Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-021-00712-1 OPEN

Cognitive biases and mindfulness

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In a study testing whether mindfulness decreases cognitive biases, respondents answered 22 standard cognitive bias questions to measure susceptibility to the endowment effect, overconfidence, mental accounting, anchoring, loss aversion, and 17 other biases, as well as the 14 questions of the Langer mindfulness survey (LMS), measuring the traits of novelty-seeking, novelty producing, and engagement. A portion of the respondents were randomly pre-assigned to a condition that induced mindfulness. On 19 of the 22 biases, those induced to be mindful were less likely to show the bias. They also scored higher on 11 of the 14 LMS questions. The method by which we induced mindfulness was unrelated to the context of the later questions, involving image comparisons and standard Langerian instructions to notice three new things. People can boost their decision-making abilities merely by increasing their mindfulness, with no need for meditation, psychological training, or statistical education.

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Introduction

Mindfulness as Langer has defined it (Langer, 1978, 1989, 2000) is simply the act of noticing new things. When we notice or create novelty, we come to recognize that answers are context-dependent. Thus, mindful people should be less susceptible to cognitive biases and less likely to use inappropriate heuristics.

The study of cognitive biases presumes that a person who displays fewer biases is more "rational." Kahneman (1994) notes that rationality is often taken to be "synonymous with flawless intelligence," and summarizes both the narrow, technical definition of rationality as meaning internal consistency with formal rules of logic, and the broader, non-technical definition as meaning grossly suboptimal decisions. Haselton et al. (2015) summarize the standard definition of cognitive biases as systematic deviations from rationality.

Being rational is seemingly good. Being mindful is seemingly good. Yet the relationship between rationality and mindfulness leads to an interesting paradox. Rationality as typically studied (e.g. Oppenheimer, 2008) suggests a correct answer, without regard to context. Mindfulness suggests multiple perspectives and explicit context dependence.

For example, research participants have been asked (Moldoveanu and Langer, 2002a), which is more likely, spilling coffee or spilling hot coffee? The "rational" answer depends on presuming that the category "coffee" includes hot, iced, and warm coffee. Yet for a hot coffee drinker, if hot coffee isn't available, they might choose hot tea or hot chocolate rather than iced coffee. The point being that "hot coffee" is just a compound name for a beverage. If we called it x and iced coffee y and asked, which is more likely to be spilled, either answer could be rational. Furthermore, it is not unreasonable for a subject to assume in the original question that the questioner linguistically intended for "coffee" to mean all kinds of coffee except hot.

Rationality can also be person-dependent: Margolis and Langer (1990) argue, in effect, that the distinction between a motivated behavior and an addiction or any other apparent irrationality may well become blurred if one views the behavior in a mindful manner, considering not just the costs but also the benefits of the activity. Langer (1989, 2014) notes that behavior makes sense from the actor's perspective or else they wouldn't do it: a person who considers himself reliable, spontaneous, and trusting may be viewed by others as rigid, impulsive, and gullible. When we are being judgmental, we are being mindless.

Indeed, Langer and Newman (1979) argues that most experiments in social psychology may be the result of the mindlessness of the participants being studied, not the absence of rationality. When the experimenter puts some strong cue in the situation, participants often comply blindly. In one study, participants listened to a speaker they had been told was either warm or cold. Those who were ultimately influenced by the initial label did not seem to process the content of what the speaker actually said; they merely parroted the label they had been told, mindlessly.

Moldoveanu and Langer (2002a) go even further and argue that many biases in the literature may reflect mindlessness on the part of the researchers themselves rather than actual cognitive deficits of the subjects.

A variety of behavioral and cognitive biases have been identified in the literature (e.g. Kahneman, 2011 for a thorough overview) for which most people do not answer with the ostensibly rational choice. One such example is the following question (ibid, p. 7):

> Consider the letter K. Is K more likely to appear as the first letter in a word OR as the third letter?

The fact that human brains more easily recall words starting with the letter K than those having K in the third letter is explained as an availability bias, by which humans estimate likelihood based on the ease of recall, sometimes leading to error.

There are problems with this letter K example. The first is simply a delightful curiosity: it turns out from a simple calculation using a standard online dictionary that there are in fact more common words that start with the letter K than that have it in the third position! So all of those who answered it "irrationally" were in fact completely correct and completely rational. This is not a major indictment on the experiment, since it can be replaced with the letter R to be correct, and people will still answer in the same way. However, it does serve to caution that whatever we deem "rational" may in fact later turn out to be incorrect.

The second problem is playfulness. A mindful person, asked such a question, might actually find it relatively easy and more enjoyable to try to come up with third-letter K words, one of which is literally part of the question: ask, like, likely, bake, cake, fake, coke, joke, poke, etc. Then, even though they are still relying on the availability heuristic to estimate the probability, they would get the opposite answer.

The implication of the above two problems is that the experimenter's definition of rationality is possibly incorrect and certainly circular if they assert that rational people are those who answer this specific question in this specific way.

Wherever we use the word "rational" in what follows, we may mentally replace it with the phrase "survey rational," meaning that people are answering survey questions in the way the experimenter thinks is rational. We thus use the term in a technical, not a pejorative, sense, in appreciation of it being a highly contested and discussed concept.

In short, the cognitive bias literature such as the ones cited throughout this paper claims particular survey questions have correct answers, yet most people answer incorrectly, by relying on the wrong or overly simplistic heuristics. The mindfulness literature suggests, first, that more mindful people tend to be more aware of context and possibilities, and thus less likely to rely on the wrong heuristic inappropriately, and, second, that people can be relatively easily induced into a mindful state. Thus, our central question is: what would happen to the proportion of rational answers if respondents are induced into a mindful state? Does mindfulness reduce the incidence of behavioral and cognitive biases?

Definitions of mindfulness

While a handful of earlier works such as Deatherage (1975) used mindfulness in the Thera (1972) Buddhist tradition referring to the abstract idea of coming "to know and understand one's own mental processes," the earliest concrete or systematic definition of mindfulness in the scholarly literature appears to be Langer (1978), where mindfulness is operationalized as "that process of consciously making use of information relevant to the situation" and interventions are described that introduce novelty and drawing distinctions in order to overcome mindlessness; in other words, mindfulness is the act of noticing new things.

Two separate traditions of mindfulness later emerged that initially differed from the original Langer (1978) definition but over time came more into line: the meditative and the psychometric.

Continuing the Deatherage (1975) line of research of clinical applications of mindfulness meditation, Kabat-Zinn (1982) defined mindfulness solely in the context of meditation as "detached observation" in order to distinguish it from concentration meditation practices that involve focusing on a single

object. The result of such mindfulness or awareness meditation techniques was termed "bare attention" or "choiceless awareness," and explicitly included "an effort to avoid judgment or interpretation," in sharp contrast to the Langerian definition of actively noticing new things. Later, Kabat-Zinn (1994), while still keeping mindfulness tied to meditative practices, rephrased the definition as "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally." While this comes closer to Langer's definition it still doesn't spell-out the kind of distinction-making and novelty-seeking that are the hallmarks of Langerian mindfulness. To tell people "to pay attention on purpose" may be an empty instruction because people are oblivious to their own mindlessness.

The psychometric approach began with Brown and Ryan (2003)'s Mindful Attention Awareness Scale, which differentiated from Langerian mindfulness in attempting to measure internal mental processes rather than actively focusing attention on external stimuli. Later research in this vein included a host of additional inventory questionnaires and surveys (e.g. Black, 2011 for a survey). Such scales tend to ask introspective questions of its subjects regarding their ability to focus or be conscious of an emotion, etc. In other words, they attempt to measure some recent historical average of a person's general state of mindfulness, but, unlike the immediately operational Langerian definition, they neither induce nor seek to induce mindfulness, and thus are not useful either for our experimental intervention or our post-survey measures of the Langerian components of mindfulness.

The primary conceptual difference between these other two strands of mindfulness research is attainability: both the meditative and the psychometric literature asserts or assumes that attaining mindfulness involves practice and training, while the original and consistent Langerian definition notes that the state of mindfulness can be achieved instantly. It is this unique and operational feature of instant attainability that is crucial to our present study.

Methods

Logic. The between-subjects study comprised one of three types of interventions, a sequence of relatively standard questions measuring behavioral biases, and the standard Langer mindfulness survey (LMS) (Pirson et al., 2018), all described further below. As demographic information was rarely collected in the original studies cited below, because demographics are not expected to play a role in the results, and because the participants are randomly assigned to conditions in any case, no demographic information was collected or analyzed here either.

Design. The study randomly assigned participants to one of three conditions:

Mindless. No warm-up section, going immediately to the Scenarios section of the survey.

Low Mindful. This condition had a warm-up section before proceeding to the Scenarios section of the survey. The warm-up section was very similar to that of the *Mindful* condition except the differences between the pairs of photos was easier to spot.

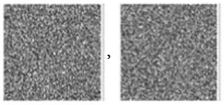
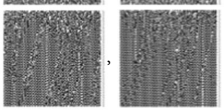
Mindful. This condition had a warm-up section before proceeding to the Scenarios section of the survey. The intent of this condition's warm-up section was to induce Langerian mindfulness into the subjects by guiding them into noticing new things. They are asked to make a choice between two black and white computer generated images with subtle differences, to spot a hard-to-find difference between two photos, to attempt to see both a vase and the faces in a standard optical illusion, and to actively write down three new things in their environment.

It is important to note that the interventions had no overlap in either content or context with the later survey questions. In other words, it is not a form of training or education or even priming for improved performance.

Computed images. Both pairs of images were generated by evolving a cellular automaton with a random 500-length starting condition of black and white cells for 500 time steps. The *Low Mindful* condition images used Wolfram (2002)'s elementary cellular automaton rule 30, which appear approximately random with some barely discernable triangles, while the *Mindful* images used rule 110, which have obvious and different structures in them.

Subjects in the *Low Mindful* group were allowed to skip this question, but the *Mindful* group had a forced-choice design intended to encourage respondents to continue looking for differences.

Although the specific choices did not matter, they are reported here for completeness.

Low Mindful	Which image do you prefer? You can skip this question if you like.		A: 21 B: 14 (skip): 4
Mindful	Which image do you prefer?		A: 17 B: 15

Spot-the-differences. In both conditions, respondents were asked the same question and offered the same three choices, and responses were required.

Can you spot the missing fruit?
A: Yes, I see the missing fruit
B: No, I don't see the missing fruit
C: No, I don't think there is a missing fruit

Again, although the specific choices did not matter, they are reported here for completeness. (Can you spot both pairs of differences? Hint: each condition does indeed have a missing fruit.) To be able to use the same starting image with modified versions of varying difficulty, the automated spot-the-differences program of Maymin (2019) and Maymin and Maymin (2019) was used.

Low Mindful		A: 33 B: 2 C: 4
Mindful		A: 26 B: 0 C: 6

Vases and faces. In both conditions, respondents were asked the same question but offered slightly different choices, and responses

were required. Again, although the specific choices did not matter, they are reported here for completeness.

Low Mindful	What can you see here? A: I see a vase. B: I see two faces. C: I see both a vase and the two faces.		A: 2 B: 0 C: 37
Mindful	What can you see here? A: I see the vase on the left and the vase on the right, but no faces anywhere. B: I see only the vase on the left, and the vase and faces on the right. C: I see only the vase on the right, and the vase and faces on the left. D: I see the vase and faces on the left and the vase and faces on the right.		A: 0 B: 4 C: 0 D: 28

Noticing new things. The essence of Langerian mindfulness is to actively notice new things. In the *Mindful* condition, that is precisely what this question asks of respondents. In the *Low Mindful* condition, the language is tempered and allows for you to notice anything, old or new.

This was a free-form text response field, so no proportions can be measured. Instead, the word clouds visually summarize the responses (ignoring stopwords such as *the*, etc.).

Low Mindful	Look around where you are right now, and try to notice three things that you may or may not have noticed before. What are those three things?	
Mindful	Look around where you are right now, and try to notice three new things that you have never noticed before. What are those three things?	

Subjects. Over a period of two weeks in early June 2020, a total of 109 anonymous people clicked on a publicly available link for the survey, answered all of the required questions, and submitted their results. There were only two missing values, one missing Salzman test in the *Mindful* group and one missing LMS question 2 ("I generate few novel ideas.") in the *Low Mindful* group. The random assignments resulted in 38 subjects in the Mindless group, 39 in the Low Mindful group, and 32 in the Mindful group. No demographic or personally identifiable information was collected at any time. The link had been distributed on various social media including LinkedIn, Facebook, and Twitter, as well as by one-time postings to former undergraduate students. The survey and the research project were verified as exempt by the Institutional Review Board of Fairfield University to be in the exemption category for benign behavioral interventions. Informed consent was obtained from all individual participants involved in the study.

Measures. These questions comprised the "Scenarios" portion of the survey, with both the questions and possible answers always presented in the same order. The traditionally "survey rational" responses are in **bold**.

They were followed by the LMS14 questions. Pirson et al. (2018) document the development, validation, and reliability of the LMS14 scale.

Loss aversion. People tend to feel the pain from losses twice as much as they feel the pleasure from gains (e.g. Kahneman and Tversky, 1991 and Rabin, 2000).

Here, they are asked to choose between $20 for sure, and a gamble with an expected value of $100 and a loss-averse value of $50 (loss-averse values can be calculated as expected values after doubling the magnitudes of the losses).

The gamble is the rational choice; a person who rejects many such bets sequentially is almost surely under-earning.

1. Suppose you had to choose one of these two options. Which would you prefer?
   a. You get $20 for sure.
   b. **You toss a fair coin. Heads you get $300. Tails you lose $100**.

Hyperbolic discounting. People tend to view "now" as special (e.g. Green and Myerson, 2004). We tend to make a rational tradeoff based on the implied 20% interest rate for 1 month when choosing between receiving $1500 in 10 months vs. $1800 in 11 months, and we'd almost surely choose the latter, but if we fast forward 10 months, "now" feels substantially different than "a month from now," and we often end up choosing the traditionally less rational choice of $1500 today. This could potentially result in a money pump: if I borrow $1600 from you today to repay you $1800 in a year, then if after 11 months I offer to pay you $1500, if you indeed act as the irrational choice below indicates, then you will have lost out on $100 plus foregone interest.

2. Would you prefer to receive $1500 today or $1800 1 month from now?
   a. $1500 today
   b. **$1800 1 month from now**

Conjunction fallacy. In certain cases, people erroneously view a specific event as more likely than a more general event. The idea that Linda is a feminist matches what we know about her. However, a feminist bank teller is also a bank teller. There's no way Linda is more likely to be a feminist bank teller than to be a bank teller.

While many of the standard examples used in this survey have been criticized on various grounds, perhaps none have been criticized as much as the Linda fallacy here (e.g. Hertwig and Gigerenzer, 1999). The main objection has typically been that the results are highly sensitive to changes in word choice. This criticism is accurate. Rephrasing the question to prime or educate respondents to evaluate the situation in terms of Venn diagrams and proportions does mitigate the effect. Moldoveanu and Langer (2002b) further argue that respondents choosing among statements describing possible worlds rather than a single world are answering perfectly rationally from a Bayesian perspective, and respondents choosing among possible scientific explanations are answering perfectly rationally from a Popperian perspective.

Nevertheless, for the purposes of our study, we are exploring whether induced Langerian mindfulness by itself, with no specific education or priming about the actual questions, situations, or biases, can in fact increase the responses of the traditionally rational choice.

3. Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. Which is more probable?

   a. **Linda is a bank teller**.
   b. Linda is a bank teller and is active in the feminist movement.

Mental accounting. Although money is fungible, people often compartmentalize earnings into different mental accounts (Thaler, 1999). Specifically, traditional economic modeling suggests that people have optimized their lifetime consumption and savings choices at the margin, so that an unexpected financial windfall should be largely saved for the future rather than spent today. While there is no exact right or wrong answer below, we will be comparing the percentage of the windfall earmarked for retirement across the conditions.

4. Suppose you just unexpectedly came into $1000. How much would you put away into your savings for your retirement? Please choose whichever option below is closest to your answer.

   a. $0—nothing into savings for retirement
   b. $250 into retirement
   c. $500 into retirement
   d. $750 into retirement
   e. $1000—all of it into savings for retirement

Anchoring. People tend to anchor to early even unjustified estimates (Tversky and Kahneman, 1974). In this series of questions, people are asked first to consider whether a number is higher or lower than (effectively) a random number. The correct answer, in fact, is $14 million (AP, 2008). We will compare the differences between early-birthday (15th of the month or earlier) guesses and late-birthday (16th of the month or later) guesses across the conditions, normalized to percentages of $15 million.

5. What day of the month is your birthday (1–31)?
6. Let's call that number you wrote above "X". So X is the day of the month you were born. Please think about that number in terms of millions of dollars. In 2008, Brad Pitt and Angelina Jolie sold the rights to the baby photos of their children to two celebrity magazines, with the proceeds going to charity. Without looking it up, do you think they sold the photos for more, or less, than $X million? Remember that X is your number from above.

   a. More
   b. Less

7. Without looking it up, what's your best guess of how much they sold the rights for, in millions of dollars? Please write the number that represents your best guess; for example, if you think it is $15 million, type in 15.

Gambling fallacies. Tossing a fair coin a few times should not substantially change our assessment of the next coin toss, but it often does. People who expect a surprising but short run of heads to continue are performing a hasty generalization. People who expect it to turn around because tails is somehow "due" are operating under the gambler's fallacy (Oppenheimer and Monin, 2009).

8. If you take a coin that you happen to have out of your pocket, and you toss it high in the air in five times, and it surprisingly comes up heads all five times, what do you think will happen if you toss it one more time?

   a. More likely to come up tails
   b. **Equally likely to come up heads or tails**
   c. More likely to come up heads

Confirmation bias. The Wason (1968) selection task highlights the confirmation bias we have when looking for evidence relating to a rule. When mindless, we tend to look for evidence conforming to what we believe, rather than looking to disprove our hypothesis.

9. Below are four cards. You would like to evaluate whether the following rule is true: "Any card that has a vowel on one side will have an even number on the other side." Turn over only those cards that you need to, in order to check the rule.

   a. Turn over card 3 only.
   b. Turn over cards 1, 2, 3, and 4.
   c. **Turn over cards 3 and 4 only**.
   d. Turn over cards 1, 3, and 4 only.
   e. Turn over cards 1 and 3 only.

Positional bias. Hill and Buss (2006) define positional bias as the over-weighting of relative vs. absolute value, particularly in deciding between two incomes.

It is true that living in a neighborhood where you are slightly wealthier than average can have some advantages over living in a neighborhood where you are slightly less wealthy than average. Those advantages can possibly persist even if the second neighborhood has a higher absolute amount of wealth. However, if we limit the question to sufficiently similar opportunities where cost of living and similar issues do not matter, the more rational response would be to take the higher salary, all the more so if it is at a firm with more growth potential.

10. Which of these two job offers would you prefer? Assume there are basically no other differences between the two opportunities.

    a. **A job paying $44,000 in a firm where the average salary is $50,000**
    b. A job paying $42,000 in a firm where the average salary is $38,000

Emotional attachment. Psychologically, there is a difference between asking how much you would pay for a particular dog and asking how much you would have to be paid to give up your dog, and it is not unreasonable if mindful people exhibit a difference.

For relatively fungible consumer items such as tickets, however, it is irrational to refuse to sell, because you would not have paid this much for the item, and if you sell it for such a large profit, you can likely find a close substitute.

Kahneman et al. (1991) argue that the phenomenon in the question below is an endowment effect, but Shu and Peck (2011) have shown that emotional attachment can explain or mediate many of the endowment effect findings in the literature, and Martinez et al. (2011) show that inducing regret and disappointment can either eliminate or even reverse the endowment effect, respectively. Thus, this is better viewed as an emotional attachment question.

The question below focuses on the emotional attachment with a strong reference to love.

11. A few days ago, you bought a ticket to a sold-out concert. You really love their music and would have paid up to $500 for the ticket, but you got a great deal and were able to buy it for only $200. Today, you notice that richer or more desperate fans on the internet would pay up to $3000 for your ticket. Would you sell it?

    a. **Yes, I would sell it**
    b. No, I would not sell it

Fairness. Raising the price of a good following a sudden boost in demand increases the chance that the good goes to the highest utility purchasers. In the example below, rather than just one person purchasing the shovel to shovel their driveway and then shove the shovel into their garage, maybe now it would be purchased by an enterprising youth who would then offer to shovel many people's driveways. Kahneman et al. (1986) showed that fairness considerations such as these restrict market pricing mechanisms.

12. Your local hardware store has been selling snow shovels for $15. This morning, after a very large snowstorm, the store raises the price to $20. How would you rate this action by the store?

    a. **Completely fair**
    b. **Acceptable**
    c. Unfair
    d. Very unfair

Availability bias. We think whatever is easy to recall is more likely, and because it is far easier to recall words that start with a certain letter than words that have a certain letter in the third place, that could lead us to error. Recall the discussion in the introduction that the original version of this standard question (Kahneman, 2011, p.7) erroneously asked about the letter K.

13. Consider the letter R. Is R more likely to appear as the first letter in a word, or as the third letter?

    a. R is more likely to appear as the first letter in a word
    b. **R is more likely to appear as the third letter in a word**

Equiprobability Illusion. This is a reworded example of the Monty Hall problem, which has been explained variously as relating to the endowment effect (Kahneman et al., 1991), status quo bias (Samuelson and Zeckhauser, 1988), or omission vs commission regret avoidance (Gilovich et al., 1995). It can also be thought of as a failure to apply proper Bayesian updating or conditional probabilities. Tubau et al. (2015) argue that it at least partly represents an equiprobability illusion in which people wrongly update all remaining options to be equally likely after the elimination of a third option. The correct way to think of the example below is to note that at the beginning, Al had a one-third chance to be a pro. Bob beat Carl so Carl is definitely not the pro, so the remaining two-thirds probability must go to Bob.

14. You see three people named Al, Bob, and Carl wanting to play chess at a public park. You know that two of them are equally ranked amateurs, and one is a pro who will always beat either amateur, but you don't know which one is the pro. They ask you to match them up in a tournament. You randomly guess that Al is the pro so you have Bob and Carl face off first. Bob wins that game, and now will face Al for the championship. If you had to bet, who do you now think is the pro?

    a. Al
    b. **Bob**
    c. Carl

Representativeness bias. When we evaluate a person based almost solely on their stereotypical traits, we are engaging in representativeness bias. We ignore the fact that there are far more farmers than librarians, and Steve is far more likely to be a slightly odd farmer than a stereotypical librarian.

15. An individual has been described by a neighbor as follows: "Steve is very shy and withdrawn, invariably helpful but with very little interest in people or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail." Is Steve more likely to be a librarian or a farmer?

    a. Librarian
    b. **Farmer**

Base rate neglect. It would be unreasonable to expect people to accurately calculate the right answer, but our intuitions should not lead us as far astray as they tend to here. We anchor to the large 90 and 95% numbers and erroneously conclude that we are quite likely to have the cancer identified by the screening test. We ignore the base rate that it is in fact a very rare kind of cancer.

16. There is a type of cancer that afflicts 0.1% of the population. A screening test correctly identifies the cancer 90% of the time when it is truly there, and correctly reports there is no cancer 95% of the time when it is truly not there. You take the screening test and it reports that you have the cancer. What is the probability that you really do? Please pick the answer closest to your best guess of the probability.

    a. Definitely 0%—you do not think there is any chance you have the cancer
    b. Between 0 and 0.1%
    c. **Between 0.1 and 5%**
    d. Between 5 and 40%
    e. Between 40 and 60%
    f. Between 60 and 90%
    g. Between 90 and 95%
    h. Between 95 and 99.9%
    i. Definitely 100%—you are completely sure you have the cancer

Inattentional blindness. We often filter out short common words when preoccupied with another task. Rayner et al. (2011) show that short, predictable words are often skipped. For example,

mindless people often miss the duplicate *the* in the following phrase:

17. How many occurrences of the letter "F" are there in this sentence: "FINISHED FILES ARE THE RESULT OF YEARS OF SCIENTIFIC STUDY COMBINED WITH THE EXPERIENCE OF YEARS."

a. 1	b. 2	c. 3	d. 4
e. 5	**f. 6**	g. 7	h. 8

Overconfidence. When forecasting, we tend to be overly confident in our first point estimate, failing to make the range around it large enough (Russo and Shoemaker, 1992).

The standard deviation of high daily temperatures in New York City is 10–15 degrees Fahrenheit. Thus, a proper two-standard-deviation confidence interval around 70 would range from 40 to 100, or from 50–90. Either of those two answers counted as "rational" here.

18. Suppose you had to predict the high temperature of the day for New York City 2 months from now. Suppose your best guess is that it will be 70 degrees Fahrenheit. What would be the range of your estimate, so that you would be 95% confident that the real temperature 2 months from now will in fact be in that range?

    a. 69–71
    b. 65–75
    c. 60–80
    d. **50–90**
    e. **40–100**

Endowment effect. This experiment is the clearest example of an endowment effect (Langer, 1975 and Kahneman et al., 1990) because it offers you the opportunity to double your chances of winning without losing anything, particularly since neither you nor the questioner even have knowledge, irrelevant as it may be in any case, of what random numbers were on your ticket. Furthermore, this experiment distinguishes from the concert ticket question above, in which psychological ownership is tied to a pre-existing emotional attachment. It is more in line with van Dijk and van Knippenerg (1996) in that the future value of the exchange good is uncertain, by definition of being a lottery ticket.

19. You just paid $1 for a lottery ticket with random numbers, and you haven't seen the numbers yet, when suddenly someone offers to pay you $2 for your lottery ticket. (They haven't seen your random numbers yet either.) There is still plenty of time for you to buy more lottery tickets before the drawing. Would you sell your ticket for $2?

a. **Yes**	b. No

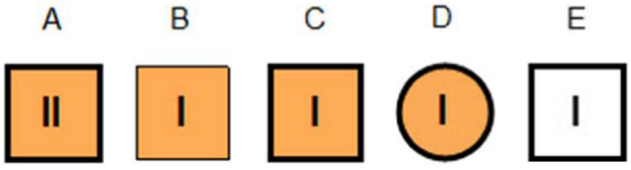
Overdiversification bias. If the choices below were simply labeled one through ten, we would probably recognize that the first five are the optimal choices. However, with the coin toss involved, we want to feel like we are "in it to win it," which causes us to overdiversify and choose some suboptimal tails.

20. There are two envelopes in front of you, one labeled Heads and one labeled Tails. Each envelope has five poker chips numbered from one to five. We'll flip a fair coin, then draw a random number from the indicated envelope. So there are ten possibilities (Heads 1…Heads 5 and Tails 1…Tails 5), but you can only pick three. If you correctly predict heads and the right number, you get $3. If you correctly predict tails and the right number, you get $2. Please select three of these possibilities.

a. Heads 1	f. Tails 1
b. Heads 2	g. Tails 2
c. Heads 3	h. Tails 3
d. Heads 4	i. Tails 4
e. Heads 5	j. Tails 5

Leaping to conclusions. This question is essentially the Salzman test (Turner, 2008). We often leap to our first conclusion. Instead, being able to pause and attempt another solution can often reveal that we are missing an important consideration. The correct answer is the middle shape, the only one with no unique characteristics: the first one is the only one with two bars, the second is the only one with a thin border, the fourth is the only circle, and the fifth is the only one with a white background.

21. Which of these does not belong? (There is only one correct answer.)



    a. A
    b. B
    c. **C**
    d. D
    e. E

Cognitive reflection. The Frederick (2005) cognitive reflection tests consists of three problems, of which this is the first, that test for people's abilities to pause and re-evaluate their answers even after being strongly cognitively pulled to a compelling first response.

22. A bat and a ball cost $110 in total. The bat costs $100 more than the ball. How much does the ball cost? Numerical responses required.

Correct response: 5.

Table 1 Average responses and 95% confidence intervals to the Langer mindfulness survey 14 (LMS14).

		Mindless	Low Mindful	Not Mindful	Mindful
NS	I like to investigate things	5.39 [4.92, 5.87]	5.44 [4.93, 5.94]	5.42 [5.08, 5.76]	**5.72 [5.23, 6.21]**
NP	I generate few novel ideas [*]	2.82 [2.14, 3.49]	3.58 [2.97, 4.19]	3.20 [2.74, 3.65]	**3.97 [3.37, 4.57]**
NP	I make many novel contributions	4.21 [3.65, 4.77]	4.18 [3.64, 4.72]	4.19 [3.82, 4.57]	**4.47 [3.92, 5.02]**
E	I seldom notice what other people are up to [*]	4.00 [3.47, 4.53]	4.41 [3.89, 4.93]	4.21 [3.84, 4.58]	4.00 [3.41, 4.59]
E	I avoid thought provoking conversations [*]	4.55 [4.02, 5.09]	4.72 [4.24, 5.20]	4.64 [4.29, 4.99]	**4.88 [4.34, 5.41]**
NP	I am very creative	4.53 [3.99, 5.07]	4.44 [3.88, 4.99]	4.48 [4.10, 4.86]	**4.53 [3.96, 5.10]**
NS	I am very curious	5.50 [4.99, 6.01]	5.36 [4.88, 5.84]	5.43 [5.09, 5.77]	**5.44 [4.86, 6.02]**
NS	I try to think of new ways of doing things	5.26 [4.78, 5.74]	5.33 [4.85, 5.82]	5.30 [4.97, 5.63]	**5.47 [4.88, 6.06]**
E	I am rarely aware of changes [*]	4.74 [4.34, 5.13]	4.59 [4.09, 5.09]	4.66 [4.35, 4.97]	**4.75 [4.38, 5.12]**
NS	I like to be challenged intellectually	5.50 [5.01, 5.99]	5.33 [4.83, 5.83]	5.42 [5.07, 5.76]	**5.88 [5.43, 6.32]**
NP	I find it easy to create new and effective ideas	4.63 [4.08, 5.18]	4.46 [3.87, 5.05]	4.55 [4.15, 4.94]	**4.69 [4.08, 5.29]**
E	I am rarely alert to new developments [*]	4.71 [4.30, 5.12]	4.33 [3.81, 4.86]	4.52 [4.19, 4.85]	4.31 [3.88, 4.75]
NS	I like to figure out how things work	5.50 [5.04, 5.96]	5.38 [4.89, 5.88]	5.44 [5.11, 5.77]	5.28 [4.69, 5.87]
NP	I am not an original thinker [*]	3.97 [3.44, 4.51]	4.05 [3.48, 4.63]	4.01 [3.63, 4.40]	**4.34 [3.78, 4.91]**

The *Not Mindful* category merges the *Mindless* and *Low Mindful* conditions. Questions marked [*] had their numerical values x replaced with $7 - x$. Trait groups are notated as novelty-seeking (NS), novelty producing (NP), or engagement (E). Questions for which the *Mindful* average exceeded the *Not Mindful* average are highlighted.

Shallow thinking. If all people were perfectly rational and it was common knowledge that all people were perfectly rational, the only correct response would be zero in this version of the Nagel (1995) game. In practice, the lower the guesses, the better they tend to be, except for those who guess zero, as they are incorrect in presuming that others are equally rational. Thus, rather than comparing the proportion answering zero, we convert the responses to percentages and compare their remainders when subtracted from one, so that the computed number represents the portion of the way towards zero, so that higher numbers correspond to more rationality.

23. A lot of people are going to answer this survey. For this question, they (and you) will all choose a number between 0 and 100. What do you think will be half the average of everybody's answer to this question? Please respond with a number between 0 and 100.

Disposition effect. We often hold on to losing positions too long (Shefrin and Statman, 1985). This disposition effect is a form of sunk cost fallacy because if we were to accidentally sell out the position, we would not later attempt to re-establish it, even without transactions costs.

24. You bought one-hundred shares of a stock when it cost $50. It now costs $30. You no longer like the stock: if you weren't already an owner of the stock, you would not want to buy it now. What do you want to do with the shares that you do currently own?

    a. Hold on no matter what until the price gets back to $50 or higher, then sell
    b. **Sell now**
    c. Sell if it drops even lower to $15, or if it gets back up to $50

Results

Mindless and Low Mindful were both Not Mindful. Table 1 below reports the average responses to each of the 14 questions of the LMS (LMS14) for each of the three conditions *Mindless*, *Low Mindful*, and *Mindful*, as well as for the combined *Not Mindful* category comprising all respondents in either of the two non-*Mindful* conditions.

The highlighted values in Table 1 represent the eleven out of the fourteen questions for which the *Mindful* responses were above the *Not Mindful* responses. For ten of those eleven, the *Mindful* responses were also greater than the higher of the *Mindless* or *Low Mindful* conditions.

Under the null hypothesis that there is no difference between *Mindful* and *Not Mindful* responses, relative to the alternative hypothesis that *Mindful* responses should be higher, the probability of randomly observing eleven out of fourteen in this manner, i.e. $\frac{1}{2^{14}}\sum_{k=11}^{14}\binom{14}{k}$, is <2.87%. So we can reject the null. Thus, it is reasonable to combine those two into a single *Not Mindful* category, which we will do for the remainder.

In other words, there is effectively no difference between the presumed mindless state of a typical respondent and the state after a mild intervention. The results we will see for mindfulness, therefore, do not arise from the activities of comparing photos, spotting differences, or listing objects.

Respondents in the Mindful Condition became more Mindful. The three primary traits measured by LMS14 and notated alongside each question in Table 1 are novelty-seeking, novelty producing, and engagement. Table 2 below summarizes those traits.

Two of the three individual questions for which the *Mindful* condition did not exceed the *Not Mindful* responses are in engagement, and indeed the average *Mindful* engagement was 4.48 compared with 4.50 for the *Not Mindful*. Indeed, average engagement hardly changed across any of the conditions. For the two novelty traits, however, the *Mindful* averages of 5.56 for novelty-seeking and 4.40 for novelty producing were each above the *Not Mindful* averages of 5.40 and 4.09, respectively, and above each of the *Mindless* and *Low Mindful* conditions, though not at an individually statistically significant level.

Furthermore, since the *Mindful* intervention focused on seeking and producing novelty, it is perhaps not a surprise that engagement was unaffected overall. Future interventions could attempt to increase engagement as well.

Mindful respondents were more "Rational". Table 3 shows the average responses for each Scenario question. The average *Mindful* response was higher, meaning it was more in line with

Table 2 Average responses and 95% confidence intervals to the three traits of the Langer mindfulness survey 14 (LMS14).

		Mindless	Low Mindful	Not Mindful	Mindful
NS	Novelty-seeking	5.43 [5.30, 5.56]	5.37 [5.32, 5.42]	5.40 [5.33, 5.47]	**5.56 [5.26, 5.85]**
NP	Novelty producing	4.03 [3.13, 4.94]	4.14 [3.70, 4.59]	4.09 [3.41, 4.76]	**4.40 [4.06, 4.74]**
E	Engagement	4.50 [3.95, 5.05]	4.51 [4.24, 4.79]	4.51 [4.17, 4.84]	4.48 [3.84, 5.13]

Traits for which the *Mindful* average exceeded the *Not Mindful* average are highlighted.

Table 3 Proportion of respondents answering rationally.

	Not Mindful	Mindful	Difference
Loss aversion	44.16%	31.25%	−12.91%
Hyperbolic discounting	89.61%	87.50%	−2.11%
Conjunction fallacy	31.17%	53.13%	**21.96%**
Mental accounting	48.70%	58.59%	**9.89%**
Anchoring	19.18%	27.01%	**7.83%**
Gambling fallacies	83.12%	84.38%	**1.26%**
Confirmation bias	15.58%	21.88%	**6.29%**
Positional bias	76.62%	78.13%	**1.50%**
Emotional attachment	62.34%	46.88%	−15.46%
Fairness	68.83%	75.00%	**6.17%**
Availability bias	48.05%	62.50%	**14.45%**
Equiprobability illusion	72.73%	78.13%	**5.40%**
Representativeness bias	37.66%	46.88%	**9.21%**
Base rate neglect	11.69%	15.63%	**3.94%**
Inattentional bias	40.26%	56.25%	**15.99%**
Overconfidence	48.05%	53.13%	**5.07%**
Endowment effect	63.64%	71.88%	**8.24%**
Overdiversification bias	45.45%	46.88%	**1.42%**
Leaping to conclusions	27.27%	28.13%	**0.85%**
Cognitive reflection	61.04%	75.00%	**13.96%**
Shallow thinking	70.82%	77.34%	**6.53%**
Disposition effect	29.87%	40.63%	**10.75%**

Positive differences between the Mindful and Not Mindful numbers are highlighted.

the traditional rational answers, in nineteen out of the twenty-two questions. In other words, yes, mindfulness increases rationality.

Figure 1 plots the mindful rationality vs the mindless rationality for each of the 22 questions, as well as the identity line to visualize the differences. It also shows a cumulative count of the number of biases for which either mindful or mindless respondents scored better.

Following the same non-parametric estimation method above, the probability of observing 19 or more heads out of 22 coin tosses, $\frac{1}{2^{22}}\sum_{k=19}^{22}\binom{22}{k}$, is <0.04%, meaning less than one in two thousand. Similarly, a regression of the 22 pairs of numbers yields a p-value of 3% with a functional form that can be summarized simply: for any bias measured on a scale of zero to one-hundred, a mindful person scores ten points higher on average.

The statistical power of this test is the probability of properly rejecting the no-difference null hypothesis when the improvement alternative hypothesis is actually correct. The probability of observing a higher mindful score than a non-mindful score, given our sample sizes and a ten percentage point improvement as the alternative hypothesis, is:

$$\Pr(m/32 > n/77 | m \sim B(32, .6), n \sim B(77, .5)) = 0.83$$

where $B(k,p)$ represents the binomial distribution with k trials having success probability p.

Therefore, the expected number of biases out of 22 to correctly reflect a mindful improvement is: $E(x|x \sim B(22, 0.83)) = 18.3$ In a separate but similar analysis when comparing the performance of all respondents grouped by their LMS14 scores, those scoring above the mean outperformed those scoring below on 17 out of the 22 biases. In other words, across all subjects, those who scored as more mindful were also more "rational."

Discussion

Mindfulness increased survey rationality in 19 of the 22 cognitive biases. Furthermore, subjects induced to be mindful did in fact become more mindful on the Langer mindfulness scale. In light of this large effect and explanation, it is interesting to consider why it did not appear to work in the three remaining biases.

Hyperbolic discounting. Approximately, 90% of even mindless people answered that question rationally, leaving hardly any room for improvement.

Emotional attachment. Note the difference between the emotional attachment question in which respondents decided whether or not to sell their *concert* tickets at an inflated price and the endowment effect question in which respondents decided whether or not to sell their *lottery* tickets at an inflated price. A concert ticket indicates a pre-existing emotional attachment with the band, the music, the culture, and the like. A lottery ticket does not. While much psychological literature refers to both the concert and lottery ticket as examples of the endowment effect, we see here through the lens of mindfulness that they are different in intensity.

Loss aversion. Mindful respondents reject positive expected value gambles even more forcefully than mindless ones, opting for the small sure thing instead. Perhaps probability assessments have certain patterns of learning (e.g. Estes, 1976) that appear the same as loss aversion among mindful participants. Alternatively, since this question was the first one they were exposed to, and the sure thing is the first option, and the subjects can see on the form that there are more questions to follow, and the subjects understand that it's not real money anyway, and they correctly view it as a contrived, context-less example, perhaps it is sensible for the mindful subjects to simply answer with that first, sure option, and go on to the more interesting and engaging and context-dependent questions below.

Implications, limitations, and future research

Mindfulness increases rationality because it improves decision-making by reducing behavioral biases. Moreover, the Langerian method by which mindfulness is induced here is easy and quick: just notice three new things. Incorporating mindfulness takes virtually no time and is likely to increase the rationality of decision-making by ten points on a one-hundred point scale.

One important potential limitation of this study is the absence of demographic controls, at odds with recent experimental

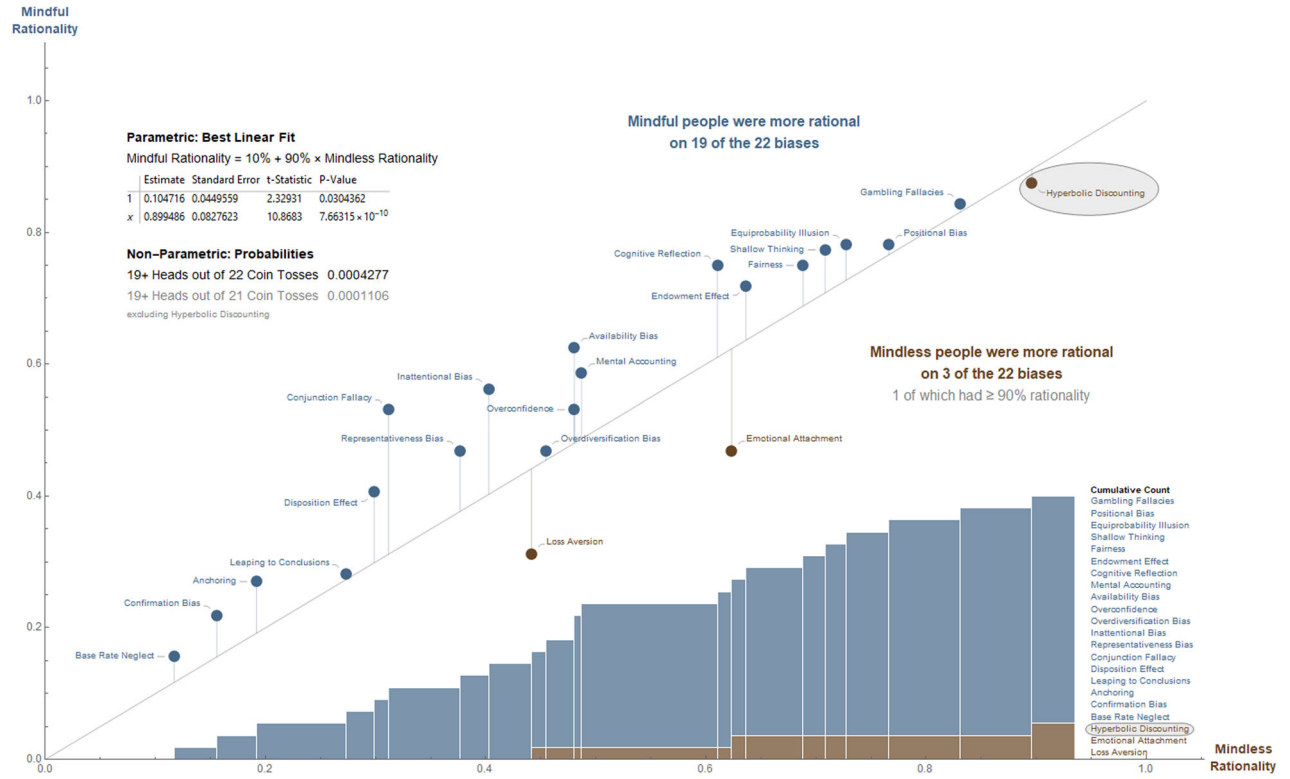


Fig. 1 Mindful vs. mindless rationality. Average mindful rationality vs. average mindless rationality for each of the 22 questions, as well as the identity line to visualize the differences. Below is a cumulative count of the number of biases for which either the mindful or mindless respondents scored better. Estimates from a linear regression and non-parametric probabilities are also shown.

literature that has shown that experimental results differ significantly according to demographic characteristics such as age class, employment vs. student status, gender, etc.. Future research may show that such variables could make a difference to the findings.

Loss aversion merits further, separate investigation. The standard question for that bias involves asking subjects to choose between two prospects, some of which may be riskless and some of which may involve risk or uncertainty or loss. This is an arguably mindless way of looking at alternatives, but also very consistent and clear, so could be a good testbed to see in what cases and in what directions mindfulness impacts responses. That future work should vary the order of the questions and answer options, add context, and ask more questions with different parameters.

Data availability

The datasets generated and analyzed during the current study are available in the Wolfram Data Repository with UUID 1ad960b4-04b4-4a2f-8763-86de337de18b.

Received: 31 July 2020; Accepted: 11 January 2021;
Published online: 03 February 2021

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Acknowledgements

We are grateful for useful comments, suggestions, and discussions to Stuart Albert, Peter Aungle, Jay Olson, Francesco Pagnini, and Dasha Sandra.

Competing interests

The authors declare no competing interests.

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