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Retrieval Fluency Inflates Perceived Preparation for Difficult Problems

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Abstract

When faced with a difficult problem, people often rely on past experiences. While remembering clearly helps us reach solutions, can retrieval also lead to misperceptions of our own abilities? In three experiments, participants encountered 'worst case scenarios' they likely had never experienced and that would be difficult to navigate without extensive training (e.g., *bitten by snake*). Learning brief tips improved problem solving performance later, but retrieval increased feelings of preparation by an even larger margin. This gap occurred regardless of whether people thought tips came from an expert or another participant in the study, and did not reflect mere familiarity with the problems themselves. Instead, our results suggest that the ease experienced while remembering, or *retrieval fluency*, inflated feelings of preparation.

Keywords

problem solving; episodic memory; retrieval fluency; metacognition

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Imagine walking along a beach and realizing that a swimmer is caught in a riptide. You might immediately think back to news coverage of a similar emergency at Panama City Beach, where beachgoers formed a human chain to save a family, and enlist others on the beach to do the same. Relying on our pasts can help us solve a current problem. For example, brief training in recollecting the details of a recent event facilitates subsequent *means-end problem solving*: Participants generate more steps needed to solve everyday problems (e.g., *wanting to exercise more*; Madore & Schacter, 2014), including personal problems that participants report worrying about (e.g., *exam coming up soon*; Jing et al., 2016, 2020). In addition, reactivating memories of previously unsolved puzzles during sleep facilitates performance the next day (Sanders et al., 2019). By contrast, groups with known episodic memory impairments due to temporal lobe excision (Sheldon et al., 2011), amnestic mild cognitive impairment (Sheldon et al., 2015), and healthy aging (Madore & Schacter, 2014; Peters et al., 2019; Sheldon et al., 2011) struggle with means-end problem solving. Consistent with these findings, overlapping neural regions, including anterior hippocampus,

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support the generation of both autobiographical memories and means-end solutions to personal problems (e.g., *car not starting*; Peters & Sheldon, 2021).

But remembering during some forms of problem solving can also *harm* performance if old solutions do not actually apply. Exposure to a misleading distractor (e.g., *pear*) makes it harder to solve for the associate (e.g., *pit*) related to each word of a triad (e.g., *arm*, *coal*, *peach*; Smith & Blankenship, 1991). Fixation resolves in new contexts (Smith & Beda, 2020), after time passes (i.e., *incubation*; see Sio & Ormerod, 2009, for a meta-analysis), or when inhibiting inappropriate solutions (Storm et al., 2011). Thus, forgetting can paradoxically enable creative problem solving – participants think of more new uses for common household objects (e.g., *newspaper*) when they forget recently studied uses (Storm & Patel, 2014).

People may be unaware of how recently learned information impacts the quality of their solutions. They report *more* confidence in their ability to solve for remote associates after seeing fixating information, even though their performance is worse (Storm & Hickman, 2015). More generally, people monitor their own reasoning less accurately than they monitor their own memory. For example, participants can predict what they will remember (*feeling-of-knowing*), but not whether they will solve problems (*feeling-of-warmth*; Metcalfe, 1986a). In fact, people make more errors after reporting that they are getting very 'warm,' or close to a solution (Metcalfe, 1986b).

Meta-reasoning is imperfect partly because people rely heavily on heuristics (see Ackerman & Thompson, 2017). One such 'shortcut' involves ease of processing, or *fluency* (see Alter & Oppenheimer, 2009, for a review), which broadly influences what we like (Westerman et al., 2015), believe (Brashier et al., 2020), consider beautiful (Vogel et al., 2020), and think we have learned (Koriat, 2008). We also overinterpret ease during 'aha!' moments, when the solution to a problem suddenly becomes clear (Kounios & Beeman, 2014). These subjective experiences of *insight* occur because solutions feel fluent (Topolinski & Reber, 2010a) and often accompany correct ideas (Stuyck et al., 2022). However, wrong answers that come to mind quickly also elicit confidence (Ackerman & Zalmanov, 2012). This 'dark side' of epiphanies extends to adjacent information – false claims seem truer when they immediately follow 'aha!' moments (Laukkonen et al., 2020).

Insight is an intense and specific feeling that arguably reflects a special process – as examples, neither cognitive load (Stuyck et al., 2022) nor distraction (Ball et al., 2015) constrain 'aha!' moments. But fluency informs many other perceptions of problems and their solutions. Participants who repeatedly watch demonstrations of magic tricks or dart-throwing become more confident that they can perform those same tasks, compared with people who only watch once (Kardas & O'Brien, 2018). People assume that easy-to-pronounce anagrams (e.g., NOGAL) take longer to solve than hard-to-pronounce anagrams (e.g., HNWEI; Topolinski et al., 2016). And participants accept candidate solutions, both correct and incorrect, more often when they appear quickly after an anagram (50 vs. 150 ms; Topolinski & Reber, 2010b).

Providing people with speedy solutions makes them seem higher quality – do people draw the same inference after easily retrieving solutions from memory? *Retrieval fluency* leads people to assume that they will recall information just as effortlessly in the future (Bjork et al., 2013), to confidently provide wrong answers to general knowledge questions (Kelley & Lindsay, 1993), and to accept claims as true (Ozubko & Fugelsang, 2011). People expect to remember information they find quickly, whether they are searching their own memories (Benjamin et al., 1998) or the Internet (Stone & Storm, 2021).

In the current research, we investigated whether retrieval fluency also makes people feel overprepared for difficult, real-world problems. Jordan and colleagues (2022) showed people an uninformative video of a pilot landing a plane. This passive exposure inflated participants' confidence in their ability to land a plane themselves without dying, even though this skill requires hundreds of hours of training. Thinking back to the clip likely felt fluent, ease that people misinterpreted as evidence that they could achieve the implausible. We set out to test whether retrieving someone else's solution makes people feel more prepared for a problem than generating their own – even though the latter provides actual evidence that they can think on their feet.

In three experiments, we ensured that new learning occurred by presenting people with problems they likely had no personal experience with. Participants encoded expert tips (e.g., *strike eyes or gills*) for 'worst case scenarios' that would prove very challenging for novices (e.g., *shark attacks*). Later, they listed steps to solve these problems (*retrieval*), as well as new problems they did not see at encoding (*generation*). Participants also indicated how prepared they felt for each scenario. These experiments were not formally preregistered, but all data and materials are available on the Open Science Framework (OSF; https://osf.io/vgu9t).

Experiments 1 and 2

These experiments share a design and nearly identical methods, so we report them together. Experiment 2 is a direct replication of Experiment 1 that uses the same scenarios, with four substitutions.

Method

Participants.—In Experiment 1, 34 young adults (22 women, *M* age = 21.15 years, 19 – 27 years) participated for course credit or monetary compensation. Another 35 young adults (17 women, *M* age = 20.40 years, 18 – 24 years) participated in Experiment 2. We excluded additional participants (n = 2 in Experiment 1, n = 2 in Experiment 2) for poor performance (three standard deviations from the mean). [1] Our previous experiments identified differences in means-end problem solving in samples of a similar size (*n*s = 24-35) following an episodic specificity induction (Madore & Schacter, 2014; Jing et al., 2016).

Design.—These experiments manipulated retrieval fluency within subjects.

[1]When we include low performers, analyses yield the same key differences between the retrieval and generation conditions.

Materials.—We generated 30 "worst case scenarios" that sound plausible, but are unlikely (e.g., shark attack, which involves 1 in 11.5 million odds). These dangerous situations would be difficult to navigate without extensive previous training. For each problem (e.g., *fall onto subway tracks*), we identified four discrete steps (e.g., *yell to bystanders*, *avoid third rail*, *run to end of platform*, *wave hands to get operator's attention*) to reach a goal state (e.g., *stop train*). Pilot participants (N = 36) found the situations somewhat plausible (M = 2.45 on a 4-pt scale) but almost never reported personal experience with them (M = 0.02). We divided the problems into two sets of 15 scenarios. One set was learned during encoding (old) and the other appeared for the first time at test (new). Oldness was counterbalanced across participants.

We replaced four of these scenarios in Experiment 2. Pilot participants also found this revised set to be somewhat plausible (M = 2.50 on a 4-pt scale) and almost never reported personal experience with them (M = 0.03).

Procedure.—The Institutional Review Board at Harvard University approved all procedures (protocol 18-1081). After giving informed consent, participants completed the *encoding phase*. For each of 15 problems (e.g., *plane nosedives*), they learned four "expert tips" (e.g., *count number of rows to exit*, *remove sharp objects from pockets*, *assume a brace position*, *pad legs with bags*). These steps appeared together on one screen. Participants indicated how difficult it would be to carry out each step on a scale from 1 (*very easy*) to 4 (*very difficult*).

Immediately after encoding, participants completed the *means-end problem solving phase*, based on Platt and Spivack's (1975) procedure. They viewed 30 scenarios that presented a problem (e.g., *plane nosedives*) and a goal state (e.g., *minimize injury*). Half could be solved with "expert tips" encoded earlier, while the other half were new. Each scenario included an explicit prompt to *retrieve* steps presented earlier or *generate* novel steps. After listing four steps, participants answered *How prepared do you feel for this scenario?* from 1 (*very unprepared*) to 4 (*very prepared*). Participants solved each problem with a time limit of 1 minute and then rated how prepared they felt. In Experiment 2, preparedness ratings appeared on a separate screen after participants provided each solution. As a manipulation check, we also measured the total time spent solving each problem.

Coding.—Two raters scored participants' solutions. For old problems, they rated whether cued recall responses matched encoded steps (*recalled*) or not (*forgotten*). For new problems, they rated responses based on Platt and Spivack's (1975) categories: steps that lead to the goal state (*relevant*), work toward another goal not described in the prompt (*irrelevant*), or contain tangential information (*no step*). For example, when participants provided steps to *free their own leg from a bear trap*, the raters coded *'keep leg still'* as relevant and *'take antibiotics'* as irrelevant; the latter step serves a separate goal of treating the wound. In all analyses, we collapse over irrelevant and no steps. Inter-rater reliability was high for both old (Experiment 1: κ = 0.90; Experiment 2: κ = 0.94) and new (Experiment 1: κ = 0.86; Experiment 2: κ = 0.89) problems. A third rater resolved discrepancies. To allow for direct comparisons between the retrieval and generation conditions, solutions to old problems were also recoded as relevant, irrelevant, or no steps (Experiment 1: $\kappa = 0.91$; Experiment 2: $\kappa = 0.70$).

Results

Table 1 shows performance and perceived preparation in each condition.

Steps.—Overall, participants provided a similar number of steps in the retrieval (Experiment 1: $M = 3.46$, Experiment 2: $M = 3.59$) and generation (Experiment 1: $M = 3.40$, Experiment 2: $M = 3.70$) conditions. In the retrieval condition, they correctly remembered some steps (Experiment 1: $M = 2.42$, Experiment 2: $M = 2.39$), but also provided others that did not match tips they learned previously (Experiment 1: $M = 1.04$, Experiment 2: $M = 1.20$). Recoding for relevance, rather than correct recall, revealed that some of this additional content was useful (Experiment 1: relevant $M = 3.24$, other $M = 0.23$; Experiment 2: relevant $M = 3.32$, other $M = 0.27$). By this metric, participants performed better in the retrieval than the generation condition (Experiment 1: relevant $M = 2.90$, other $M = 0.50$, $t(33) = 5.15$, $p < .001$, $d = 0.88$; Experiment 2: relevant $M = 3.06$, other $M = 0.63$, $t(34) = 3.29$, $p = .002$, $d = 0.56$).

Preparedness ratings.—Paired samples *t*-tests compared participants' preparedness ratings for old and new problems. People felt more prepared after recalling steps (Experiment 1: $M = 2.36$; Experiment 2: $M = 2.48$) than after generating their own steps (Experiment 1: $M = 1.94$, $t(33) = 5.20$, $p < .001$, $d = 0.89$; Experiment 2: $M = 1.95$, $t(34) = 7.44$, $p < .001$, $d = 1.26$). Participants also provided more relevant steps during retrieval, but this performance gap only correlated with the difference in preparedness ratings in Experiment 2 ($r = 0.39$, $p = .022$) and not in Experiment 1 ($r = 0.01$, $p = .963$). In other words, better performance did not always accompany feeling more prepared. Critically, a one-way analysis of covariance (ANCOVA) confirmed that people felt more prepared during retrieval, (Experiment 1: $F(1, 32) = 14.36$, $p < .001$; Experiment 2: $F(1, 33) = 32.87$, $p < .001$), even when controlling for performance differences between conditions (relevant steps given in the retrieve – generate conditions).

Reaction times.—Paired samples *t*-tests compared the total time that participants spent solving old and new problems. People solved problems more quickly by retrieval (Experiment 1: $M = 39.72$ s; Experiment 2: $M = 37.62$ s) than by generation (Experiment 1: $M = 46.45$ s, $t(33) = 7.76$, $p < .001$, $d = 1.33$; Experiment 2: $M = 43.77$ s, $t(34) = 6.92$, $p < .001$, $d = 1.17$). Thus, subjective experiences of fluency differed between the retrieval and generation conditions.

Discussion

In two experiments, participants felt more prepared for problems after retrieving solutions than after coming up with their own. This metacognitive boost was of a similar size or larger (*d*s = 0.89-1.26) than the difference in objective performance (i.e., number of relevant steps produced) between the retrieval and generation conditions (*d*s = 0.56-0.88). We replicated this effect in a smaller experiment ($n = 21$) with no time constraint; participants still felt more prepared after retrieving solutions ($M = 2.42$) than after generating their own ($M =$

2.08), $t(20) = 2.93$, $p = .008$, $d = 0.64$. Across experiments, people solved problems more quickly by retrieving steps than by generating them. This pattern fits with a retrieval fluency account, but it is also possible that people infer that steps provided by experts are more effective than their own. To address the role of source credibility, we instructed participants in Experiment 3 that solutions came from another participant in the study.

Experiment 3

Method

Participants.—Thirty-four young adults (21 women, *M* age = 19.85 years, 18 – 24 years) participated for course credit or monetary compensation. We excluded an additional 3 participants for low performance (three standard deviations from the mean). [1]

Design, Materials, and Procedure.—This experiment is identical to Experiment 2, except for the supposed source of tips learned at encoding. In Experiments 1 and 2, participants believed that steps came from an expert. In this study, initial instructions stated that tips came from another participant in the study.

Coding.—Two raters scored participants' solutions using the same criteria as Experiments 1 and 2. Inter-rater reliability was high for both old ($\kappa = 0.89$) and new ($\kappa = 0.75$) problems. A third rater resolved discrepancies. Again, solutions to old problems were recoded as relevant, irrelevant, or no steps ($\kappa = 0.72$).

Results

Table 1 shows performance and perceived preparation in each condition.

Steps.—Again, participants provided a similar number of steps in the retrieval ($M = 3.42$) and generation ($M = 3.39$) conditions. In the retrieval condition, they correctly remembered some steps ($M = 2.63$), but also provided others that did not match tips they learned previously ($M = 0.79$). Recoding for relevance, rather than correct recall, revealed that some of this additional content was useful (relevant $M = 3.32$, other $M = 0.10$). By this metric, participants performed better in the retrieval than the generation condition (relevant $M = 3.00$, other $M = 0.38$), $t(33) = 4.70$, $p < .001$, $d = 0.81$.

Preparedness ratings.—A paired samples *t*-test compared participants' preparedness ratings for old and new problems. As in Experiments 1 and 2, people felt more prepared after recalling steps ($M = 2.46$) than after generating their own steps ($M = 1.94$), $t(33) = 6.63$, $p < .001$, $d = 1.14$. Participants also provided more relevant steps during retrieval, but this performance gap did not correlate with the difference in preparedness ratings ($r = -0.04$, $p = .842$). Again, a one-way ANCOVA confirmed that people felt more prepared during retrieval, $F(1, 32) = 26.98$, $p < .001$, even when accounting for the performance difference between conditions (relevant steps given in the retrieve – generate conditions).

Reaction times.—A paired samples *t*-test compared the total time that participants spent solving old and new problems. Again, people solved problems more quickly by retrieval (*M*

= 37.53 s) than by generation (*M* = 44.47 s, $t(33) = 6.08$, $p < .001$, $d = 1.04$), confirming that subjective ease differed between conditions.

Discussion

People feel more prepared for worst-case scenarios after retrieving someone else's solutions than after generating their own – even if they believe that advice came from a peer, rather than an expert. We tend to believe that our own abilities exceed those of our average peer (*better-than-average effect*; see Zell et al., 2020, for a meta-analysis). Over 90% of people, for example, regard themselves as more skillful than the average driver (Svenson, 1981). If anything, people likely assumed that they were better problem solvers than other participants in the study. Thus, source credibility is probably not driving the metacognitive boost we have observed. But perceived preparation may also reflect familiarity with a dangerous situation, rather than learning any tips to address it. A single, brief exposure to a complex problem can increase people's belief that they can solve it, even if that passive observation was not informative (Jordan et al., 2022). In addition, recipes and exercise routines seem easier to do when they appear in easy-to-read (fluent) fonts (Song & Schwarz, 2008). Thus, repeatedly encountering the 'worst case scenarios' themselves in the retrieval condition may make them fluent, creating the illusion that they are more manageable. We tested this account in Experiment 4 by presenting problems alone, with no expert tips.

Experiment 4

Method

Participants.—Fifty-three Amazon Mechanical Turk workers (25 women, *M* age = 35.98 years, 20 – 67 years) participated for monetary compensation. We increased our sample size due to the prevalence of inattentive and fraudulent users on MTurk (Moss et al., preprint).

Design.—These experiments manipulated repetition within subjects.

Materials.—We used a larger set of "worst case scenarios," which pilot participants deemed somewhat plausible (*M* = 2.70 on a 4-pt scale) and rarely reported personal experience with (*M* = 0.07). One half was presented during exposure (old) and the other half appeared for the first time at test (new). Oldness was counterbalanced across participants.

Procedure.—At exposure, participants saw 30 worst case scenarios (e.g., *plane nosedives*). Unlike the previous three experiments, participants did not receive any tips for solving these problems. Instead, they simply indicated how plausible each problem seemed from 1 (*very implausible*) to 4 (*very plausible*). Immediately afterwards, participants judged their own preparation for 60 scenarios; half they saw earlier, while the other half were new. They answered *How prepared do you feel for this scenario?* from 1 (*very unprepared*) to 4 (*very prepared*).

Results

A paired samples *t*-test compared participants' preparedness ratings for old and new problems. In the absence of any tips, participants felt similarly prepared for familiar (*M*

= 2.01) and new (*M* = 1.97) problems, $t(52) = 1.13$, $p = .264$. These data rule out the possibility that participants felt more prepared in the retrieval condition of Experiments 1-3 simply because they saw problems for a second time.

General Discussion

The present studies demonstrate that relying on our pasts to solve current problems can be misleading. In three experiments, people quickly and successfully applied advice for worst-case scenarios after a single learning episode, in line with other evidence that episodic retrieval supports real-world problem solving (e.g., Madore & Schacter, 2014; Sheldon et al., 2011). But this boost to performance came at a cost, as participants felt prepared for dangerous situations, like getting frostbite or being arrested overseas, by an even larger margin. This gap occurred regardless of the perceived source of tips – an expert or another participant in the study. In an additional experiment, we also confirmed that feelings of preparation did not reflect mere exposure to problems themselves; after seeing scenarios with no advice (e.g., just *attacked in elevator*), participants later felt similarly prepared for these familiar problems and new ones. Instead, our results suggest that recalling someone else's solution feels easy, which people misattribute to their ability to handle a crisis themselves.

The human mind exploits an automatic byproduct of memory – retrieval fluency – to make judgments that extend well beyond what we remember and forget. In the *ease-of-retrieval effect*, remembering more examples of an ability or trait makes it seem less applicable (see Weingarten & Hutchinson, 2018, for a meta-analysis). Winkielman and colleagues (1998) asked participants to recall either twelve or four childhood events. Despite remembering triple the content, people inferred that their memory was worse after providing more events. In another study, participants regarded themselves as less assertive after providing twelve instances of assertive behavior from their past, compared to only six instances (Schwarz et al., 1991). People use this heuristic flexibly – for example, they rely more on retrieval fluency when making judgments about the self, compared to judgments about others (Caruso, 2008). And generally, it is adaptive to consider not only the content of memories, but how effortfully they came to mind. Retrieval fluency tracks statistical regularities in the world – as a few examples, bigger cities, more prolific artists, and higher-earning companies are remembered more quickly than smaller ones (Hertwig et al., 2008). Here, we find that this shortcut leads people astray when reasoning about worst-case scenarios where success is unlikely.

We identified costs of remembering during problem solving, an inversion of the finding that problem solving often impairs memory. Jacoby (1978), for example, asked participants to recall words (e.g., *shoe*) after solving relevant puzzles (e.g., *foot s_ _ e*) or after simply rereading them; problem solving lowered recall relative to rereading. Similarly, *thinking-induced forgetting* occurs when people solve for remote associates (e.g., *playing, credit, report*) and forget stronger ones (e.g., *union* for the cue *credit*; Storm et al., 2011). Finally, people forget problems themselves (e.g., *Make the equation true by moving only one line: II = VI*) after successfully solving them (Patalano & Seifert, 1994). Our results suggest that not only can active problem solving increase forgetting, but retrieval can yield metacognitive illusions about real-world problems.

Crucially, participants did not simply misremember solutions as their own (i.e., make source memory errors) – they followed explicit instructions to think back to recently learned steps. But in many studies, people unintentionally take credit for solutions that are not theirs. For example, people inadvertently plagiarize responses that a ‘computer partner’ generated during the word search game Boggle (i.e., *cryptomnesia*; Marsh & Bower, 1993). Fisher and Oppenheimer (2021) asked participants to unscramble anagrams (e.g., AFILMY) either with or without the first three letters of the solutions displayed (e.g., FAM). Then they predicted the percentage of a new set of anagrams they could solve with no outside help. People underestimated how much they relied on hints by 25%. Indeed, when people see solution words before solving for remote associates, they often do not even realize they received incidental hints (Moss et al., 2007, 2011). We showed that people feel prepared to tackle real-world problems that they *know* they received external assistance with.

A little knowledge can be a dangerous thing, leading to a ‘beginner’s bubble’ where people overestimate their abilities. Sanchez and Dunning (2018), for example, asked participants to diagnose ‘zombie diseases’ based on symptoms. After just a few learning experiences, confidence judgments ballooned and exceeded people’s accuracy. In the present work, remembering four simple steps made people feel overprepared for worst case scenarios (e.g., an avalanche). Learning tips for these situations may make related behaviors (e.g., skiing alone) seem safer, since we infer risk from disfluency – amusement rides and food additives with names that are hard to pronounce seem riskier than those with ‘easy’ names (Song & Schwarz, 2009). In addition, feeling protected can paradoxically increase risk propensity (*risk compensation*). People take more risks and engage in more sensation seeking when wearing a helmet, for example (Gamble & Walker, 2016). Similarly, easily retrieving advice for a situation may lead to a false sense of security. Retrieval fluency could impact not only our perceived problem-solving abilities, but our willingness to put them to the test.

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Data Availability

Our materials and anonymized behavioral data are available on OSF (https://osf.io/vgu9t).

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Table 1

Performance and Perceived Preparation by Condition

	Number of Steps				Preparedness Ratings	
	Relevant		Other			
	M	***SE***	***M***	***SE***	***M***	***SE***
Experiment 1						
Retrieval	3.24	0.08	0.23	0.05	2.36	0.10
Generation	2.90	0.09	0.50	0.04	1.94	0.09
Experiment 2						
Retrieval	3.32	0.08	0.27	0.05	2.48	0.08
Generation	3.06	0.05	0.63	0.05	1.95	0.07
Experiment 3						
Retrieval	3.32	0.10	0.10	0.02	2.46	0.09
Generation	3.00	0.10	0.38	0.04	1.94	0.08