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The law of large numbers and beliefs about luck: An asymmetry in recognition of the risks and benefits of chance

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ABSTRACT

Three studies (n = 655) examined beliefs about chance, focusing on participants' recognition of some implications of the principle that small samples are more subject to chance fluctuation. Participants consistently demonstrated an asymmetry in their views about luck. Although they tended to recognize the possible decrements of chance fluctuation, they consistently failed to appreciate its potential benefits, especially in a context in which the outcome was largely contingent on factors under their personal control. Participants preferred a 100 question exam to a 10 question exam, correctly believing that an atypically low score was more likely with fewer questions. In contrast, they failed to recognize that an atypically high score was also more likely with fewer questions, and preferred the long exam even when there was no possible detriment from a low score and a potential benefit from a high one. This asymmetry was reduced, although not eliminated, in a ball drawing task in which the outcome was entirely chance determined. Results suggest that people associate chance fluctuation with bad luck more than with good luck, and are therefore reluctant to exchange control for the possible benefits of chance.

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> "The key to winning the game is maximizing the good luck and minimizing the bad luck."Yul Kwon, winner of CBS "Survivor: Cook Islands", December, 2006.

> "What does chance ever do for us?"William Paley

> "Depend on the rabbit's foot if you will, but remember it didn't work for the rabbit."R.E. Shay

Introduction

Survivor, a long running CBS "reality" show, features a contest involving physical, cognitive, and interpersonal skills, as well as the occasional deployment of some Byzantine stratagems of deception. Given the skill dependent nature of the game, it may seem bizarre for a winner of that contest to stress the importance of luck. The above quotation from Yul Kwon, however, represents an acknowledgment that, even when the outcome is largely controlled by the effort and ability of the players, it is still possible to benefit from the vicissitudes of fortune. In the choices that people make, they can position themselves not only to avoid the pitfalls of chance, but also to take advantage of its windfalls. Particularly when outcomes are determined by skill and ability, however, we suggest that people's view of chance is more consistent with the last two beginning quotations. Although people may recognize the risks that are presented by chance, its benefits may be less obvious. They may be better at minimizing their bad luck than at maximizing their good luck.

The law of large numbers revisited

The principle most relevant to these studies is known as "the law of large numbers" (LLN), first identified by the eighteenth century mathematician Jacob Bernoulli (Nickerson, 2004). The law simply holds that large samples are more reliable—they are more likely than small samples to closely resemble the population from which they are drawn. Although Bernoulli claimed that this theorem was intuitively obvious, research on understanding of the principle has yielded mixed results (see Nickerson, 2004, for a summary). In their well known study of the maternity ward problem, for example, Kahneman and Tversky (1972) asked participants to choose which of two hospitals, a large one or a small one, was more likely to record more days on which more than 60% of the babies born were boys. Most participants either chose the larger hospital or saw no difference between the two, failing to recognize that deviations from the population mean of about 50% were more likely with a smaller sample.

In contrast, Nisbett, Krantz, Jepson, and Kunda (1983) contend that people do indeed have some intuitive understanding of the principle. They argue that the extent of this understanding may vary with the context, with the domain of the samples, and with their relative size.

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It seems obvious, for example, that most people would place more confidence in a poll of 100 people than in a poll of 10. Somewhat more recent research has suggested that the effects of variations in sample size may be influenced by so-called "hot" cognitions, related to perceived personal relevance and motivation. In Darke et al. (1998), for example, participants who were led to believe that a proposed exam policy might affect them, and were presumably motivated to scrutinize information more closely, based their attitudes on poll information only if the poll was reliably large. Those who believed that they would not be affected by the policy, in contrast, were influenced regardless of poll size.

Sample size, luck, and personal control

The findings of Darke et al. (1998) suggest that people may be sensitive to variations in sample size when the potential for large chance fluctuation harbors potential relevance, either real or hypothetical, for them. To test this hypothesis, we asked people to imagine themselves in a situation in which their grade in a college course was contingent on their score on the final exam. Under the LLN, their "true average" (their past average on all previous exams in this course) is more likely to be reflected by a final of 100 questions than by a final of only 10 questions. To assess their understanding of the implications of this principle, we asked them to suppose that they had an average of 90% on prior exams in a course, entitling them to a grade of A in the class, but that under the grading policy of the instructor only students who answered at least 80% of the questions correctly on the final would receive an A. Given the research on personal relevance, we expected people to recognize the applicability of the LLN and the greater hazard to their grade that was presented by the less reliable short exam. Accordingly, we predicted that they would prefer the 100 question final, which involved less chance of a score substantially lower than their "true average."

But what would people choose if the short exam entailed no potential negative consequences, but only the greater likelihood of a substantial benefit? In another scenario, we asked participants to imagine that their average grade on prior exams was 80%, entitling them to a B, but also to suppose that the instructor, in a burst of end-of-term generosity, promised an A to everyone who received a score of at least 90% on the final. In addition, we instructed them to assume that, having taken all prior exams in the class, they had the option of simply dropping the grade on the final exam if less than 90% of their answers were correct. Accordingly, they were guaranteed at least a B in the course, regardless of the score on the last exam. In this way, we changed the circumstances so that chance was no longer a potential "spoiler", but a potentially useful ally. Presented with this scenario, would most people realize that the short exam offered the greater opportunity for "lucking out" (by attaining a score that exceeded their past average) and choose it instead of the longer version?

We believed there were reasons for proposing an asymmetry in participants' recognition of chance effects. If people recognize that a score on a long exam is less subject to chance fluctuation, they will also tend to believe that it is more under their control—e.g., more likely to be affected by their preparation for, and effort on, the exam. Past research demonstrates that people generally prefer to be in control (Inglehart & Weizel, 2005; Langer & Rodin, 1976), and this motivation may contribute to a consistent preference for the long exam.

Relatedly, preference for a long exam may also be influenced by a biased perception about chance outcomes—a belief that may underlie the desire for control. Although people undoubtedly value freedom of choice and dislike the unpredictability of arbitrary events, research suggests that their preference for control may also be rooted in a belief that random events are not really random. People, that is, may tend to associate chance with bad outcomes more than with good.

This bias is suggested by attribution research, which demonstrates that people take personal credit for positive outcomes, but tend to ascribe negative outcomes to bad luck (e.g., Langer & Roth, 1975). Similarly, Gilovich and Douglas (1986) report that participants recognize the role of fluke events in producing their losses, but do not credit fluke events for their wins. More recently, Risen and Gilovich (2007) complement this research by demonstrating a negativity bias in estimations of the likelihood of some specific chance-determined events. Their participants believed that it was less likely that their own ticket would win the lottery than that the lottery would be won by a person who had acquired the winning ticket from the participant. Particularly aversive chance outcomes (e.g., a disliked person winning the lottery with the exchanged ticket) were seen as especially likely. Finally, Risen and Gilovich (2008) also demonstrate that people believe that it is bad luck to tempt fate—i.e., people assume that taking risks that expose oneself to chance makes negative outcomes more likely than positive ones.

These studies hint at a general proposition: People may be reluctant to surrender their control to a universe that they believe is not only capricious, but somewhat malicious to boot. Accordingly, they may forego the potential benefits of chance.

In these studies we extend research by examining recognition of the risks and benefits of chance fluctuation. Study 1 investigated exam preference in each of the above described scenarios. Because a short exam poses greater possibility of a chance-related loss (an atypically low score), we predicted that participants would prefer a long exam when a low score would decrease their grade. Because they might be less cognizant of the benefits of chance, however, we also predicted that they would fail to choose the short exam in a situation that presented substantial gain from an atypically high score and no potential detriment from a low one. Study 2 compared probability estimations and preferences in the exam context, in which ability and effort are important determinants of the outcome, with probability estimations in a ball-drawing context, in which the outcome was entirely chance-determined. Study 3 examined participants' responses when they believed that they would be rewarded for correct answers. Finally, Studies 2 and 3 also examined participants' beliefs about good luck, bad luck, and personal control, as well as the relation between these measures and sample choice.

Study 1

Method

Participants

Participants were 136 undergraduates (110 women and 26 men) at the University of California, Davis.[1]

Design, procedure, and dependent measures

In a within-participant design, participants were asked to imagine themselves in each of two scenarios, described on separate pages. Order of scenarios was counterbalanced between participants.

> (Potential Loss Scenario) You have worked hard in a particular course, and at the end of the quarter you have an average of 90% on the exams. This would entitle you to a grade of "A". Under the grading policy of the instructor, however, you will receive a final grade of "A" in the class only if you answer at least 80% of the questions correctly on the final. Assume that achieving an "A" is very important to you, and also assume that questions on each of two exams have been randomly selected from the same pool of 1000 questions. Although these questions vary in their level of difficulty, on average they are neither easier nor more difficult than previous exam questions in the course.

[1] In all studies described in this article, participants were randomly assigned to the between-participant conditions. All participants were undergraduates at the University of California, Davis, and received credit in a psychology course for their participation.

After reading the potential loss situation, participants indicated their preference between a 10 question and a 100 question multiple choice exam. Preference was indicated on a nine-point scale, with one endpoint reading "I would strongly prefer to take the 10 question exam" and the other reading "I would strongly prefer to take the 100 question exam." The midpoint 5 was labeled "no preference." The labels on the scale endpoints were counterbalanced between participants.

> (Potential Gain Scenario) You have worked hard in a particular course, and at the end of the quarter you have an average of 80% on the exams. This would entitle you to a grade of "B". Under the grading policy of the instructor, however, you will receive a final grade of "A" in the class if you answer at least 90% of the questions correctly on the final. Because you have taken all of the other exams during the quarter, you have the option of dropping your grade on the final if you answer less than 90% of the questions correctly. Consequently, you are guaranteed at least a "B" in the course, regardless of how well you do on the final exam.

As in the potential loss scenario, participants then read the final two sentences describing how the questions on each exam had been randomly selected from the same pool of 1000 questions and indicated their preference between exams.

Results and discussion

A univariate analysis of variance (ANOVA) assessed exam preference. Scenario (potential gain versus potential loss) was the within-participant variable. Ratings on the preference scale were reversed in one of the two endpoint label conditions, so that for all participants higher numbers denoted a stronger preference for the 100 question exam.

Participants preferred the long exam in the loss scenario, $M=6.82$, where the greater potential for chance fluctuation that was presented by the short exam increased the possibility of a lower than average grade. However, they also preferred the long exam in the gain scenario, $M=6.87$, where the greater potential for chance fluctuation inherent in the short exam actually increased the likelihood of an A in the course (without risking a guaranteed B). Responses did not vary between scenarios, $F<1$, and the confidence interval bounds indicated that both mean preference ratings were significantly higher than 5, the "no preference" midpoint of the scale, $ps<.0001$. Further ANOVAs showed that neither the order in which the scenarios were presented nor the order of labels on scale endpoints affected preferences, $Fs<1$.

In sum, these results show that participants are sensitive to some implications of the LLN. When confronted with the risk of a loss, participants tend to protect their grade by opting for the normative choice of the more reliable exam. In the gain scenario, in contrast, they bypass the opportunity to "luck out" and increase their grade by getting 9 out of 10 questions correct on the shorter test. Instead, they make a counternormative choice, preferring the exam more likely to replicate their past 80% performance.[2]

[2] A follow-up experiment to Study 1, omitted here for the sake of brevity, investigated the possibility that participants may not have realized that their exam choice in the potential gain scenario was "risk free"—that their prior average entitled them to a grade of "B" and that this guaranteed grade could not be decreased by a low score on the final. After having read and rated their preference in the vignette describing the potential gain situation, only 3 of the 90 participants did not recall their guaranteed grade. As in Study 1, participants in this study significantly preferred the long exam in the gain situation, $p<.0001$. Results did not differ according to whether the 3 participants who did not recall their grade were included in the analysis.

Study 2

Although in Study 1 we demonstrated a preference for a long exam, we did not test some basic assumptions about cognitions related to this preference. Specifically, we did not measure beliefs about the relative importance of luck in the two exams. In addition, we did not examine our suppositions that participants believed that a long exam afforded them greater personal control over their score and that estimated control was related to exam choice. We directly addressed these issues in Study 2. Specifically, we measured perceived differences between exams in good luck, bad luck, control, and probability of a successful outcome, as well as the relation between these measures.

In another variation from Study 1, we changed the relevant a priori probabilities. In Study 1 there was obviously more "room" for adverse chance-related effects in the loss scenario (where an abnormally low score of less than 80% would reduce the grade) than for beneficial chance-related effects in the gain scenario (where an abnormally high score of 90% or above would improve the grade). It therefore may have been less apparent to participants that chance factors might increase their score than that chance might decrease it. This possibility raises the question of whether the Study 1 results would replicate when the a priori probabilities allowed equal room for improvement and decline. By setting the past exam average at 50%, we examined this issue in Study 2.

Most important, Study 2 also examined perceived sample size differences in a context in which the outcome was entirely chance-determined. In an exam context, in which the outcome is generally determined by internal causes like ability and effort, people may be especially sensitive to factors, such as small sample size, that might undermine their personal control. This sensitivity, and the desire to maintain that control, may lead to preference for a long exam. When the outcome is not primarily determined by controllable factors, however, the preference for a large sample may be reduced. Accordingly, we made the following predictions for Study 2: Compared to their choices when the outcome is chance-determined, participants in a situation in which the outcome is largely contingent on ability and effort are (1) more likely to avoid the risks of chance by choosing a large sample in the loss scenario, in which that choice is *normative*, but (2) also more likely to forego the benefits of chance by choosing a large sample in the gain scenario, in which that choice is *counternormative*.

Finally, Study 2 included a six item questionnaire in which participants were asked to compare themselves with the "average person." Consistent with research on preference for control, we expected people to rate themselves as above average in desire to control events in their lives. In addition, we expected to validate our assumption that people view chance in negative terms. We expected them to profess below average trust in luck and to view themselves as less lucky than the average person.

Method

Participants

Participants were 308 undergraduates (201 women and 107 men) at the University of California, Davis.

Overview

Participants read a description of a gain scenario and a loss scenario in both an exam context and a context in which the outcome was entirely chance-determined. Context order and order of scenario within context (gain first or loss first) were counterbalanced between participants. Immediately after reading each scenario, participants completed the measures pertaining to it, then proceeded to the next scenario.

Design, procedure, and measures

The two exam scenarios were identical to those of Study 1, except that participants were told that all questions involved one word answers. Departing from Study 1, however, participants were asked to assume that their past average on class exams was 50%. In the loss scenario, we also asked them to assume that this past average entitled them to an 'A', but that to maintain the 'A' they would have to answer at least 40% of the questions on the final correctly. In the gain scenario, we asked them to assume that their past average entitled them to a 'B', but that the instructor had promised an 'A' to anyone who answered at least 60% of the questions correctly. All participants were told that course had been difficult, that their average was higher than that of most people in the class, and that the instructor had lowered grading standards, thus explaining why an average of only 50% entitled them to either an 'A' or a 'B'. As in Study 1, the gain scenario informed participants that they were guaranteed at least a 'B' in the course, regardless of their score on the final.

As in Study 1, dependent measures were rated on nine-point scales, with endpoint labels counterbalanced between participants. First, participants completed a scale to indicate the exam on which their score was more likely to be affected by good luck and another scale to indicate the exam on which their score was more likely to be affected by bad luck. Endpoint labels read "more likely on the 10 question exam" and "more likely on the 100 question exam", whereas the midpoint read "equally likely on the two exams". We counterbalanced order of luck scales between participants.

Following the luck scales, participants completed a scale to assess their belief as to which exam allowed them more control over their score. Endpoints read "more control on the 10 question exam" and "more control on the 100 question exam", whereas the midpoint read "equal control on the two exams." This measure was followed by a scale to assess perceived exam differences in probability of success in attaining the desired score. After the loss scenario, participants were asked "On which exam do you have the greater chance of scoring at least 40%?" (the score necessary to preserve an A). Endpoints read "the chance is greater on the 10 question exam" and "the chance is greater on the 100 question exam", whereas the midpoint reads "the chance is equal between the two exams." After the gain scenario, the question reads "On which exam do you have the greater chance of scoring at least 60%?" (the score necessary to increase the grade to A). Finally, participants completed the preference scale used in Study 1. We added the measure of estimated success probability because exam preference may be affected by factors irrelevant to estimated score. For example, preference estimations may be influenced by the perceived tedium associated with answering the larger sample of questions, or by the inclination to feel less satisfied if a successful result can be attributed to chance. For this reason, the probability of success measure, compared to our measure of exam preference, may be viewed as a more valid assessment of the perceived relation between sample size and successful performance.

To examine sensitivity to sample size when the outcome was entirely chance-determined, we constructed analogous scenarios involving choices in a random ball drawing context. The gain scenario was described as follows:

> You are a contestant on a game show, and you have an opportunity to win $100 by withdrawing a certain percentage of red balls from a large bowl containing 1000 balls. Some of the balls in the large bowl are red, but some are green. To win the $100, you simply have to pick a sample consisting of at least 60% red balls from the large bowl. Unfortunately, only 50% of the 1000 balls in the large bowl are red (whereas 50% are green), and you will have to be blindfolded while you pick balls from the bowl. Although these conditions make your chances of success uncertain, you are allowed to choose the number of balls in the sample that you withdraw from the bowl.

Assume that winning the $100 is very important to you and that the game show host is offering you a choice between two different sample sizes, each to be selected from the same large bowl of 1000 balls.

The loss scenario had a similar structure. It differed only in that participants were told that they had won $100, but needed to succeed on the ball drawing task to keep it. Success constituted withdrawing at least 40% red balls from the bowl in which 50% of the balls were red. Immediately after reading a ball-drawing scenario, participants completed measures analogous to those for the exam scenarios.

As a final task, participants completed the six-item questionnaire assessing preference for control and beliefs about their own luck. Ratings pertaining to the items were made on nine-point scales. Endpoint 1 was labeled "much less than the average person" and endpoint 9 was labeled "much more than the average person." The six items were presented in two random orders, counterbalanced between participants.

Results and discussion

Mean ratings on measures, in terms of difference from the scale midpoint of 5, are illustrated in Figs. 1a and b. Ratings above the midpoint indicate that estimations of good luck, bad luck, control, and probability of a successful outcome are greater for the large sample than for the small, and also indicate greater preference for the large sample. Ratings below the midpoint indicate higher ratings for the small sample.

A 2×2 (Context×Gain Scenario/Loss Scenario) ANOVA on preference ratings revealed the predicted effect for context, F (1, 307) = 28.10, $p < .0001$, and no effect for the gain/loss variable, $F < 1$. Although there was a marginal context by gain/loss interaction, F (1, 307) = 3.78, $p < .06$, separate ANOVAs on ratings in each scenario showed that participants preferred a large sample more in the exam context than in

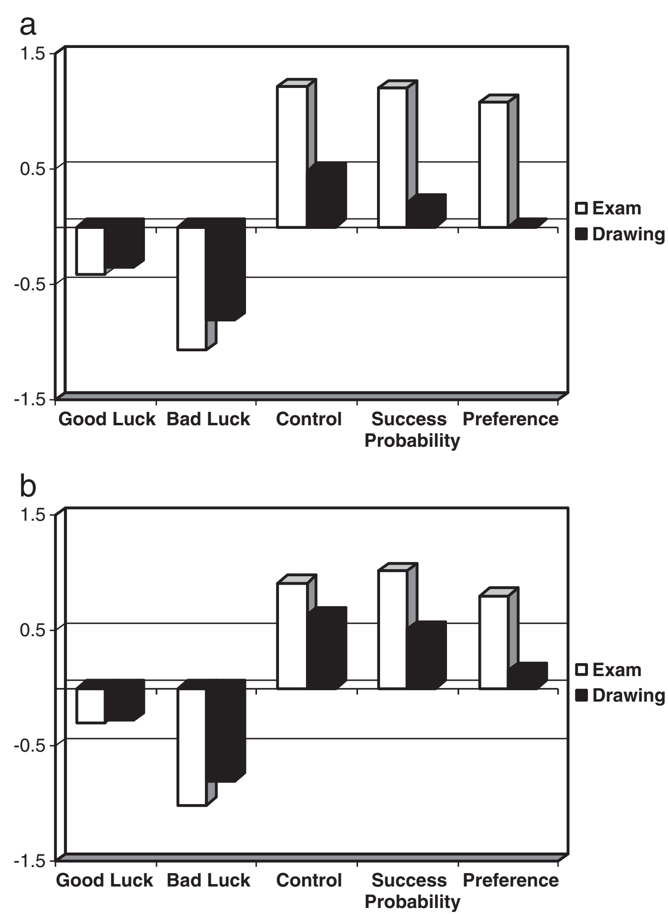

Fig. 1. a. Mean sample ratings in distance from the scale midpoint, gain situation of Study 2. b. Mean sample ratings in distance from the scale midpoint, loss situation of Study 2. Ratings below the midpoint indicate higher relative estimations and greater preference for the small sample. Ratings above the midpoint indicate higher relative estimations and greater preference for the large sample.

the ball drawing context, both when the scenario involved a potential loss, F (1, 307) = 10.18, p<.002, and when it involved a potential gain, F (1, 307) = 28.10, p<.0001. In the exam context, mean preferences for the long exam in both scenarios were greater than the "no preference" scale midpoint, ps<.0001. In the ball-drawing context, preference trends in the two scenarios did not differ significantly from the midpoint.

As with preference ratings, a Context by Gain/Loss ANOVA on estimated probability of a successful outcome revealed a main effect for context, F (1, 307) = 23.03, p<.0001, and no effect for the gain/loss variable, F<1. The belief that a large sample was more likely to yield the desired outcome (avoidance of a loss or attainment of a gain) was stronger in the exam context. This pattern prevailed in both scenarios, although a context by gain/loss interaction indicated that the difference was somewhat greater if a potential gain was involved, F (1, 307) = 4.40, p<.05.

Importantly, however, even ratings in the ball-drawing context demonstrate an asymmetry in recognition of the consequences of chance. As in the exam context, ratings in the ball drawing loss scenario exceeded the scale midpoint, p<.001, indicating that participants correctly recognized that a successful outcome (loss avoidance) was more probable with the larger sample. In contrast, they did not recognize that the small sample was more likely to yield the desired outcome if a potential gain was involved. Indeed, they showed a nonsignificant tendency to believe that a gain was more likely if the sample was large.

Mean control ratings in both contexts were higher than the scale midpoint, ps<.05, indicating participants believed that the large sample afforded them more control. However, a Context by Gain/Loss ANOVA showed that this tendency was stronger in the exam context, F (1, 307) = 11.96, p<.001. Although a context by gain/loss interaction indicated that this between context difference was somewhat greater in the gain scenario, F (1, 307) = 4.49, p<.05, the same pattern prevailed in both scenarios.

The confidence intervals for mean luck ratings demonstrated that participants, consistent with the recognition that small samples are characterized by greater chance fluctuation, believed that luck was more important when the sample was small. On a scale on which lower ratings indicated the belief that luck was more important with a small sample, the mean ratings for both good luck and bad luck were below the scale midpoint of 5 in both contexts, ps<.05.

However, a 2 × 2 × 2 (Context × Gain/Loss × Good Luck Rating/Bad Luck Rating) repeated measures ANOVA also revealed effects for both context and kind of luck. The tendency to associate the small sample with luck was greater in the exam context, F (1, 306) = 4.57, p<.05. Most important, and consistent with the assumption that people view chance fluctuation in negative terms, participants consistently associated a small sample with bad luck more than with good luck, F (1, 306) = 14.25, p<.0001. There were no significant interactions, and no main effect for gain/loss.[3]

[3] Additional analysis indicated that the effects of context on the measures assessing sample preference, control, probability of a successful outcome, and luck were not significantly modified by any of the counterbalanced order variables. Nevertheless, one might still suspect that the pattern of results might have been somehow affected by the within-participant nature of the design. To address this issue, we performed ANOVAs on the responses of participants to the first scenario they read, with order of context and order of gain/loss as between-participant variables. All important effects identified in the within-participant analyses were replicated. Specifically, there was an effect for context on preference, F (1, 303) = 13.85, p<.0001, success probability, F (1, 303) = 13.67, p<.0001, control, F (1, 303) = 4.01, p<.05, and luck, F (1, 303) = 8.50, p = .004. However, even ratings in the ball-drawing context demonstrated asymmetry in recognition of the potential effects of chance. Although ratings in both contexts indicated that participants generally believed that luck was a more important factor when the sample was small, ps<.0001, participants also associated the small sample more with bad luck than with good luck, F (1, 303) = 18.15, p<.0001, and this effect did not differ with context, F (1, 303) = 1.03. In addition, in both gain and loss scenarios of the ball drawing context, participants believed that the probability of success was greater when the sample was large, although this tendency did not reach significance in the gain scenario.

Table 1
Zero order correlations among mean ratings of dependent measures, Study 2.

	Good luck	Bad luck	Control	Success probability	Sample preference
Good luck	–	−.15**	.06	.17**	.14*
Bad luck		–	−.43**	−.45**	−.40**
Control				.65**	.59**
Success probability				–	.67**
Sample preference					–

* p<.05.
** p<.01.

The zero-order correlations among the mean ratings (averaging across context and gain/loss) are displayed in Table 1. Sample preference and success probability are positively correlated with control and good luck, but negatively correlated with bad luck. Bad luck is negatively associated with control, whereas the correlation between good luck and control is nonsignificantly positive. This indicates that diminished control is associated with increased bad luck, but not with increased good luck.

A final set of analyses examined responses on the items assessing desire for control and belief in personal good luck. Mean ratings on these items are displayed in Table 2. On a nine-point scale with endpoints labeled "much more than the average person" and "much less than the average person", ratings on each item differed significantly from the midpoint 5, ps<.001. However, the control and luck items differed in their direction from the midpoint. Whereas participants indicated that they preferred control and liked to reduce the influence of chance more than the average person did, they also indicated that they trusted luck less, and were less lucky, than the average person. These findings are consistent with their general reluctance to forgo greater control over their score on a long exam in exchange for the potential benefits of chance fluctuation. Individual differences on these measures, however, were not significantly correlated with ratings on the measures assessing sample size differences.

Summary

Supplementing findings of Study 1, these results provide additional insight into participants' beliefs about the difference between large and small samples. Perceived sample size differences in the estimated influence of luck are especially informative. Consistent with the LLN, participants believed that the small sample offered the greater potential for the influence of luck. However, they also associated the small sample more with bad luck than with good luck. Results also indicate that ratings of estimated control were negatively related to the potential for bad luck (the less control, the more bad luck), but not to good luck. This asymmetry is consistent with the assumption that people recognize the risks of chance more than they appreciate its potential benefits. Participants believe that the greater exposure to chance that accompanies a loss of control portends more harm than good.

Although the results on luck ratings were generally robust across context, there were context-related differences on other measures. In the exam context, compared to the ball drawing context, participants tended more to associate the large sample with personal control and a greater probability of a successful outcome. In contrast to their responses in the ball-drawing context, they preferred the large sample not only in the loss scenario, when that choice was normative, but also in the gain scenario, when the choice was counternormative. In a context in which the outcome is strongly affected by controllable internal factors, that is, participants displayed a stronger preference for the sample that allowed them to maintain that control.

Ratings in the ball-drawing context, however, also demonstrated an asymmetry in beliefs about the consequences of chance fluctuation. Even in that context, participants associated a small sample more with bad luck than with good luck, and they also believed that it would be less likely to yield a successful outcome. Although they

Table 2
Mean ratings on items assessing preference for control and belief in luck, Study 2.

	Mean distance from "average person" midpoint
1) I prefer to leave things to chance and to trust in good luck	−1.05
2) I find that things in life I can't control usually tend to go my way because I'm lucky.	−.69
3) I consistently have good luck.	−.61
4) I like to reduce the influence of chance events in my life.	.41
5) I like to control what happens to me.	2.00
6) I try to avoid basing decisions on how lucky I feel.	.50

Note: Items were presented in two different random orders. Items 1, 2, 3, and 6 in the table are based on the Belief in Good Luck Scale (Darke & Freedman, 1997). Numbers in the final column reflect mean distance of participant ratings from the "average person" (midpoint 5 on a 9 point scale). Positive numbers indicate mean ratings of "more than the average person" and negative numbers indicate ratings of "less than the average person." All mean ratings differed from the scale midpoint at the .001 level.

correctly recognized that a small sample would increase the possibility of an atypical negative result, they also showed a nonsignificant counternormative tendency to believe that it would decrease the possibility of an atypical positive one. Even in this chance-determined situation, that is, people viewed luck as more foe than friend.

Given their belief that it afforded them a greater chance of success, why did participants in the ball-drawing context not express a significant preference for the larger sample? Most likely this is because the preference measure, unlike the measure assessing probability of success, reflects the influence of countervailing considerations on sample choice—e.g., the greater effort, and greater tedium, entailed in withdrawing 100 balls. Despite the perceived advantages of a larger sample, participants may have recoiled from the very thought of devoting their time to such a mundane and boring task.

It might seem even more surprising that participants see significant, albeit reduced, sample size differences in controllability and the influence of chance in the entirely chance-determined ball drawing task. These findings, however, can be explained by an "illusion of control"—a belief that one can control the outcome of a chance-determined event. In a classic series of experiments, Langer (1975) demonstrated that this illusion may occur when one attributes characteristics of skill-determined situations to situations in which the outcome is determined by chance. In skill-determined situations, for example, the ability to control the outcome usually increases with degree of involvement—e.g., the more time and effort spent on a task, the greater one's influence on the result. Because people frequently incorporate this characteristic of skill-contingent situations to chance-contingent situations, increasing one's involvement in a chance situation may engender an illusion of outcome control. In terms of expended time and effort, one's involvement in a 100 ball drawing task is considerably greater than one's involvement in a 10 ball task, perhaps giving rise to the illusory belief that one has greater control over the outcome of the 100 ball sample.[4]

Study 3

Although Studies 1 and 2 showed consistent results, they both examined participants' judgments when the consequences of their choice were entirely hypothetical. It seemed possible that results might differ if participants thought that their choice would be accompanied by real life consequences. If participants believed that they would receive an actual reward for a "correct" decision, they might process the information more thoroughly, realize the potential benefits of chance, and tend more to make judgments that were normatively correct. Study 3 investigated this possibility. We predicted, however, that people facing consequences for their decision would still demonstrate an asymmetry in recognition of the risks and benefits of chance.

Method

Participants

Participants were 211 undergraduates (147 women and 64 men) at the University of California, Davis.

Design, procedure, and measures

With the exceptions described, the materials, design, procedure, and measures were similar to those of Study 2. Immediately after reading each scenario, participants completed the luck and control measures. Then, instead of making an interval scale estimation of which sample offered the greater chance of attaining a successful outcome, participants in the exam context/potential gain scenario were asked to circle one of three alternative answers to the following question: "On which exam do you have the greater chance of scoring at least 60%?" For their answer, participants were asked to choose either the 10 question exam or the 100 question exam, or to indicate that the chance was equal between exams. For the exam context/potential loss scenario, participants were asked to choose one of the three alternatives to the question "On which exam do you have the greater chance of scoring at least 40%?" In the ball-drawing context, participants received analogous questions, then were asked to choose the 10 ball sample or the 100 ball sample, or to indicate that the chance was equal between samples. We deleted the measure of sample preference.

Before reading the materials, participants were informed that one of the questions pertaining to each of the four situations would ask them to indicate their belief about chances of success in the situation by circling one of three alternatives. They were also informed that experts generally agreed that one of the three alternatives constituted the correct answer, and that the correct answer for one situation was not necessarily the correct answer for any other situation. To encourage careful thinking about their answers, participants were told that they would receive double the amount of extra credit if all their answers to the chance estimation questions were correct. (In fact, all participants received the promised amount of extra credit, regardless of their answers.)[5]

Finally, to investigate an implication of some findings of Study 2, we added a new between-participant variable. Because people believe they are less lucky than the average person, their asymmetrical beliefs about luck may apply only to the self. If so, responses may evince more evenhanded views of chance when the individual in the scenarios is described as "a person" rather than as "you." However, if chance, despite this relative self/other difference in ascribed luck, is viewed as a universal adversary, responses should not be affected by this variation. To investigate this issue, one half of participants were told that the scenarios involved a generic "person", and all measures referred to "the person" (instead of to "you.").

[4] In an additional study (Johnson & Kang, 2012), we asked some participants to imagine that their exam score would be determined entirely by random factors. Their responses on these same dependent measures did not differ significantly from those of participants in a "normal exam" condition. Because exam context is a potent cue that the outcome is potentially controllable, these results are explainable in terms of the illusion that one has greater personal control over the more effortful long exam, even when the final score is determined entirely by chance.

[5] Although a potential doubling of extra credit is obviously not the most consequential of all possible rewards, it is of clear significance to most undergraduates. Because the addition of extra credit can raise one's final grade, some undergraduates, if offered the opportunity to choose, prefer it to cash for their participation in a study.

Table 3
Participant choice of sample most likely to yield successful outcome, Study 3.

	Gain situation		Loss situation	
	Exam	Ball drawing	Exam	Ball drawing
Large sample	104	71	110	86
Small sample	31	55	25	44
Equal chance	76	85	76	81

Results and discussion

We first conducted chi-square analyses on the three alternative answers to the question that assessed perceived sample size differences in probability of a successful outcome. As indicated by Table 3, results were significant for all four of the context by gain/loss scenarios, with χ^2s (2, 211) ranging from 6.41, $p<.05$, for the ball drawing gain scenario to 52.05, $p<.0001$, for the exam loss scenario. For three of these four scenarios, at least a plurality of participants selected the larger sample, whereas for the ball drawing/gain scenario a plurality selected the equal chance alternative. In both gain scenarios the normative choice of the small sample was the least popular alternative.

We next analyzed this measure as an interval scale (1 = greater chance of success with sample of 10; 2 = equal chance between the two samples; 3 = greater chance of success with sample of 100). A 2×2 (Context×Gain/Loss) ANOVA displayed a borderline effect for gain/loss, F (1, 210) = 3.62, $p<.06$, and a main effect for context, F (1, 210) = 18.97, $p<.0001$, but no context by gain/loss interaction, $F<1$. Participants displayed a marginal tendency to choose the larger sample more in the loss scenario. Replicating Study 2, participants in the exam context also believed that the larger sample offered a relatively greater chance for success than did participants in the ball drawing context, both in the gain scenario, $M=2.35$ vs. $M=2.08$, F (1, 210) = 15.73, $p<.0001$, and the loss scenario, $M=2.40$ vs. $M=2.20$, F (1, 210) = 8.28, $p<.004$.

Once again, however, even ratings in the ball-drawing context demonstrated asymmetrical beliefs about chance. Responses in the loss scenario of that context, like responses in the exam context, exceeded the scale midpoint of 2, $p<.001$, indicating that participants recognized that a large sample decreased the possibility of a loss. In the gain scenario, however, participants also displayed a nonsignificant counternormative tendency to believe that a large sample increased the possibility of a gain.

When the between-participant variable of person in the scenario (self vs. "a person") was added to the ANOVA, results indicated that participants were somewhat more likely to choose the larger sample when the scenario involved someone else, F (1, 209) = 5.35, $p=.022$, $M=2.32$ vs. $M=2.19$, although both means differed significantly from the scale midpoint, $ps<.0001$. Person did not interact with context or gain/loss and the counterbalanced order variables did not interact with any of the other variables.

ANOVAs on control and luck replicated the important effects of Study 2. Mean control ratings were higher than the scale midpoint, $p<.0001$, indicating that participants believed that the larger sample offered them greater control. This effect, however, was stronger in the exam context, $M=6.28$ vs. $M=5.51$, F (1, 210) = 24.01, $p<.0001$. Mean ratings of luck were lower than the scale midpoint, $p<.0001$, indicating that participants generally believed that luck was more important in the smaller sample. There was also a marginal effect for kind of luck, F (1, 210) = 3.36, $p<.07$, such that participants associated the small sample with bad luck more than with good. However, there was also an interaction between context and kind of luck, F (1, 210) = 7.15, $p<.008$. In the exam context participants associated the smaller sample more with bad luck than with good, $M=4.18$ vs. $M=4.89$, F (1, 210) = 8.54, $p<.005$, whereas participants in the ball context did not make this distinction, $M=4.60$ vs. $M=4.55$, $F<1$. As in Study 2, the relation between mean control ratings and mean bad luck ratings was negative, $r=-.21$, $p=.003$ (less control was associated with more bad luck), whereas the correlation between control and good luck was positive but not significant, $r=.02$.[6]

Summary

Study 3 participants expressed greater optimism about their score on a long exam, in both gain and loss scenarios, even when they believed that their answers would have real consequences. Because we did not include a "no real consequences" condition, it is inappropriate to conclude that responses were not in any way affected by this accuracy motivation. The results, however, do provide evidence that participants still forego the benefits of chance when they have a clear motivation to be accurate.

As in Study 2, participants believed that luck, particularly bad luck, was more influential on a short exam, and that a short exam afforded them less control. Sample size differences in control and success probability were smaller in a ball drawing context. Nevertheless, responses in the ball-drawing context demonstrated asymmetry. As in Study 2, participants in the ball-drawing context recognized that the large sample, which minimized chance fluctuation, decreased the probability of an atypical negative outcome. However, they failed to recognize that the small sample, which maximized chance fluctuation, also increased the probability of an atypical positive result.

General discussion

In Study 1 we predicted an asymmetry in recognition of some implications of sample size. When faced with a possible low grade in a course, we expected that participants would prefer the more reliable long exam. However, we also expected that they would fail to capitalize on the fact that a short exam presented the greater possibility of an above average score. Results showed that participants in fact preferred the long exam in both situations.

Replicating these results, Study 2 also demonstrated that participants believed that a long exam offered the greater probability of a successful outcome, even when a potential gain was involved. Study 3 showed that this effect prevailed even when participants believed that their judgment would have real consequences. Studies 2 and 3, however, also demonstrated that perceived sample size differences were reduced with a randomly determined ball drawing task. The finding that the optimism about a larger sample is greater in an exam context suggests that people are most sensitive to the adverse consequences of loss of control and increased chance fluctuation when the outcome is generally related to controllable factors—e.g., motivation and adequate learning of the course material. In such contexts they appear especially likely to associate increased chance fluctuation with negative outcomes. This tendency leads to normative judgments in the loss scenario, but counternormative judgments in the gain scenario.

Despite this effect for context, Studies 2 and 3 also show an asymmetry in judgments in the ball drawing task. In both contexts of both studies, participants believed that a large sample diminished bad luck and afforded them greater personal control. As in the exam context, responses in the loss scenario of the ball-drawing task also demonstrated a significant tendency to make the normative choice—participants

[6] As in Study 2, we performed between-participant ANOVAs on the responses of participants to the first scenario they read. Consistent with the results of Study 2, the effect of context was significant on the interval scale that assessed success probability, F (1, 207) = 11.01, $p<.001$. It was also marginally significant on ratings of control, F (1, 207) = 2.94, $p<.09$, although not on ratings of luck, F (1, 207) = 2.12, $p>.14$. Also as in Study 2, even ratings in the ball-drawing context demonstrated asymmetry in recognition of the potential effects of chance. Although participants believed that luck was more important when the sample was small, $p<.0001$, they tended to associate the small sample more with bad luck than with good luck, F (1, 207) = 3.43, $p<.07$, and this tendency did not interact with the between-participant variable of context, $F<1$. There was also a marginal tendency for participants in the ball drawing context to believe that the probability of success was greater when the sample was large, $p<.07$, and this tendency did not interact with gain/loss scenario, $F<1$.

apparently recognized that a large sample increased the probability of avoiding a loss. As in the exam context, however, they failed to appreciate that increased chance fluctuation can increase the possibility of an atypical gain. These results suggest that people are generally more sensitive to the negative than to the positive consequences of chance, even in a situation in which the outcome is randomly determined.

The Study 3 results display this same pattern when the individual in the scenario is described in generic terms. This suggests that, despite the Study 2 findings that participants view themselves as less lucky than the average person, asymmetrical beliefs about chance extend beyond the self. Despite these self/other differences, people may still tend to view chance as the enemy of all humanity, and may believe that everyone is best advised to guard against its pitfalls. Such a conclusion, however, should be approached with caution. Self/other differences may have been obscured by the incentive to be accurate, or by a tendency for participants to identify with the protagonist in the scenario. Future research might investigate whether such differences emerge in a within-participant design, when people make explicit self/other comparisons.

Potential self/other differences aside, the current findings offer strong support for at least two important generalizations. First, consistent with prior research, they demonstrate a positivity bias pertaining to events that people believe that they can control. Second, they supplement prior research by demonstrating an asymmetry in peoples' beliefs about luck when their control is diminished. These findings suggest that people view control as a friend, but tend to see chance as a dangerous foe.

Control as friend

Past studies demonstrate that people generally prefer to be in control (Inglehart & Weizel, 2005; Langer & Rodin, 1976). It seems quite likely that this preference for control is closely related to the desire to feel personally responsible for a positive outcome. People, that is, may be more satisfied when their success is due to their own skill or effort than when their success is due to luck. Alternatively, their preference for control might be explained in terms of counterfactual thinking. Anticipated regret when one fails due to luck ("I could have taken the long exam and received an 'A'") may be greater than anticipated regret when the failure is due to personal causes ("I might have lucked out with the short exam and received an 'A', but at least I gave it my best shot.").

Despite the possible influence of these factors, our results suggest that desire for control is also rooted in the robust belief that control actually enhances one's probability of success. Consistent with prior findings that people are relatively optimistic about outcomes they can control by virtue of their own knowledge and ability (Taylor, 1989; Taylor & Brown, 1988; Weinstein, 1980), participants in Studies 2 and 3 estimate that they are more likely to score at least 60% on the 100 question exam than on the 10 question exam—a dubious assumption given the information that their average score on prior exams was only 50%. These findings also comport with McCrea and Hirt (2009). Their results indicate that participants making predictions about a basketball tournament believe that they will be more successful if they rely on their own knowledge than if they utilize a normative strategy (consistently predicting wins by lower seeded teams).

Chance as foe

From an evolutionary perspective, the ability to control events and to steer them in the desired direction is obviously conducive to survival. Generally speaking, one may gain more by attempting to influence an outcome than by passively submitting to the vicissitudes of fortune. Despite one's best efforts, however, limitations on personal ability sometimes make failure more probable than success. It is in these cases that one may especially benefit from the greater potential for good luck that is presented by a smaller sample. For example, although the stronger of two closely matched teams is always somewhat more likely to win, the LLN suggests that the weaker team has a greater chance of prevailing in a single game playoff than in a seven game series.

However, our results provide converging evidence that such potential benefits of chance are not fully appreciated. Instead, people have a biased attitude toward luck. Participants are not oblivious to the LLN, and correctly associate small samples with greater chance fluctuation. Importantly, however, they also associate small samples more with bad luck than with good luck. They also indicate that they distrust luck and believe that they are less lucky than the average person (although Study 3 suggests that their biased view of chance extends to people other than the self). Finally, the findings also demonstrate an asymmetric view of the relation between luck and control. If people believe that luck is truly random, they should also believe that good luck, as well as bad luck, will increase as control is diminished. Instead, participants believe that when control is surrendered, bad luck *increases*, but good luck actually tends to *decrease*.

Luck in life and the rituals of control

As in research involving lottery tickets (Langer, 1975; Risen & Gilovich, 2007), our participants were asked to make choices in hypothetical situations that they would be unlikely to encounter in daily life. The artificial nature of these scenarios represents a limitation of our studies. We argue, however, that these results are in fact consistent with certain "real world" behavior, and may provide some insight as to why that behavior occurs. For instance, an example of real world preference for control over chance may be found in the behavior of investors. As some economists have argued, individual stocks follow a random and unpredictable path (Malkiel, 2007). It is therefore possible that for any given period of time an investor may profit more by randomly picking stocks than by selecting the ones that she/he considers most likely to increase. Although recognition of the unpredictable nature of the market has led many investors to prefer index funds, many others prefer a selective investment strategy that allows for more exercise of personal control. In contrast, we suspect that few investors would be comfortable choosing stocks by throwing darts. Future studies might extend the current research by investigating aversion to chance in such "real world" settings.

Our results, which suggest that the feared consequences of bad luck may loom larger than the potential advantages of good luck, may also have some relevance to superstitious behavior. Although superstitions about good luck exist, we suggest that superstitions involving bad luck, as well as the rituals to avoid it, are perhaps even more abundant. You get bad luck by walking under a ladder or stepping on a sidewalk crack, and breaking a mirror brings on seven years of it. It is also arguable that some charms and amulets, as well as certain substances of alleged magical potency, actually have a prevention, rather than promotion, orientation. A knotted threat was once believed to prevent disease and, as any aficionado of horror movies knows, garlic repels vampires and wolfsbane wards off werewolves. Such observations have been used to support the conclusion that the primary basis of superstition is not the hope of good fortune, but the fear of being damaged by a potentially malignant universe (Planer, 1988).

In this connection, it is instructive to consider another element of many superstitions—the notion that bad luck can be thwarted by certain volitional actions that bear no obvious causal connection to the dreaded event. Tradition has it that you can avoid the hazards of tempting fate (e.g., voicing the expectation that something good will happen) if you knock on wood three times after making the ill-advised prophecy. You can escape the consequences of walking under a ladder if you do it with your fingers crossed, and you can dispel the bad fortune of a broken mirror if you bury the shards by the light of the moon (www.oldsuperstitions.com). The psychological function of these rituals, we suggest, is to instill some sense of personal agency and the accompanying feeling, albeit illusory, that one's fate really is under one's control. The problem, of course, is that an exaggerated belief in one's control of an outcome may engender a false sense of security. As our research demonstrates, it may also lead people to ignore the real benefits of chance.

References

Darke, P. R., Chaiken, S., Bohnner, G., Einwiller, S., Erb, H. P., & Hazlewood, J. D. (1998). Accuracy motivation, consensus information, and the law of large numbers: Effects on attitude judgment in the absence of argumentation. *Personality and Social Psychology Bulletin*, *24*, 1205–1215.

Darke, P. R., & Freedman, J. L. (1997). The belief in good luck scale. *Journal of Research in Personality*, *31*, 378–392.

Gilovich, T., & Douglas, C. (1986). Biased evaluations of randomly determined gambling outcomes. *Journal of Experimental Social Psychology*, *22*, 228–241.

Inglehart, R., & Weizel, C. (2005). *Modernization, cultural change, and democracy: The human development sequence.* New York: Cambridge University Press.

Johnson, J. T. & Kang, C. K. (2012). Unpublished manuscript.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, *3*, 430–454.

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology*, *32*, 311–328.

Langer, E. J., & Rodin, J. (1976). The effects of choice and enhanced personal responsibility for the aged: A field experiment in an institutional setting. *Journal of Personality and Social Psychology*, *34*, 191–198.

Langer, E. J., & Roth, J. (1975). Heads I Win, Tails it's Chance: The illusion of control as a function of the sequence of outcomes in a purely chance task. *Journal of Personality and Social Psychology*, *32*, 951–955.

Malkiel, B. G. (2007). *A random walk down Wall Street: The time-tested strategy for successful investing* (9th ed.). NY: W.W. Norton.

McCrea, S. M., & Hirt, E. R. (2009). Match madness: Probability matching in prediction of the NCAA basketball tournament. *Journal of Applied Social Psychology*, *39*, 2809–2839.

Nickerson, R. S. (2004). *Cognition and chance: The psychology of probabilistic reasoning.* Mahwah, NJ: Lawrence Erlbaum Associates.

Nisbett, R. E., Krantz, D. H., Jepson, C., & Kunda, Z. (1983). The use of statistical heuristics in everyday inductive reasoning. *Psychological Review*, *90*, 339–363.

Oldsuperstitutions.com. Available from http://www.oldsuperstitions.com

Planer, F. E. (1988). *Superstition* (2nd ed.). Buffalo, NY: Prometheus Books.

Risen, J. L., & Gilovich, T. (2007). Another look at why people are reluctant to exchange lottery tickets. *Journal of Personality and Social Psychology*, *93*, 12–22.

Risen, J. L., & Gilovich, T. (2008). Why people are reluctant to tempt fate. *Journal of Personality and Social Psychology*, *95*, 293–307.

Taylor, S. E. (1989). *Positive illusions: Creative self-deception and the healthy mind.* NY: Basic Books.

Taylor, S. E., & Brown, J. D. (1988). Illusion and well-being: A social psychological perspective on mental health. *Psychological Bulletin*, *103*, 193–210.

Weinstein, N. D. (1980). Unrealistic optimism about future life events. *Journal of Personality and Social Psychology*, *39*, 806–820.