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THEORETICAL NOTE

Unrealistic Optimism About Future Life Events: A Cautionary Note

Adam J. L. Harris and Ulrike Hahn
Cardiff University

A robust finding in social psychology is that people judge negative events as less likely to happen to themselves than to the average person, a behavior interpreted as showing that people are "unrealistically optimistic" in their judgments of risk concerning future life events. However, we demonstrate how unbiased responses can result in data patterns commonly interpreted as indicative of optimism for purely statistical reasons. Specifically, we show how extant data from unrealistic optimism studies investigating people's comparative risk judgments are plagued by the statistical consequences of sampling constraints and the response scales used, in combination with the comparative rarity of truly negative events. We conclude that the presence of such statistical artifacts raises questions over the very existence of an optimistic bias about risk and implies that to the extent that such a bias exists, we know considerably less about its magnitude, mechanisms, and moderators than previously assumed.

Keywords: wishful thinking, response scale bias, probability estimates, human rationality

For almost 30 years now, it has been the received wisdom that "people have an optimistic bias concerning personal risk" (Weinstein, 1989b, p. 1232); that is, they "tend to think they are invulnerable" (Weinstein, 1980, p. 806) and "are often overoptimistic about the future" (Chambers, Windschitl, & Suls, 2003, p. 1343). This is based on the phenomenon, often referred to as *unrealistic optimism*, whereby people seemingly perceive their own future as more positive than the average person's. Specifically, people rate negative future events as less likely to happen to themselves than to the average person and positive events as more likely to happen to themselves than to the average person (e.g., Burger & Burns, 1988; Campbell, Greenauer, Macaluso, & End, 2007; D. M. Harris & Guten, 1979; P. Harris & Middleton, 1994; Kirscht, Haefner, Kegeles, & Rosenstock, 1966; Lek & Bishop, 1995; Otten & van der Pligt, 1996; Perloff & Fetzer, 1986; Regan, Snyder, & Kassin, 1995; Weinstein, 1980, 1982, 1984, 1987; Weinstein & Klein, 1995; Whitley & Hern, 1991).

Not only is unrealistic optimism seemingly a firmly established empirical phenomenon, it is also deeply embedded in applied work pertaining to risk perception and risk behavior, as documented by the sizeable literature relating to the phenomenon within health psychology (e.g., Cohn, Macfarlane, Yanez, & Imai, 1995; Gerrard, Gibbons, Benthin, & Hessling, 1996; Gerrard, Gibbons, & Bushman, 1996; Hampson, Andrews, Barckley, Lichtenstein, & Lee, 2000; Lek & Bishop, 1995; Rothman & Kiviniemi, 1999; van der Velde, Hooykas, & van der Pligt, 1992; van der Velde & van der Pligt, 1991; van der Velde, van der Pligt, & Hooykas, 1994; Weinstein, 1999, 2000; Weinstein & Klein, 1996; Welkenhuysen, Evers-Kiebooms, Decruyenaere, & van den Berghe, 1996). Here, researchers and practitioners are concerned that people will not take the necessary preventative steps to protect themselves because they underestimate their chances of contracting disease. It suffices to say, a clear understanding of the psychology of risk perception is essential for the effective communication of health information.

Not only has the basic finding of unrealistic optimism been replicated in many studies, but there has also been detailed investigation of potential mediators of the unrealistic optimism effect. Evidence has been found in support of cognitive mediators of the effect as well as for the contention that the effect results from a self-serving motivational bias designed to protect self-esteem and guard against depression (for reviews, see Chambers & Windschitl, 2004; Helweg-Larsen & Shepperd, 2001; Taylor & Brown, 1988).

Unrealistic optimism about risk is often viewed as but one aspect of a more general self-enhancement bias that also encompasses phenomena such as the *planning fallacy* (e.g., Buehler & Griffin, 2003; Buehler, Griffin, & MacDonald, 1997; Buehler, Griffin, & Ross, 1994; Kahneman & Tversky, 1979), the *illusion of control* (e.g., Langer, 1975; Langer & Roth, 1975), people's tendency to overestimate their own skill relative to others (the so-called *better-than-average effect*; e.g., Svenson, 1981), and findings of *overconfidence* in judgment (e.g., Kahneman & Tversky, 1973). Though we return briefly to critiques of this wider set of phenomena in our Conclusions section, the immediate focus of this article is on how one might know that people's judgments of

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Adam J. L. Harris and Ulrike Hahn, School of Psychology, Cardiff University, Cardiff, Wales.

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Correspondence concerning this article should be addressed to Adam J. L. Harris, who is now at Department of Cognitive, Perceptual and Brain Sciences, University College London, Gower Street, London, WC1E 6BT, United Kingdom. E-mail: adam.harris@ucl.ac.uk

the likelihood of experiencing certain future events are genuinely unrealistically optimistic. The term *unrealistic optimism* will hence be used to refer specifically to judgments about risk for future life events.

In the present article, we reexamine the methods of unrealistic optimism research and seek to show how the results of studies demonstrating unrealistic optimism could parsimoniously be viewed as statistical artifacts rather than demonstrations of a genuine human bias. Specifically, we show how responses made by participants in typical studies could result from accurate probabilistic knowledge but seemingly imply optimism due to the statistical mechanisms of scale attenuation and minority undersampling. Seeming optimism could further be exaggerated through the statistical mechanism of regressive base rate estimates. This calls into question the widely held view that people are unrealistically optimistic. Furthermore, we show that the majority of "known" moderators of unrealistic optimism are also consistent with the impacts of these statistical confounds. These moderators are central to both theory development and practical applications; it thus seems imperative that they be conceptually and empirically reevaluated in light of these artifacts, even if robust evidence for a genuine optimistic bias can be gained from other methods that do not suffer from these problems. In summary, we argue that the presence of confounding artifacts means, at the very least, that we know considerably less about the unrealistic optimism phenomenon than is presently assumed.

The Methodology of Unrealistic Optimism Research

> It is usually impossible to demonstrate that an individual's optimistic expectations about the future are unrealistic. An individual might be quite correct in asserting that his or her chances of experiencing a negative event are less than average. (Weinstein, 1980, p. 806)

Without detailed individual knowledge about our participants, coupled (ideally) with an ability to see into the future, it is impossible to determine whether a specific individual is accurate in stating that he or she is less likely to experience a given event than the average person. However, it has been assumed that the realism of people's expectations can readily be assessed at a group level. Campbell et al. (2007, p. 1275; see also Bauman & Siegel, 1987, p. 331; Taylor & Brown, 1988, p. 194), for example, stated that "on a group level unrealistic optimism is evident when the majority of respondents feel that negative events are less likely to happen to them than the average person." Both the terms *majority* and *average* are ambiguous. *Majority* can refer simply to the largest group (a *simple majority*) or to a group that constitutes more than 50% (an *absolute majority*); *average*, of course, can refer to a mean, median, or mode. In terms of detecting "unrealism," simple majorities are useless, as it is readily possible to be the largest group but nevertheless be below average, whether the average is assessed by the mean, median, or mode, as shown in the left panel of Figure 1 (see also von Hippel, 2005). Absolute majorities, however, are only somewhat more constraining, and it is still possible for more than 50% of observations to lie below the mean or mode. Only a moderate degree of skew and a limited range of values are enough to give rise to distributions (such as in the right panel of Figure 1) where the absolute majority is above or below the mean (see also Moore, 2007a; Weinstein, 1980, p. 809). Moreover, many real-world distributions have this property. In particular, it arises readily for binomial distributions associated with binary outcomes, for example, whether or not a person will experience a given negative life event.

Nevertheless, it has been suggested that further constraints on the size of the majority allow the desired inference. For example, McKenna (1993, p. 39) proposed that "when as a group, the *vast* majority perceive their chances of a negative event as being less than average then clearly this is not just optimistic but also unrealistic." The validity of such a conclusion depends on the frequency of the event being judged. The negative events used in unrealistic optimism studies are typically rare. To illustrate, cancer, which is a disease generally considered to be quite prevalent, will affect less than half the population, approximately 40% (Office for National Statistics [ONS], 2000).[1] Moreover, contracting cancer is one of the least rare of the negative events typically used in unrealistic optimism studies. In most studies a specific type of cancer is specified. Weinstein (1982), for example, not only used cancer, but also lung cancer and skin cancer, and reported unrealistic optimism only for the two specific (and hence rarer) items. Lung cancer is the most common form of cancer in men and the third most common in women. However, it is predicted that only approximately 8.0% of men and 4.3% of women will contract lung cancer (ONS, 2000), that is, approximately 6% of the population overall.

In order to clarify the impact of event rarity, and to aid our subsequent exposition of the statistical problems associated with standard tests of unrealistic optimism, we introduce a simple thought experiment that we refer back to throughout this article.

A Thought Experiment: "Unrealistic Optimism" in Perfect Predictors

In this thought experiment, we initially assume that people have perfect knowledge (an assumption that will subsequently be relaxed). Because they have perfect knowledge, people know (for certain) whether or not they will eventually contract Disease X, which has a lifetime prevalence of 5% (i.e., in the course of their lifetime, 5% of people will contract Disease X). As they are perfect, our perfect predictors also know that the prevalence (base rate) of Disease X is 5%.

Experiment. Participants are asked whether they have a chance of contracting Disease X that is smaller than, greater than, or the same as the average person's.

Thought process. Participants *know* whether or not they will contract the disease and thus assign a percentage of either 0% or 100% to their chance. Participants also *know* the base rate of the disease, which is the best answer they can give to the question "What is the chance of the average person . . ." (see also Klar, Medding, & Sarel, 1996). Consequently, they assign the average person a chance of 5%. To answer the question posed, participants would compare their chance (0% or 100%) with the average person's chance (5%) to report whether their chance is smaller than or greater than the average person's.

Results. Ninety-five percent of these participants (a percentage presumably sufficiently high to be classified as a vast major-

[1] All prevalence statistics reported are for England and Wales.

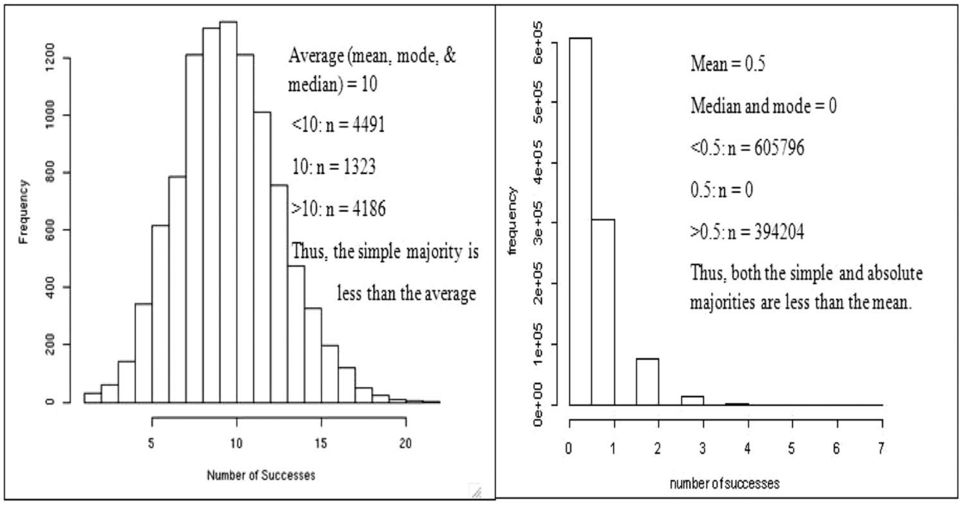

Figure 1. Sample distributions in which the majority outcome is less than the average. The histograms represent the outcome distributions of simple simulations of binomial numbers. The left panel shows the results of 10,000 samples of 100 trials of a binomial process in which the probability of success is .1. The right panel presents a simulation result for a binomial process in which the probability of a success is .005.

ity), knowing that their chance of catching Disease X is 0%, will *accurately* report that they are less likely to contract the disease than the average person, whilst just 5% of participants will report that they are more likely to contract the disease than the average person. Crucially, the reports of these perfect predictors cannot (by definition) be unrealistic.

In other words, even a "vast majority" of people indicating that their chance of experiencing the event in question is less than the average person's cannot guarantee that this group of people has anything other than entirely realistic expectations. For sufficiently rare events, not just the majority but also the "vast majority" of people can genuinely have a less than average (mean) chance of experiencing those events.

In summary, any evaluation based merely on the number of people providing an "optimistic" response relative to the number providing a nonoptimistic response is insufficient evidence that a group of people are unrealistic in their reports.

A Different Methodology

The most popular measure for assessing unrealistic optimism was first used by Weinstein (1980). This *direct method* does not ask participants simply to indicate whether their chance of experiencing a given event is greater or less than the average person's. Rather, participants are required to make a comparative, quantitative response indicating the *degree* to which they are more or less likely to experience an event than the average person. The logic of this approach is simple: Within a population, the average of all participants' individual levels of risk should equal the average risk in that population. For example, with our perfect predictors, 95% of them have a 5% less than average chance (−5%) of contracting Disease X, whilst 5% have a 95% greater than average chance (+95%). If the members of this population accurately report these percentage differences, the mean of their responses will be $(95\% \times -5) + (5\% \times 95) = 0$. Consequently, a population average less than zero would suggest that at least some of the population are unrealistically optimistic regarding this negative event. Weinstein found mean responses less than zero for negative events and greater than zero for positive events. Thus, Weinstein's participants were seemingly unrealistically optimistic, perceiving their future as likely to be rosier than that of the average person.

A variant of this methodology that is less widely used is the so-called *indirect method* (e.g., Dewberry, Ing, James, Nixon, & Richardson, 1990; Dewberry & Richardson, 1990; Eysenck & Derakshan, 1997; Hoorens & Buunk, 1993; Miller, Ashton, & McHoskey, 1990; Pietromonaco & Markus, 1985; Pyszczynski, Holt, & Greenberg, 1987; Salovey & Birnbaum, 1989; van der Velde et al., 1992, 1994; van der Velde & van der Pligt, 1991; for a review see Helweg-Larsen & Shepperd, 2001). Within this paradigm, participants provide estimates of the average person's chance of experiencing an event and of their own chance of experiencing that same event. A relative judgment is then calculated by the experimenter, who subtracts the participant's judgment of the average person's chance from his or her judgment of self risk. This procedure yields a difference score, which (for negative events) is taken as evidence for relative optimism if negative.

In the following, we demonstrate that both these methodologies are vulnerable to statistical artifacts from three different mechanisms: scale attenuation, minority undersampling, and base rate regression. We first demonstrate how any one of these statistical mechanisms allows unbiased participants to falsely appear unrealistically optimistic. We then detail the extent to which these mechanisms fit with what is known about the determinants of (seeming) unrealistic optimism. All of this suggests a possible alternative account for the data of unrealistic optimism studies whereby it is the rare nature of the negative events most frequently studied that leads to a statistical illusion of an optimistic bias. In the presence of such confounds, it is evident that we know less about the optimism of people's risk judgments about future life events than presently believed. We conclude with general considerations for the future of unrealistic optimism research.

The Statistical Mechanisms

The First Mechanism: Scale Attenuation

The effects of scale attenuation differ somewhat across the direct and indirect methods of optimism research. Hence, we deal with each of these in turn.

Scale attenuation and the direct method. Unrealistic optimism studies using Weinstein's (1980) direct method of comparative responses generally do not use a continuous –100% to +100% response scale. Rather, the response scale typically used in this paradigm is a 7-point scale from –3 (*chances much less than the average person's*) to +3 (*chances much greater than the average person's*; e.g., Covey & Davies, 2004; Klar et al., 1996; Price, Pentecost, & Voth, 2002; Weinstein, 1982, 1984, 1987; Weinstein & Klein, 1995). It is the nature of this attenuated response scale that could be producing the results most commonly interpreted as demonstrating unrealistic optimism, as we first demonstrate with further reference to the thought experiment outlined previously.

In this version of our thought experiment, our perfect predictors are required to make a response on a –3 to +3 response scale regarding their relative chance of catching Disease X, which, once again, has a base rate of 5%. Thus 95% of these participants know for certain that they have a slightly lower chance than the average person of catching Disease X (because 0% is 5% less than the 5% average) and hence circle –1 on the response scale.[2] Five percent of these participants know for certain that they have a much greater chance than the average person of catching this disease (because 100% is 95% greater than 5%) and therefore circle +3 on the response scale. The mean response of our population of perfect predictors is therefore −0.8 and not 0. Indeed, even for a representative sample of just 20 participants, the standard analysis of such data would find significant "unrealistic" optimism, $t(19) = 4$, $p = .001$.

At the heart of this seeming paradox, where individually unbiased responses lead to a seemingly biased group level response, is the restricted nature of the response scale. The choice of the –3 to +3 response scale was justified in the original unrealistic optimism studies with the following considerations: "It emphasizes the comparative aspect of the risk judgments, does not demand unnatural numerical estimates (such as percentile rankings), and, unlike a scale used previously (Weinstein, 1980), *is not vulnerable to a few extreme responses*" (Weinstein, 1982, p. 446, footnote 2, emphasis added).

Although this might often be a desirable property of scales, the problematic result of the thought experiment above stems directly from the scale's invulnerability to a few extreme responses in conjunction with the rarity of Disease X. Only a few will get the disease, and their responses are necessarily "extreme." Had this representative sample of participants been able to use the whole percentage range to indicate their relative chances, the mean response would have been zero. Figure 2, however, illustrates that even if the "worse off" (affected) were always to rate themselves as being maximally more likely to experience an event than the average person (i.e., +5 on a less attenuated –5 to +5 scale; +3 on the –3 to +3 scale), for rare events, the average response would be negative. The truncated scale simply does not allow the responses of the two groups to be far enough apart that they can numerically balance out.

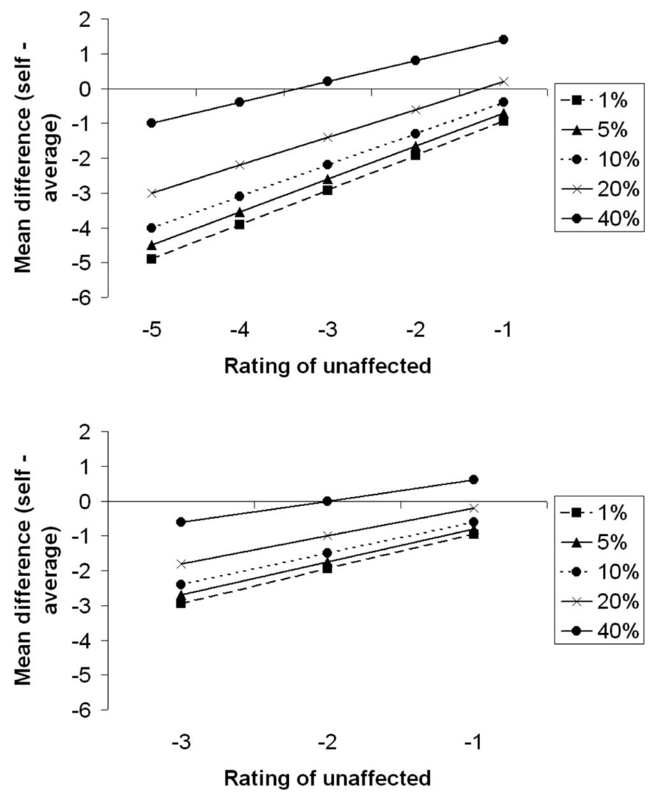

Figure 2. The effect of scale attenuation on the mean difference score (*y*-axis) provided by perfect predictors for events of different base rates and for different negative ratings provided by those who will not experience the event (*x*-axis). Calculations assume that those people who will get the disease report the maximum value on the scale. The top panel shows the effect for a –5 to +5 response scale. The bottom panel shows the effect for a –3 to +3 scale.

Not all studies have used the –3 to +3 response scale. For example, Weinstein (1980) gave participants a 15-point scale with the values "100% less (no chance), 80% less, 60% less, 40% less, 20% less, 10% less, average, 10% more, 20% more, 40% more, 60% more, 80% more, 100% more, 3 times average, and 5 times average" (Weinstein, 1980, pp. 809–811). Clearly this scale enables more extreme responses than the typical –3 to +3 scale. However, this is still not enough for our example of people with perfect knowledge about their susceptibility to a disease with a base rate of 5%. The worse off minority who have a 100% chance of contracting the disease would want to state that they are 20 times (i.e., 100/5) more likely than the average person to contract

[2] Alternatively, participants might consider the relative difference, not the absolute difference in risk, in which case they evaluate the ratio of the difference between their risk and the average person's risk and thus consider the distinction between 5% and 0% to be maximal. Assuming that participants consider their relative risk as a difference score consequently constitutes a conservative assumption.

the disease. The 15-point scale still does not, however, allow for such a response. Consequently, it can still give rise to an artifactual effect of seeming optimism, although the effect will be less pronounced.

That greater scale attenuation leads to (seemingly) greater unrealistic optimism is demonstrated by comparing the two panels of Figure 2. Figure 2 displays *statistical* optimism (mean difference less than zero) and pessimism (mean difference greater than zero) in samples of perfect predictors for diseases with different base rates and in situations where the "better off" majority (unaffected by the disease) report different less-than-average chances. For example, in situations where the unaffected report –1, greater "optimism" will be observed using the –3 to +3 response scale (bottom panel) than the less attenuated –5 to +5 scale (top panel).

Consistent with the proposed role of scale attenuation in unrealistic optimism data is the empirical finding that greater optimism is observed when participants are given an attenuated (–4 to +4) scale than when they are given a larger (–100 to +100) scale (Otten & van der Pligt, 1996).

Scale attenuation and the indirect method. The attenuated response scale is problematic for the indirect method, just as it is for the direct method. The effects of scale attenuation are, however, less easily quantified for the indirect method. In order to demonstrate the difficulties with this scale, we once again use perfect predictors. On the indirect method, these perfect predictors must supply two separate ratings, one for their true individual outcomes of either 0% or 100% and one for the true base rate. However, they must translate both of these values onto 1–7 response scales. Table 1 shows two seemingly plausible candidates for the rational translation of percentage estimates onto a 1–7 scale. For each translation scheme, we calculated the resultant mean difference score as used in unrealistic optimism research; that is, we took both sets of ratings resulting from that translation and subtracted the mean rating of the average person's risk from the mean rating of self risk. Again, negative scores would typically be interpreted as optimism and positive scores as pessimism for negative events. Figure 3 shows the mean difference scores obtained for events of different base rates using the two different translation criteria illustrated in Table 1. Though the two schemes lead to different patterns in detail,[3] neither scheme allows these perfect predictors to appear unbiased at a group level, thus seriously calling into question the validity of this scale.

The mere necessity of a translation table (e.g., Table 1) demonstrates the subjective nature of this response scale (see also Benoit & Dubra, 2009; Moore, 2007a, 2007b). Given that there is no single, obvious, way to translate real-world knowledge of risk onto a 1–7 response scale, it seems entirely plausible that different participants may choose different strategies. Moreover, participants have the option to choose translations in such a way as makes their future look rosier. Such a strategy would not imply that people are genuinely unrealistically optimistic but would mean only that when a crude response scale forces them to choose between seeming either pessimistic or optimistic, they choose the latter. Hence, data obtained from the indirect method are inherently more difficult to interpret than those obtained using the direct method (see also Klar & Ayal, 2004, for further critiques of the indirect method).

Real-world feasibility of scale attenuation. Thus far we have demonstrated the conceptual frailty of the standard comparative tests by demonstrating how seeming unrealistic optimism could be observed for perfect predictors. Of course, the participants in these empirical studies are not perfect predictors. However, com-

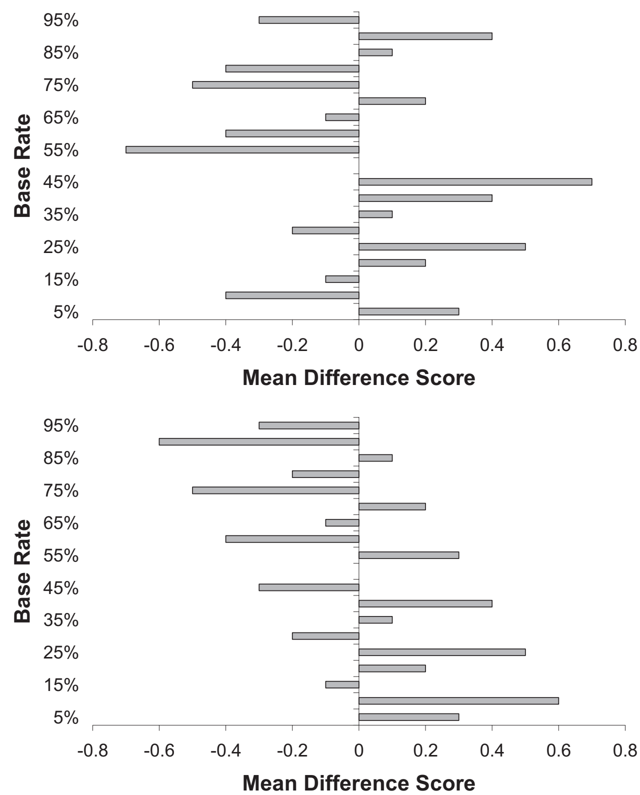

Figure 3. Predicted mean difference scores of perfect predictors reporting their (and the average person's) chances of experiencing events of different base rates on a 1–7 scale. The top panel uses Translation A; the bottom panel uses Translation B.

Table 1
Two Possible Translations (A and B) of Percentage Risks Onto a 7-Point Scale

Scale value	Value meaning	Percentage risk (A)	Percentage risk (B)
1	*Extremely unlikely*	0–9	0–14
2	*Very unlikely*	10–29	15–29
3	*Unlikely*	30–49	30–44
4	*50:50*	50	45–55
5	*Likely*	51–70	56–70
6	*Very unlikely*	71–90	71–85
7	*Extremely likely*	91–100	86–100

[3] The differences in detail result from those cases where the same "average person's risk" is idiosyncratically assigned to a different number on the scale on each translation scheme. As every member of the population's difference score is calculated on the basis of that number, this will lead to qualitative differences in the pattern of results (seen across the top and bottom panels of Figure 3).

plete knowledge of the future is not required in order for the mechanism of scale attenuation to exert an influence, and we next demonstrate how the same statistical effects arise with only partial (but again, intuitively realistic) knowledge of the future. People's knowledge of both their personal risk and the general, average risk (base rate) stems from a variety of sources: Accessible healthcare, public information campaigns, personal experience, and family history all provide informative cues regarding the chance of contracting a certain disease. In fact, regarding personal risk, the strongest predictor is typically also the most accessible, given that "for many common diseases, having an affected close relative is the strongest predictor of an individual's lifetime risk of developing the disease" (Walter & Emery, 2006, p. 472). For example, a longitudinal study investigating the relationship between family history and risk of coronary heart disease illustrated that relative risk is substantially different for men with and without a family history of heart disease. Hawe, Talmud, Miller, and Humphries (2003) reported that men with a family history of heart disease were 1.73 times more likely to suffer a "coronary heart disease event" than men without a family history. Added to this, smokers with a family history were 3.01 times more likely to suffer a coronary heart disease event than nonsmokers with no family history. Were an unrealistic optimism study conducted with a sample in possession of this knowledge (because they had heard about this research, for example), what would the results look like?

To make this example "real," one can simply use the actual figures from the Hawe et al. (2003) study. Here, 6.6% of all men in the study had a coronary event during the follow-up period. This 6.6% constitutes the "average risk" against which men should compare themselves (see also Klar et al., 1996). The rate of heart attack in those reporting a family history of heart attack was 9.0%; it was 5.3% for those without. Given this, we can simulate the responses from these two different groups on a –3 to +3 unrealistic optimism scale with the simplification that knowledge of family history is the only risk indicator these individuals possess. In Hawe et al.'s study, 1,827 men answered "no" to the question "Has any person in your family ever had a heart attack?" (Hawe et al., 2003, p. 99). Comparing the actual rate of 5.3% within that group with the overall base rate, 6.6%, it would seem reasonable (and realistic) for all 1,827 of these men to answer "–1" (i.e., "I am slightly less likely than the average person to suffer a heart attack"). Exactly 1,000 men reported a family history of heart attack. For these men it would seem reasonable (and realistic) to answer "+1" (i.e., "I am slightly more likely than the average person to suffer a heart attack"). An increase in risk from 6.6% to 9.0% does not seem to merit a response higher than this on the scale (though clearly how people believe they should convert such a relative risk onto such a response scale is an empirical question; see also footnote 2). Given this overall set of plausible and rational seeming responses, what would be the result of the statistical analysis of this hypothetical unrealistic optimism study? The mean response from all 2,827 men would equal −0.29, and the standard single-sample t test would confirm that this is significantly less than zero, $t(2826) = 16.26$, $p < .001$. Thus, such responses would be interpreted by an unrealistic optimism researcher as demonstrating unrealistic optimism.[4] Moreover, a representative sample of only 60 people from these 2,827 would give rise to a significant effect of seeming unrealistic optimism, with 39 reporting –1 and 21 reporting +1, $t(59) = 2.42$, $p < .02$. Once again, however, the responses made by each individual seem perfectly realistic. The observed effect stems entirely from the rarity of the event and the low discriminability of an attenuated response scale. This again demonstrates the unsatisfactory nature of using group data to infer a bias at the level of the individual. In the above example, it would be hard to argue that any of the individuals' responses were biased, but the group level results suggest exactly that.

More generally, any individual can have some knowledge reflecting a disease's base rate and, typically, some personal information that increases or decreases his or her own likelihood of contracting the disease. According to the normative procedure for estimating individual risk (see, e.g., Hardman, 2009; Kahneman & Tversky, 1973), the rational person should combine these two pieces of knowledge using Bayes' theorem to calculate his or her own chance of contracting the disease. Even on the basis of a test result with extremely limited diagnosticity, the responses of entirely rational individuals can easily result in seemingly unrealistic optimism at a group level, once the responses are translated onto an attenuated, –3 to +3, response scale.

The diagnosticity of a test is captured in the ratio between a true positive test result, $P(e|h)$, and a false positive test result, $P(e|\neg h)$, where evidence e is a positive test result, hypothesis h is contracting the disease, and ¬ is the negation symbol (i.e., ¬h means "not h"). Equations 1 and 2 (Bayes' theorem) show the normative updating of belief in contracting a disease, given a positive test result, $P(h|e)$, and a negative test result, $P(h|\neg e)$, respectively. In these equations, $P(h)$ represents the prior degree of belief that Disease X will be contracted, which, if people are rational and possess accurate knowledge, would equal the disease base rate (see also Klar et al., 1996).

$$P(h|e) = \frac{P(h)P(e|h)}{P(h)P(e|h) + P(\neg h)P(e|\neg h)} \tag{1}$$

$$P(h|\neg e) = \frac{P(h)P(\neg e|h)}{P(\neg h)P(\neg e|\neg h) + P(h)P(\neg e|h)} \tag{2}$$

The actual proportion of people in the population who will receive a positive or negative test result is given by Equations 3 and 4, respectively.

$$P(h)P(e|h) + P(\neg h)P(e|\neg h) \tag{3}$$

$$P(h)P(\neg e|h) + P(\neg h)P(\neg e|\neg h) \tag{4}$$

We can now consider again a case like lung cancer with its base rate of 6% (ONS, 2000). To demonstrate, we assume that the ratio between true positives and false positives (the likelihood ratio) is only 1.5:1; that is, $P(e|h) = .6$ and $P(e|\neg h) = .4$. In other words, a positive test result is only marginally more likely if the hypothesis is true than if it is not. Finally, the same ratio is assumed to

[4] This simulation is dependent on the assumption that those men with a family history reported +1. We argue that this does not seem to constitute a biased response. For the reader who disagrees with this assumption, the insufficiency of the response scale is demonstrated by showing that were these individuals to report +2, the mean response would be 0.05, not zero, thus suggesting unrealistic pessimism in the population. The crucial point is that this method is not consistent with the status of an average of zero being the gold standard of rationality, as is generally believed.

hold for negative test results. Given the base rate of 6% and these test characteristics, Equations 1–4 mean that, overall, 41% of people should rate their chance of contracting lung cancer as 8.7%, and 59% of people should rate their chance as 4.1%. Were participants to report these figures on a continuous response scale, their responses would average out to equal 6%, that is, the base rate or average person's risk.

However, participants must translate these figures onto a –3 to +3 response scale. It is not obvious how participants should do this. However, the deviations from the base rate seem comparable for both those receiving a positive test result and those receiving a negative result: 8.7% versus 6% for the "worse off" and 4.1% vs. 6% for the "better off". Consequently, 41% of responses of +1 for the worse off might rationally be combined with 59% of responses of –1 for the better off, resulting in an average response of –0.18. Even on the basis of such a nondiagnostic test result, significant "optimism" would be observed in a representative sample of 115 participants, $t(114) = 1.98$, $p = .05$. This effect stems solely from the attenuated nature of the response scale used. Once again, entirely rational responses at the individual level resemble a bias at the group level on such an attenuated scale. Less than perfect knowledge simply diminishes the effect somewhat, both for a direct and an indirect scale.

Empirical support for the notion that people both have access to and may make use of knowledge about risk factors can be found within the unrealistic optimism literature and in the general literature on risk perception. Though Weinstein (1984) expressed doubts about a link between actual risk factors and people's relative judgments, at least one risk factor correlated significantly with risk judgments for seven out of the 10 events considered in his study (Weinstein, 1984, Study 3). For one of the remaining three events (automobile accident injury), no comparative optimism was observed either, and for the other two events (suicide and mugging) significant correlations between risk factors and risk judgment were later observed (Weinstein, 1989a). Subsequent research has commonly found that engaging in risky behaviors is associated with reduced unrealistic optimism (e.g., Cohn et al., 1995; Sparks, Shepherd, Wieringa, & Zimmermanns, 1995; see also Shepperd, Helweg-Larsen, & Ortega, 2003, for further references). Finally, general studies on risk perception suggest that people's estimates of personal risk are grounded in an objective reality: The more risk behaviors people engage in, the more vulnerable they rate themselves to negative consequences resulting from those behaviors (Gerrard, Gibbons, Benthin, & Hessling, 1996; Gerrard, Gibbons, & Bushman, 1996; Martha, Sanchez, & Gomà-i-Freixanet, 2009).[5]

In summary, there is evidence to suggest that people have access to sufficient knowledge and are sufficiently sensitive to it in their judgments of risk for scale attenuation to make unbiased individual responses appear biased at a group level.

The Second Mechanism: Minority Undersampling

Unrealistic optimism studies typically obtain responses from a sample of the population and not the population as a whole. It is a statistical consequence of binomial distributions that minorities in the population are more likely to be underrepresented than overrepresented in a sample of that population (for implications of this fact in other judgment contexts, see Fox & Hadar, 2006; Hertwig, Barron, Weber, & Erev, 2004; Ungemach, Chater, & Stewart, 2009). Consequently, regardless of the response scale chosen or the methodology used, the worse off minority (those more likely than the average person to contract the disease) are more likely to be underrepresented in the sample than are the better off majority. If underrepresented, the crucial influence of the positive responses from the worse off minority on the group average will be missing. Whereas scale attenuation means that the worse off minority cannot provide sufficiently extreme responses to balance out the better off, undersampling means that the responses of some of the worse off are *not even there*. This too will lead to an overall appearance of optimism in the group data.

If we return to our hypothetical example in which all members of the population have perfect knowledge as to whether they will contract a given disease, the mean of these responses (given an unattenuated response scale) will be zero, assuming that responses are obtained from the whole population. If responses are obtained only from a sample of that population, then the mean of these responses will equal zero only in the event that the characteristics of the sample match the characteristics of the population. The fact that the minority are more likely to be undersampled than oversampled from the population makes it more likely that the mean will be less than zero as opposed to greater than zero, thus giving the statistical illusion of an optimistic bias. The magnitude and prevalence of this undersampling can be estimated from distributions such as those shown in Figure 1: Displayed are the results of samples drawn from a population in which a binary outcome (e.g., success/no success reflecting disease/no disease) occurs with a base rate corresponding to the respective probability of success. As the base rate becomes lower (right panel vs. left panel) the proportion of samples that contain fewer than average successes becomes more and more extreme.

Figure 4 graphs this excess proportion for different base rates and sample sizes in order to give a further indication of the effect of event rarity and study sample size on the extent to which the less likely outcome (the minority) is undersampled rather than oversampled relative to the population distribution.

The Third Mechanism: Base Rate Regression

We have already demonstrated how the responses of entirely rational agents in possession of realistic amounts of partial knowledge could lead to data resembling unrealistic optimism as a result

[5] The only other exception came from Bauman and Siegel (1987), who reported that 83% of the gay men in their sample who engaged in sexual practices that put them at high risk for contracting AIDS (66 men in total) rated the risk of their sexual practices (with regards to contracting AIDS) as 5 or less on a 10-point scale (on which 10 indicated most risky). Eight-five percent of these men reported engaging in at least one practice that they believed to reduce the risk of AIDS but that objectively made no difference. Consequently, the underestimation of risk reported in this study might be a result of an accurate risk assessment based on inaccurate knowledge, rather than reflecting systematic optimism. In addition, Bauman and Siegel did not include any questions relating to participants' knowledge about their sexual partners. Any men who engaged in high risk sexual practices with a partner who they knew to be HIV negative would be quite accurate in reporting the riskiness of these activities as low. In the absence of such a question, it is difficult to interpret Bauman and Siegel's results.

of scale attenuation and minority undersampling. The idea of partial knowledge is crucial to the third and final statistical mechanism—base rate regression. Given limited knowledge, people's statistical estimates are likely to be regressive (e.g., Pfeifer, 1994); that is, they are likely to be less extreme than the true value.

Statistical regression to the mean, as depicted in Figure 5 (top panel), explains the widely documented phenomenon whereby people generally overestimate the frequency of rare events and underestimate the frequency of common events (on estimates of frequency see, e.g., Attneave, 1953; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978; for regression based explanations thereof see, e.g., Erev, Wallsten, & Budescu, 1994; Hertwig, Pachur, & Kurzenhäuser, 2005; Pfeifer, 1994). Likewise, people seem to overestimate, and hence be *pessimistic* about, the prevalence of the rare negative events used in unrealistic optimism research; this can be seen in those studies employing the indirect method where the estimate of average risk is explicitly reported and the relevant statistics for the population in question are known, as in Klar and Ayal (2004), Rothman, Klein, and Weinstein (1996), and van der Velde et al. (1992).

Regression has already been invoked in explanations of seeming biases in past research (e.g., Dawes & Mulford, 1996; Erev et al., 1994; Krueger, Acevedo, & Robbins, 2006; Moore, 2007a; Moore & Healy, 2008; Moore & Small, 2007). In particular, Moore and Healy (2008) provided a formalization and elegant experimental demonstration of how better-than-average/worse-than-average effects regarding skilled performance might be explained.

We next detail how regressive estimates of event base rate will lead to seeming optimism with our hypothetical, entirely rational predictors. As discussed above, the normative, textbook procedure for deriving estimates of individual risk requires that diagnostic information concerning that individual be combined with the base rate via Bayes' theorem (e.g., Hardman, 2009; Kahneman & Tversky, 1973). Diagnostic information, such as family history, will be either positive or negative (i.e., indicating either greater or lesser risk). Bayes' theorem ensures that the mean estimate of individual risk will equal the group base rate as long as the underlying base rate estimate is accurate (see the Appendix). This is analogous to the way that the mean of a group of "perfect" individual predictions, reporting the true percentage of either 0% or 100%, will, by definition, equal the group base rate; furthermore, it is because Bayesian updating guarantees this equality between mean individual risk and base rate that the procedure is normative.

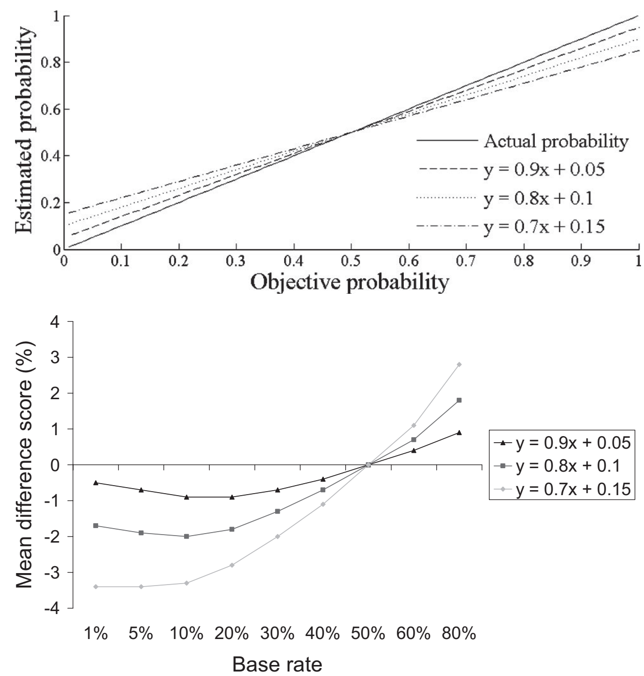

Figure 5. Top panel: The effect of regression to the mean on probability estimates. Bottom panel: The effect of such base rate regression on mean difference scores for events of different base rates. Responses are made by predictors who have a result of a test with a likelihood ratio of 4:1. Responses are made on an unattenuated response scale.

If estimates of the base rate itself, however, are regressive, then this equality will no longer hold. As we shall show, the mean of the individual estimates will now be lower than the regressive base rate estimate and so would be interpreted as demonstrating optimism. However, this effect arises even though each individual is, in absolute terms, pessimistic: The base rate of rare negative events is overestimated, not underestimated, and this overestimation is propagated into the estimate of individual (self) risk.

The effect of the base rate regression mechanism rests on the discrepancy between the actual base rate and the perceived base rate. The absolute value of an individual's self estimate depends on the perceived base rate (because it is derived from it via Bayesian updating). The actual number of individuals receiving particular test outcomes (or any other individuating information such as family history), however, is driven by the actual base rate. The test results necessarily depend on the way the world actually is, not the way it is perceived. As the actual base rate of rare events will be lower than the regressive base rate estimate, more participants will receive negative test results (indicating lesser risk) than is compatible with the (over)estimated average risk. Hence the mean of the self estimates within the sample will be biased and will be lower than the perceived base rate, once again suggesting relative optimism.

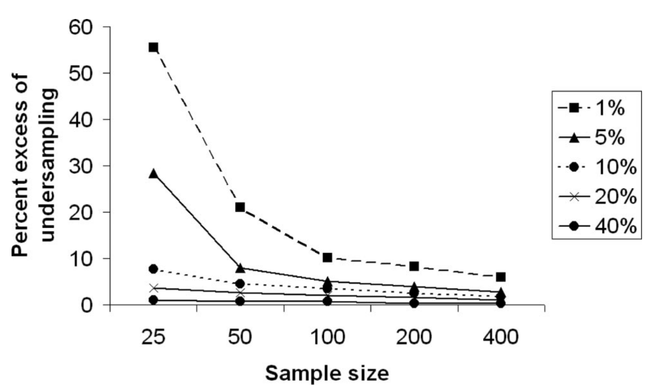

Figure 4. The excess of instances in which the minority was undersampled relative to the majority. Graphed are the results for 1 million simulated samples of size 25–400, for five different base rates.

The effect of base rate regression is visualized in the bottom panel of Figure 5. Regressive base rate estimates were simulated using the formula $y = mx + c$, where x is the objective probability, m is less than 1, and c is solved for the condition where both objective (x) and subjective (y) probability estimates equal .5.[6] We calculated, via Bayes' theorem (Equations 1 and 2), the effects of regressive base rate estimates in a population of rational Bayesians receiving the outcome of a diagnostic test. For this test, individuals were 4 times more likely to contract the disease if they received a positive test score than if they received a negative test score (i.e., the test's hit rate, $P(e|h)$, was .8, and its false positive rate, $P(e|\neg h)$, was .2). To demonstrate the effect of this statistical mechanism in isolation, our simulations involved participants rating both their own and the perceived (regressive) average person's risk on an unattenuated, continuous, 0–100 scale. Figure 5 (bottom panel) shows the resulting mean difference scores across the range of base rates for rare (and not so rare) events, at each of three different levels of regressiveness. As can be seen, normative updating from a regressive estimate of the base rate gives rise to mean difference scores that appear optimistic for rare negative events.

Unpublished data from our lab provide a crude, first estimate of the degree of regressiveness that participants in unrealistic optimism studies actually exhibit: Clutterbuck (2008) presented participants with 10 standard negative events such as contracting particular cancers, diabetes, or coronary heart disease or being in a road traffic accident. Participants indicated the expected incidence within a sample of 1,000 people. Their estimates were compared with actual figures published by the United Kingdom government and relevant health-related charities (e.g., British Heart Foundation). The actual mean rate for the events was approximately 50 per 1,000; participants' estimates, by contrast, were approximately 200 per 1,000. This corresponds to an objective estimate of 5% and a subjective estimate of 20%. Thus, the regressive estimates assumed in Figure 5 seem psychologically plausible and, in fact, might even be considered conservative (however, see also Windschitl, 2002, on potential difficulties associated with the interpretation of such data).

The effects of such regressive base rate estimates should be mitigated by providing participants in optimism studies with accurate base rate knowledge. Evidence to this effect comes from a study by Rothman et al. (1996). In their Study 1, one group of participants provided estimates of risk for the self and the average person for a variety of negative life events, whilst another group was provided with the actual base rate statistic and simply asked to estimate their own risk. Rothman et al.'s interests were different from our own, but it is straightforward to derive from the reported data the standard difference scores of the indirect method for both conditions and to compare the seeming degrees of optimism observed. Columns 3 and 4 of Table 2 show difference scores (self risk – average risk) for each of the two conditions.[7] The difference scores in the condition where participants were given the actual base rate (column 3) are considerably less negative than where they were not (column 4). This lends some support to the claim that base rate regression plays a role in unrealistic optimism studies.

Relationships Between Mechanisms

All three of the mechanisms outlined apply to both direct and indirect rating scales (though scale attenuation has a less uniform effect for indirect scales). Hence, each mechanism can independently give rise to seeming optimism. Jointly, they can exhibit additive or even multiplicative effects, and we conclude with some examples.

Figure 5 provided an estimate of the degree to which base rate regression brings about differences between the means of participants' underlying estimates of self and average person's risk. These underlying estimates must still be translated into an overt response on either a direct or an indirect scale. In the case of the indirect scale, the exact outcome of the combination of scale attenuation and base rate regression is impossible to predict, given that participants have a choice between more than one nonlinear mapping of estimates onto the response scale and that each of these itself has a non-uniformly biasing effect. Figure 6 provides just one example of the combination of base rate regression and an attenuated indirect response scale.

Conceptually straightforward, by contrast, is the relationship between base rate regression and minority undersampling. Base rate regression is driven by a difference between the estimated and the actual base rate; hence, its effects will be amplified by minority undersampling. For rare events, minority undersampling will reduce the *actual* base rate in the sample, thus increasing the discrepancy between this actual base rate and the regressive estimate of the population base rate. The resulting multiplicative relationship between these two mechanisms is demonstrated in Figure 7, which graphs the effect of both mechanisms on mean difference scores for an event with a base rate of 10%.

In conclusion, not only do the statistical mechanisms suffice individually to generate seeming optimism, their effects can mutually reinforce each other. These mechanisms can lend the judgments of rational agents the appearance of optimistic bias at the group level. Of course, participants in unrealistic optimism research need not be rational agents. However, the existence of these statistical mechanisms suggests that the most popular group level methodology of optimism research is inappropriate for establishing that fact: At a minimum, a suitable method for probing human rationality should render rational judgments rational.

Reexamining Unrealistic Optimism Data

The three mechanisms of scale attenuation, undersampling, and base rate regression potentially confound the results of unrealistic optimism studies. However, research has sought to establish not only the existence of an optimistic bias. Over the last three decades, there has also been much examination of the moderators of the optimism effect. In order to gauge the potential impact of these

[6] This regression equation is a psychological simplification at the extreme ends of the probability scale. Probabilities of 0 and 1 will generally be estimated accurately by participants. We do not consider impossible or certain events in this article, nor does the following hinge in any way on extremely low or extremely high probabilities.

[7] We excluded risk estimates relating to the likelihood of presently being infected with the human papillomavirus from Table 2, as Rothman et al. reported that participants had not generally heard of the virus, making the responses difficult to interpret. It seems entirely plausible to assume one is not infected with a disease one has never heard of when feeling healthy. For this disease too, however, the actual base rate condition displays considerably less optimism than the estimated base rate condition.

Table 2
The Provision of Accurate Base Rate Knowledge Reduced the Degree of Seeming Optimism in Rothman et al. (1996; Column 3 vs. Column 4)

	Reported in Rothman et al. (1996) Table 2			Column 1 – Column 2
	No base rate information		Base rate provided	No base rate information
Event	Estimated personal risk – actual base rate	Estimated average risk – actual base rate	Difference score: Estimated personal risk – actual base rate	Difference score: Estimated personal risk – estimated average risk
Suicide	2.4	10.7	1.1	−8.3
Chronic liver disease	3.5	9.6	1.2	−6.1
Colon cancer	4.8	7.8	0.0	−3.0
Alcohol	1.5	15.8	−1.6	−14.3
Panic disorder	1.4	6.6	0.8	−5.2
Divorce	−16.9	4.7	−17.9	−21.6
Obesity	−1.1	14.8	−6.0	−15.9
Chlamydia	−3.8	12.5	−4.8	−16.3
Pregnancy	−3.4	13.0	−5.6	−16.4

Note. Data are from Rothman et al. (1996), Study 1, Table 2 (p. 1222). Columns 1 to 3 are taken directly from Rothman et al.'s table; the difference score (as typically defined in the literature) for the standard condition in which no base rate information is provided (Column 4) is calculated by taking Column 1 and subtracting Column 2 (as $[x - c] - [y - c] = x - y$). As can be seen, difference scores in the base rate provision condition (Column 3) are less negative, and hence seemingly optimistic, than those from the standard condition (Column 4).

three mechanisms, an obvious next question is the extent to which their effects fit with what is known about these moderators.[8]

Moderators of Unrealistic Optimism

It is known that event frequency, specificity of the comparison target, experience with the event, event controllability, and mood/anxiety of the participant all affect the degree of unrealistic optimism observed. We next demonstrate how these moderators relate to the three statistical mechanisms identified.

Event frequency. It is well established that unrealistic optimism decreases as the frequency of the event increases (e.g., Chambers et al., 2003; P. R. Harris, Griffin, & Murray, 2008; Kruger & Burrus, 2004; Weinstein, 1980, 1982, 1987). Scale attenuation, minority undersampling, and base rate regression all have a direct relationship with event frequency (see Figures 2, 4, and 5), though the relationship between scale attenuation and event frequency is less uniform and hence less strong within the indirect method (see Figure 3). Hence the mechanisms identified not only explain the general moderating effect of frequency, but they also provide an explanation for why the effect of frequency is less pronounced in studies using the indirect method (e.g., Klar & Ayal, 2004; Price et al., 2002; Rose, Endo, Windschitl, & Suls, 2008; see also Chambers et al., 2003). Consequently, this moderator supports the contention that statistical artifacts are actually present in the data.

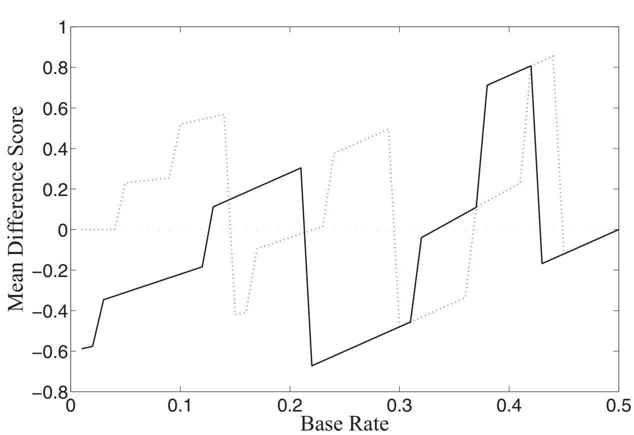

Figure 6. The effect of base rate regression on responses translated onto a 1–7 scale, using Translation B of Table 1. In the simulation, participants have received the result of a test with a likelihood ratio of 4:1. The dotted line indicates the effect of scale attenuation alone, whilst the solid line shows the mean difference score for events of different base rates, for individuals whose base rate estimates are regressive ($y = 0.7x + 0.15$).

Specificity of the comparison target. The degree of unrealistic optimism generally decreases as the target with whom participants are comparing themselves becomes more specific (Burger & Burns, 1988; P. Harris & Middleton, 1994; Klar et al., 1996; Perloff & Fetzer, 1986; Regan et al., 1995; Whitley & Hern, 1991; Zakay, 1984, 1996; see also Alicke, Klotz, Breitenbecher, Yurak, & Vredenburg, 1995). We have assumed in the preceding that the judgments people make of their own risks are qualitatively different from those they make for the average other. When assessing their own chances of experiencing a negative event they are estimating a probability about a singular event (an epistemic probability). However, when assessing the chances of the average person experiencing the event, they estimate a frequentist probability, which relies on distributional statistics, namely, the base rate—for example, what percentage of people contract cancer (see also Klar et al., 1996). As the comparison target is made more specific, the judgments between self and the target become more consistent, for participants are now estimating an epistemic prob-

[8] We follow Helweg-Larsen and Shepperd (2001) in our use of the term *moderator* to refer to variables that have been shown to produce "differences . . . in people's optimistic bias reports" (Helweg-Larsen & Shepperd, 2001, p. 75).

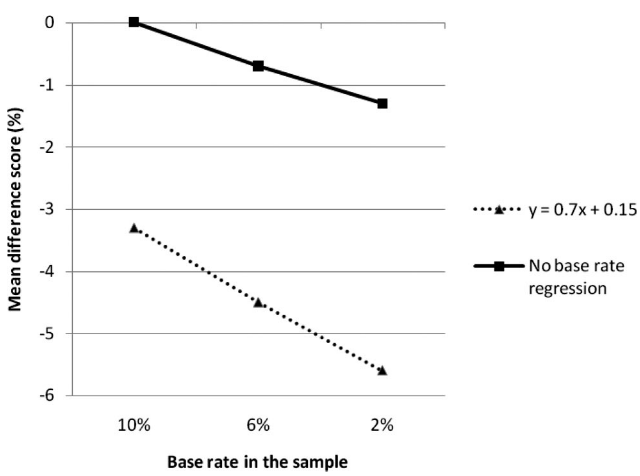

Figure 7. The interaction between minority undersampling (*x*-axis) and base rate regression. The mean difference scores result from simulated responses on a continuous response scale for an event with a population base rate of 10%.

ability for the unique event of this other, single, person contracting cancer. Given the assumption that estimates concern the risks of experiencing *rare* events in these studies, once again it is probable that the likelihood of an individuated comparison target experiencing a negative event will be less than the average person's; so less relative optimism *should* be observed. This proposal is further supported by Helweg-Larsen and Shepperd's (2001) extensive review, which established that the moderating effect of the comparison target affected unrealistic optimism through the risk associated with the comparison target rather than the risk associated with the self.

The same conceptual difference between judgments about the self and judgments about the average person can also explain another finding, namely that, overall, comparative judgments are better predicted by judgments of self risk than judgments of the average peer's risk (e.g., Chambers et al., 2003; Kruger & Burrus, 2004; Price et al., 2002; Rose et al., 2008). Together with the moderating effect of event frequency, this finding has been used to support the egocentrism account of unrealistic optimism, which posits that people's comparative judgments are predominantly based on their own absolute chances of experiencing an event with an insufficient consideration of the chances of others (Chambers et al., 2003; Kruger & Burrus, 2004; Weinstein & Lachendro, 1982; see also Klar & Giladi, 1999; Kruger, 1999; Windschitl, Kruger, & Simms, 2003).[9] There are, however, once again purely statistical reasons for why group risk is expected to be a less powerful predictor (see also Moore, 2007a; Moore & Small, 2007, 2008). All estimates of group risk within a sample concern the same objective quantity; estimates of self risk should be individually derived from that on the basis of person-specific information. Hence there should be greater variability in estimates of self risk than in estimates of group risk, which generally increases predictive power (Howell, 1997, p. 266).

Experience with the event and event controllability. Unrealistic optimism has been shown to decrease as people's experience with the event increases, and to *increase* as the perceived controllability of the event decreases (e.g., Helweg-Larsen, 1999; van der Velde et al., 1992; Weinstein, 1980, 1982, 1987, 1989a; Zakay, 1984, 1986; see also Klein & Helweg-Larsen, 2002, for a meta-analytic review). Helweg-Larsen and Shepperd (2001) demonstrated that both these factors influenced estimates of personal risk, rather than estimates of the comparison target's risk. Such a finding makes sense, as both experience and controllability can be considered sources of knowledge. Consequently, given that family history will increase experience with a disease as well as increasing susceptibility to it (Walter & Emery, 2006), it can be expected to increase ratings of personal susceptibility whilst not changing perceptions of the average person's susceptibility, thus making a relative response appear less optimistic. Controllability also affects knowledge to the extent that people make efforts to avoid undesirable but controllable events. Self-knowledge of one's endeavor (or lack thereof) to avoid the event provides information with which to differentiate one's personal risk from the base rate. Thus, people become more like perfect predictors and the effects of the statistical mechanisms are amplified.

Typically, people have been faulted for not sufficiently taking into account protective measures made by the average person (e.g., Chambers et al., 2003; Kruger & Burrus, 2004; Weinstein, 1980; Weinstein & Lachendro, 1982). However, calculation of the base rate, by definition, includes *all* people, which means it will include both people who do and people who do not take protective measures. Hence those who do take protective measures are in actual fact necessarily less at risk than the average person (base rate).

Finally, in addition to being a source of knowledge, controllability will have a separate impact through its influence on event frequency. The controllability of a negative event is likely to reduce its base rate because people will tend to take protective measures to avoid it. Hence, the moderating effect of controllability is only interpretable once event frequency has been controlled for. Zakay (1984), for example, observed significant interactions between event valence and controllability in comparative responses. It is clear from his data, however, that these effects are readily explained with reference to the event's perceived frequency, which is lower for controllable negative events and higher for controllable positive events than it is for their uncontrollable counterparts.

Mood and anxiety. Responses are typically less optimistic when a negative mood is induced in individuals (e.g., Abele & Hermer, 1993; Drake, 1984, 1987; Drake & Ulrich, 1992; Salovey & Birnbaum, 1989), and unrealistic optimism is frequently not observed in dysphoric individuals (so-called *depressive realism*; e.g., Alloy & Ahrens, 1987; Pietromonaco & Markus, 1985; Pyszczynski et al., 1987; but see also Colvin & Block, 1994; Dunning & Story, 1991). That dysphoric individuals are more negative about their future than normal individuals only implies that they are more realistic than normal individuals *if* normal individuals are independently shown to be unrealistic in their

[9] One difficulty for the egocentrism account lies in recent evidence by Price, Smith, and Lench (2006), who found that comparative ratings between the self and the average member of a group were reduced when perceptions of the average member's chance of experiencing an event increased, under circumstances where individual risk was held constant. This clearly indicates sensitivity to the average at least in some circumstances.

future expectations. This is the very issue challenged in the present article. The same argument, finally, applies to other individual difference moderators of the effect, such as anxiety and defensiveness (see, e.g., P. R. Harris et al., 2008), as well as cross-cultural results that have generally found less optimism in Eastern cultures (e.g., Chang & Asakawa, 2003; Chang, Asakawa, & Sanna, 2001; Heine & Lehman, 1995). Regarding this last phenomenon, however, it is worth noting that research has also found cross-cultural differences in people's general use of response scales (Chen, Lee, & Stevenson, 1995), as well as in probability judgment (for a recent review see Yates, 2010) and risk assessment more generally (e.g., Weber & Hsee, 2000). Such differences could readily influence the effects of the statistical mechanisms we identified.

Implications. What is known about the moderators of unrealistic optimism either supports, or otherwise does not conflict with, a potential influence of the confounding statistical mechanisms of scale attenuation, minority undersampling, and base rate regression. In light of this, one must, we think, conclude that these mechanisms render uninterpretable the evidence collected within the standard paradigm. There seems no way of disentangling potential artifacts from real effects in extant data.

However, the standard paradigm of either direct or indirect comparative rating is also presently the main source of evidence for unrealistic optimism about self risk. This raises the further possibility that unrealistic optimism is, in fact, *solely* a statistical artifact, a possibility we refer to as the *statistical artifact hypothesis*.

Demonstrating that present evidence fails to clearly establish that people are unrealistically optimistic is distinct from establishing that they are, in fact, not optimistically biased. Whether more robust evidence for unrealistic optimism might be found, or whether it cannot, simply because people are not generally unrealistically optimistic about risk, is a question that lies beyond the scope of this article.

It is worth pointing out, however, that critical comparisons exist for which the statistical artifact hypothesis and the hypothesis of a genuine optimistic bias make opposite predictions. Moreover, studies including these comparisons have already been conducted, and we discuss these next.

Evidence Against the Optimistic Bias: The Role of Positive Events

As we have seen, the rare nature of negative events plays a critical role in producing what is potentially an illusion of unrealistic optimism at a group level. Furthermore, under the statistical artifact hypothesis, the rarer a negative event, the greater the degree of seeming optimism that should be seen, and this is observed in practice (e.g., Chambers et al., 2003; Kruger & Burrus, 2004; Weinstein, 1980, 1982, 1987).

We have thus far focused on people's estimates of negative events, as these constitute the bulk of the unrealistic optimism literature. However, the same statistical mechanisms should apply to judgments about the chance of experiencing positive events, on the reasonable assumption that very positive events, like very negative events, are rare. Again, the low base rate of extremely positive events implies that most people will not experience the event in question. For positive events, however, this failure constitutes a bad thing, not a good thing. Hence, the statistical mechanisms introduced above that push the group response toward the majority outcome will result in seeming *pessimism* for positive events. By definition, this is the opposite of what should be found if people were genuinely overoptimistic about their futures. Consequently, while the unrealistic optimism and statistical artifact hypotheses make the same predictions for negative events, they make opposite predictions for positive events.

Studies investigating the possibility of unrealistic optimism for people's estimates of positive events are far fewer than those investigating negative events, and the results for positive events are much more equivocal. A number of studies have reported optimism, such that people view themselves as more likely than the average person to experience positive events (e.g., Campbell et al., 2007; Regan et al., 1995; Weinstein, 1980), but others also report pessimism (e.g., Chambers et al., 2003; A. J. L. Harris, 2009; Kruger & Burrus, 2004; Moore & Small, 2008).

Crucially, the statistical artifact hypothesis predicts unrealistic pessimism only for positive events that are rare. For positive events that are relatively common, the reverse logic applies. For common events, the chance of *not* experiencing them constitutes the rare outcome. However, the positive events in those studies that have largely found optimism are arguably not rare, an observation also made by Hoorens, Smits, and Shepperd (2008). For example, Weinstein's (1980) seminal article used positive events such as "owning your own home" and "living past eighty" (p. 810), which were far less rare than the negative events, and the statistical artifact hypothesis would thus not predict pessimism for them. Weinstein found further that the perceived probability of the event was the single biggest predictor of participants' comparative judgments for positive events, such that greater comparative responses (interpreted as greater optimism) were displayed the more prevalent the positive event was perceived to be, which is in keeping with the statistical artifact claim.

Putting the unrealistic optimism and statistical artifact hypotheses in direct opposition requires studies that also include rare positive events. A number of recent studies have explored both positive events and event frequency more fully. These studies found comparative responses indicative of optimism for common events but of *pessimism* for positive, rare events, as predicted by the statistical artifact hypothesis and in direct opposition to a genuine optimistic bias (Chambers et al., 2003; A. J. L. Harris, 2009; Kruger & Burrus, 2004; and see also, using a ranking methodology, Moore & Small, 2008).

I Wish for, Therefore I Believe . . .?

Finally, a cautionary note regarding the existence of a genuine optimistic bias for future life events may be taken from other research within the judgment literature. There has been much research on whether people consider what they find desirable to be more likely. Early experiments found some evidence for the effects of desirability (e.g., Irwin, 1953; Marks, 1951), and these findings have sometimes been cited in the context of unrealistic optimism research (e.g., Taylor & Brown, 1988). Subsequent research, however, has generally failed to find evidence of wishful thinking under well-controlled laboratory conditions (see for results as well as critical discussion of early research, e.g., Bar-Hillel & Budescu, 1995; Bar-Hillel, Budescu, & Amar, 2008; A. J. L. Harris, Corner, & Hahn, 2009). At the same time, previous observations of the *wishful thinking effect* outside the laboratory (e.g., Babad & Katz, 1991) seem well explained as "an unbiased evaluation of a biased body of evidence" (Bar-Hillel & Budescu, 1995, p. 100; see also, e.g., Denrell & Le Mens, 2007; Fiedler, 2000; Gordon, Franklin, & Beck, 2005; Kunda, 1990; Morlock, 1967; Radzevick & Moore, 2008; Slovic, 1966). For example, Bar-Hillel et al. (2008) observed potential evidence of wishful thinking in the prediction of results in the 2002 and 2006 football World Cups. However, further investigation showed that these results were more parsimoniously explained as resulting from a *salience effect* than from a "magical wishful thinking effect" (Bar-Hillel et al., 2008, p. 282). Specifically, they seemed to stem from a shift in focus that biases information accumulation and not from any effect of desirability per se. Hence Krizan and Windschitl (2007) concluded in their comprehensive review that, whilst there are circumstances that can lead to desirability *indirectly* influencing probability estimates through a number of potential mediators, there is little evidence that desirability *directly* biases estimates of probability.

In short, there is little evidence for a broad "I wish for, therefore I believe . . ." (Bar-Hillel et al., 2008, p. 283) relationship between desirability and estimates of probability. This makes the existence of a general optimistic bias seem somewhat less likely.

Of course, some of us might sometimes be overoptimistic. Certain subgroups of the population might demonstrate a bias: for example, entrepreneurs, gamblers, smokers, motorcyclists, and indeed dispositional optimists (e.g., Cooper, Woo, & Dunkelberg, 1988; Coventry & Norman, 1998; Delfabbro & Winefield, 2000; Griffiths, 1994, 1995; Hansen & Malotte, 1986; Ladouceur, Gaboury, Dumont, & Rochette, 1988; Lee, 1989; McKenna, Warburton, & Winwood, 1993; Rogers & Webley, 2001; Rutter, Quine, & Albery, 1998; Wagenaar, 1988; Walker, 1992; Weinstein, Marcus, & Moser, 2005; but see also Delfabbro, 2004; Rise, Strype, & Sutton, 2002; Sutton, 1999, 2002). Similarly, almost all of us might be optimistic about some very particular things (and it might, indeed, be considered positive to be optimistic about certain events; see Armor, Massey, & Sackett, 2008). However, the existence of a general optimistic bias about risk for future life events cannot be inferred from these specific ones.

The Future for Unrealistic Optimism

The material presented thus far lends itself to skepticism about whether unrealistic optimism genuinely exists. Whether or not it does, however, is an empirical question and one that we believe to be important. It is clear, however, that changes to the standard methodology are required if compelling evidence for optimism is to be found. As seen throughout this article, studying optimism is an extremely difficult task, and there are other methods that one might consider that also suffer problems similar to the ones identified here. Recent research, for example, has indicated that the use of rankings instead of comparative ratings also fails to offer a viable alternative (Benoit & Dubra, 2009). In considering alternatives, no single method clearly stands out as ideal. Nevertheless, we conclude with some tentative suggestions for the improvement of future research.

Improving Present Techniques

Our critique of traditional unrealistic optimism studies has centered around the confounds associated with three statistical mechanisms: scale attenuation, minority undersampling, and base rate regression. Minimally, we suggest that researchers be sensitive to these three mechanisms when designing future studies. We therefore begin by specifying how their effects may be mitigated.

The effects of scale attenuation are removed if participants are able to provide any response required. This suggests the use of a continuous response scale. This alone may not solve all problems in that it must also be practically possible to distinguish sufficiently among low probabilities (see also Klar & Ayal, 2004). It will also not help if ratios, not differences, turn out to be a more natural way to conceptualize discrepancies in risk. In this case, a direct scale would be preferable, but it would need to be unbounded.

In practice, however, the use of a discrete –100 to +100 response scale should already dramatically reduce the confounding impact of scale attenuation. Indeed, future researchers might be able to convincingly argue that, despite its noncontinuous nature, such a scale would be psychologically superior to one that is continuous, though perhaps harder for participants to understand.

Minority undersampling is reduced as study size increases, reflecting the law of large numbers (Bernoulli, 1713) so that increasing the number of participants will have a beneficial effect. Moreover, undersampling is eliminated if research is conducted with an entire population of individuals. Some researchers (e.g., Moore & Small, 2008) have used this logic to design studies in which participants are required to rate themselves relative to "other participants in the experiment" (Moore & Small, 2008, p. 147). It is difficult to know, however, to what degree this question is interpretable to participants. Without extra knowledge about the characteristics of this (newly defined) population, a reasonable simplifying strategy would be to assume that this new population is a representative subsample of the general population about which participants have more knowledge. In this case, minority undersampling again becomes an issue. Furthermore, where participants must construct the sample risk ad hoc, the estimate is likely to be regressive (Moore & Small, 2008).

This leads to the final mechanism, base rate regression. If participants can be provided with accurate base rate statistics for the population against whom they are to compare themselves, this mechanism is nullified. An example of this is seen in Rothman et al. (1996), as discussed above. Here participants were simply told the relevant percentage; however, there may be better methods for communicating the base rate information to participants than simply stating it, for example, by using frequency formats (e.g., Cosmides & Tooby, 1996; Gigerenzer & Hoffrage, 1995; but see also Mellers & McGraw, 1999; Sloman, Over, Slovak, & Stibel, 2003) or other graphical representations (e.g., Bar-Hillel & Budescu, 1995; A. J. L. Harris et al., 2009; A. J. L. Harris & Hahn, 2009).[10]

[10] It seems extremely confusing, however, to both provide an accurate base rate and still ask participants to supply an estimate of the average person's risk as in Lin, Lin, and Raghubir (2003) and Lin and Raghubir (2005). It is an important question whether participants do take the base rate to represent the average person's risk, but this should be assessed in other ways.

Longitudinal Designs

If researchers could see into the future, it would be possible to compare individuals' expectations with the outcomes that they will actually experience. Longitudinal studies essentially allow researchers to see into the future by comparing outcomes at Time 2 with expectations at Time 1, and this provides an alternative route for optimism research (see, e.g., Dunning & Story, 1991; Shepperd, Ouellette, & Fernandez, 1996).

An issue, however, that requires consideration is that optimism studies typically involve estimates about binary events: For example, a person will either have a heart attack or not have a heart attack; they cannot have 0.7 of a heart attack. Thus individual events and probability estimates concerning these events cannot directly be compared.[11] One potential method is to ask an individual to provide binary ratings for a whole range of events, providing either a "yes" or "no" response to the question of whether they will experience each one within a particular time frame (e.g., 10 years). At a future date, the researcher checks the number of those events that the participant actually experienced. The total number of "yes" responses both for expectation and outcome is then compared. For negative events, if the number of "yes" expectations is less than the number of "yes" outcomes then that individual might be considered unrealistically optimistic.

This method was employed by Dunning and Story (1991), who asked participants to indicate whether they would or would not experience 37 different events in the course of one semester. Reading from Table 4 in their article, it can be seen that participants appeared to overestimate the likelihood of both desirable and undesirable events occurring; thus the degree to which these results indicate optimism is unclear.[12] The results of such a methodology do, however, appear to have the potential for a clear interpretation as demonstrating unwarranted optimism, pessimism, or realism.

Dunning and Story (1991), however, predominantly used relatively benign undesirable events such as being ill one day as a result of drinking and missing more than 2 days of class with sickness. The degree to which the same method can be extended to the more severe events of standard optimism research is unclear. When completing a questionnaire whilst healthy, and without the ability to forecast the future, it would seem strange for a participant to say "yes" to any individual, low probability, life-threatening event (e.g., road accident, cancer, kidney failure, etc.). Yet it would seem inappropriate to attribute such reluctance to unrealistic optimism.

An alternative method would be to adopt the approach used widely in the literature on judgment confidence. This literature studies the extent to which people's probability assessments are "calibrated". This requires a large selection of potential events for which participants provide probability estimates. Events are then combined by "binning" all events that the participant assigned a particular range of probabilities to (e.g., 10%–20% chance; 21%–30% chance, etc.). The calibration of the participant's responses is then subsequently evaluated by calculating the proportion of events in each "bin" that actually occurred. To the degree that the participant's responses were well calibrated, between 10% and 20% of events that he or she assigned a 10%–20% chance of occurring should occur, and so on (see, e.g., Keren, 1991; Lichtenstein, Fischhoff, & Phillips, 1982; Wallsten & Budescu, 1983; Yates, 1990). However, this method is itself subject to statistical artifacts, such as regression effects (e.g., Erev et al., 1994; Juslin, Winman, & Olsson, 2000).

Finally, longitudinal studies could use non-binary dependent variables. Shepperd et al. (1996) asked student participants to estimate both future starting salary and an exam score, which were later compared with actual salaries and exam performance. Shepperd et al. reported that estimates 5 months prior to graduation (salaries) and 1 month prior to the exam appeared optimistic relative to the salaries and exam results actually achieved. Although the events studied differ necessarily from the classic material of optimism research and the judgments do not concern probability estimates, this methodology provides a promising approach for future research.

Experimental Manipulation

A final route for optimism research is experimental manipulation. Participants can be asked to estimate the risks of experiencing events that are experimentally defined. Participants could, for example, be presented with a visual representation of probability such as the proportion of yellow cells in a black and yellow matrix (see, e.g., Bar-Hillel & Budescu, 1995; Cohen & Wallsten, 1992; A. J. L. Harris et al., 2009; Wallsten, Budescu, Rapoport, Zwick, & Forsyth, 1986). Such a matrix, if large enough, requires an estimate (because participants cannot simply count) but objectively defines the risk. A given matrix could be presented wherein the yellow cells represent either the participant's own risk or the average person's risk. Any systematic difference between judgments of those risks then clearly indicates bias. An initial experiment within this paradigm failed to find evidence for such differences (A. J. L. Harris, 2009); however, this methodology seems worth further exploration.

Conclusions

We have introduced a range of methodological concerns that plague traditional studies "demonstrating" that people are unrealistically optimistic when judging the likelihood of future life events. Typically, these demonstrations are based on people rating their chances of experiencing negative events as being less than the average person's. At the root of these concerns lies the fact that the negative events that form the focus of these studies are generally rare events. This gives rise to three statistical problems: the effects of scale attenuation, minority undersampling, and base rate regression. All three are independent statistical mechanisms by which seeming optimism may emerge from entirely unbiased predictors.

Indeed, we demonstrated that the response scales most often used in this research give rise to seeming bias with predictors that

[11] Although the Brier score was developed in order to measure the calibration of probabilistic forecasts about binary outcomes and could, of course, be used to compare the accuracy of different individuals' forecasts, it could not be used to assess the systematicity of an optimistic or pessimistic bias.

[12] Dunning and Story (1991) were primarily interested in the differences between mildly depressed individuals and nondepressed individuals. Consequently, the pattern of results reported here has not been verified by statistical analyses.

are not only rational, but perfect, that is, in possession of fully accurate knowledge about the state of the world. This is true of the scales used in both the prevalent so-called direct method and the less common indirect method. It would seem a minimum requirement for any response measure of accuracy that responses that are entirely accurate do, in fact, appear accurate on that measure. Consequently, the response scales on which unrealistic optimism research is based would seem to fail most basic requirements of validity.

We also demonstrated how scale attenuation would generate seeming optimism, given plausible amounts of imperfect, but unbiased, knowledge. Assuming only very weak diagnostic information, “unrealistic optimism” emerges readily, as we showed both with general calculations and specific examples modeled on extant research. Moreover, we cited empirical evidence for an effect of scale attenuation from comparisons of the amount of optimism observed when more and less attenuated scales are used. Finally, we showed how scale attenuation, minority undersampling, and base rate regression can combine and even mutually enhance each other.

These statistical mechanisms also seem able to explain a number of established moderators of the unrealistic optimism phenomenon, including specificity of the comparison target, event controllability, experience, and event frequency. Moreover, these mechanisms readily explain the weaker correlation typically observed between optimism and event frequency when measured using the indirect method as opposed to the direct method. This lends further credibility to the claim that these mechanisms have given rise to statistical artifacts in the data of unrealistic optimism research. At the very minimum, this suggests that even if unrealistic optimism does exist, these statistical problems cloud our present understanding of both its magnitude and determinants.

However, these statistical artifacts also raise questions about the very existence of a general, unrealistically optimistic bias. Given that the majority of optimism studies have used the comparative methodology, one may wonder whether such a bias actually exists and whether or not more compelling evidence could be found. One concern here must be that there is evidence against an optimistic bias even within the standard paradigm; the studies that have included events for which optimism and the statistical artifact hypothesis make opposing predictions have obtained results that favor the latter (e.g., Chambers et al., 2003). Moreover, the balance of evidence in the wider judgment literature is moving away from the claim that people’s estimates of probability are inherently biased by desirability.

As we noted in the introduction, however, unrealistic optimism is often viewed as one of a wider range of self-enhancement phenomena, such as the better-than-average effect, the planning fallacy, or overconfidence (see, e.g., Dunning, Heath, & Suls, 2004). Seen in this context, unrealistic optimism may seem more likely. However, many of these related bias phenomena have themselves come under critical scrutiny. People, for example, do not always consider themselves to be better than average but also worse than average (see, e.g., Kruger, 1999), nor is their planning always overoptimistic (see, e.g., Boltz, Kupperman, & Dunne, 1998), and Erev et al. (1994) demonstrated that the same judgment data could be interpreted as evidence of both overconfidence and underconfidence depending on the mode of analysis. Moreover, a growing body of literature has offered rational and statistical accounts as explanations for many of these phenomena (e.g., on false consensus, see Dawes & Mulford, 1996; on the illusion of control, see Matute, Vadillo, Blanco, & Musca, 2007; on better-than-average/worse-than-average effects, see, e.g., Moore & Healy, 2008, and Kruger, Windschitl, Burrus, Fessel, & Chambers, 2008; on under- or overconfidence, see Erev et al., 1994; Juslin et al., 2000; Pfeifer, 1994; Soll, 1996; and on overoptimism generally, see van den Steen, 2004). Clearly, only time will tell for unrealistic optimism itself, and there remain a number of potential methodological avenues for future optimism research. However, a considerable, and growing, body of research suggests that people’s judgments may be more rational than often assumed.

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(*Appendix follows*)

Appendix

The Average Personal Risk Estimate of a Population of Rational Bayesians, Possessing Accurate Statistical Information, Equals the Base Rate

To calculate the average response of the entire population, it is necessary to sum the average responses of those people receiving a positive test result and those receiving a negative test result. These averages are obtained by multiplying the respective posterior degrees of belief (Equations 1 and 2) with the proportions of people expressing them (Equations 3 and 4). It can be seen from Equations 1 and 3 and from Equations 2 and 4 that this multiplication process will cancel out the denominators in Equations 1 and 4, leaving the average response of the population equal to Equation 5. As $P(\neg e|h)$ and $P(e|h)$ must sum to 1, Equation 5 reduces to $P(h)$, which equals the base rate.

$$P(h|e) = \frac{P(h)P(e|h)}{P(h)P(e|h) + P(\neg h)P(e|\neg h)} \tag{1}$$

$$P(h|\neg e) = \frac{P(h)P(\neg e|h)}{P(\neg h)P(\neg e|\neg h) + P(h)P(\neg e|h)} \tag{2}$$

$$P(h)P(e|h) + P(\neg h)P(e|\neg h) \tag{3}$$

$$P(h)P(\neg e|h) + P(\neg h)P(\neg e|\neg h) \tag{4}$$

$$P(h)P(\neg e|h) + P(h)P(e|h) \tag{5}$$

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