals during the course of a day's work reduce the likelihood that stable individual differences (e.g., openness to experience) explain the demonstrated relationships.

We see several additional opportunities for future research to extend and advance our examination of specific curiosity, idea linking, and creativity. Like other processes of conceptual combination, idea linking is likely influenced by variables that support creative idea generation, such as associative hierarchy (Mednick, 1958, 1962) and divergent thinking (Guilford, 1968, 1982). For example, future research might manipulate the "steepness" of associative hierarchy structures (e.g., Gino & Ariely, 2012; Gino & Wiltermuth, 2014) to examine whether the ease with which individuals can make associations between seemingly different concepts influences idea linking. Further, since divergent thinking is concerned with both idea fluency (the number of ideas that are generated) and flexibility (how different the ideas are from one another), future research might explore how divergent thinking influences the diversity of ideas that are considered during idea linking, and by extension whether the diversity of early ideas influences the creativity of final ideas.

Additionally, while the present research examines idea linking during the idea generation stage of the creative process, idea linking may also support the developments that take place during other stages of the creative process, such as idea elaboration. Idea elaboration typically refers to the final phase of the creative process and involves the practical pursuit of the creative idea, including conducting validation checks (Amabile, 1988) and amassing the resources needed to refine the idea and prepare it for implementation (Staw, 1990; Mainemelis, 2010; Csikszentmihalyi, 1997). As such, idea elaboration "usually requires much more than cognitive resources" (Mainemelis, 2010, p. 561). While the present research examines idea linking during the idea

generation stage, prior to this translation from the mind to the medium in which the idea will be implemented (Csikszentmihalyi, 1997; Mainemelis, 2010), idea linking may also support the process of refining and validating ideas, as individuals "test" their ideas against the task criteria and make appropriate changes (Amabile, 1988).

Another direction for future research concerns the temporal nature of curiosity episodes. While our experimental studies examine the effects of a specific curiosity episode on idea generation that immediately follows, our field study of online artisans found a relationship between individuals' daily specific curiosity and next-day creativity, which suggests that state specific curiosity is not necessarily fleeting. Future research should investigate whether and how the length and intensity of specific curiosity episodes influence subsequent creative efforts.

Finally, future research might examine whether there is a feedback loop between episodes of specific curiosity and creativity. If specific curiosity benefits the creative process, as we have shown, it may be that the enhanced creativity brought about by specific curiosity in turn makes individuals more curious, which then feeds back into future cycles through the creative process. That is, the creative process itself may engender specific curiosity by raising new questions about novel associations, creating a positive spiral of specific curiosity and creativity.

Appendix A

Vanishing Elephant Specific Curiosity Manipulation

[Control description is in brackets]

Houdini announced: "The animal is gone!" [.]

Magicians often rely on mirrors, trap doors, and hidden wires. However [no "however" for control], *The Vanishing Elephant*, one of Harry Houdini's most mysterious [standard] tricks, was truly unique [relied on these methods]. For more than 90 years, long after his death, the secret by which Houdini made an elephant disappear remained a puzzle that even other magicians could not to solve. [Observant audience members could see that the elephant was simply hidden behind a drape in the box.]

It began in 1918. Harry Houdini walked across the stage. A crowd of over 5000 had gathered to watch him perform, what, at the time, was considered the world's most incredible illusion [a common illusion].

"Ladies and gentlemen," Houdini cried. To the audience's alarm [as the audience sat calmly], a full-grown Asian elephant came into view.

The elephant raised her trunk in greeting to the wide-eyed crowd [indifferent crowd], before being led into a huge, brightly colored box on wheels. The doors were closed behind her. There was a dramatic [the usual] drum roll. Then, the stage hands flung open the doors at both ends of the box to reveal that it was now completely empty [but some of the audience members could see where the elephant was hiding].

Imagine that you were in the audience. In the space below, describe how would you *feel* watching this trick.

How do you think Houdini did it?

Manipulation: "Please wait approximately 5 s while the survey program compares your answer to the correct one. The survey will automatically advance when ready."

Experimental: "You are close, but not completely right." Control: "Yes, you figured it out."

Appendix B

Idea Linking Manipulation

Idea Linking Condition:

One way to come up with new ideas involves moving from one idea to another before settling on a final idea, using one idea as a springboard to the next, rather than stopping at the first viable solution that comes to mind.

As an example of idea linking, magicians often come up with new ideas by starting with one concept and then using that idea as a stepping stone to a new idea. Magicians familiar with Houdini's Vanishing Elephant trick might start by thinking about an elephant disappearing. Then building on the idea of jungle animals, they might come up with cutting a tiger in half. That might lead to considering even more rare animals, like doing a trick with animals that are extinct: doing a card trick with a dinosaur. Thinking of dinosaurs, they might think of dinosaur bones, and finally decide to make a set of dinosaur bones float. Each idea provides a starting point for the next, so that the final idea is now something completely different than the starting idea.

Brainstorming Condition:

One way to come up with new ideas is by brainstorming, or generating a large number of different ideas by saying whatever comes to mind and avoiding criticizing or evaluating the ideas, and then picking one.

As an example of brainstorming, magicians familiar with Houdini's Vanishing Elephant trick might start by listing as many different ideas as they can think of without worrying about whether the idea is feasible. Magicians might generate a list that includes cutting a tiger in half, doing a card trick with a dinosaur, or making a set of bones float. Each idea might be the best idea, so generating as many ideas as possible gives magicians the best chance of finding an idea that is something completely different from the starting idea.

Appendix C

Idea Linking Scale

1. I develop early ideas knowing that I'll use them mainly as a stepping stone to a final idea.
2. I use one idea as a springboard to the next.
3. Initial ideas often point me towards additional possibilities.

Appendix D. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.obhdp.2018.10.007.

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