Psychonomic Bulletin & Review
2009, 16 (1), 156-162
doi:10.3758/PBR.16.1.156

"100% of anything looks good": The appeal of one hundred percent

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People overweight certainty, even when certainty is only an illusion. A vaccine that was described as 100% effective against 70% of disease targets was preferred to one described as 70% effective against 100% of disease targets (Studies 1 and 2). The appeal of 100% extends beyond the probability attribute. In Study 2, participants preferred both of the vaccines above to normatively equivalent vaccines that were less than 100% effective toward fewer than 100% of targets. In Study 3, participants preferred a 100% discount on a cup of coffee every 10 days to other more frequent, but lower amount, discounts. This preference evaporated, however, when savings were framed as points rather than as percentage discounts. We propose that people view 100% as a salient reference point and overweight it in those domains where it cannot be exceeded (e.g., probability, discount); the overweighting is weaker in domains where 100% can be exceeded (e.g., target range, points).

"Not to be absolutely certain is, I think, one of the essential things in rationality," wrote the great English philosopher Bertrand Russell (1949). However, people tend to overweight outcomes that are considered certain relative to outcomes that are merely possible—a phenomenon labeled the *certainty effect* by Kahneman and Tversky (1979).

One famous example of the certainty effect is the Allais paradox (Allais, 1953), shown in Table 1. The modal response was choosing A in Choice 1, but D in Choice 2, even though Choice 2 is derived by deducting a .89 chance of \$1 million from both options in Choice 1. The preference for certainty was demonstrated further by Kahneman and Tversky (1979). As shown in Table 1, participants preferred A to B, but also preferred D to C, even though Choice 2 was derived by dividing the probabilities in Choice 1 by a common ratio. These examples illustrate the general appeal of certainty. Prospect theory (Kahneman & Tversky, 1979) originally described the weight that people attach to probabilities as a function that is shallow for intermediate probabilities and that changes abruptly near the endpoints of certainty. Subsequent research suggests an inverse S-shaped probability weighting function: concave for low probability and convex for high probability (Camerer & Ho, 1994; Gonzalez & Wu, 1999; Hartinger, 1999; Tversky & Kahneman, 1992; Wu & Gonzalez, 1996). Tversky and Kahneman hypothesized *diminishing sensitivity* to be the underlying psychological mechanism for the shape of the weighting function: People become less sensitive to changes in probability as they move away from the two natural reference points of 0 (*certainly will not happen*) and 1 (*certainly will happen*).

Not only do people overweight certainty, they are also subject to an illusion of certainty, even when outcomes are not certain, and they overweight this pseudocertainty relative to other probabilities. For example, Slovic, Fischhoff, and Lichtenstein (1982) demonstrated that people were more attracted to a vaccine that was described as eliminating a 10% risk for one of two equiprobable diseases than if it was described as reducing the risk for one disease from 20% to 10%. This preference violates principles of normative expected utility theory (Savage, 1954), because the net risk reduction is the same across the two versions. The Slovic et al. study demonstrated a pseudocertainty effect: Certainty contingent upon a condition (e.g., risk elimination within a specified risk subset) is overweighted, as is true certainty (Kahneman & Tversky, 1979).

In the present article, we first demonstrate the real-world application of the pseudocertainty effect on a timely topic: the *human papillomavirus* (HPV) vaccine. Second, we extend the certainty effect to a general *100% effect*. As mentioned earlier, overweighting of certainty can be explained by diminishing sensitivity to probabilities away from the reference point. We demonstrate that 100% on other attributes can be overweighted because of the same principle. Finally, we explore the boundary conditions under which the 100% effect occurs.

STUDY 1

The pseudocertainty effect has real-world implications for how the effectiveness of vaccines is interpreted. In June 2006, the Food and Drug Administration approved a vaccine that protects against cervical cancer by preventing HPV infection, which can cause cervical cancer. The vaccine is 100% effective against the two strains of HPV that cause 70% of cervical cancer cases (Centers for Dis-

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Table 1
Examples of the Certainty Effect

Study	Choice 1	Choice 2
Allais paradox (Allais, 1953)	A. 100% chance of $1 M	C. 11% chance of $1 M
	B. 10% chance of $5 M 89% chance of $1 M	D. 10% chance of $5 M
Common ratio effect (Kahneman & Tversky, 1979)	A. 100% chance of $3,000	C. 25% chance of $3,000
	B. 80% chance of $4,000	D. 20% chance of $4,000

ease Control and Prevention, 2006). From the responses to the hypothetical vaccine in Slovic et al.'s (1982) study, we predicted that decisions to vaccinate against HPV may be swayed by how information about the vaccine is presented. Study 1 replicated the pseudocertainty effect by using a vaccine scenario that mimicked that of the HPV vaccine. We constructed two descriptions of a cancer vaccine based on features of the HPV vaccine. The descriptions were equivalent in terms of the net effectiveness of the vaccine (both were .70), but differed in whether the vaccine was described as 100% effective against a subset (70%) of cancer risks or as 70% effective against the entire set of cancer risks. The first version involves risk elimination, whereas the second involves risk reduction. If people overweight apparent certainty, the first description should make the vaccine seem more appealing.

Method

College participants (N = 470) were assigned randomly to receive one of two versions of an Internet questionnaire. Version 1 described a vaccine that was "100% effective in preventing virus infections that cause 70% of known cases of a specific type of cancer." Version 2 described a vaccine that was "70% effective in preventing virus infections that cause all known cases of a specific type of cancer." It was stated that 4% of people develop this cancer without vaccination. Students then indicated their intentions to vaccinate on a 0% (*definitely would not vaccinate*) to 100% (*definitely would vaccinate*) scale, with 10% increments.

Results and Discussion

Students who received Version 1 indicated higher intentions to vaccinate (M = 77.32, SD = 25.61) than did students who received Version 2 (M = 66.28, SD = 27.23) [$t(468) = 4.53$, $p < .001$, $d = .41$]. This result is consistent with findings reported by Slovic et al. (1982): People overweight the apparent certainty (100% effective) associated with a subset (70%) of disease targets in Version 1.

Study 1 had limitations. Noticeably, Version 1 contained two percentage numbers, but Version 2 contained only one. Also, the probability *100%* appeared first in Version 1, but *70%* appeared first in Version 2. The higher vaccination intention in Version 1 could have occurred because of a primacy effect, where the impression of the vaccine was determined by whichever number people first encountered in the description. These limitations were addressed in Study 2.

STUDY 2

Study 1 illustrated a preference for 100% effectiveness, which is consistent with the inverse S-shape of the probability weighting function in prospect theory. The psychophysical principle that underlies this weighting function (i.e., sensitivity diminishes with an increase in distance from the reference point) is not limited to probability (see Arkes, 1991). One hundred percent is a maximum, not only for probability, but for other attributes as well. For example, target range, the proportion of disease-causing agents targeted by the vaccine, also has a natural reference point of 100%, and diminishing sensitivity would imply that 100% target range should be overweighted.

To explore this question, Study 2 included four other vaccines that were less than 100% effective toward fewer than 100% of targets, in addition to the two vaccines from Study 1, holding the net effectiveness constant at .70 (see Table 2). These vaccines were presented within subjects, to make the equivalent net effectiveness potentially transparent. If people indeed overweight 100% in general, the medium-range vaccines with no 100% element should be preferred less than the two vaccines with 100% as either effectiveness or target range.

We also examined whether the pseudocertainty effect would be reduced if people had a broader perspective of other disease risks unprotected by the vaccine. Such a manipulation may trigger people to realize that full effectiveness is relative, depending on the scope of targets in consideration. We used a subtle version of a similar manipulation used by Ubel, Baron, and Asch (2001). They demonstrated that people's preference for equity in allocating a medical test among a population was reduced when the population in consideration was phrased as 50% of two states, versus 100% of one state. To test whether scope of considered targets influences people's preference for 100% effectiveness, and to mimic real-world presentations of vaccines, we simply reminded participants of another cancer risk unaffected by the vaccine.

To address the alternative explanations mentioned in the discussion of Study 1, we made the two alternative vaccine descriptions more equivalent by replacing the word "all" with "100%" and by manipulating the order in which effectiveness and target range appeared in the sentence, so that *100%* did not always precede *70%* (see Table 2).

Method

College participants in an Internet survey (N = 180) read a description of cancer X, which affects about 5% of the population and is caused only by certain strains of viruses. They were told that various vaccines were developed to prevent these virus infections, and they rated six vaccines (see Table 2) on an 7-point scale, where 1 =

Table 2
Vaccine Descriptions in Study 2

Effectiveness First
(A) It is 70% effective against 100% of all virus strains that cause cancer X.
(B) It is 74% effective against 95% of all virus strains that cause cancer X.
(C) It is 82% effective against 85% of all virus strains that cause cancer X.
(D) It is 68% effective against 68% of all virus strains that cause cancer X.
(E) It is 95% effective against 74% of all virus strains that cause cancer X.
(F) It is 100% effective against 70% of all virus strains that cause cancer X.
Target First
(A) Against 100% of all virus strains that cause cancer X, it is 70% effective.
. . .
(F) Against 70% of all virus strains that cause cancer Y, it is 100% effective.

Note—All six vaccines (A–F) were presented to each participant. Participants were assigned randomly to one of four conditions created by two fully crossed factors: phrasing and scope. The two phrasing conditions were *effectiveness first* or *target first*. The two scope conditions were *one cancer mentioned* (as presented in the table) or *two cancers mentioned* (vaccines were described in the same way as in the one-cancer condition, except that "it is not effective against cancer Y" was added to the end of each vaccine description).

extremely unappealing and 7 = *extremely appealing*. Another question asked which vaccine was the most appealing.

The wording was modified slightly from Study 1 ("virus strains causing *x*% of known cases of a cancer" was changed to "*x*% of virus strains that cause a cancer") to make the description more straightforward. The net effectiveness was .70 for all vaccines, except for vaccine D, which was included as a comprehension check, because it was inferior in both effectiveness and target range. The order of the six vaccines was randomized.

Students were assigned randomly to one of four conditions (Table 2): Vaccines phrased with *effectiveness* first or *target* first, in a narrow scope (one cancer X mentioned) or broad scope (in this condition, students also read about cancer Y, which was also said to affect 5% of the population, but which was caused by different virus strains from those causing cancer X; the vaccines were said to be ineffective against cancer Y).

Results

Forty-four participants rated vaccine D as more appealing than one or more other vaccines; an additional 7 gave inconsistent responses in vaccine ratings and the choice of the most appealing vaccine. These participants were excluded, leaving 129 in the analysis.[1]

To answer specific questions about the two vaccines derived from Study 1 we conducted a 2 (vaccine A, *70% effective against 100% target*, vs. F, *100% effective against 70% target*) × 2 (scope) × 2 (phrasing) ANOVA using rating as the dependent measure (see Figure 1). Despite the within-subjects design, the analysis revealed significantly higher ratings for vaccine F ($M = 6.27$, $SD = 0.90$) than for vaccine A ($M = 5.81$, $SD = 1.04$) [$F(1,125) = 26.13$, $p < .001$]. Scope did not have a significant main effect, although vaccine ratings tended to be lower in the broad scope ($M = 5.89$, $SD = 0.98$) than in the narrow scope ($M = 6.16$, $SD = 0.71$) [$F(1,125) = 2.60$, $p = .11$]. Importantly, there was no interaction between scope and vaccine type, which indicates that reminding students of another cancer unprotected by the vaccines did not reduce

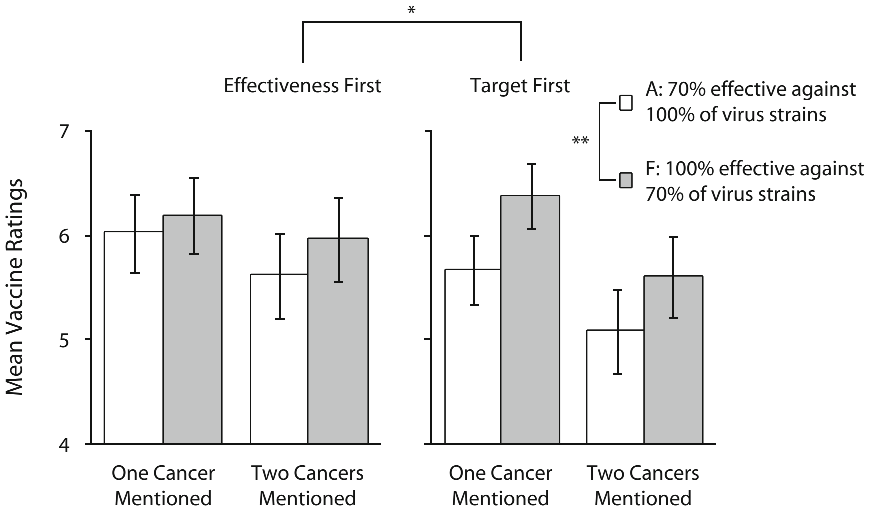

Figure 1. Mean ratings for vaccines A and F on a 1 (*most unappealing*) to 7 (*extremely appealing*) scale. Error bars = ±2 standard errors. $^{*}p < .05$. $^{**}p < .001$.

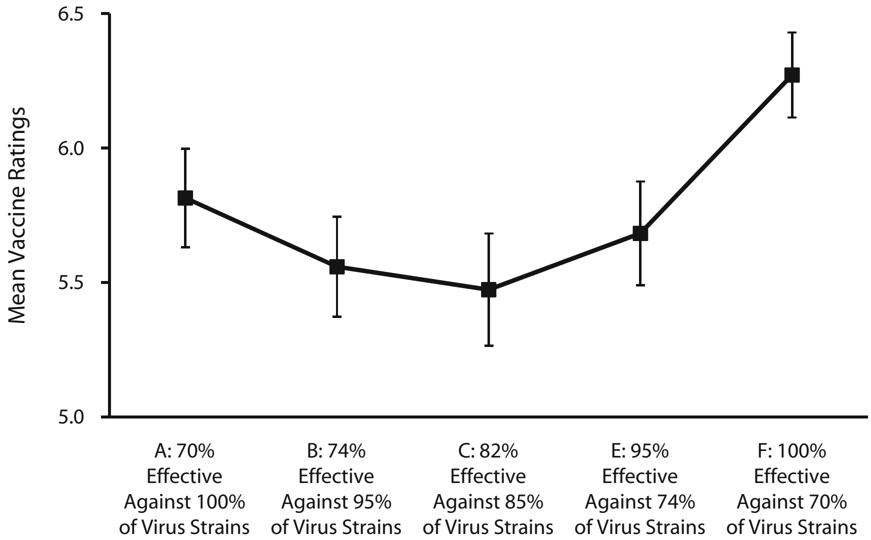

Figure 2. Mean ratings of five vaccines on a 1 (*most unappealing*) to 7 (*extremely appealing*) scale. Error bars = ±2 standard errors.

the pseudocertainty effect. There was also no interaction between phrasing and vaccine type: Preference for vaccine F over A did not change even when the position of 100% was reversed between the two vaccines, eliminating the primacy effect explanation. Describing the vaccines with target first did make the vaccines less appealing in general ($M = 5.89$, $SD = 0.93$), as compared with describing effectiveness first ($M = 6.22$, $SD = 0.70$) [$F(1,125) = 5.63$, $p < .05$]. This unexpected main effect of phrasing likely occurred because of the unusual structure of the sentence when *target* was mentioned first.

Next, we performed a one-way within-subjects ANOVA for ratings among all five vaccines (excluding vaccine D). The purpose was to test whether 100% was overweighted in comparison with other percentages, either as 100% effectiveness (as in vaccine F) or as 100% target range (as in vaccine A). Figure 2 shows mean ratings of the five vaccines. A planned contrast showed that vaccine F was rated as more appealing than the mean of the other four vaccines [$F(1,128) = 83.13$, $p < .001$]. A second contrast showed that vaccine A was rated as more appealing than the mean of vaccines B, C, and E—the medium-range vaccines [$F(1,128) = 8.67$, $p < .01$]. A third contrast between two medium-range vaccines (vaccine B and vaccine E) did not show significant difference in ratings [$F(1,128) = 1.59$, $p = .21$]. Choice of the most appealing vaccine yielded the same pattern of results (not presented).

Discussion

Study 2 replicated the pseudocertainty effect in a more transparent within-subjects design. When two vaccines were presented at the same time, people were attracted by a vaccine that was 100% effective against 70% of virus strains causing a certain cancer, in comparison with a vaccine that was 70% effective toward 100% of virus strains causing this cancer, despite the equivalence in net effectiveness. This tendency to overweight 100% effectiveness within a subset remained even when people were reminded of a broader scope of cancer targets. In addition, the preference was not an artifact of the position of *100%* in a sentence.

A critical finding in Study 2 is that the 100% target range is also overweighted in comparison with the fewer than 100% target range, suggesting that people may overweight 100% in general. This preference for 100% was demonstrated in the ratings of the five normatively equivalent vaccines. Although vaccines A–F increased in effectiveness, vaccine rating was an asymmetric U-shaped function, with the vaccines on the two ends (i.e., either 100% effective or covering 100% of targets) rated as more appealing than the three medium-range vaccines in the center.

The value of 100% is a salient reference point that cannot be exceeded in various contexts (e.g., probability, subset). The preference for certainty may constitute a specific case of a more general psychophysical principle of overweighting differences that are close to a reference point (Arkes, 1991). The fact that preference for 100% is stronger for effectiveness than for target range is potentially due to the different salience of 100% as an unsurpassable reference point: Probability can never exceed 100%, but target range sometimes can (e.g., the new vaccine covers 150% of the virus strains that were covered by the previous vaccine). Following this reasoning, we predicted that when 100% cannot be exceeded, it becomes a natural reference point and hence is overweighted; when 100% can be exceeded, however, it is not overweighted (as much). Study 3 was designed to test this hypothesis and to extend the 100% effect to other domains.

STUDY 3

Vaccination is one of many domains in which the preference for 100% may influence decisions. In Study 3, we

Table 3
Coffee Saving Programs

Plan Type		
Discount	Points	Frequency of Saving
(A) 10%	10	100% of the days during a year (every day)
(B) 20%	20	50% of the days during a year (every other day)
(C) 50%	50	20% of the days during a year (every 5 days)
(D) 70%	70	1/7 of the days during a year (every 7 days)
(E) 100% (free)	100	10% of the days during a year (every 10 days)

Note—All five programs (A–E) were presented to each participant. Participants were assigned randomly, either to the discount condition or to the points condition, but they saw the same descriptions of saving frequencies as listed in the table.

examined whether people overweight 100% more when it is interpreted as the maximum than when it is not. The design required a scenario involving something other than vaccinations. We presented a series of coffee saving programs, either in a discount format or in a "points for coffee" format, in which points could be accumulated and used later in exchange for coffee or as a discount (see Table 3). Thus, 100% savings was a maximum in the discount format (no discount is higher than 100%), but could be exceeded when it referred to the equivalent savings in the point format (more than one coffee's worth of points can be accumulated). Each participant evaluated five savings programs that varied on the amount (e.g., 10%, 20%, 100%) and frequency (e.g., 100% of days/every day, 50% of days/every other day, 10% of days/every 10 days) of savings, with the same net overall savings. If overweighting of 100% indeed occurred because of its unsurpassable nature, people should prefer the program that offered 100% savings in the discount version, but not the equivalent points version.

Note that, in addition to savings amount, savings frequency also has a maximum at "100% of the days (every day)": The coffee lovers were said to buy only one coffee a day. Following our hypothesis that the 100% effect is strongest when 100% is perceived as a maximum, we predicted that this 100% time coverage would be overweighted in comparison with other frequencies. However, we did not have a prediction for the relative weight people assign to 100% savings discount versus 100% savings frequency, because both could serve as a salience reference point. Because of the round numbers and the explicit percentage presentation in both savings amount and frequency, the (equivalent) net savings in all programs were easy to calculate; thus, this study constituted a fairly conservative test for the 100% effect.

Method

College participants ($N = 232$) completed an Internet survey that described five coffee lovers who lived in different parts of town and always went to their respective coffee shops to buy one cup of the same coffee every day; the coffee cost the same in these coffee shops, and each shop had a coffee savings program for people who bought coffee every day. We presented five programs (see Table 3) that varied in magnitude of savings (from 10% to 100%) offered each time and the frequency of savings offered during a year (from 100% of the days during a year/every day to 10% of the days during a year/every 10 days), with the net overall savings held constant at 0.1. Students saw the programs presented in random order on the same page and they rated how appealing each program was on an 11-point scale, where 0 = *not appealing at all* and 10 = *very appealing*.

Participants were assigned randomly to one of two between-subjects conditions. In the discount condition, all five programs

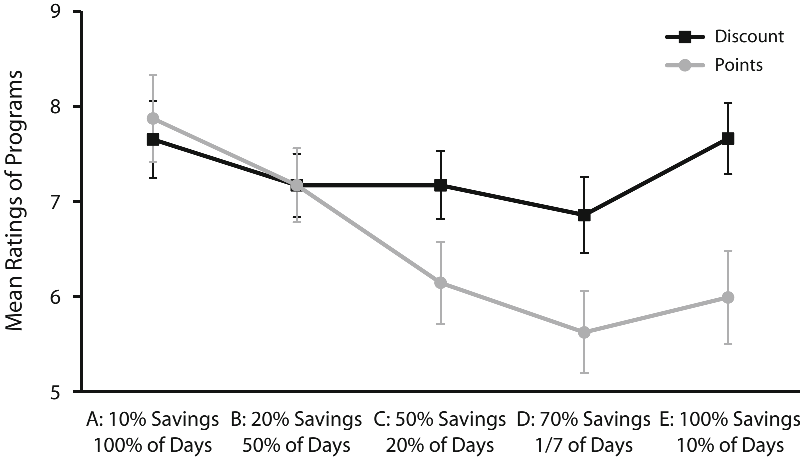

Figure 3. Mean ratings of five coffee savings programs by plan type (discount vs. points) on a 0 (*not appealing at all*) to 10 (*very appealing*) scale. Error bars = ±2 standard errors.

were described as discounts toward the coffee purchase; in the points condition, the coffee shops were said to offer "points for coffee" programs, where 100 points was worth one free cup of coffee and points could be redeemed any time for coffee or a discount.

Results

Three outliers, who rated one or more programs over 3 *SD*s away from the mean, were excluded from analysis, leaving a total of 229 participants.

The results are shown in Figure 3. Ratings for all five programs were submitted to a 5 (program) × 2 (plan type: discount vs. points) mixed-factor ANOVA, with program as a within-subjects variable and plan type as a between-subjects variable. There was a significant linear relationship between rating and amount of savings per instance offered in programs [$F(1,227) = 25.49, p < .001$]. However, this linear contrast interacted with plan type [$F(1,227) = 24.64, p < .001$]. In the points condition, rating decreased as programs offered smaller amounts but more frequent savings [$F(1,116) = 42.82, p < .001$]; such a linear trend was absent in the discount condition ($F < 1$, n.s.). A significant quadratic relationship also emerged between rating and savings amount [$F(1,227) = 40.34, p < .001$], with the programs on the two ends of the curve (A and E, providing either savings every day or 100% savings each time) rated higher than the three programs in the middle, where no 100% attribute was present. There was no interaction between the quadratic contrast and plan type.

Also of interest were the almost identical ratings for programs A and E in the discount condition ($M = 7.65$, $SD = 2.16$, vs. $M = 7.66$, $SD = 1.98$), whereas program A was rated much higher than program E in the points condition ($M = 7.87$, $SD = 2.47$, vs. $M = 5.99$, $SD = 2.64$), resulting in a significant interaction [$F(1,227) = 19.74$, $p < .001$].

Discussion

Study 3 extended the 100% effect from vaccination decisions to consumer choice, and specifically in two domains: savings discount and savings frequency. Participants preferred programs A and E equally over other programs in the discount condition, where both programs contained an unsurpassable attribute of "100%," either offering savings on 100% of the days during a year (A) or offering 100% discount per savings instance (E). Furthermore, the results supported our hypothesis that people use 100% as a reference point when 100% is a salient maximum and that they assign extra weight to it; this does not occur if 100% is not a maximum. Despite the strong preference shown for program E in the discount condition (i.e., 100% discount per instance), the special appeal of this program is lost when savings are in a points format and are thus capable of exceeding 100%.

One difference between the discount and points conditions is that a discount must be applied immediately, whereas points can be accumulated and applied at any time. These different application schedules for savings are necessary to allow points, but not discounts, to exceed 100%. Had this difference influenced participants' preference beyond the effect of perceived maximum savings amount, 100 points would have appeared to be more attractive than a 100% discount because of its flexible application schedule. To the contrary, the ratings for program E in the points and discount conditions showed the reverse pattern (Figure 3).

GENERAL DISCUSSION

The decision-weighting function of prospect theory (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992) predicts people's tendency to overweight certainty. Studies 1–3 demonstrated that the appeal of genuine and apparent certainty can be easily applied to real-world decisions. Studies 2 and 3 extended the predictions of prospect theory and suggest that people prefer 100% relative to other percentages in general, even when it refers to nonprobability attributes: target range, discount, and time coverage. The well-documented certainty effect can be viewed as a special case of the 100% effect. Insofar as 100% cannot be exceeded (e.g., probability, discount), it serves as a salient reference point and receives special weight above what its numerical value deserves; this overweighting does not seem to exist when 100% can be exceeded (savings in points).

This 100% effect is consistent with a general principle: Sensitivity to changes diminishes as the distance from the reference point increases (Tversky & Kahneman, 1992). Arkes (1991) pointed out that nonlinear functions with this attribute save cognitive effort, although errors also occur as side effects. For example, our brain seems to use less time in processing certainty than it does in processing other probabilities. In a study using gambles that either incorporated a certain outcome or did not, participants' response times and brain activation both exhibited less computation and evaluative processing when certainty was present (Dickhaut et al., 2003). It is possible that people process 100% of other attributes in a similar way, with less computation and more intuition, for better or for worse.

The appeal of 100% has important implications for health promotion, consumer decisions, and public policy. It is another cognitive bias that can intentionally or unintentionally sway decisions, especially because it is subject to a framing effect: A proportion of a whole set is 100% of a subset; risk reduction is elimination of specific risks; a small savings is a 100% discount on a single item. After all, anything can be described as "100% of something."

AUTHOR NOTE

Preliminary results of Study 1 were presented at the 2007 Annual Meeting of the Association for Psychological Science; results from Studies 1 and 2 were presented at the 2007 Annual Meeting of the Society of Judgment and Decision Making. Part of this article also constitutes the first author's master's thesis. This project was supported in part by Award 220020114 from the McDonnell Foundation to Alison Galvani. We thank Dave Thomas for programming assistance in Study 1 and Alison Galvani for comments on the manuscript. Correspondence concerning this article should be addressed to M. Li, Department of Psychology, Rutgers University, 152 Frelinghuysen Rd., Piscataway, NJ 08854 (e-mail: mli@rci.rutgers.edu).

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NOTE

1. Including these cases in the analysis did not change the conclusions we derived from the results.

(Manuscript received March 5, 2008;
revision accepted for publication July 22, 2008.)