HARVARD Kennedy School
MOSSAVAR-RAHMANI CENTER
for Business and Government 30 YEARS

Is The Price Right?
Reexamining the Relationship Between Age and the Value of Statistical Life

Daniel Eric Herz-Roiphe
Harvard College

2010

M-RCBG Associate Working Paper Series | No. 5

Winner of the 2010 John Dunlop Undergraduate Thesis Prize in Business and Government

Mossavar-Rahmani Center for Business & Government
Weil Hall | Harvard Kennedy School | www.hks.harvard.edu/mrcbg

IS THE PRICE RIGHT?
REEXAMINING THE RELATIONSHIP BETWEEN AGE AND THE VALUE OF STATISTICAL LIFE

An Essay Presented

by

Daniel Eric Herz-Roiphe

to

The Committee on Degrees in Social Studies

in partial fulfillment of the requirements
for a degree with honors
of Bachelor of Arts

Harvard University
March 2010

TABLE OF CONTENTS

INTRODUCTION:
PRICING LIFE AND DISCOUNTING DEATH

"Insanity," Albert Einstein once noted, "is doing the same thing over and over again and expecting different results." So when the eminently sane Environmental Protection Agency (EPA) Administrator Christine Todd Whitman got up to speak to an audience of seniors on May 7, 2003, in Baltimore, Maryland—the sixth and final stop on a "listening tour" designed to engage with the elderly on environmental regulation—she knew what was coming.[1] At each of the past five events, Whitman and her colleagues had been treated to a barrage of protests and complaints from a well-mobilized army of indignant senior citizens. As the circus gathered attention, the tour—conceived as a form of community outreach—was quickly becoming an embarrassment.[2]

The cause of all the trouble was the recently released *Methodologies for the Benefit Analysis of the Clear Skies Initiative* —the kind of dry, technical document that is rarely read by anyone outside of policymaking circles. Somehow, this dense examination of the costs and benefits of an emissions-reducing measure had managed to turn heads—heads that now spent their time shouting at Christie Whitman.

It might not have seemed surprising that the report caused so much controversy, since it did something that many people find repulsive: It put a price on human life. Yet this alone was hardly notable. For years, the EPA and other similar

---

[1] For a description of the tour and its stops, see "Public Listening Sessions | Aging Initiative | US EPA," U.S. Environmental Protection Agency, http://www.epa.gov/aging/listening/index.htm (accessed March 1, 2010).
[2] Katherine Q. Seelye and John Tierney, "E.P.A. Drops Age-Based Cost Studies," *New York Times*, May 7, 2003, Late ed., sec. A.

agencies have devised ways to translate prevented fatalities into dollars and cents.[3] Ever since the early 1980s, when cost-benefit analysis became a required part of the regulatory process by executive order, the lives saved through regulation have been monetized and tallied.[4] Pricing a life is no easy task. But it is also an unavoidable one, as mortality risk reductions comprise most of the benefits for many regulations.[5]

For the past 40 years, economists have tackled this problem by calculating the value of statistical life (VSL).[6] Given the inherent obstacles to reliably determining how much people are willing to pay to avoid certain death, their method instead examines tradeoffs between money and small mortality risks. Suppose individuals are willing to pay $500 to eliminate a 1 in 10,000 chance of death. Then VSL is the amount that 10,000 people would pay to eliminate one "statistical death," (which in this case is $5 million = $500 x 10,000). Alternatively, the $500 figure represents an individual's WTP per unit of risk, in which case it can be multiplied by 10,000 to once again obtain a $5 million value of life.[7] Either way of thinking about the problem produces equivalent results. The important takeaway is that preferences

---

[3] See Lisa Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions," *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007), for an overview of current practice.
[4] CBA was originally required under Reagan by Exec. Order No. 12291, 3 C.F.R. (1981). Clinton continued the practice with Exec. Order No. 12866, 3 C.F.R. (1993), which makes similar demands of agencies, but also asks them to consider "distributive concerns" when conducting analyses. See Cass R. Sunstein, "Congress, Constitutional Moments, and the Cost-Benefit State," *Stanford Law Review* 48, no. 2 (January 1996), for an overview of the rise of CBA in American regulatory policy.
[5] For example, 80% of the $22 trillion of benefits of the Clean Air Act from 1970-1999 came from prevented fatalities according to United States Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1970-1990* (Washington, D.C., 1997).
[6] See Thomas C. Schelling, "The Life You Save May Be Your Own," in *Problems in Public Expenditure Analysis. Papers presented at a conference of experts held Sept. 15-16, 1966*, ed. Samuel B. Chase (Washington: Brookings Institution, 1968) and E.J. Mishan, "Evaluation of Life and Limb: A Theoretical Approach," *Journal of Political Economy* 79, no. 687 (1971), for the origins of this approach.
[7] See W. Kip Viscusi, "Value of Life," in *The New Pagrave Edition of Economics*, ed. Steven N. Durlaufe and Lawrence E. Blume, 2nd ed. (New York: Palgrave Macmillan, 2008), for an introduction to the concept.

between risk and wealth determine how much people will pay to save one statistical life.[8]

Under the Reagan Administration, this VSL approach came to dominate federal regulatory policy, replacing older techniques such as the human capital method—which calculates the cost of death from the net present value of a deceased individual's future earnings stream.[9] At the time, not everyone was thrilled about VSL's newfound prominence. In 1985, an editorialist in the Washington Post asserted that inquiring into the proper monetary value of life was a question that "could only be asked in Washington." Elsewhere, "death wears a face."[10] Today, some still find it morally abhorrent to put a price on the seemingly unquantifiable.[11] But the dissidents are less vocal, and VSL calculations have become so ubiquitous in public policy that the practice has lost some of its controversial character.[12] It's not going anywhere, nor is it clear that it should—at least theoretically, it promotes the development of a cost-efficient federal regulatory regime, capable of saving more lives for less money.[13]

---

[8] The use of the adjective "statistical" in "value of statistical life" is meant to distinguish saving a person in the abstract and protecting an identified individual.

[9] See W. Kip Viscusi, "The Value of Risks to Life and Health," *Journal of Economic Literature* 31, no. 4 (December 1993), 1942-1943, for a brief account, and W. Kip Viscusi, *Fatal Tradeoffs: Public and Private Responsibilities for Risk* (New York: Oxford University Press, 1992), 149-293, for a more comprehensive treatment.

[10] Pete Earley, "What's a Life Worth," *Washington Post*, June 9, 1985, Magazine sec.

[11] For example, Frank Ackerman and Lisa Heinzerling, *Priceless: On Knowing the Price of Everything and the Value of Nothing* (New York: New Press, 2004).

[12] See Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions" and Lisa Robinson, *Valuing Mortality Risk Reductions in Homeland Security Regulatory Analysis,* report prepared for U.S. Customs and Border Patrol, Department of Homeland Security (2008) for accounts of how ubiquitous the practice is across many different agencies.

[13] See Robert W. Hahn and Cass R. Sunstein, "A New Executive Order for Improving Federal Regulation? Deeper and Wider Cost-Benefit Analysis," *University of Pennsylvania Law Review* 150, no. 5 (May 2002), 1489-1515 both for a discussion of the potential for CBA to improve lifesaving regulation, and for a critical assessment of whether it has accomplished this goal so far.

So anyone who had been paying attention for the past 20 years wouldn't have been shocked by the EPA's *Clear Skies* regulatory analysis solely because it tried to put a price on life. What did ruffle feathers, however, was exactly how the EPA went about matching up lives and dollars. In its primary benefit calculation, the Agency's *Clear Skies* report applied a constant VSL of $6.1 million to any life saved by the regulation. But in a sensitivity analysis, the EPA used what came to be known as the "senior discount." While lives of individuals under 70 were valued at $3.7 million, persons over 70 were given a VSL of only $2.1 million—a discount of 37 percent.[14]

Judging by the furor that ensued, one would have guessed that the EPA had never done anything like this before. In fact, it had carried out similar procedures more than once under the Clinton Administration.[15] But even if this wasn't the first time that the EPA had tried its hand at senior discounting, an army of angry advocates sprung up to ensure that it would be the last. Organizations that had long been wary of EPA cost-benefit analyses, such as Ralph Nader's U.S. Public Interest Research Group (PIRG), began to build coordinated resistance to the policy, recruiting senior citizens, who might have otherwise paid little attention to their newly "devalued" status. America's elderly were not pleased to hear that federal bureaucrats had marked them down. David Certner, the Director of Federal Affairs for the AARP, claimed he was "deeply troubled" by the senior discounting policy.[16] Given the political clout his organization wields, this was no laughing matter. As

---

[14] United States, Environmental Protection Agency, *Technical Addendum: Methodologies for the Benefit Analysis of the Clear Skies Initiative* (2002), 33-37. The VSL in the sensitivity analysis is calculated using different academic studies than the figure in the primary analysis, explaining why it is lower for both groups.

[15] See for example United States, Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements* (2000).

[16] Cindy Scrzycki, "Under Fire, EPA Drops the 'Senior Death Discount'" *Washington Post*, May 13, 2003, Final ed., Financial sec.

American Enterprise Institute scholars Robert Hahn and Scott Wallsten would later remark on the ensuing firestorm, "tangling with the AARP can be more dangerous to a politician than blocking the entrance to the Boca Raton Sizzler when it opens for the early bird special."[17]

This unrest percolated during the months following the EPA report's release in September, and by the time the "listening tour" rolled around the following spring, it was ready to boil over. At the tour's first stop in Tampa, Florida, no fewer than 17 different seniors got on the microphone to excoriate Whitman and her colleagues over the discounting policy.[18] The rest of the trip produced more of the same. At each location, angry crowds of protesters greeted the EPA with signs proclaiming "Seniors on Sale" and literature denouncing the Agency for deciding that the elderly were "worth 3/5 of a person."[19] (As luck would have it, the adjustment used in the EPA's analysis was virtually identical to the infamous discount of slaves that appears in the U.S. Constitution.) By the time the tour reached Baltimore, Whitman had seen enough. Before any questions could be asked, she told the assembled audience, "The Senior Discount factor that has caused so much concern has been discontinued by OMB for EPA regulations, and the bottom line is that EPA will not—repeat not—use an age-adjusted analysis for decision making with Clear Skies or any other program or regulatory effort."[20] Had Whitman

---

[17] Robert Hahn and Scott Wallsten, "Who's Life is Worth More? (And Why Is It Horrible to Ask?)," *Washington Post*, June 1, 2003, Final ed., Outlook sec.
[18] See "Tampa, FL Listening Session | Aging Initiative | US EPA," U.S. Environmental Protection Agency, http://www.epa.gov/aging/listening/2003/tampa.htm (accessed March 1, 2010).for a sampling of some of the comments
[19] See Scrzycki, "Under Fire, EPA Drops the 'Senior Death Discount'"; John Tierney, "Life: The Cost-Benefit Analysis," *New York Times*, May 18, 2003, Late ed., Week in Review sec.
[20] See "Statement Of Christine Todd Whitman | Aging Initiative | US EPA," U.S. Environmental Protection Agency, http://www.epa.gov/aging/listening/2003/balt_ctw.htm (accessed March 1, 2010).

not decided to pull the plug on senior discounting, Congress would have taken care of matters for her. In its appropriations bill for fiscal year 2004, the House blocked funding for any analyses that employed the age-adjusted VSL that had caused so much trouble.[21] (Incidentally, Whitman resigned later that year.)

Since then, senior discounting has fallen further. Shortly after Whitman's *mea culpa*, John D. Graham, Administrator of the Office of Information and Regulatory Affairs (OIRA), circulated a memo that advised all agencies to avoid employing any sort of senior discount.[22] Later that year, the Office of Management and Budget's *Circular A-4*—which provides guidance on how to conduct cost-benefit analyses—unequivocally rejected age adjustment.[23] This unfavorable assessment still stands as the official government-wide stance on the practice.

Yet the renouncement of age adjustment reflected more than a populist uprising against technocratic policymaking. Criticism of the EPA's senior discounting scheme could also be found in the academic community, where many scholars argued that the age-adjustments were not founded in empirical evidence.[24] In fact, (albeit perhaps for strategic reasons), this civil academic chatter, rather than the boisterous protests, was the justification ultimately cited by the government for reverting to an age-invariant VSL figure.

Before the crisis, many bureaucrats and economists believed that younger individuals were willing to pay more for mortality risk reductions than their older counterparts since they had more at stake—the chance of dying prematurely is

---

[21] H.R. Res. 2673, 108th Cong. (2004) (enacted).
[22] John D. Graham, *Benefit-Cost Methods and Lifesaving Rules*, Memorandum to the President's Management Council, Office of Management and Budget, May 30, 2003, 1-2.
[23] United States, Office of Management and Budget, *Circular A-4* (2003), 29-31.
[24] See Richard L. Revesz and Laura J. Lowenstein, "Anti-Regulation under the Guise of Rational Regulation: The Bush Administration's Approaches to Valuing Lives in Environmental Cost-Benefit Analyses," *Environmental Reporter* 34, no. 10954 (2004), for example.

greater cause for concern if you are otherwise going to live for 60 years than if your end is already approaching. This intuitive belief found support in several early empirical results that provided the basis for the EPA's adjustments in 2002.[25] Yet soon after the controversial *Clear Skies* report surfaced, new evidence began to challenge these assumptions about how age affected VSL. A study by Alberini et al. published in 2004, for example, found no statistically significant decline in WTP with age among a large sample of elderly Americans.[26] And as more and more research on the subject accumulated in the years that followed, this age-independence view continued to gather support.

There are two major ways in which VSL is calculated. The first type—revealed preference studies—primarily look at the premia paid for risky jobs in the labor market.[27] The second—stated preference studies—typically employ the contingent valuation survey methodology, which asks individuals about their WTP for hypothetical small risk reductions.[28] Comprehensive reviews of both literatures'

---

[25] See Michael W. Jones-Lee, M. Hammerton, and P. R. Phillips, "The Value of Safety: Results of a National Sample Survey," *Economic Journal* 95 (1985): 49-72; Michael W. Jones-Lee, *The Economics of Safety and Physical Risk* (Oxford: Basil Blackwell, 1989); Michael W. Jones-Lee et al., "The Value of Preventing Non-Fatal Road Injuries: Findings of a Willingness-to-Pay National Sample Survey," *TRY Working Paper, WP SRC2* (1993).

[26] Anna Alberini et al., "Does the Value of Statistical Life Vary with Age and Health Status? Evidence from the U.S. and Canada," *Journal of Environmental Economics and Management* 48 (2004).

[27] This idea has its origins in the writings of Adam Smith, who originally posited the existence of compensating differentials for jobs that were dangerous or unpleasant, see Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. Jonathan B. Wight (Petersfield: Harriman House, 2007), 65. The modern revealed preference method proceeds through hedonic wage regression analysis, using some variant of the form: $\ln(w_i) = \alpha + H_i'\beta_1 + X_i'\beta_2 + \gamma p_i + \varepsilon_i$, where w is the wage, H is a vector of personal characteristics, X is a vector of job characteristics, and p is the fatality risk, and seeking to measure impact that risk has on wages, see Viscusi, "The Value of Life."

[28] Contingent valuation, which involves asking individuals to value goods for which there are no markets, has been practiced for decades, with origins in Siegfried V. Ciriacy-Wantrup, "Capital Returns from Soil Conversation Practices," *Journal of Farm Economics* 29 (1947). For a description of modern methodology see Ian J. Bateman et al., *Economic Valuation with Stated Preference Techniques: A Manual* (Cheltenham: Elgar, 2002).

findings on the interaction between age and VSL were published in 2007.[29] The consensus from the revealed preference studies appears to be that VSL follows an inverted-U trajectory over the lifespan, rising in middle age and then falling towards the end of life. However, the rise is much steeper than the decline, meaning that the average 60-year-old is willing to pay considerably more to reduce risk than the average 20-year-old.[30] The stated preference literature, meanwhile, has a hard time identifying any statistically significant interaction between age and WTP. In his

---

[29] Both methods have come under criticism. With regard to revealed preference studies, many assert that individuals may misunderstand their risk levels or lack sufficient flexibility in labor markets to incorporate risk information into their decisions, see Kristin Shrader-Frechette, *Environmental Justice: Creating Equality, Reclaiming Democracy* (Oxford: Oxford University Press, 2002); William T. Dickens, "Assuming the Can Opener: Hedonic Wage Estimates and the Value of Life," in *The new hedonics primer for economists and attorneys*, ed. John O. Ward and Thomas R. Ireland (Tucson, AZ: Lawyers & Judges Pub., 1996); Peter Dorman, *Markets and mortality: economics, dangerous work, and the value of human life* (Cambridge [England]: Cambridge University Press, 1996); Elizabeth Anderson, *Value in ethics and economics* (Cambridge, Mass.: Harvard University Press, 1993). Revealed preference studies are also criticized because they are limited to collecting data about young, employed people contemplating immediate accidental deaths, which may not reflect the conditions most relevant for government regulation, see Alan Krupnick et al., "Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents," *Journal of Risk and Uncertainty* 24, no. 2 (2002). Contingent valuation is often attacked as well, though, since the numbers it generates are purely hypothetical, and are subject to many biases, see Peter A. Diamond and Jerry A. Hausman, "Contingent Valuation: Is Some Number Better than No Number?" *Journal of Economic Perspectives* 45 (1994); Anon., "Ask A Silly Question...: Contingent Valuation of Natural Resources Damages," *Harvard Law Review* 1981 (1992); Roger Bate, *Pick A Number: A Critique of Contingent Valuation and its Application in Public Policy*, report (Competitive Enterprise Insitute, 1994).

[30] Joseph E. Aldy and W. Kip Viscusi, "Age Differences in the Value of Statistical Life: Revealed Preference Evidence," *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007). For more examples see Thomas J. Kniesner, W. Kip Viscusi, and James P. Ziliak, "Life-Cycle Consumption and the Age-Adjusted Value of Life," *Contributions to Economic Analysis and Policy* 5, no. 1 (2006); W. Kip Viscusi and Joseph E. Aldy, "Labor Market Estimates for the Value of Statistical Life," *Journal of Environmental Economics and Management* 53, no. 3 (May 2007).; Joseph E. Aldy and W. Kip Viscusi, "Adjusting the Value of a Statistical Life for Age and Cohort Effects," *The Review of Economics and Statistics* 90, no. 3 (August 2008). Earlier revealed preference studies often found a more significant negative effect of age, but such work was less sophisticated, see Richard Thaler and Sherwin Rosen, "The Value of Saving a Life: Evidence from the Labor Market," in *Household production and consumption: conference on household production and consumption, Washington, D.C. 1973.*, ed. Nestor E. Terleckyj (New York: Columbia University press, 1975); Paul R. Portney, "Housing prices, health effects, and valuing reductions in risk of death," *Journal of Environmental Economics and Management* 8 (1981); Ronald Meng, "Compensating Differences in the Canadian Labour Market," *Canadian Journal of Economics* 22, no. 2 (1989). Some more recent revealed preference work has even revealed a *positive* relationship between age and WTP, see V. Kerry Smith et al., "Do the 'Near' Elderly Value Mortality Risks Differently?" *Review of Economics and Statistics* 86, no. 1 (2004); Mary R. Evans and V. Kerry Smith, "Do We Really Understand the Age-VSL Relationship?" *Resource and Energy Economics* 28 (2006).

review, Allan Krupnick concludes that existing data paints "a mixed and confusing picture."[31]

This "mixed and confusing picture" explains why federal agencies would likely be hesitant to engage in age-adjustment even in the absence of political constraints. Under the assumptions of welfare economics—which undergird the regulatory regime—"the value of a reduction in mortality risk (e.g., in the probability of dying over a stated period) is what a person is willing to pay for it."[32] This premise has profound implications. According to its dictates, observed WTP evidence gives regulators precise instructions on how to treat age in cost-benefit analysis. And as long as studies find no significant difference in WTP between young and old, then this theory correspondingly asserts that age adjustment fails to promote welfare. Demonstrating their commitment to this approach, recent government analyses have argued against VSL adjustment—or other monetization techniques that give less weight to seniors—on account of the lack of evidence that WTP for risk reductions declines with age.[33] Current standard practice is to employ one VSL figure for all age groups, and it is unlikely that this will change unless dramatic new data emerge from revealed or stated preference studies.[34]

---

[31] Alan Krupnick, "Mortality Risk Valuation and Age: Stated Preference Evidence," *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007)—for more, see Anna Alberini, Alistair Hunt, and Anil Markandya, "Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study," *Environmental and Resource Economics* 33 (2006); L. G. Chesnut, R. D. Rowe, and W. S. Breffle, *Economic Valuation of Mortality Risk Reduction: Stated Preference Approach in Canada*, report for Health Canada (2004); J.R. Deshazo and Trudy A. Cameron, *Mortality and Morbidity Risk Reduction: An Empirical Life Cycle Model of Demand with Two Types of Age Effects*, University of California at Los Angeles, 2004.
[32] Maureen Cropper et al., *SAB Advisory on EPA's Issues in Valuing Mortality-risk Reduction.* Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Advisory Committee, to EPA Administrator Stephen L. Johnson, report no. EPA-SAB-08-001 (2007), 10.
[33] Cropper et al., *SAB Advisory*. See also, National Academy of Sciences, *Estimating mortality risk reduction and economic benefits from controlling ozone air pollution* (Washington, D.C.: National Academies Press, 2008).
[34] Robinson, "How US Government Agencies Value Mortality Risks"

Treating everyone the same has an immediate appeal. But there is something intuitively unsavory about the status quo as well. As noted earlier, younger individuals do seem to get more from a mortality risk reduction than their grandparents in some absolute sense. After all, "saving" lives really just means extending them—and shouldn't it make some difference whether this extension is for 7 years or 70? Cass Sunstein has outspokenly advocated that it should. He asserts that we should monetize life-years (using a value of statistical life-year) rather than lives—a system that appears to give obvious preference to the young, who have much longer remaining lifespans.[35] Behind a veil of ignorance that prevented any person from knowing her age, he claims, each would prefer life-saving programs for the young to those for the old, since the former generate so many more additional years of living.[36]

Yet this intuitive view of who should count for more in cost-benefit analysis seems to point us in a different direction than the data, no matter whether we monetize lives or life-years. The absence of a significant negative association between age and VSL observed in empirical evidence suggests that older individuals are actually willing to pay considerably more for a life-year than their younger counterparts. As a result, government guidance advises that any method of VSLY analysis must use significantly higher values for senior citizens—thereby diminishing

[35] Another consideration that might be incorporated into valuation is the quality of remaining life. This provides the motivation behind the idea of the Quality-Adjusted Life Year (QALY), which figures prominently in healthcare analysis, see Graham Loomes and Lynda McKenzie, "The Use of QALYs in Health Care Decisionmaking," *Social Science and Medicine* 28 (1989): 299.
[36] Cass R. Sunstein, "Lives, Life-Years, and Willingness to Pay," *Columbia Law Review* 104, no. 1 (January 2004).

this practice's ability to differentiate between age groups.[37] At their core, VSL and VSLY are simply measures of the willingness-to-pay for small risk reductions. As long as revealed and stated preference studies suggest that the old are not willing to pay less for these risk reductions than the young, then any monetization system, whether VSL or VSLY-based, would have to flout these findings in order to value younger lives more highly.

Traditional economic theory decisively rejects such age-adjustment as an arrogant assertion that policymakers know how to prioritize risks better than their citizens.[38] One of the oldest traditions in economic theory is to accord predominant weight to individuals' revealed preferences when determining what constitutes their welfare.[39] Consequently, observed evidence on WTP is taken to provide the definitive guide on how to conduct age adjustments in a welfare-maximizing manner.

Under an informed preference conception of welfare, however—which is distinctly different from that adopted by most economists—people's interests are determined by what they would choose under conditions of full information and rationality, which can diverge from what they actually pick in practice.[40] Consequently, observed WTP figures would only provide normatively significant information if they accorded with the amounts that individuals would be willing to pay after fully comprehending the welfare consequences of their choices. In the

---

[37] Graham, *Benefit-Cost Methods and Lifesaving Rules,* 1-2. Note that if the VSLY value employed for a 60-year-old is sufficiently larger than that used for a 30-year-old, a risk reduction to either will carry the same monetary value despite the fact that the 30-year-old has many more years left to live.
[38] See W. Kip Viscusi, "The Devaluation of Life," *Regulation and Governance* 3 (2009), 112: "What matters from the standpoint of benefit valuation is whether the personal willingness to pay for risk reduction has declined, irrespective of whether a third party government policymaker thinks that people should be willing to pay less for risk reduction if fewer years of life are being saved."
[39] Lee S. Friedman, *The Microeconomics of Public Policy Analysis* (Princeton, N.J.: Princeton University Press, 2002).
[40] One of the most famous defenses of this view can be found in John Rawls, *A Theory of Justice* (Cambridge: Harvard University Press, 1971).

absence of this comprehension, the implications of empirical findings on age and VSL are open to question. If most people provide WTP figures that they themselves would not accept if fully informed and rational, then why should we use this WTP data to guide policy?

As a result, it becomes critically important to determine why the age/VSL relationship looks the way it does—whether it stems from the considered judgments of rational individuals or the biased guesses of heuristic-driven decision-makers. Sunstein anticipates the crucial nature of this question. Consequently, he suggests that it should not surprise us unduly if WTP fails to decline with age due to the presence of cognitive errors that could influence the valuation of risk reductions.[41] Indeed, a wide variety of authors have noted that errors may creep into the valuation process.[42] Yet there have been few sustained explorations of the role psychology plays in risk valuation as it relates specifically to age. Whether distortions of the age/VSL relationship are likely given research in other domains, whether they actually occur, and what it means for public policy if they do, are all relatively unexamined questions.

This thesis attempts to fill all three lacunas. To do so, it straddles the intersection of economics, government, philosophy, and psychology. As a result, it cannot explore all of the issues raised by any of these disciplines. But by examining how they inform one another, it synthesizes a new approach to an important problem.

---

[41] Sunstein, "Lives, Life-Years, and Willingness-to-Pay."
[42] See for example Jonathan Baron, "Biases in the Quantitative Measurement of Values for Public Decisions," *Psychological Bulletin* 122, no. 1 (1997).

In Chapter One, I engage in an extended discussion of the influence that cognitive limitations might have on the lifetime behavior of VSL. Drawing heavily on a variety of previous psychological findings, I present several possible explanations for how mental shortcomings might induce the young and old to pay similar amounts for risk reductions that in fact bring them vastly different benefits. Specifically, I argue that misprediction of future life quality, inaccurate subjective risk perceptions, irrationally myopic discount rates, and inadequate sensitivity to the magnitude of remaining life might all play a role in the valuation of mortality risk. I assert that each of these possibilities presents a way in which WTP could be biased downward for the young, helping to explain why VSL does not decline over the lifespan. I single out the last of these explanations—magnitude insensitivity—as the most likely cause of distortion.

I then present original contingent valuation research in Chapter Two that empirically tests some of these proposed hypotheses. Using a novel research method, I collected a subject pool through Amazon's Mechanical Turk online labor marketplace and paid each respondent a small fee to take a questionnaire hosted on Lime Survey. The experiment yielded several interesting findings. First, it suggests that Mechanical Turk may provide a viable method of gathering a large sample cheaply while still producing meaningful results, even for a complicated task like contingent valuation. In addition, the study finds a significant association between self-reported wellbeing and WTP for risk reductions, an important finding that has never before been directly documented. The data also offer an interesting glimpse into how subjects think their wellbeing levels will change with age—a question that has received little empirical attention. With more direct implications for the overall

argument of this thesis, the results additionally find support for the claim that inadequate sensitivity to magnitude may prevent many individuals from understanding the important impact that the length of a lifespan has on its value.

Finally, in Chapter Three, I explore the implications of my findings for federal regulatory policy. I claim that cost-benefit analysis should be understood as a welfare-maximizing decision procedure.[43] Consequently, policy should attempt to employ the age-adjustment system that is most likely to maximize welfare within the bounds of practicality. Given the prominence of cognitive errors in shaping the age/WTP relationship (along with the significant distortionary effects of differential marginal utility of wealth—a phenomenon that I pay less attention too since it has already been documented by many other authors, but is essential for interpreting observed WTP data), I suggest that that empirical findings on WTP do not provide a welfare-maximizing guide to age adjustment. I propose that policymakers should consider both intuitive beliefs and WTP evidence in a Bayesian manner when deciding how to monetize regulatory benefits.[44] In the case of age adjustment, I assert that our prior conviction that the value of a risk reduction is inversely associated with the age of its beneficiaries is far more reliable than our error-riddled WTP evidence. Consequently, I advocate for a system of downward age adjustment in spite of contravening (unreliable) empirical results, and assert that the current single-minded reliance on observed WTP to determine proper age-adjustments is unwise in light of the errors that infect all known methods of gathering such data.

---

[43] This argument is convincingly articulated in Matthew D. Adler and Eric A. Posner, *New Foundations of Cost-Benefit Analysis* (Cambridge, Mass.: Harvard University Press, 2006).
[44] Following in the vein of Matthew D. Adler, "QALYs and Policy Evaluation: A New Perspective," *Yale Journal of Health Policy, Law, and Ethics* 6, no. 2 (2006).

This thesis belongs to a growing behavioral literature that questions the neoclassical assumption that individuals are dispassionate, welfare-maximizing agents.[45] The economic approach to policymaking embodied in current agency practice on pricing life rests upon this assumption. Once we make it compete with a more psychologically realistic conception of human behavior, a number of the recommendations of welfare economics become suspect. As a result, policymaking must be revised to reflect a new understanding of decision-making.[46] With regard to VSL age-adjustment, this means no longer discarding a powerful intuitive conviction simply because it doesn't accord with unreliable evidence and the shaky theory that guides its interpretation.

---

[45] See for example, Daniel Kahneman and Richard H. Thaler, "Utility Maximization and Experienced Utility," *Journal of Economic Perspectives* 20, no. 1 (Winter 2006).

[46] Chrstine Jolls, Cass R. Sunstein, and Richard Thaler, "A Behavioral Approach to Law and Economics," *Stanford Law Review* 50, no. 5 (May 1998); Cass R. Sunstein and Richard H. Thaler, "Libertarian Paternalism Is Not an Oxymoron," *The University of Chicago Law Review* 70, no. 4 (Autumn 2003); Colin Camerer et al., "Regulation for Conservatives: Behavioral Economics and the Case for 'Asymmetric Paternalism'" *University of Pennsylvania Law Review* 151, no. 3 (January 2003), provide examples of this new approach

CHAPTER 1:
AGE, COGNITION, AND VSL

In late 2003, only a few short months after the EPA was blasted for its foray into "senior discounting," another often-controversial body made its own statement on the value of life: In the annual Human Development Report, the United Nations asserted that one of the most meaningful indicators of the world's progress over the past several decades was the consistent, upward climb of global life expectancies. The international organization felt so concerned about length of life that it even ranked the world's countries on a Human Development Index, whose primary component was life expectancy.[47] It was clear that the UN believed—not unlike the hapless civil servants who concocted the EPA's discounting scheme—that more life-years per capita made the world a better place.

But unlike the attempts of EPA's bureaucrats to integrate concern for the length of life into American regulatory policy, the UNDP's report didn't have the AARP up in arms. No indignant seniors protested in the streets. No incredulous academics questioned whether the UN's goals were justified by empirical research. In fact, no one really seemed to care much at all.

This non-event is only worth mentioning because it calls attention to the widespread agreement on a simple, uncontroversial principle: All other things being equal, longer lives are better than shorter ones. The UN's report made no attempt to justify this claim because it appears self-evident. While many different philosophers have offered many different accounts of human welfare, almost none of them fail to

[47] See United Nations Development Programme, *Human Development Report 2003* (2003). The Human Development Index appears on pages 237-240, but concern for the length of life suffuses the entire document.

value life over death.[48] As a corollary, more life is uncontroversially accepted as better than less life (excluding the rare circumstances when life is, in fact, worse than death).[49]

This "more is more" logic applies not only to lives, but to segments of lives as well. Just as we expect a person who dies at 60 to derive more welfare from his life than an otherwise identical individual who dies at 20, so too might we expect a 20-year-old, with about 60 years left to live, to derive more welfare from the rest of his life than a 60-year-old with only 20 years to live.[50] This helps explain why death appears more tragic when it strikes a college student than when it fells a retiree: The young are robbed of a larger—and therefore, all else being equal, better—chunk of their lives through premature demise.[51]

The intuition that a person who dies at 20 has lost something more substantial than an otherwise identical individual who dies at 60 has important implications for the relative value of mortality risk reductions at different ages. A decrease in the risk of dying is useful because it raises the probability of being able to enjoy the rest of life. Since the desirability of the rest of life depends critically on its length, it would seem that, all other beings equal, individuals with long expected

---

[48] There is, however, an interesting philosophical debate over whether death itself can be considered a misfortune, since it automatically eliminates the person who it theoretically harms. For a discussion of this problem in the context of risk regulation, see Matthew D. Adler, "Risk, Death and Harm: The Normative Foundations of Risk Regulation," *Minnesota Law Review* 87, no. 5 (2003).

[49] Leonard W. Sumner, *Welfare, Happiness, and Ethics* (Oxford: Clarendon Press, 1996), categorizes approaches to welfare under "objective," "hedonistic," and "desire" labels. Any of these three conceptions is compatible with the idea that longer lives contain more welfare. More time allows us enjoy more hedonic experiences, attain more objective goods, and satisfy more desires.

[50] In the United States, the actual remaining life expectancies are 58.8 years for the 20-year-old and 22.5 years for the 60-year-old according to Elizabeth Arias, "United States Life Tables, 2004," *National Vital Statistics Reports* 56, no. 9 (2007): 3. For the sake of simplicity, though, I often assume that all individuals live to 80.

[51] Though this reaction is probably motivated by a sense of fairness as well. To the extent we feel that people are "entitled" to a life of a certain length, then a college student who dies is "cheated" of his just deserts in a way that an elderly person is not, see Alan Williams, "Intergenerational Equity: An Exploration of the 'Fair Innings' Argument," *Health Economics* 6 (1997).

future lifespans—i.e., the young—would benefit the most from mortality risk reductions.

But this intuitive conclusion does not sit well with empirical data, raising a troubling question: If the welfare benefit of a risk reduction decreases with expected future lifespan, and therefore with age, then why does the observed pattern of willingness-to-pay for risk reductions fail to behave in a similar manner?[52] One (unappealing) response to this conflict between intuition and empirics is to abandon the commonsense assumption that, all else being equal, risk reductions bring greater benefits to those with longer remaining lifespans. Even the most adamant defenders of the legitimacy of observed WTP data don't advocate this course of action, and concede that, *ceteris paribus*, a longer expected future life should push the value of risk reductions upward.[53] But if we are not willing to give up on the idea that mortality risk reductions bring more to the young than to the old, then the combined results of dozens of revealed preference and contingent valuation studies have created something of a mystery: young people benefit more from mortality risk reductions, and yet they aren't willing to pay more for them. This riddle has two potential solutions. The first concerns costs: perhaps, while the young get more from risk reductions, they also have to give up more to get them. The second involves errors of perception: maybe, when buying risk reductions, no one, no matter how old or young, fully understands what he is getting.

---

[52] As discussed in the Introduction, empirical evidence suggests the connection between age and WTP is murky, see Aldy & Viscusi, "Age Differences in the Value of Statistical Life," Krupnick, "Mortality Risk Valuation and Age", for summaries.

[53] For example see Aldy & Viscusi, "Age Differences in the Value of Statistical Life," 244, who claim that a "forty-year-old should value a risk reduction more than [a] 60-year-old, *ceteris paribus,* because there are seventeen more expected years at stake for the younger individual."

Economists focus on the former explanation. Their commonly employed argument from marginal cost notes that while the benefits of mortality risk reduction may decrease as life passes by, as long as the marginal utility of wealth declines with age as well, then the old might reasonably pay as much as, or perhaps even more than, the young for risk reductions.[54] This possibility leaves the relationship between age and VSL theoretically indeterminate even if everyone acts to further their best interests.[55]

The second proposal—errors of perception—doesn't sit quite as well with neoclassical economic theory. It posits that the observed pattern of lifetime VSL isn't the product of rational behavior at all, but instead emerges from of a combination of psychological forces that bias the valuation process. Many authors note that cognitive errors can impact individuals' revealed or stated WTP for risk reductions.[56] To the extent that such mistakes systematically lower the WTP of the young relative to that of their older counterparts, they can help explain why VSL fails to decline with age.

In this chapter, I argue that these behavioral errors may play a critical, and often overlooked, role in driving the observed relationship between age and VSL. The incredible complexity involved in putting a price on the risk of death tests the

---

[54] See James K. Hammitt, "Valuing Changes in Mortality Risk: Lives Saved Versus Life Years Saved," *Review of Environmental Economics and Policy* 1, no. 3 (Summer 2007): 234-236, for an introduction to some of these theoretical issues.

[55] For more on the modeling of various effects that could influence age, see Albernini et al. "Does the Value of Statistical Life Delcine with Age?", 771-773, or James K. Hammitt, "QALYs Versus WTP," *Risk Analysis* 22, no. 4 (2002): 993.

[56] Cass Sunstein has written extensively on this topic. See Sunstein, "Lives, Life-Years, and Willingness to Pay," along with Cass R. Sunstein, "Cognition and Cost-Benefit Analysis," in *Cost-Benefit Analysis: Legal, Economic, and Philosophical Perspectives*, ed. Matthew D. Adler and Eric A. Posner (Chicago: University of Chicago Press, 2001) and Cass R. Sunstein, "Willingness to Pay Versus Welfare," *Harvard Law and Policy Review* 1 (2007): 303-330. For other explorations see Baron, "Biases in the Quantitative Measurement of Values for Public Decisions" or Daniel Kahneman, Ilana Ritov, and David Shckade, "Economic Preferences or Attitude Expressions? An Analysis of Dollar Responses to Public Issues," *Journal of Risk and Uncertainty* 19, no. 1 (1999).

limits the human mind's cognitive capabilities. As a result, it is hard to believe that revealed preferences in this domain are entirely in line with what agents would pick under conditions of full information and rationality. These biases may have disparate impacts on different age groups, meaningfully distorting the relationship between age and VSL.

Past authors have suggested that WTP might fail to decline with age for psychological reasons.[57] Here, I intend to elaborate on their arguments and provide detailed proposals for how bounded rationality might affect the movement of WTP over the lifespan. I consider several potential psychological factors that could not only affect WTP, but also specifically induce the young to pay less than the old, providing an explanation for the absence of a downward-sloping age/VSL curve. This by no means exhaustive list includes the possibilities that overly pessimistic conceptions of aging, perceived invulnerability to risk, irrationally high discount rates, or an inability to appreciate the impact of life's length on its value could all drive the VSL of the young downward relative to that of their older counterparts. I settle on the final possibility—insensitivity to life's duration—as the most compelling explanation. The prominent role it likely plays in the process of risk valuation compels us to understand the observed relationship between age and VSL as the product of psychological limitations that hinder humans from always making choices that maximize their welfare.

[57] See in particular Sunstein, "Lives, Life-Years, and Willingness to Pay," and Adler, "QALYS and Policy Evaluation."

What is Welfare?

The argument that a longer life has "more welfare" in it than a shorter one carries intuitive appeal. But to formally justify this intuition, we need to specify what welfare means in the first place. Under the traditional axioms of economics, an agent's welfare reduces to the satisfaction of his actual preferences as revealed through his choices. This conception implies that all behavior is, by definition, rational and welfare-maximizing.[58] There are a number of ways in which this view is unattractive, though, as it characterizes many observed behaviors that do not appear to be optimal (e.g., heroin addictions) as the best course of action for the agents who perform them.[59] I will not dwell on the extensive philosophical debate over the nature of welfare here, but instead propose what I believe to be a more compelling account—that of informed or "idealized" preference. This view is articulated by Rawls, who argues that, "the best plan for an individual is the one that he would adopt if he possessed full information. It is the objectively rational plan and determines his real good."[60] By full information, it is assumed that "the agent's knowledge of his situation and the consequences of carrying out each plan" are "accurate and complete."[61] This view has acquired a wide variety of defenders.[62] It is compelling because it grants the individual autonomy over his own conception of his good, but doesn't treat observed behavior as an unfailing indicator of normative

---

[58] For a discussion of the concept of rationality in economics, see Herbert Simon, "Rationality in Psychology and Economics," *Journal of Business* 59 (1986): 209, who notes that "Economics has almost uniformly treated human behavior as rational."
[59] Sumner, "Welfare, Happiness, and Ethics,"113, writes that the revealed preference account of welfare "is so unpromising that some background is necessary in order to explain its popularity." For more on its unappealing nature, see Adler and Posner, *New Foundations of Cost-Benefit Analysis,* 28-35.
[60] Rawls, *A Theory of Justice,* 417
[61] Rawls, *A Theory of Justice*, 417.
[62] See Sumner, "Welfare, Happiness, and Ethics," 122, for an account of its prominence in modern philosophy.

preference, and therefore avoids the morass of assuming all actions are welfare-maximizing even when this goes against our common-sense understanding of the world.

This definition gives content to the claim that an individual derives welfare from living the rest of his life, which is true if and only if he would prefer to live than to die under conditions of full information and rationality (a highly plausible assumption, in this case). But what does it mean to state that a 20-year-old derives more welfare from the rest of his life than a 60-year-old does? Conventional economic theory has little to say on this matter, as it primarily computes utility in ordinal terms, and therefore rejects the possibility of interpersonal utility comparisons.[63] Under this view, two states of the world, one in which millions of people die and another in which a single person receives a paper cut are simply "Pareto Non-Comparable"—there is no way to balance their utility consequences. This leaves something to be desired. But the difficulty of conducting interpersonal welfare comparisons—which is partly what led economists to largely abandon the concept of cardinal utility in the first place—should not be underestimated.[64]

Still, one promising option emerges from John Harsanyi's conception of the preferences of rational spectators over extended lotteries.[65] In this view, an outcome

---

[63] See Lionel Robbins, *An Essay on the Nature and Significance of Economic Science* (London: Macmillan, 1952) and John R. Hicks, "The Foundations of Welfare Economics," *The Economic Journal* 49, no. 196 (December 1939): 708, for early discussions of this problem. For a more modern account, see Daniel M. Hausman, "The Impossibility of Interpersonal Utility Comparisons," *Mind* 104, no. 415 (July 1995): 474.

[64] See Jon Elster and John E. Roemer, eds., *Interpersonal Comparisons of Well-being* (Cambridge: Cambridge University Press, 1991), for a more extensive exploration.

[65] Harsanyi explains his theory in John C. Harsanyi, "Morality and the Theory of Rational Behavior," in *Utilitarianism and Beyond*, ed. Amartya Sen and Bernard A.C. Williams (Cambridge: Cambridge University Press, 1982), 39. For a discussion of Harsanyi's view and potential criticisms, see John A. Weymark, "A Reconsideration of the Harsanyi-Sen Debate on Utilitarianism," in *Interpersonal Comparisons of Well-Being*, ed. Jon Elster and John E. Roemer, 255.

O_1 concerning N individuals is a set of N person-state pairs, $\{O_{1,1}, O_{1,2},\ldots O_{1,N}\}$, each of which represent the life-history of a given individual under O_1. A group of "sympathetic spectators" are understood to be capable of appreciating the welfare consequences of living any of these N life-histories, and to have preferences between them. The idealized spectators can also evaluate equiprobability lotteries corresponding to particular outcomes, in which each would have a 1/N chance of living any of the N life-histories contained in that outcome. The possibility of interpersonal welfare comparisons emerges from the spectators' preferences over these equiprobability lotteries—if they prefer the lottery in outcome O_1 to the lottery in outcome O_2, then O_1 possesses greater overall welfare than O_2. Consequently, a 20-year-old derives more welfare from the rest of his life than a 60-year-old in so far as idealized spectators would prefer an equiprobability lottery in which the 20-year-old lived the rest of his life and the 60-year-old did not over an otherwise identical equiprobability lottery in which the 60-year-old lived the rest of his life but the 20-year-old did not.

Therefore, our intuition about the differential welfare benefits of risk reductions to different age groups corresponds to an intuition about the preferences of idealized spectators. It seems reasonable to assume that such spectators would prefer a world in which a certain number of 20-year-olds were saved from premature death—granting each 60 more years of life (on average)—to an otherwise comparable world in which an identical number of 60-year-olds—with only 20 more

years to live—were saved instead. As a direct result, it is also reasonable to assume that risk reductions bring more welfare to 20-year-olds than to 60-year-olds.[66]

Welfare and WTP

The implications of the age/VSL curve depend critically on the relationship between welfare, as just defined, and willingness-to-pay. Traditional economics often seems to imply that second perfectly tracks the first by accepting that "the value of a good to somebody is what that person is willing to pay for it."[67] But under the Harsanyian definition of overall welfare, the two can behave in very different ways. In its idealized form, individual *i*'s WTP for some state of the world P* represents the compensating variation that must be subtracted from *i*'s endowment in P* so that his welfare (determined by informed preference) is the same in P* as in the status quo, P. This definition provides two clear reasons to reject the claim that observed WTP is a perfect proxy for welfare—one rational, and one behavioral.[68]

The first emerges from the fact that the rate of tradeoff between money and welfare is not identical for every person—some have much higher marginal utility of wealth than others. Suppose Microsoft founder Bill Gates doesn't care much for football, but thinks it might be interesting to attend the Super Bowl for a few minutes. Meanwhile, Brian is a die-hard fan of modest means who would love to see the big game in person. Tickets cost $3,000 and Bill Gates snatches one up. Brian

---

[66] Cass Sunstein uses a similar argument to compellingly claim that a risk reduction for younger individuals generates more welfare than a similar risk reduction for the elderly, though he does not specifically invoke Harsanyi's theory. See Sunstein, "Lives, Life-Years, and Willingness to Pay," 214-216.

[67] Barry C. Field, *Environmental Economics: An Introduction*, 2nd ed. (New York: McGraw-Hill, 1997), 44, cited in Revesz & Loewenstein, "Anti-Regulation."

[68] These possibilities correspond to the two classes of explanations for the age/VSL curve discussed earlier. See Adler, "QALYS and Policy Evaluation," 25, for an extended discussion of both.

decides he can't afford it and watches from home. It would be foolish to conclude from this observed behavior that Gates derives more welfare from Super Bowl tickets than Brian—if tickets were being given out for free, an impartial spectator would no doubt prefer to have the tickets in Brian's hands rather than Gates's.[69] Instead, the correct interpretation is that the welfare impact of *$3,000* is much greater for Brian than for Gates. As a result, Brian rationally expresses lower WTP for the tickets, even though seeing the game would bring him far more welfare.

The second possibility for divergence between WTP and welfare has its origins in human fallibility. Welfare economics often assumes that individuals possess a full understanding of the consequences of their actions.[70] Experience, on the other hand, suggests otherwise. And if people are mistaken about the welfare impact of their choices, either through lack of information or irrationality, then it is possible that they would have chosen differently were they better informed or more cognitively capable. Consequently, observed WTP can diverge from idealized WTP—while an individual might demonstrate WTP of Q for attaining outcome P* rather than the status quo of P, the compensating variation that would actually make him equally well off in P* and in P could be higher or lower than this value. In the absence of perfect rationality, observed WTP will prove an unreliable guide to welfare.

---

[69] This preference could derive from simple risk aversion—if spectators believed that Gates's life was already vastly superior to Brian's, they might be more concerned with enhancing the latter's welfare, as Rawls argues with his maximin principle, see Rawls, *A Theory of Justice*, 152. But risk aversion is not the only factor at work here. Idealized spectators would likely prefer to have the tickets given to Brian over a rich, but otherwise miserable, man as well, as long as that rich man didn't care much for football.

[70] See Louis Kaplow and Steven Shavell, *Fairness Versus Welfare* (Cambridge, MA: Harvard University Press, 2002), 18-23, for a discussion of the economic view of welfare.

Conventional Economic Modeling of VSL over the Lifespan

But "the economic approach," writes Nobel Laureate Gary Becker, "does not take refuge in assertions about irrationality."[71] True to form, economists provide a framework that is capable of explaining the observed pattern of WTP without abandoning the premise that individuals are rational utility maximizers.[72] In fact, the observed data on the relationship between age and WTP for mortality risks doesn't confound the predictions of economists' theoretical models—often, it supports them. According to the standard economic model, individuals choose between money and safety by maximizing expected lifetime utility with respect to wealth, *w,* and probability of death in the current period, *p*, such that:[73]

$$EU(p,w) = (1-p)u_a(w) + pu_d(w)$$

Here, u_a is the utility function when alive and u_d is the utility function when dead. The VSL can be obtained by differentiating this equation with respect to *p* while holding utility constant:

$$VSL = \frac{\partial w}{\partial p} = \frac{u_a(w) - u_d(w)}{(1-p)u'_a(w) + pu'_d(w)}$$

This shows that VSL is equal to the utility gain associated with not dying divided by the marginal utility of wealth—it increases as the value of future life goes up, and decreases with the marginal utility of money.

Consequently, as long as the marginal utility of wealth varies systematically across age groups, it will have a significant impact on the age/VSL relationship.

---

[71] Gary Becker, "The Economic Approach to Human Behavior," in *Foundations of the Economic Approach to Law*, ed. Avery Wiener. Katz (New York: Oxford University Press, 1998), 6.
[72] Note that these models were not created to explain the empirical data *per se*—they are theoretical explanations. However, we can use them to generate a possible account of why observed evidence on the lifetime pattern of VSL looks the way it does.
[73] Explanations of these equations can be found in Hammitt, "QALYs Versus WTP," 992-993.

There are a number of reasons to believe that this may be the case. First, consumption varies across the lifespan—older individuals typically have more financial resources at their disposal than the young. This has powerful implications for VSL. Economic models often indicate that VSL would be strictly decreasing in age if lifetime consumption never varied due to perfect annuities and contingent claims markets.[74] But in the real world, lifetime consumption is not constant. Instead, it follows an inverted U-shape pattern, peaking in middle age. Once models incorporate this feature, they typically posit that VSL should follow an inverted U-shape pattern as well, loosely tracking lifetime consumption.[75]

Consequently, the absence of an age-based decline in VSL in empirical findings could be explained by the impact of differing financial resources. Older individuals might be willing to pay as much or more than the young for risk reductions because they have more money, and therefore lower marginal utility of wealth. While some studies find that VSL does not decline with age even after controlling for income, these investigations generally do not control for wealth, which could be an important omitted variable, since the ratio of wealth to income rises with age.[76]

Other factors could drive age-related differences in the marginal utility of wealth as well. Yew-Kwang Ng, for example, suggests that the marginal utility of

---

[74] Such models can be found in Michael W. Jones-Lee, *The Value of Life.: An Economic Analysis.* (Chicago: University of Chicago Press, 1976) and Donald S. Shepard and Richard J. Zeckhauser, "Survival Versus Consumption," *Management Science* 30, no. 4 (1984).
[75] For examples, see the "Robinson Crusoe" case in Shepard & Zeckhauser, "Survival Versus Consumption," or more recent theoretical models such as Per-Olov Johansson, "On the Definition and Age-Dependency of the Value of Statistical Life," *Journal of Risk and Uncertainty* 25, no. 3 (2002); Isaac Ehrlich and Yong Yin, "Explaining Diversities in Age-Specific Life Expectancies and Values of Life Saving: A Numerical Analysis," *Journal of Risk and Uncertainty* 31, no. 2 (2005); Joesph E. Aldy and Seamus J. Smyth, *A Numerical Model of the Value of Life*, RFF Discussion Paper 07-09 (2007).
[76] Hammitt, "Valuing Changes in Mortality Risk," 237.

money is higher for younger individuals because their longer remaining lifespans offer better investment prospects.[77] Even more significantly, the presence of background risks influences opportunity costs. Since the marginal utility of money is extremely low when dead (unless there is an unreasonably high bequest motive), individuals facing a significant probability of imminent death should display a low MU of wealth, and consequently pay a great deal for risk reductions. This "dead anyway" effect would likely increase VSL for older individuals, who generally face higher background risks.[78]

As a final possibility, it seems conceivable that older individuals could display lower MU of money for any given level of wealth due to changes in their dispositions and material circumstances. The elderly may have fewer dependents, fewer debts, or simply fewer desires to buy expensive things—all of which might explain why they would be willing to pay substantially more for risk reductions than the young.[79]

These possibilities allow economics to explain the observed behavior of the age/VSL curve while maintaining that revealed WTP for risk reductions is in line with idealized preferences. Financial resources, background risks, and other age-related factors that influence the marginal utility of wealth likely drive down the opportunity cost of money for older individuals, making it possible that they

---

[77] Yew-Kwang Ng, "The Older the More Valuable: Divergence between Utility and Dollar Values of Life as One Ages," *Journal of Economics* 55, no. 1 (1992).
[78] John W. Pratt and Richard J. Zeckhauser, "Willingness to Pay and the Distribution of Risk and Wealth," *The Journal of Political Economy* 104, no. 4 (August 1996). As a solution, these authors ultimately suggest considering what WTP values would be accepted behind a veil of ignorance.
[79] For some examples of how health states, though not age explicitly, can change the MU of consumption, see W. Kip Viscusi and William N. Evans, "Utility Functions that Depend on Health Status: Estimates and Economic Implications," *The American Economic Review* 80, no. 3 (June 1990).

rationally decide to pay as much or more than the young for risk reductions that bring them substantially less welfare.

Risk and Rationality: the Behavioral Alternative

Yet while rational actor models can generate predictions that match the data, they lack psychological realism. It is highly implausible that everyday people always engage in dispassionate, farsighted calculation when responding to contingent valuation surveys or choosing between occupations.[80] Trading in this idealization of behavior for a psychologically richer conception of the risk valuation process provides new insights into the relationship between age and VSL.

The cognitive demands of valuing mortality risk reductions should not be understated. The task requires not only comprehending the meaning of tiny probabilities of death but also understanding the welfare consequences of living the rest of one's life.[81] Given the challenging and unfamiliar nature of this problem, it is reasonable to expect that stated or revealed preferences for risk reduction might deviate from what agents would desire under conditions of full information and rationality. While the welfare benefits of a risk reduction decrease with age, the perceptions of boundedly rational individuals might not follow suit.

This behavioral explanation of age and VSL is linked to a burgeoning reconceptualization of the nature of human decision-making that has come to decisively reject the claim that choices always reflect the considered judgments of

---

[80] See George F. Loewenstein et al., "Risk as Feelings," *Psychological Bulletin* 127, no. 2 (March 2001) for a discussion of just how different actual risk decisions are from this idealized model.
[81] Probability sensitivity is particularly challenging in cases when emotions are triggered, as likely occurs during consideration of mortality risks, see Yuval Rottenstreich and Christopher K. Hsee, "Money, Kisses, and Electric Shocks: On the Affective Psychology of Risk," *Psychological Science* 12, no. 3 (May 2001).

rational individuals. According the axiom of revealed preference, agents maximize welfare by definition.[82] But a growing literature suggests that it is hard to characterize much of human behavior as optimal within an informed preference framework.[83] Considerable research has found that humans are often very bad at predicting the consequences of their actions. People think that living in California brings happiness, but it doesn't.[84] They think that winning the lottery brings happiness, but it doesn't.[85] They think being denied tenure brings a lifetime of misery, but it doesn't either.[86] Across a variety of domains, affective forecasts are consistently inaccurate.[87]

This research most clearly demonstrates that individuals don't maximize welfare understood hedonically. But it provides good evidence that revealed preferences often deviate from idealized preferences as well. Individuals usually select options because they believe these choices will generate certain hedonic outcomes—if they knew that their forecasts were inaccurate, they might very well choose something different. For example, in a well-known test, participants selected three snacks from a menu of six options, which they would then consume on three different days. When the subjects picked all their snacks at once at the beginning of the experiment, they tended to opt for more variety than when they were allowed to pick each snack on the day of consumption.[88] It seems likely that if subjects in the

---

[82] See Sumner, "Welfare, Happiness, and Ethics," 113-122.
[83] See Kahneman & Thaler, "Utility Maximization and Experienced Utility," for an excellent overview.
[84] David Schkade and Daniel Kahneman, "Does Living in California Make People Happy? A Focusing Illusion in Judgments of Life Satisfaction," *Psychological Science* 9 (1998).
[85] Phillip Brickman, Dan Coates, and Ronnie Janoff-Bulman, "Lottery Winners and Accident Victims: Is Happiness Relative?" *Journal of Personality and Social Psychology* 36 (1978).
[86] Daniel T. Gilbert et al., "Immune Neglect: A Source of Durability Bias in Affective Forecasting," *Journal of Personality and Social Psychology* 75, no. 3 (1998).
[87] For more on this literature see Timothy D. Wilson and Daniel T. Gilbert, "Affective Forecasting: Knowing What to Want," *Current Directions in Psychological Science* 14, no. 3 (2005).
[88] Itamar Simonson, "The Effect of Purchase Quantity and Timing on Variety-Seeking Behavior," *Journal of Marketing Research* (May 1990). For more on the diversification bias, see Daniel Read et al.,

simultaneous choice condition knew that their preferences for snacks in the future would not reflect the same taste for diversity, they might choose less variety. In this case, as in many others, idealized and actual preferences likely diverge because of inaccurate forecasting.

The valuation of mortality risk reductions should be particularly vulnerable to these kinds of errors. The divergence between normative and revealed preferences is most common in situations involving complexity, long time horizons, and limited personal experience—all of which are present when individuals weigh the value of reduced mortality risk.[89] The problem is only exacerbated by the emotional arousal likely induced by the contemplation of death, which can also contribute to irrational decision-making.[90]

The probable divergence between observed and idealized WTP for mortality risk reductions has important implications. First, it should remind us to refrain from regarding published VSL values with too much reverence, as they are, at best, an approximation of what people would pay under conditions of full information and rationality. Second, and more importantly for the current discussion, it can help explain the observed relationship between age and VSL as long as cognitive limitations affect people of different ages in different ways

Perhaps, what drives the VSL of the young down isn't just the marginal utility of wealth, but also the constraints imposed by human psychology. I now outline four different reasons why the young might be particularly inclined to

---

"Which is Better: Simultaneous or Sequential Choice," *Organizational Behavior and Human Decision Processes* 84, no. 1 (2001).

[89] For more on the impact of each of these factors, see John Beshears et al., "How Are Preferences Revealed?" *Journal of Public Economics* 92, no. 8-9 (August 2008).

[90] See Richard Zeckhauser and Cass R. Sunstein, "Dreadful Possibilities, Neglected Probabilities," in *The Irrational Economist: Making Decisions in a Dangerous World*, ed. Erwann Michel-Kerjan and Paul Slovic (New York: Public Affairs, 2010).

undervalue the benefits of risk reduction relative to their older counterparts. Specifically, it seems conceivable that inaccurate perceptions of aging, unrealistic optimism about personal risk levels, myopic indifference towards the future, and a general inability to process the important connection between a good's magnitude and value might all contribute to a downward bias in young VSL. Recognizing the importance of these psychological explanations is essential to comprehending why the VSL/age relationship behaves the way it does.

(Mis)Predicting Happiness

The benefits of being alive are related, in some important way, to the quality of life. Death is a smaller misfortune if it befalls someone whose life is consumed by pointless suffering than if it ends a happy and fulfilled existence. As a result, it would be natural for individuals to pay more to preserve good lives than to extend bad ones. Johannson & Johannesson, for example, find that WTP for an extra year of life is highly sensitive to perceptions of life quality during that year.[91] This result would seem to transfer naturally to WTP for risk reductions. All other things being equal, predictions of a rosy future should induce individuals to pay more to ensure that they stay alive to see it.

To examine this possibility and its implications requires a concrete, easily measurable, and widely studied metric for the quality of life. Self-reported wellbeing data fit the bill nicely. While these survey measures of respondents' happiness and satisfaction do not perfectly track the welfare benefits of living, they can provide a

[91] Magnus Johannesson and Per-Olov Johansson, "Quality of Life and the WTP for an Increased Life Expectancy at an Advanced Age," *Journal of Public Economics* 65 (1997).

reasonably good proxy. Recently, there has been a surge of interest in self-reported wellbeing, particularly in the economics profession.[92] Some quibble with the validity of these measures, but on closer inspection they appear to reveal meaningful information about the quality of peoples' lives. For example, higher self-reported wellbeing is correlated with a variety of desideratum such as faster illness recovery, more favorable patterns of brain activity, increased smiling, being rated as happy by friends, and sleep quality.[93]

Intuitively, individuals who display higher self-reported wellbeing should also demonstrate higher WTP for risk reductions—having a better life likely induces rational agents to be more interested of preserving it.[94] Some previous empirical research provides weak support for this claim. Krupnick et al., for example, found that higher mental health scores on the diagnostic test SF-36—which contains questions asking about happy and calm feelings—correlated positively with VSL.[95] Therefore, it seems reasonable to use self-reported wellbeing as a proxy for life quality and to hypothesize that it might be positively associated with WTP risk reductions.

---

[92] The first five years of the 2000s saw 25 times more papers related to the science of wellbeing appear on EconLit than the equivalent period a decade earlier, see Daniel Kahneman and Alan B. Kreuger, "Developments in the Measurement of Subjective Well-Being," *Journal of Economic Perspectives* 20, no. 1 (Winter 2006): 3.

[93] See Kahneman & Kreuger, "Developments in the Measurement of Subjective Wellbeing," 7-9, for an overview of these correlations, along with Richard Layard, *Happiness: Lessons from a New Science* (New York: Penguin Press, 2005); Heather Urry et al., "Making a Life Worth Living," *Psychological Science* 15, no. 6 (2004); Ed Diener et al., "Subjective Well-Being: Three Decades of Progress," *Psychological Bulletin* 125, no. 2 (1999).

[94] Though this relationship could be complicated by the possibility that happier people have higher MU of wealth, since perhaps they are happy because they are good at spending money in way that makes them happy. See Elizabeth W. Dunn, Lara B. Aknin, and Michael I. Norton, "Spending Money on Others Promotes Happiness," *Science* 319 (2008), for an example of how knowing how to spend money properly can increase happiness.

[95] Krupnick et al., "Age, Health, and the Willingness to Pay for Mortality Risk Reductions," 163.

But current wellbeing is unlikely to tell the whole story. What is truly important from the standpoint of valuing risk reductions is how well life will go, not how well it has gone so far. A person who is elated at present but expects continual misery beginning tomorrow would be unlikely to pay too much to lower his mortality risk.[96] This does not mean that measures of present wellbeing would not be associated with WTP, as people often use their current state to predict future feelings.[97] However, it does imply that to the extent VSL interacts with perceived life quality, it will depend both on current wellbeing levels and on predictions for how these levels will change in the future.

There is no guarantee that these forecasts will be accurate, though. If individuals are overly pessimistic about future life prospects, this will bias VSL downward, and visa versa. And to the extent that certain kinds of misperceptions are more or less prevalent in different age groups, they could impact the lifetime pattern of VSL. In particular, if the young have a more (unrealistically) pessimistic estimate of future life quality than the old, then this forecasting error will bias their demonstrated WTP for risk reductions downward relative to their elderly counterparts. A survey of the literature on life satisfaction suggests that this kind of bias is a distinct possibility.

In a 1967, the psychologist Warner Wilson asserted that happy people were young and healthy.[98] This claim seems intuitive. Old age is associated with decrepitude, decline, the death of friends, and the fading of mental acuity. Many studies confirm that the elderly experience considerable losses, both of loved ones

---

[96] Though one also wonders why he would be so happy at present if he knew that things were going downhill within 24 hours.
[97] See Daniel T. Gilbert, *Stumbling on Happiness* (New York: A.A. Knopf, 2006).
[98] Warner Wilson, "Correlates of Avowed Happiness," *Psychological Bulletin* 67 (1967): 294.

and physical capabilities.[99] Yet the field of wellbeing research has come a long way in the past 40 years, and new findings do not support the claim that the golden years are a dismal time.

In fact, several studies argue that self-reported wellbeing may actually increase with age.[100] Not everyone agrees with this position, but even fewer seem to side with Warner Wilson.[101] The clearest trend to emerge from recently published papers supports a U-shaped relationship between age and wellbeing, in which happiness falls throughout young adulthood, reaches a trough in middle age, and then rises later in life.[102]

A literature on how the balance of positive and negative affect changes over the lifespan also finds reassuring results for seniors. Mroczek & Kolarz argue that positive affect increases with age while negative affect declines, implying the elderly have a more favorable mix of emotions than the young.[103] Other findings don't entirely confirm this rosy picture, but they do often suggest that aging might have a salutary impact on wellbeing. In a large, longitudinal study, for example, Charles et al. find evidence of improved affect balance among the old, as positive affect decreases slightly—but more or less stays flat—with age, while negative affect drops

---

[99] For an account of the privations associated with aging, see Kenneth G. Manton, "Mortality and Morbidity," in *Handbook of Aging and the Social Sciences*, ed. Robert H. Binstock and Linda K. George, 3rd ed. (San Diego: Academic Press, 1990), 64-89.

[100] See for example Yang Yang, "Social Inequalities in Happiness in the United States, 1972 to 2004: An Age-Period-Cohort Analysis," *The American Sociological Review* 73 (April 2008): 204-226 and Michael Argyle, *The Psychology of Happiness* (London: Routledge, 2001).

[101] See Diener et al., 294: "Wilson's conclusion about the elderly appears to be too pessimistic in light of recent data."

[102] A considerable number have researchers have come to this conclusion. For representative examples see David G. Blanchflower and Andrew J. Oswald, "Is Well-Being U-Shaped over the Life Cycle," *Social Science and Medicine* 66 (2008); Angus Deaton, "Income, Health, and Well-Being around the World: Evidence from the Gallup World Poll," *Journal of Economic Perspectives* 22, no. 2 (Spring 2008); Bruno S. Frey and Alois Stutzer, *Happiness and Economics: How the Economy and Institutions Affect Well-Being* (Princeton, N.J.: Princeton University Press, 2002), 49-66.

[103] Daniel K. Mroczek and Christian M. Kolarz, "The Effect of Age on Positive and Negative Affect: A Developmental Perspective on Happiness," *Journal of Personality and Social Psychology* 75, no. 5 (1998).

significantly.[104] Therefore, the relationship between of aging and wellbeing is more favorable than one might expect, with few standing up to defend the intuitive belief that happiness is the prerogative of the young.[105]

But in spite of this research, most people may still be under the grip of Wilson's fallacy, and believe that life quality diminishes over time. There is fairly little research on how individuals expect happiness to change over the course of the lifespan, but one study provides some clues. Lacey et al. examined a sample of older and younger participants, and found that both groups believed that the average person's happiness decreased from age 30 to 70—in spite of the fact that the older

---

[104] Susan T. Charles, Chandra A. Reynolds, and Margaret Gatz, "Age-Related Differences and Change in Positive and Negative Affect over 23 Years," *Journal of Personality and Social Psychology* 80, no. 1 (2001). These findings are echoed in Laura L. Carstensen et al., "Emotion Experience in Everyday Life across the Adult Life Span," *Journal of Personality and Social Psychology* 79 (2000). Also, see A.F. Jorm, "Does Old Age Reduce the Risk of Anxiety and Depression? A Review of Epidemiological Studies Across the Adult Life Span," *Psychological Medicine* 30 (2000) for research indicating that the prevalence of anxiety and depressive disorders tends to diminish over the lifespan once other risk factors are controlled for.

[105] Why might life satisfaction fail to decline, and possibly even increase, as we age? Many explanations stress adaptation, arguing that the elderly have lower expectations, revise their goals to reflect what can reasonably be accomplished, or learn to adjust to their conditions, see for example, Angus Campbell, Philip E. Converse, and Willard L. Rodgers, *The Quality of American Life: Perceptions, Evaluations, and Satisfactions* (New York: Russell Sage Foundation, 1976). In particular, socioemotional selectivity theory provides a conceptual basis for understanding why old age might be a particularly pleasant time of life. According to this set of claims, older adults focus on emotion-related goals rather than knowledge-acquisition, allowing them to regulate their emotions more effectively and experience less negative affect, see Laura L. Carstensen, Derek M. Isaacowitz, and Susan T. Charles, "Taking Time Seriously: A Theory of Socioemotional Selectivity," *American Psychologist* 54, no. 3 (1999). The predictions of the theory are borne out by a number of empirical tests that suggest that older individuals tend to spend less time bogged down by concerns than the young. See Mara Mather and Laura L. Carstensen, "Aging and Motivated Cognition: The Positivity Effect in Attention and Memory," *Trends in Cognitive Science* 9, no. 10 (October 2005) for a review of the literature on the tendency of the elderly to focus on the positive. Mara Mather et al., "Amygdala Responses to Emotionally Valenced Stimuli in Older and Younger Adults," *Psychological Science* 15, no. 4 (2004) even find differential patterns of brain activation among young and old adults that help explain the tendency of negative affect to decrease with age. Therefore, it seems plausible that some combination of mental adaptation and learning life's lessons may allow the old to enjoy a more fulfilling existence than the young.

subjects reported higher levels of current happiness than their younger counterparts.[106]

This divergence between perceptions and reality makes psychological sense—there are good reasons to believe that most young people harbor an unrealistically pessimistic conception of aging. Behavioral research suggests that humans tend to suffer from a "focusing illusion," fixating on the aspect of a potential scenario that comes to mind most readily, while ignoring other important components.[107] The most available quality of old age—and therefore that upon which people likely focus—is physical and mental decline, which may prevent them from considering other, positive aspects of aging. Many findings also suggests that people underestimate their own ability to adapt to changing circumstances—in particular physical health impairments such as paralysis.[108] Therefore, individuals likely do not anticipate how gracefully they may handle the changes that come with old age, and presume that deteriorating health and diminished capabilities will have a more severe impact on wellbeing then they actually do. Finally, studies show that people inaccurately assume that future preferences will closely resemble current preferences.[109] In the case of contemplating aging, this suggests a grim outlook on the future. After all, many of the things that young people like to do—mountain biking, picking up attractive members of the opposite sex—become impossible (or at

---

[106] Heather P. Lacey, Dylan M. Smith, and Peter A. Ubel, "Hope I Die before I Get Old: Mispredicting Happiness across the Adult Lifespan," *Journal of Happiness Studies* 7 (2006).
[107] See George Loewenstein and David Schkade, "Wouldn't It Be Nice? Predicting Future Feelings," in *Well-being: the Foundations of Hedonic Psychology*, ed. Daniel Kahneman, Ed Diener, and Norbert Schwarz (New York: Russell Sage Foundation, 1999). Schkade & Kahneman explain the "California effect" discussed earlier in terms of the focusing illusion, hypothesizing that people tend to focus on the readily available image of California's nice weather.
[108] See Gilbert et al., 618.
[109] George Loewenstein, Ted O'Donoghue, and Matthew Rabin, "Projection Bias in Predicting Future Utility," *Quarterly Journal of Economics* 118, no. 4 (November 2003).

least very difficult) with advanced age. If the young fail to realize the extent to which their tastes will change, they may assume that old age will rob them of the ability to do what they love instead of recognizing that what they love to do will likely shift considerably as they grow older.

If wellbeing does not actually decline—and possibly even rises—with age, but we are systematically biased to believe that old age brings unhappiness, this could have a meaningful impact on the lifetime behavior of VSL. Under plausible assumptions, younger individuals are fairly unhappy and expect further decline, despite the fact that good things lie ahead, driving their WTP for risk reductions downward.[110] Older individuals, however, may be quite happy and lack their younger counterparts' expectations of a dismal future, having already experienced their capacity to adapt to the effects of aging. Therefore, unrealistic pessimism could have a greater impact on younger individuals' VSL.

These results only have direct implications for the behavior of subjective wellbeing, which is not equivalent to welfare. It is possible that even though metrics like self-reported happiness fail to decline over the lifespan, welfare, properly understood, does fall with age. However, subjective wellbeing is an important component of what people desire, and an agent's informed preferences over states of the world are likely shaped in large part by what those states mean for his subjective wellbeing.[111] As a result, it does not seem wrong to say that research on self-reported wellbeing suggests that inaccurate perceptions of aging may cause many younger

---

[110] This entire argument assumes, however, that the effects of pessimistic conceptions of aging are not outweighed by the young's optimism about their own prospects, see Chapter Two for an extensive discussion of this.

[111] See Matthew Adler and Eric A. Posner, "Happiness Research and Cost-Benefit Analysis," *Journal of Legal Studies* 37 (June 2008): 253, who argue that happiness is not identical to welfare, but is an important component of it.

individuals to systematically underestimate the welfare benefit of their future lifespan. Because they do not realize what is in store for them, they do not know how to value it, allowing psychological limitations to influence the relationship between age and VSL.

Subjective Probability and Unrealistic Optimism

Homo Economicus possesses a very sophisticated understanding of probability theory. *Homo Sapiens,* on the other hand, has a bit more trouble with numbers. While neoclassical economic models often posit that agents can properly understand and respond to information about probability, many scholars now find this view highly unrealistic.[112] New research suggests that probabilities are subject to non-linear transformations when they move from objective numbers to subjective conceptions of risk in peoples' minds.[113] When a person hears that the probability of a particular event is, say, 0.15, he may understand that chance as something entirely different altogether.[114] One implication of this new understanding is that different individuals may react to the same information in very different ways, depending on the shape of their subjective probability functions.

---

[112] For the classic text on how rational agents approach choice under uncertainty, see John Von Neumann and Oskar Morgenstern, *Theory of Games and Economic Behavior* (Princeton: Princeton University Press, 1947). At the center of the new behavioral literature is the Prospect Theory of Daniel Kahneman and Amos Tversky, see Amos Tversky and Daniel Kahneman, "Advance in Prospect Theory: Cumulative Representation of Uncertainty," *Journal of Risk and Uncertainty* 5 (1992).
[113] See for example Michael Kilka and Martin Weber, "What Determines the Shape of the Probability Weighting Function under Uncertainty," *Management Science* 47, no. 12 (December 2001).
[114] In fact, one of the standard findings about subjective probability is that most individuals tend to significantly overweight small chances, behaving as if unlikely events were common occurrences This finding is replicated in many studies, including Tversky & Kahneman; Colin F. Camerer and Teck-Hua Ho, "Violations of the Betweeness Axiom and Nonlinearity in Probability," *Journal of Risk and Uncertainty* 8, no. 2 (1994); George Wu and Richard Gonzalez, "Curvature of the Probability Weighting Function," *Management Science* 42 (1996).

This is only exacerbated when the probabilities in question are personal risk levels. Perceptions of risk are not exempt from the exceptionalism that seeps into so many areas of self-evaluation.[115] Consequently, most individuals tend to systematically misinterpret what general risk information means for them. Many studies discover that the vast majority of people believe themselves to be less likely than average to experience a wide variety of negative outcomes, a phenomenon known as unrealistic optimism.[116]

These findings have powerful implications for the interpretation of observed WTP for mortality risk reductions. If different people understand the same probability information in different ways, then it is incorrect to conclude that their demonstrated WTP numbers really mean the same thing. Suppose Daredevil Dave and Cautious Cara are both subjects in the same contingent valuation study. Dave thinks he is impervious to all risks. Consequently, he expresses very low WTP for the hypothetical risk reduction offered to him. Cara, on the other hand, does not possess Dave's high level of unrealistic optimism, but does tend to overvalue small probabilities. As a result, she is willing to pay a great deal to reduce the minute mortality risk presented to her. This does not mean that Cara values her life much more than Dave does—though this would be the interpretation of standard VSL

---

[115] See David Dunning, Chip Heath, and Jerry M. Suls, "Flawed Self-Assessment: implications for Health, Education, and the Workplace," *Psychological Science in the Public Interst* 5, no. 3 (2004), for a discussion of the pervasive human tendency to self-identify as having above-average abilities and below-average risk levels.

[116] Neil D. Weinstein, "Unrealistic Optimism about Susceptibility to Health Problems: Conclusions from a Community-Wide Sample," *Journal of Behavioral medicine* 10, no. 5 (1987) finds that most individuals think they are unlikely to encounter common health problems. See also L. S. Perloff and B. K. Fetzer, "Self-Other Judgments and Perceived Vulnerability to Victimization," *Journal of Personality and Social Psychology* 50 (1986): 502-510 and F. P. McKenna, "It Won't Happen to Me: Unrealistic Optimism or Illusion of Control?" *British Journal of Psychology* 84 (1993): 59-30.

analysis—she just has a different conception of what low-probability risks mean for her.

What if certain demographic groups consist disproportionately of people like Dave while others are primarily comprised of individuals like Cara? Suppose, specifically, that the elderly tend to take mortality risks seriously, while the young write them off as having little relevance to their lives. This could imply that the observed relationship between age and VSL is driven in no small part by differences in subjective probability functions—something that carries little normative weight. Idealized, fully-informed agents should have a comprehensive understanding of what objective probability information means for their individual risk levels. A person does not derive fewer benefits from a risk reduction simply because he has unrealistically optimistic beliefs about his own probability of death.[117] Therefore, age-based differences in risk perception could potentially distort the relationship between age and VSL.[118]

There are some signs that the young may indeed be less responsive than the old to the same objective mortality risk data. In general, young people tend to take more risks.[119] There are many potential explanations for this, but one is that the young have a different understanding of personal vulnerability than the elderly and believe they are less likely to fall prey to small probability risks. This is far from certain, though. Empirical research does not establish a robust connection between

---

[117] Unless we consider the reduction of psychological anxiety as an important component of risk reduction—in general VSL analysis counts only the benefits of avoiding death, since it is designed to monetize lives rather than public fear, however

[118] While he does not explore the psychology in depth, Sunstein, "Lives, Life-Years, and Willingness to Pay," 234, speculates that the old might be more risk averse, inducing them to demonstrate higher VSL.

[119] Julia Deakin et al., "Risk Taking During Decision-Making in Normal Volunteers Changes with Age," *Journal of the International Neuropsychological Society* 10 (2004), for example find that willingness to take on risk in a gambling task decreases with age.

age and unrealistic optimism—in many situations, the old appear to be just as unrealistically optimistic as the young.[120] However, there are some studies that do conclude that unrealistic optimism decreases with age.[121] And even if this finding is not universally replicated in general, it remains plausible that unrealistic optimism might be associated with age for certain types of risks.

Unrealistic optimism is generally higher for unfamiliar risks than for well-known ones.[122] Therefore, it is unsurprising that Madey & Gomez find unrealistic optimism about age-related health conditions decreases with respondent age.[123] Death, of course, is far more familiar for the elderly, who have already seen many friends and family succumb to its effects. It therefore appears at least plausible that unrealistic optimism about mortality risks could be more pronounced among the young.

It is also conceivable that the very nature of the subjective probability function changes with age. Perhaps the young are simply less likely to overweight small probabilities than the old.[124] If this is true, then younger individuals may react to small mortality risks with more indifference than the elderly even if they have comparable levels of unrealistic optimism, because their conception of probability itself is different.

---

[120] Marie Helweg-Larson and James A. Shepperd, "Do Moderators of the Optimistic Bias Affect Personal or Target Risk Estimates? A Review of the Literature," *Personality and Social Psychology Review* 5, no. 1 (2001): 92, for example, conclude that the results on age and unrealistic optimism "are generally inconsistent."

[121] See Matthew W. Kreuter and Victor J. Strecher, "Changing Inaccurate Perceptions of Health Risk: Results from a Randomized Trial," *Healthy Psychology* 14, no. 10 (1995), who find greater unrealistic optimism among younger individuals.

[122] See Weinstein, 496.

[123] Scott F. Madey and Rowena Gomez, "Reduced Optimism for Perceived Age-Related Medical Conditions," *Basic and Applied Social Psychology* 25, no. 3 (2003).

[124] Some findings actually do provide weak support for this claim, see William T. Harbaugh, Kate Krause, and Lise Versterlund, "Risk Attitudes of Children and Adults: Choices over Small and Large Probability Gains and Losses," *Experimental Economics* 5 (2002): 53.

In one contingent valuation study, Itoaka et al. found that younger participants were more likely to express doubts about the efficacy of a mortality risk reduction than older subjects.[125] The potential differences in subjective probability between young and old raise the possibility that this type of effect might impact many different facets of the risk valuation process. Since different age groups might understand the same probability information in different ways, their respective WTPs may not be in line with idealized preferences. Under plausible conditions, this deviation could drive down the VSL of the young relative to the old, not because of a normatively significant distinction in how these groups value their lives, but rather due to the distortions of probability in human minds.

The Defective Telescope

How we value risk depends on how we value the future. The purchase of a risk reduction typically carries an immediate cost, but its benefits extend far into the distance, encompassing the increased probability of living years that are separated from the present by considerable blocks of time.[126] Therefore, the question of how much an individual should pay for a risk reduction depends critically on what rate he uses to discount the utility associated with being alive in the future. Suppose each year of living brings an equivalent welfare benefit w, but individuals discount future benefits at a rate of r per year such that the value of living for a year t years in the

[125] Kenshi Itoaka et al., *Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey in Japan*, RFF Discussion Paper 05-34.
[126] Risk reductions don't carry immediate costs by definition—you could, for example, pay later for a risk reduction today. However, most revealed preference studies examine people's willingness to forgo current wages in return for safer work, while contingent valuation surveys generally ask participants how much they would be willing to give up for a risk reduction right now. Therefore, most data on VSL measures how individuals respond to risk reductions with immediate costs.

future is $w/(1+r)^t$. In that case, the welfare gain of not dying in the current period is significantly influenced by the choice of *t*. If we assume a 7% discount rate, for example, then an infinite lifespan only appears about twice as valuable as a 10-year lifespan.[127] This conclusion is deeply counterintuitive, but it may accurately approximate the way in which most people consider future benefits.

"Our telescopic facility," wrote the famous economist Arthur Pigou, "is defective, and we, therefore, see future pleasures, as it were, on a diminished scale."[128] Empirical evidence bears this claim out—across a wide variety of contexts, humans display a distinct preference for rewards that come sooner rather than later.[129] Fascinatingly, though, Pigou's "defective telescope" has become part of the standard conception of rational behavior. Paul Samuelson's discounted utility model, which assumes that individuals discount future outcomes in an exponential manner, making costs and benefits in the future less significant than those occurring today, has become the dominant paradigm in modern economics.[130] Indeed, the main economic models of VSL described earlier all assume that the utility of future living is heavily discounted, and therefore counts less in determining a risk reduction's

---

[127] Calculated in W. Kip Viscusi, "Rational Discounting for Regulatory Analysis," *University of Chicago Law Review* 74, no. 1 (2007): 228.
[128] Arthur C. Pigou, *Economics of Welfare* (London: Macmillan, 1929), 25.
[129] For reviews of this expansive literature, see Shane Frederick, George Loewenstein, and Ted O'Donoghue, "Time Discounting and Time Preference: A Critical Review," *Journal of Economic Literature* 40 (June 2002); Gregory S. Berns, David Laibson, and George Loewenstein, "Intertemporal Choice: Toward an Integrative Framework," *Trends in Cognitive Science* 11 (2007); Dilip Soman et al., "The Psychology of Intertemporal Discounting: Why Are Distant Events Valued Differently from Proximal Ones," *Marketing Letters* 16, no. 3 (2005).
[130] Fredrick et al., 355-356 describes the development and content of this model. See Paul Samuelson, "A Note on Measurement of Utility," *Review of Economic Studies* 4 (1937): 155-161, for Samuelson's original formulation.

value.[131] Numerous attempts have been made to determine the rate at which individuals discount life-years, yielding estimates ranging from 2 to 17 percent.[132]

These economic models that weight the present over the future have descriptive validity.[133] Humans are psychologically predisposed to value a year of living in the near future more dearly than one far off on the horizon. But do such revealed preferences carry normative weight? A person may not consider a 40-year future lifespan to be that much more valuable than a 20-year future lifespan because so many of the additional benefits of living 40 years rather than 20 come far in the future, but would a rational agent under conditions of full information share these somewhat peculiar beliefs? I claim that there are insufficient legitimate reasons why individuals should adjust their valuation of a life-year depending on its proximity to the present, and therefore that the impact of discounting on VSL can be considered a cognitive error of sorts, which has important consequences for the shape of the age/VSL relationship. Many may disagree with this characterization of discounting behavior, and I do not expect to convince them all. The larger point that cognitive limitations likely influence the interaction between age and WTP remains unaltered even if discounting cannot be counted among the culprits. But nonetheless, it is at least worth considering the extent to which time preference might best be viewed as one of many behavioral biases that potentially shape the observed pattern of VSL.

---

[131] Hammitt, "Valuing Changes in Mortality Risk," 235-236.
[132] Viscusi, "Rational Discounting for Regulatory Analysis," 228.
[133] At least to an extent—modern research suggests that individuals often discount hyperbolically rather than exponentially, see David Laibson, "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics* 112, no. 2 (May 1997). For a discussion of the implications of time-inconsistent preferences, see Ted O'Donoghue and Matthew Rabin, "Doing It Now or Later," *The American Economic Review* 89, no. 1 (March 1999).

While the terms are sometimes used interchangeably, time discounting and time preference are not identical.[134] The former describes weighting outcomes in the future less heavily for any reason. The latter, however, is a preference for present over future utility justified by nothing other than proximity. Time discounting does not necessarily result from time preferences—a bond trader, for example, who pays more for an asset with shorter duration does not do so because he doesn't care about future utility, but because the opportunity cost of money makes cashflows closer to the present more valuable. However, time preferences are an important reason why many forms of time discounting take place. In order to parse out these different concepts, I shall first argue that time preference is not characteristic of a rational agent, and then contend that there is no other good reason why individuals should discount future life years.

The belief that time preferences are incompatible with the dictates of prudence and rationality has a long and illustrious pedigree. In *Theory of Moral Sentiments*, Adam Smith asserts that "in his steadily sacrificing the ease and enjoyment of the present moment for the probable expectation of the still greater ease and enjoyment of a more distant but more lasting period of time, the prudent man is always both supported and rewarded by the entire of the impartial spectator."[135] These views are echoed by the great utilitarian Henry Sidgwick, who asserts that, "a small present good is not to be preferred to a greater future good."[136] More recently, Rawls argues that temporal neutrality is a cornerstone of deliberative rationality, and that "future

---

[134] See Fredrick et al., 352, for a discussion.
[135] Adam Smith, *The Theory of Moral Sentiments*, ed. Knud Haakonssen (Cambridge: Cambridge University Press, 2002), 252.
[136] Henry Sidgwick, *The Methods of Ethics* (Indianapolis: Hackett, 1981), 381.

aims may not be discounted solely in virtue of being future."[137] These arguments are compelling because diachronic intrapersonal compensation is automatic—since agents are temporally extended entities, a sacrifice of present welfare for future welfare is no real sacrifice at all.[138] There could be legitimate reasons why rational agents would care about the timing of certain goods—for example, if they prefer improving over worsening sequences of experiences, then the welfare gain associated with some benefit may be greater if it is received later—but distance from the present is not, in and of itself, one of these.[139] The idealized preferences of rational individuals do not prioritize welfare purely depending on whether it is near or far from the present.

Can anything other than time preference explain the tendency to pay less for life-years in the future when buying risk protection?[140] There are not many normative explorations of how individuals should discount their own future life-years, but there is a very active literature on the appropriate social discount rate for

---

[137] Rawls, 420.

[138] David O. Brink, "Prudence and Authenticity: Intrapersonal Conflicts of Value," *The Philosophical Review* 112, no. 2 (April 2003).

[139] The sequencing argument is laid out by J. David Velleman, "Well-Being and Time," in *The Metaphysics of death*, ed. John Martin Fischer (Stanford, Calif.: Stanford University Press, 1993), 327-357. For another possible normative justification for time preference, see Derek Parfit, *Reasons and Persons* (Oxford: Clarendon, 1984), who suggests that the future and present selves can be considered distinct persons, undermining diachronic intrapersonal compensation. Once again, though, this argument identifies a feature correlated with time—changes in identity—that might lead one to discount. In does not justify time preferences *per se*.

[140] Two common justifications for time discounting are 1) There is some probability that individuals will die before having an opportunity to receive benefits, and 2) Discounting reflects uncertainty about future preferences, see Tyler Cowen and Derrick Parfit, "Against the Social Discount Rate," in *Justice between age groups and generations*, ed. Peter Laslett and James S. Fishkin (New Haven: Yale Press, 1992), 144-162. Both of these arguments appear unsatisfactory in this context, though. When an individual considers his expected remaining life-years, he already considers the relevant information about the probability of death—that is how he arrives at an estimate of remaining life. Also, experience suggests that the preference for life over death is fairly robust, and it would be reasonable for a person to believe he will continue to hold it even in the future.

future benefits.[141] Defenders of discounting typically appeal not to the normative validity of time preferences, but rather to the importance of opportunity costs.[142] The existence of positive real interest rates means that money today is not equivalent to money tomorrow. I may rationally prefer to receive $100 today over $100 ten years from now, since $100 today can be invested to generate far more than $100 ten years hence. This argument extends to nonmonetary goods. While a life-year today cannot be invested and turned into more life-years, the money spent on saving lives can. If I am willing to pay $300,000 for a life-year t years in the future, then I should be willing to pay $\$300{,}000/(1+r)^t$ for it today, since this is the sum that I could invest today and use to purchase the life-year in question t years from now. As the Office of Management and Budget notes, "it is true that lives today cannot be invested in a bank to save more lives in the future. But the resources that would have been used to save those lives can be invested to earn a higher payoff in future lives saved."[143]

But is this reasoning applicable to the case of an individual deciding how much to pay for a current risk reduction? It makes sense for me to pay less for a widget tomorrow than for a widget today because the cost of a widget today, if invested, could be used to purchase more than one widget tomorrow. The same is not true for life-years, however. There is no market for life-years—only a market for risk reductions. I could forgo purchasing a risk reduction today, invest the money, and

---

[141] See Richard J. Zeckhauser and W. Kip Viscusi, "Discounting Dilemmas: Editors' Introduction," *Journal of Risk and Uncertainty* 37 (2008), which introduces a symposium on these questions. For a similar symposium see David A. Weisbach and Cass R. Sunstein, "Symposium on Intergenerational Equity and Discounting," *University of Chicago Law Review* 74, no. 1 (2007).
[142] See Viscusi, "Rational Discounting," Cass R. Sunstein and Arden Rowell, "On Discounting Regulatory Benefits: Risk, Money and Intergenerational Equity," *University of Chicago Law Review* 74, no. 1 (2007); John J. Donohue, "Why We Should Discount the Views of Those Who Discount Discounting," *Yale Law Journal* 108 (1998): 1901.
[143] OMB *Circular A-4*, 34, cited in Sunstein & Rowell. Donohue, "Why We Should Discount," makes a similar argument.

then buy risk protection in the future with my larger endowment, but this does not imply that investment allows me to purchase more life-years in the future. Assume I am able to buy risk reductions at the same real price in the future.[144] Because my life expectancy shrinks as I age, the price of a life-year actually gets progressively *higher*. Suppose I can expect to live for 40 more years, and a risk reduction of 1/40 costs $1,000 in real terms this year and $1,000 in real terms next year. A year from now, my life expectancy will be more or less 39 years, meaning that the cost of a life-year has gone from $1,000 to $1,025. Unless the risk-free, real rate of return is higher than 2.5%, which may be unlikely, I cannot purchase more life-years in the future by investing today.[145]

This bolsters the claim that pure time preference is required to justify the practice of discounting future life-years when considering the value of a current risk reduction. And pure time preference is not normative. A rational agent should have equal concern for all parts of his lifespan, and consequently be every bit as solicitous of a year in the distant future as of one close to the present. Pigou's broken telescope, which induces us to mistakenly decide that lifespans of dramatically different lengths confer similar welfare, is an example of irrational myopia—an error that does not serve idealization.[146]

---

[144] If risk reductions become more or less expensive in real terms over time the analysis is more complicated, but the fundamental results are unaltered.

[145] The yield on a 10-year U.S. Treasury Inflation-Protected Security (TIPS) currently stands around 1.5%, see "U.S. Treasury - Daily Treasury Yield Curve," United States - Department of The Treasury - Homepage., http://www.ustreas.gov/offices/domestic-finance/debt-management/interest-rate/real_yield.shtml (accessed March 08, 2010).

[146] This interpretation of discounting as irrational myopia is supported by recent psychological research associating time preference with misjudgment. Berns et al. provide a review. Samuel M. McClure et al., "Seperate Neural System Value Immediate and Delayed Monetary Rewards," *Science* 306 (2004), argue that the brain areas activated differ dramatically when subjects choose immediate and delayed rewards, with choice of greater future benefits promoting activation in the parts of the brain associated with rational calculation. For more on errors and discounting, see Karim S. Kassam et al., "Future Anhedonia and Time Discounting," *Journal of Experimentla Social Psychology* 44 (2008),

Myopia shrinks everyone's VSL, but its impact is greatest on those with the most living left—the young. WTP might not vary much between young and old because people are primarily concerned with protecting proximate years—which all age groups possess—and fairly indifferent towards distant years, which the old lack but the young have in spades. Therefore, pervasive devaluation of the future induces us to regard long future lifespans and short future lifespans as roughly equivalent, when in fact their welfare impact is significantly different. This problem is only exacerbated by the fact that studies consistently demonstrate that the young have higher rates of time preference than the old.[147] Therefore, myopia distorts preferences even more dramatically among younger individuals, once again pushing up the VSL of the elderly relative to that of the young.

An interesting way to consider the possibility that high levels of irrational myopia alter the shape of the observed age/VSL relationship is to compare the behavior of life-cycle VSL among high- and low-myopia individuals. One opportunity for this is presented by studies of the VSL of smokers. Smoking is a behavior that compromises long-term health for short-term enjoyment. Consequently, it is unsurprising that several studies have associated smoking with high rates of temporal discounting.[148] A smoker's decision to cause himself considerable future harm in return for modest current pleasure could, under a certain

---

who suggest that individuals mistakenly believe their affective experiences in the future will be less intense.

[147] See David M. Bishai, "Does Time Preference Change with Age?" *Journal of Population Economics* 17, no. 4 (December 2004) and Leonard Green, Astrid F. Fry, and Joel Myerson, "Discounting of Delayed Reward: A Life-Span Compoarison," *Psychological Science* 5, no. 1 (January 1994).

[148] Christopher F. Chabris et al., "Individual Laboratory-Measured Discount Rates Predict Field Behavior," *Journal of Risk and Uncertainty* 37 (2008) and Robert L. Scharff and W. Kip Viscusi, *Heterogeneous Rates of Time Preference and the Decision to Smoke*, working paper no. 08-31 (Vanderbilt University Law School, 2008) both find that smoking is associated with time preference.

interpretation, be justified by his high discount rate.[149] However, it seems more reasonable to conclude that, for many people, smoking represents the kind of myopic choice that does not maximize welfare in the informed preferentialist sense.[150]

Therefore, if smokers have particularly high myopia levels, we might expect their lifetime VSL to behave in a distinct fashion, decreasing even less with age than it does among non-smokers. Indeed, in a study of smoker VSL, Viscusi & Hersch find that VSL is strictly *increasing* in age for smokers, despite the fact that, using almost identical methods and data, Aldy & Viscusi discover an inverted U-shaped relationship between age and VSL in the population as a whole.[151] There could be many interpretations of this result, but it certainly appears consistent with a world in which irrational myopia distorts the behavior of WTP for risk reductions over the lifespan.

Therefore, it seems plausible that individuals' indifference toward distant consequences induces them to ignore some of the benefits of living in the future, even though they would not behave this way under conditions of full rationality. Since this bias affects the young more dramatically than the old, it might help explain why observed WTP for risk reductions fails to fall over the lifespan.

---

[149] W. Kip Viscusi and Joni Hersch, "The Mortality Cost to Smokers," *Journal of Health Economics* 27 (2008) seem to imply this by suggesting that the costs of smoking are decreased by smokers' high discount rates.
[150] See Fritz L. Laux, "Addiction as a Market Failure: Using Rational Addication Results to Justify Tobacco Regulation," *Journal of Health Economics* 19 (2000), for an argument to this effect.
[151] See Viscusi & Hersch, 950, for the effects of age on the VSL for smokers and compare with cross-sectional VSL presented in Aldy & Viscusi, "Adjusting the Value of Statistical Life for Age and Cohort Effects," 578.

Magnitude Neglect

The entire discussion of age and VSL up to this point has been predicated on the assumption that individuals take the number of years remaining in their lives into account when they decide how much to pay for risk reductions. This seems like an obvious requirement to make of rational consumers. But that doesn't mean that real people will meet it. Our entire understanding of how age interacts with WTP is reshaped when we consider the surprisingly likely possibility that many individuals are almost completely insensitive to the amount of time remaining in their lives when considering the value of a mortality risk reduction.

Future life expectancies vary tremendously in size. It stands to reason that these size differences have a substantial impact on welfare. While it may be difficult to decide whether a 60-year future lifespan confers exactly three times more welfare than a 20-year future lifespan, it is clear that the former is substantially more valuable than the latter. Some goods display significant declining marginal utility in consumption, and consequently the relationship between their size and value is weak—for example, a 16-ounce ice cream cone may not be much more valuable than an 8-ounce ice cream cone, as we quickly grow satiated from eating ice cream. Future life expectancies shouldn't behave like this. It seems possible, though far from certain, that the marginal utility of a life-year decreases with the number of years already lived, perhaps explaining why older individuals often proclaim to be ready to die.[152] But this does not imply that the marginal utility of a life-year is decreasing in the number of remaining life-years—i.e., the value of living from 60 to 70 is not greater for a 60-year-old than for a 40-year-old just because the 40-year-old also gets

[152] See Adler, "QALYs and Policy Evaluation," 46-47, for a discussion of this possibility.

to live from 40 until 60. The welfare benefit of a year might vary with its absolute position in a life, but not with its relative position to the agent evaluating it.[153]

Consequently, it is clear that future lifespan is a good whose value is extremely sensitive to its size. But many people may not recognize this when pricing risk reductions. Consider a study by Morris & Hammitt that found no significant difference between current WTP for a risk reduction received at age 60 and current WTP for an equivalent risk reduction delayed until 70.[154] Unless we assume that individuals have negative discount rates or think that the decade following age 70 is much better than that following age 60—both highly implausible assumptions—this result is hard to reconcile with rational behavior.[155] But these findings make perfect sense if individuals don't readily appreciate the fact that risk reductions confer more value when life expectancy is longer, perhaps because they are oblivious to the significant impact that the length of a future life has on its welfare benefits.

This is not a farfetched possibility, as the phenomenon of scope insensitivity arises in a variety of contexts. One of the most formidable obstacles to valuing environmental benefits, for example, is that people seem shockingly unresponsive to varying the size of the good under consideration. In a famous experiment, Desvousges et al. discovered that subjects were willing to pay effectively the same amount to save 2,000, 20,000, or 200,000 migratory birds from uncovered oil

---

[153] In fact, if the value of a year actually is declining in the number of years already lived, this would actually cause the welfare impact of the remaining lifespan of a 20-year-old with 60 years left to live to be *more* than three times greater than that of a 60-year-old. Indeed, Maureen L. Cropper, Sema K. Aydede, and Paul R. Portney, "Preferences for Life Saving Programs: How the Public Discounts Time and Age," *Journal of Risk and Uncertainty* 8 (1994): 258, discover that individuals find it more important to protect the life-years of younger individuals.

[154] Jill Morris and James K. Hammitt, "Using Life Expectancy to Communicate Benefits of Health Care Programs in Contingent Valuation Studies," *Medical Decision Making* 21 (2001): 473-475.

[155] Subjects were randomly assigned to experimental conditions so there is no reason to believe that those contemplating a risk reduction at age 60 had different marginal utility of wealth than those faced with a risk reduction at 70.

ponds.[156] Similarly, Kahneman & Knetsch found equal WTP for cleaning up pollution in all the lakes in Ontario or only in the lakes in a small region of the province.[157] These results could accord with rational behavior under certain conditions—if WTP for environmental goods is driven exclusively by the "warm glow" effect of contributing to a worthy cause, then welfare might in fact be insensitive to the number of birds or lakes actually saved. Yet further experiments suggest that this is not an adequate explanation, as scope neglect persists for goods that only benefit the individual valuing them.[158]

In fact, insensitivity to magnitude occurs in a wide variety of contexts, especially when judgments are affective and items are considered without the opportunity for comparison to different-sized alternatives.[159] One of the most well-documented of these cases occurs when people value mortality risk reductions. Many studies indicate that subjects are inadequately responsive to dramatic changes in the size of safety benefits, demonstrating comparable WTP for very different risk reductions.[160] What has been found for risk size could easily apply to remaining life expectancy as well. Given how difficult it is for many people to properly process the

---

[156] W. Desvouges et al., *Measuring Non-Use Damages Using Contingent Valuation: An Experimental Evaluation Accuracy*, Research Triangle Institute Monograph 92-1 (1992).
[157] Daniel Kahneman and Jack L. Knetsch, "Valuing Public Goods: The Purchase of Moral Satisfaction," *Journal of Environmental Economics and Management* 22 (1992): 57-70.
[158] See Alan Shiell and Lisa Gold, "Contingent Valuation in Health Care and the Persistence of Embedding Effects without the Warm Glow," *Journal of Economic Psychology* 23 (2003): 251, and Jonathan Baron and Joshua Greene, "Determinants of Insensitivity to Quantity in Valuation of Public Goods: Contribution, Warm Glow, Budget Constraints, Availability, and Prominence," *Journal of Experimental Psychology: Applied* 2, no. 2 (1996): 107-125.
[159] See Christopher K. Hsee, Yuval Rottenstreich, and Zhixing Xiao, "When Is More Better? On the Relationship between Magnitude and Subjective Value," *Current Directions in Psychological Science* 14, no. 4 (2005): 234-237, for research on the determinants of magnitude insensitivity.
[160] Michael Jones-Lee, M. Hammerton, and P. Phillips, "Valuing the Prevention of Non-Fatal Road Injuries: Contingent Valuation Versus Standard Gambles," *Oxford Economic Papers* 47 (1995): 676-695, for example, find that WTP for reducing road injuries only rises by 29% when the risk level triples. Even more dramatically Baron & Greene, "Determinants of Insensitivity to Quantity," found equal WTP for programs that differed in number of lives saved by a factor of ten. James K. Hammitt and John D. Graham, "Willingness to Pay for Health Protection: Inadequate Sensitivity to Probability?" *Journal of Risk and Uncertainty* 8 (1999): 33-62, review this literature.

magnitude of a mortality risk reduction, there is good reason to doubt that they adequately consider the duration of remaining life as well.[161]

These doubts are supported by a large literature that suggests that magnitude sensitivity is particularly weak with regard to time. Varey & Kahneman found that prospective evaluations of sequences of pain were relatively insensitive to their duration, as were retrospective evaluations of aversive experiences that actually took place.[162] Subjects' reports of the unpleasantness of their colonoscopies, for example, vary little with the duration of the procedure. Neither do their evaluations of disturbing films and periods of exposure to cold water.[163] In fact, some subjects even choose to repeat a longer unpleasant experience over a shorter one.[164] There are some conditions in which duration sensitivity improves, such as when participants are presented with similar stimuli of different duration or are specifically induced to concentrate on the passage of time.[165] But when individuals are in unfamiliar circumstances and forced to evaluate goods in isolation, duration neglect remains very powerful.[166]

---

[161] Due to the affective, non-comparitive nature of valuing mortality risk reductions, length of remaining life appears to be a prime candidate for magnitude insensitivity.
[162] Carol Varey and Daniel Kahneman, "Experiences Extended across Time: Evaluation of Moments and Episodes," *Journal of Behavioral Decision Making* 5 (1992): 169-185.
[163] See Donald Redelmeier and Daniel Kahneman, "Patients Memories of Painful Medical Treatments: Real-Time and Retrospective Evaluations of Two Minimally Invasive Procedures," *Pain* 116 (1996): 3-8 for the first result, and Daniel Kahneman et al., "When More Pain Is Preferred to Less: Adding a Better End," *Psychological Science* 4, no. 6 (1993): 401-405 for the second.
[164] Kahneman et al., "When More Pain is Preferred," found that subjects sometimes chose to repeat longer rather than shorter cold water trials.
[165] See Dan Ariely, "Combining Experiences over Time: the Effects of Duration, intensity Changes, and On-Line Measurements on Retrospective Pain Evaluations," *Journal of Behavioral Decision Making* 11 (1998): 19-45; M. Rinot and D. Zakay, *Attending to Duration*, technical paper (Tel Aviv University, Department of Psychology, 1999); and Charles A. Schreiber and Daniel Kahneman, "Determinants of the Remembered Utility of Aversive Sounds," *Journal of Experimental Psychology: General* 129 (2000): 27-42 for findings to this effect.
[166] See Carey K. Morewedge et al., "Duration Sensitivity Depends on Stimulus Familiarity," *Journal of Experimental Psychology: General* 138, no. 2 (2009): 177-186 for a study that finds, among other things, that people who regularly took the shuttle to the Harvard Quadrangle were more sensitive to the duration of a trip.

So does the length of an individual's future life increase his perception of the welfare he will derive from it as much as it should? Given humans' weak track record with magnitude sensitivity, it seems unlikely. One result in particular drives this point home. Diener et al. solicited evaluations from subjects on the quality of several hypothetical lives.[167] In one condition, two described lives were identical except that one ended at age 30 while the other continued until age 60. Subjects' ratings of the lives' desirability and of the total happiness experienced in them were almost completely insensitive to their dramatic difference in their duration. Should we take this to mean that individuals actually believe there is the same amount of welfare in 60-year and 30-year lives that are identical in every other way? More likely, as the authors suggest, participants in this experiment were insensitive to duration. They did not automatically incorporate the length of life into an evaluation of its value, even though the two are clearly related. And the experimental subjects who answer contingent valuation surveys or the workers whose occupational choices are analyzed in hedonic wage regressions likely fall victim to the exact same biases.[168]

This combination of data suggests a psychologically plausible account of risk valuation in which individuals are fairly insensitive to the length of their future lives. As Sunstein suggests, all remaining life-years might get effectively "telescoped" into a single unit.[169] To the extent that this occurs, it represents a clear divergence between revealed and normative preferences. It is highly implausible that most people would be indifferent between a 20-year and a 40-year future lifespan if allowed to

---

[167] Ed Diener, Derrick Wirtz, and Shigehiro Oishi, "End Effects of Rated Life Quality: The James Dean Effect," *Psychological Science* 12, no. 2 (2001): 124-128.
[168] In an excellent example of this, Hammitt & Haninger find that WTP to reduce a bout of food borne illness is remarkably insensitive to the duration of the disease. See James K. Hammitt and Kevin Haninger, "Willingness to Pay for Food Safety: Sensitivity to Duration and Severity of Illness," *American Journal of Agricultural Economics* 89, no. 5 (2007): 1170-1175.
[169] See Sunstein, "Lives, Life-Years, and Willingness to Pay," 234.

comparatively value the two possibilities in a dispassionate manner, as evidenced by their behavior when others' lives are at stake. Cropper et al.'s work on preferences for life-saving programs, for example, finds that individuals are indifferent between a policy that saves one 20-year-old and an otherwise comparable initiative that saves *eight* 60-year-olds.[170] Therefore, under conditions that allow for comparison between lives and promote cognitive rather than affective judgment, most people clearly recognize that the value of a life saved is not impervious to it length. But when forced to evaluate their own lives, removing the possibility for comparison and triggering emotional arousal, individuals' revealed preferences shift to display this bizarre indifference. The impact of this cognitive error on the age/VSL relationship is obvious. If valuation of future life doesn't respond to the length of future life, then WTP will be biased significantly downward for younger individuals, who fail to recognize that their long remaining lifespans dramatically increase the benefits of risk reduction.

Therefore, while life length has an immensely powerful impact on welfare, it may have little connection to observed WTP. Considerations of duration aren't just outweighed by other important factors, either rational or otherwise—they barely enter the valuation process in the first place. Given the powerful implications of this insensitivity, the relationship between age and VSL cannot be understood without it.

How to Interpret the Age/VSL Curve

Policymakers and the economists who advise them are deeply interested in the impact of age on observed VSL. This fascination stems from a belief that the

[170] Cropper et al., "Preferences for Lifesaving Programs," 258-261. See Paul Dolan et al., "QALY Maximization and People's Preferences: A Methodological Review of the Literature," *Health Economics* 14, no. 2 (2005): 197, for a review of comparable studies, most of which come to similar conclusions.

relationship between the two tells us something important about welfare. At its extreme, this devolves into an almost religious reverence for WTP data, sustained by the catechism, "the value of a good is what a person is willing to pay for it."[171] But close consideration of why the VSL curve looks the way it does should make us wary of this approach and its implications.

The observed pattern of lifetime VSL actually says very little about welfare. The relationship between the benefits of a risk reduction and the amount individuals are willing to pay for it is distorted by so many factors—both rational and behavioral—that the two rarely move in lockstep. Age affects not only a risk reduction's benefits, but also its costs and the way in which its benefits are perceived. Drawing direct inferences about welfare from observed WTP ignores these important considerations. Even within the rigid confines of rational choice theory, it is clear that WTP provides a poor proxy for welfare, since age has such a potentially powerful impact on the marginal utility of money. And once we leave those confines behind, the relationship begins to fall apart altogether.

Adopting a psychologically realistic view of the agents upon whose behavior VSL figures are based leads us to conclude that VSL doesn't reveal the value of life so much as the way in which people value life—irrationally. The constraints imposed by human psychology prevent individuals from accurately forecasting their future quality of life. They manipulate the way that objective probabilities are represented in the mind. They induce a myopic devaluation of the future for the sake of the present. And they stop individuals from properly comprehending the very feature of aging that would lead us to expect VSL to decline over the lifespan in the first place. None

[171] See Viscusi, "The Devaluation of Life," and Cropper et al, *SAB Advisory*, for examples of academics and policymakers thinking in this manner.

of these proposed psychological explanations of the age/VSL relationship is necessarily true. But taken together, they provide several ways in which cognitive limitations could systematically devalue the WTP of the young relative to that of the old in a manner that does not accord with normative preferences. The last suggestion in particular—magnitude neglect—can stand on its own, singlehandedly obscuring the relationship between age and the welfare benefits of risk reduction. The prevalence of such insensitivity in so many similar domains suggests that this possibility is very realistic, and therefore that the VSL curve owes its shape in no small part to mental error.

It remains to be seen what the relative importance of rational considerations and cognitive limitations are in determining the relationship between age and WTP. Yet it would be very surprising if the latter played no role at all. Therefore, the riddle of lifetime VSL is partially solved by a different perplexity: that "the human mind is not capable of grasping the universe."[172]

[172] Attributed to Albert Einstein.

CHAPTER 2:
RESULTS OF AN ONLINE CONTINGENT VALUATION SURVEY

Past scholarship on the interaction between age, VSL, and cognitive limitations has been confined to the realm of theory. While several authors have suggested that mental failings might influence the way in which age affects willingness-to-pay for risk reductions, none has conducted empirical work to specifically test whether and how these effects operate.[173] This lacuna might result from the difficulty of measuring such phenomena accurately, and of differentiating between psychological and rational explanations for an observed pattern of behavior. These are obstacles to be sure, but they are not insurmountable. Empirical research can and should help clarify how human cognition affects the lifetime VSL pattern.

The explanations proposed in Chapter One, for example, if valid, would leave discernable footprints. If misperceptions of the quality of future life drive VSL, then one would expect to find a correlation between self-reported wellbeing—along with projections of future wellbeing—and WTP for risk reductions. This association is suggested by results from Krupnick et al., but has never been directly tested.[174] Similarly, if unrealistic optimism in general—and the unrealistic optimism of the young in particular—causes some to interpret personal risk levels differently from others even when presented with the same numerical information, then there should be associations between unrealistic optimism and WTP. While some work suggests that individuals who express doubts about the risk levels reported in contingent

[173] See for example Sunstein, "Lives, Life-Years, and Willingness to Pay," 233-234, who proposes that cognitive limitations might prevent WTP from decreasing with age, but limits his discussion to theory rather than empirics.
[174] Krupnick et al., 163.

valuation surveys pay less for risk reductions, no author has examined the impact of general unrealistic optimism measures on WTP.[175]

The role of discounting in risk valuation, on the other hand, has been explored extensively.[176] Yet most analyses of discounting behavior do not view the practice as an irrational phenomenon that distorts VSL values. Therefore, the status of life-year discounting as a cognitive error that induces bias is more a normative than an empirical question. There is no doubt that individuals pervasively discount the future—the real debate is over whether such behavior is normatively defensible.[177] Nonetheless, one largely unexplored, but interesting, possibility to examine is whether WTP for risk reductions is associated with conventional monetary or non-monetary discounting measures.

Finally there is the major question of magnitude insensitivity—the potential failure of most individuals to properly consider the importance of a lifespan's length when contemplating its value. In Chapter One, I conjecture that this phenomenon is the primary cognitive bias influencing the interaction between age and VSL. At the same time, it is a tough nut to crack empirically, due to the difficulty of definitively establishing that insensitivity to life's duration, rather than other rational considerations, explains the weakness of the relationship between remaining lifespan and WTP. However, there are telltale empirical signs consistent with a world in which magnitude neglect is pervasive. Some work suggests that attentiveness to

---

[175] For discussions of the role doubts play contingent valuation see Alberini et al., "Does the Value of Statistical Life Decline with Age?" and Itoaka et al.

[176] The revealed preference evidence on discounting in summarized in Viscusi, "Rational Discounting for Regulatory Analysis," 228. For contingent valuation explorations see Johannesson & Johannson, "Quality of Life and WTP for an Increased Life Expectancy at an Advanced Age," and George Van Houtven, Michell B. Sullivan, and Chris Dockins, "Cancer Premiums and Latnecy Effects: A Risk Tradeoff Approach for Valuing Reductions in Fatal Cancer Risks," *Journal of Risk and Uncertainty* 36 (2008).

[177] See Fredrick et al., 358-360.

scope can be improved through direct comparison between objects of different sizes.[178] Therefore, it is possible that if magnitude insensitivity lies behind the age/VSL relationship, its power would be diminished by manipulations that drew participants' attention to the important relationship between a life's duration and its value through the power of comparison.

Certain methods of obtaining VSL data recommend themselves for the empirical examination of these—or other similar—possibilities. The two main techniques through which VSL is calculated are revealed-preference studies and contingent valuation.[179] Revealed preference methods generally make use of existing data on wage-risk tradeoffs in labor markets. Because of their dependence on previously-gathered datasets, such as those produced by the Bureau of Labor Statistics, they do not provide a particularly attractive way to test for the impact of psychological biases on WTP, since the data required for such analyses is generally not included in conventional compilations of wages and fatality risks.[180]

Contingent valuation research, however, uses its own survey data.[181] It consequently has the advantage of flexibility, as a researcher can ask her subjects for whatever information she wants. Therefore, contingent valuation tests, despite their drawbacks, probably afford the most promising way—and quite possibly the only

---

[178] See Hsee et al., 236.
[179] See Hammitt, "QALYs Versus WTP," 998-999 for an overview of the two approaches.
[180] W. Kip Viscusi and Joseph E. Aldy, "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World," *Journal of Risk and Uncertainty* 27, no. 1 (2003) provide a comprehensive explanation of how this research is conducted.
[181] See Krupnick, "Mortality Risk Valuation and Age," for a description of conventional CV methodology.

way—to empirically investigate the presence of the psychological phenomena discussed earlier.[182]

This chapter chronicles my attempt to do this by collecting and analyzing relevant data through an online survey. To investigate the influence of cognitive biases on the willingness-to-pay for risk reductions, I conducted contingent valuation research that examined participants' WTP for a mortality risk reduction along with a variety of other factors. To capture a large sample cheaply, I obtained participants through Amazon Mechanical Turk (AMT)—the most prominent available online labor marketplace—to take a survey constructed using the Lime Survey software package. As best I can determine, there are no other examples in the VSL literature in which this new method of data collection has been employed. Therefore, the work here tests two things—the behavioral hypotheses presented in Chapter One, and the viability of using an online subject pool solicited through AMT to conduct such research.

The findings are, as a result, highly preliminary. But nonetheless, they produce some interesting information. First, the relative coherence of the study's results offers hope that Mechanical Turk can be an effective tool, even in research that demands significant effort and attention from participants. (There was little existing evidence on whether AMT could handle the complicated tasks sometimes associated with contingent valuation studies.) This experiment also uncovers new evidence on the association between self-reported wellbeing and WTP, and on how individuals predict their wellbeing levels will change over the course of their lives. These findings are potentially interesting in their own right, even though they do not

[182] See Diamond & Hausman, "Is Some Number Better than No Number?" for a scathing critique of this method.

appear to adequately explain the relationship between age and WTP. In addition, the study finds significant effects of a prime intended to make subjects sensitive to the amount of time left in their lives. It thus bolsters the claim that magnitude insensitivity is an important psychological driver of the age/VSL relationship.

Methods

What's a Mechanical Turk?

In the spring of 1770, Wolfgang von Kempelen, an ambitious Hungarian civil servant with a passion for engineering, came to the court of the Austrian Empress Maria Theresa with an astounding contraption: a chess-playing automaton, bedecked in an oriental costume and ostensibly run by an intricate series of gears and levers.[183] Kempelen's creation, which was dubbed the "Mechanical Turk" due to its dress, quickly became an international sensation, challenging the best players of its day and defeating luminaries such as Benjamin Franklin (reputed to be a very sore loser) and Napoleon Bonaparte (who unsurprisingly handled defeat even less gracefully). Ultimately, though, the project was revealed as an elaborate hoax: A chessmaster was cleverly hidden within Kempelen's device.

Now, in an era in which "automatons" actually can defeat the most skilled human grandmasters, this peculiar invention lends its name to another powerful combination of man and machine: Amazon's Mechanical Turk online marketplace. Mechanical Turk allows "workers" to log on and complete "Human Intelligence Tasks" (HITs) submitted by "requesters" (employers) in return for payment.

[183] Tom Standage, *The Mechanical Turk: The True Story of the Chess-Playing Machine that Fooled the World* (London: Penguin, 2003), provides an entertaining account of the creation and career of Kempelen's device.

Common HITs include simple exercises such as identifying objects in images or checking whether a website is pornographic. These tasks often take seconds and pay pennies. The site was originally designed for Amazon's internal use, but expanded rapidly, boasting over 100,000 workers in 100 different countries by 2007.[184] Some preliminary examinations suggest that the worker population on the site—which consists primarily of Americans—offers a fairly representative sample of the United States population, though it skews female and young.[185] Given the context, there are obvious reasons to be suspicious of the quality of work provided by Mechanical Turkers, especially on complex tasks that require considerable time and effort.

However, studies have found that under the right conditions, Mechanical Turk can provide researchers with valuable information while allowing for cheap data collection on a large scale.[186] This feature made AMT particularly attractive for my purposes. Traditional contingent valuation surveys can be quite expensive to administer, with costs for a single survey ranging up towards $100,000.[187] AMT, on the other hand, provides access to a very large sample for very little money. Given my time and resource constraints, I decided to see what Turkers could tell us about the psychology behind risk valuation.

---

[184] The growth is chronicled in Jason Pontin, "Artificial Intelligence, with Help from the Humans," *New York Times*, March 25, 2007.

[185] A good preliminary report comes from Joel Ross et al., *Who Are the Turkers? Worker Demographics in Amazon Mechanical Turk*, University of California, Irvine, 2009. The blogger Panos Ipeirotis has found similar results in his research on the demographics of Mechanical Turkers, see Panos Ipeirotis, "Mechanical Turk: The Demographics," A Computer Scientist in Business School, weblog entry posted March 19, 2008, http://behind-the-enemy-lines.blogspot.com/2008/03/mechanical-turk-demographics.html (accessed January 14, 2010).

[186] For accounts of successful research using AMT see Rion Snow et al., "Cheap and Fast--But Is It Good? Evaluating Non-Expert Annotations for Natural Language Tasks," in *Proceedings of the 2008 Conference on Empirical Methods in Natural Language Processing* (2008) and Aniket Kittur, Ed H. Chi, and Bongwon Suh, *Crowdsourcing User Studies with Mechanical Turk*, working paper (Palo Alto Research Center, 2008).

[187] Conversation with James Hammitt, September, 2009.

Survey Administration

To conduct this test, I designed a survey questionnaire using Lime Survey, a powerful online survey tool. Subjects were recruited through a Mechanical Turk human intelligence task that asked respondents to take an "Interesting Research Survey on Risks and Rewards." Subjects who clicked on the HIT were provided with a link that took them to the survey itself. Respondents were promised compensation of $1.14 for completing the survey—a very high wage by Mechanical Turk standards.[188] The large payment was intended to inspire reciprocity—and therefore diligent questionnaire completion—among survey subjects, since there was nothing to guarantee that respondents would pay attention to their task rather than just enter answers randomly. (AMT workers do accumulate reputation scores, though, which probably inhibits this tendency, since a low rating can exclude them from future work.) The above-market payments also allowed for filtering subjects so that only the most promising could take the test. AMT permits requesters to place restrictions on who can complete their HITs. In this case, participants were required to have an "HIT Approval Rate"—which is effectively a rating of the subject's past AMT work—of 98% or better.[189] (Amazon advises that anything over 95% is considered good.) Subjects also had to be located in the United States. Under these conditions, data was collected from 1,370 respondents over two weeks in January, 2010. Only

[188] John J. Horton and Lydia B. Chilton, *The Labor Economics of Paid Crowdsourcing*, working paper (Harvard University, 2010) find that the average hourly wage on AMT is only $1.38, whereas participants on my survey received an effective wage of close to $6.00 per hour.
[189] Subjects who submit poor quality work can have it rejected by a requester, which will hurt their HIT approval rating and prevent them from being paid for the task. I was a lenient employer, and rejected almost none of my workers, but since none of them knew this in advance, the threat of rejection may have still induced more engaged participation.

subjects who completed the entire survey, were kept for data analysis, leaving a final sample of 1,264.

The Survey Instrument

The survey questionnaire combined questions from a variety of disciplines in an attempt to investigate many of the hypotheses proposed earlier. Given my desire to cast a wide net, several avenues were explored that proved unproductive and receive little discussion subsequently in this thesis. Consistent with good experimental practice, though, the full questionnaire is described here.[190]

Part One of the survey solicited standard demographic information, asking about age, gender, income, and other similar characteristics. In Part Two, subjects were asked to evaluate their current level of wellbeing, and to make predictions about their future wellbeing. Half of the sample was asked to consider their current and future happiness using Fordyce's 11-point scale.[191] The other half was asked instead to contemplate present and future life satisfaction, using a different 11-point scale question from the World Values Survey. This division was made to see whether happiness and satisfaction relate to WTP in different ways, since the former is generally associated with immediate affect, while the latter prompts subjects to consider broader life characteristics.[192] Participants were also asked how happy

---

[190] Complete survey text is also included in Appendix One.
[191] Michael W. Fordyce, "A Review of Research on the Happiness Measures: A Sixty-Second Index of Happiness and Mental Health," *Social Indicators Research* 20 (1988).
[192] See Karen J. Crooker and Janet P. Near, "Happiness and Satisfaction: Measures of Affect and Cognition?" *Social Indicators Research* 44, no. 2 (1998) for a discussion of the difference between the two metrics.

(unhappy) they would be made by a gain (loss) of $100, based on a question from Kassam et al., in an attempt to gain some sense of their marginal utility of wealth.[193]

Part Four examined subjects' optimism about fatality risks. Since the goal was to see how unrealistic optimism might impact VSL, respondents were asked one question about their perception of their workplace fatality risk relative to that of a coworker, and another regarding how likely they were to die of a fatal disease compared with other Americans of their age and gender. In Part Five, subjects' time preferences were collected. Participants were asked a monetary discounting question from Chesson et al., in which they chose between present and future cash rewards, and also a non-monetary discounting question about tradeoffs between "good days" at their job in the present or the future.[194] In this part of the survey, they also received an unconventional question that asked them to estimate the amount of misfortune that would result from losing the 65th year of their life.[195]

After all this information was gathered, participants were presented with a contingent valuation test to measure their WTP for mortality risk reductions. The test was based on one from Hammitt & Haninger, which examines WTP for safer food. To prepare participants for the valuation exercise, they were first asked two

---

[193] From Kassam et al., 1534. Ultimately, these measures did not provide much useful information.
[194] Monetary discounting task derives from Chesson et al., 221. Non-monetary discounting from Shane Fredrick, "Time Preference and Personal Identity," in *Time and decision: economic and psychological perspectives on intertemporal choice*, ed. George Loewenstein, Daniel Read, and Roy F. Baumeister (New York: Russell Sage Foundation, 2003), 95.
[195] This unconventional question was mostly asked out of curiosity over how participants would respond. Since it is not particularly related to the major themes of the experiment, it receives no attention later. However, it is interesting to note that assessed level of misfortune was significantly associated with WTP, implying that the question did measure something meaningful about subects' desire to live as much as possible.

practice questions that required them to select food options that differed in safety and price, and given feedback about their choices.[196]

Once their practice questions were complete, subjects moved on to the valuation test itself. It presented participants with information about a hypothetical "Pesticide Safety System" that could reduce their risk of contracting a deadly neurological disease from dangerous pesticides in their food from 3 in 10,000 to 2 in 10,000 per year.[197] In order to improve comprehension, risks were presented with visual aids—grids of 10,000 in which white squares represented individuals who would not die from harmful pesticides and red squares represented those who would.[198] Participants were told that this Pesticide Safety System was supervised by the U.S. government, and that it would not affect their food in any way other than making it safer. As has become standard in the CV literature, WTP information was gathered through double-bounded dichotomous choice questions.[199] Participants were presented with a certain initial amount (randomly set to $100, $250, $500, or $1,000 for each subject) and asked whether they would be willing to pay that sum annually in addition to normal food expenditures in order to receive food with the Pesticide Safety System. If they responded yes, they were then asked if they would pay twice that much; if they responded no, the follow-up question inquired whether

---

[196] James K. Hammitt and Kevin Haninger, "Valuing Fatal Risks to Children and Adults: Effects of Disease, Latency, and Risk Aversion," *Journal of Risk and Uncertainty* 40, no. 1 (February 2010).
[197] These risk levels are extremely high—they would imply that close to 100,000 Americans died every year from pesticides in food—but studies suggest that smaller risk levels are hard for participants to comprehend, see Krupnick, "Mortality Risk Valuation and Age."
[198] Such displays have been shown to improve risk comprehension by Phaedra S. Corso, James K. Hammitt, and John D. Graham, "Valuing Mortality Risk Reduction: Using Visual Aids to Improve the Validity of Contingent Valuation," *Journal of Risk and Uncertainty* 23 (2001).
[199] See Kenneth Arrow et al., *Report of the NOAA Panel on Contingent Valuation* (1993), for standards on contingent valuation practice. Michael Hanemann, John Loomis, and Barbara Kanninen, "Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation," *American Journal of Agricultural Economics* 73, no. 4 (November 1991), provide an account of the benefits of the double-bounded dichotomous choice approach.

they would be willing to pay half the original sum. Once all the contingent valuation questions were complete, subjects were briefly asked how confident they were in the answers they provided, what they thought their actual level of risk from pesticides was compared with what they had been told, and whether they doubted the efficacy of the Pesticide Safety System described.

Results

Despite its inherent limitations, the survey produced several interesting results. First I review the sample characteristics and ask whether the data suggest that participants paid attention and made serious choices. Then I briefly describe the realms in which the survey yielded nothing promising. Finally, I engage in extended discussion about the two areas where the survey generated something worth commenting on: the relationship between self-reported wellbeing and WTP, and the impact of a prime that drew subjects' attention to the length of their future lifespans.

Sample Characteristics

The population taking the survey appears in line with previous work on Mechanical Turker demographics.[200] The sample skews young, with an average participant age of 31.5. Women are overrepresented, comprising close to 58 percent of the sample. Median household income appears to be about $40,000. As expected from a population of people who spend their time completing tasks online for modest pay, only 37.7 percent report being employed full time. Another 22 percent were employed part time. The sample was also predominantly white, with 78 percent self-identifying as Caucasian. Asian-Americans were overrepresented relative to their

[200] See Ross et al.

share of the U.S. population, comprising close to 8 percent of the sample; African-Americans and Hispanics each make up a little over 4 percent. Most respondents report being unmarried (59 percent) and having no children under 18 (73 percent), which is unsurprising given the young average age. About 17.5 percent are smokers, and 52 percent claim to exercise regularly.

The subject pool clearly is not a perfect cross section of the American population. In particular, the overrepresentation of women, the young, and the unemployed might cause results to deviate from those generated by a truly random sample. However, the respondent population is likely as diverse as any that could be obtained through other comparably cost-effective methods, and superior to many samples of convenience.

Figure 1: Histogram of Respondent Age:

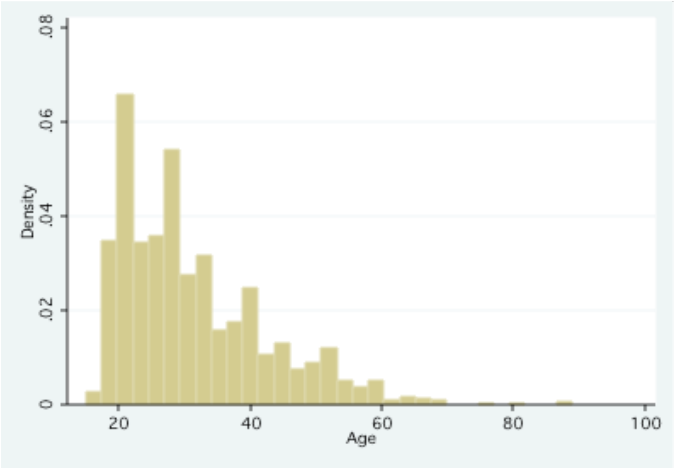


Figure 2: Gender Breakdown

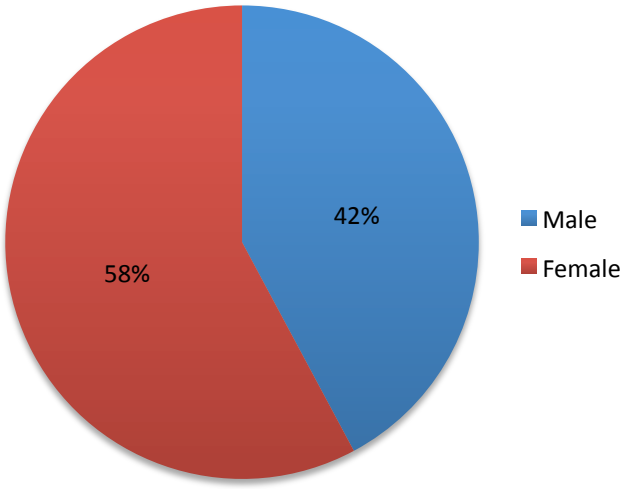
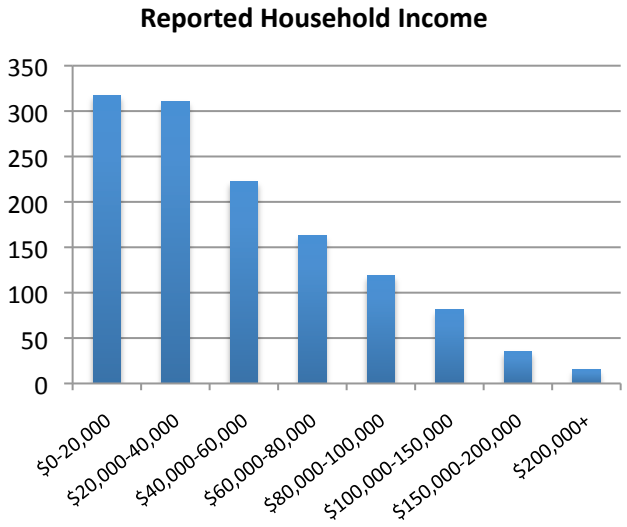


Figure 3: Sample Divided by Income Bracket:



Are the Data Reliable?

The first concern for the legitimacy of results generated by this survey is that participants failed to expend sufficient time and concentration when filling it out. Subjects looking to do nothing but maximize their effective wage could have easily clicked randomly through the entire questionnaire and then collected payment at the

end with little threat of repercussion.[201] Consequently, in order to consider any of the results generated as meaningful, it is necessary to establish that subjects actually engaged with the questions rather than simply racing through them as fast as possible.

There are several promising indicators, however, that speak to the validity of the survey data. First, Mechanical Turk provides information on the average time spent on an HIT by a worker. For this survey, average completion time was about 12 minutes—long enough to thoughtfully respond to the questions asked. In addition, this reported figure likely underestimates the true mean time, as it is driven down by the many workers who (as revealed through direct correspondence with me) completed the entire survey before ever clicking to accept the HIT, leading their completion times to be recorded as only a few seconds no matter how long they actually spent filling out the questionnaire. Consequently, while there were some exceptions, it seems that most subjects spent sufficient time on the survey to understand what was being asked and to give meaningful answers.

A couple of checks built into the questionnaire corroborate this claim. To guard against random data entry, subjects were asked to give their date of birth and current age at two separate points in the survey, so that these values could be checked against one another. Almost 98 percent of subjects gave birthdates and ages that "matched," which is not a result that one would expect to see if a significant number had been randomly filling in responses in order to complete the survey with minimal effort. In addition, the practice section of the contingent valuation test

[201] Though this could have adversely affected their wage and reputation score had I decided to reject their work. Also, since subjects were already filtered for reputation score, the population taking the survey might have been a fairly reliable group.

contained one question with a clear "right" answer—i.e., an option that was dominant, being both cheaper and safer than the alternative. An impressive 89 percent of subjects picked this cheaper and safer choice. Even a subject who is paying attention is not guaranteed to select the correct option, since it requires careful reading and a high level of comprehension to realize that one of the choices dominates the other. Therefore, the fact that almost all subjects were able to pick the better alternative suggests that the vast majority were probably paying attention.[202]

Finally, a look at the responses to the risk reduction question suggests an engaged, informed subject pool. As expected, the demand curve for risk reductions is downward sloping. The proportion of subjects who answered "yes-yes" (i.e., who were willing to pay at least twice the initial bid for the risk reduction) is highest in the lowest initial bid condition, and decreases as the initial bid rises. Similarly, the proportion of subjects who answered "no-no" (who were not even willing to pay half the initial bid for the risk reduction) is greatest in the highest initial bid condition, and decreases monotonically with the size of the initial bid.

Figure 4: Proportion of subjects falling into each response category depending on the size of the initial bid

	Y-Y	**Y-N**	**N-Y**	**N-N**
$100	0.51	0.14	0.17	0.18
$250	0.45	0.18	0.13	0.24
$500	0.31	0.20	0.12	0.37
$1000	0.25	0.12	0.21	0.41

The data yield a median WTP of $713 for the risk reduction. This implies a VSL of approximately $7.13 million, which is almost identical to that found by the Hammitt

[202] Based on correspondence with Kevin Hanninger, it appears that this figure is quite similar to the percentage who answered correctly in Hammitt & Haninger, "Valuing Mortality Risks"—an encouraging finding

& Hanninger study on which this test is based, and falls well within the range of published values.[203] Other signs also suggest that subjects understood what was going on—for example, participants who expressed doubts about the efficacy of the risk reduction had significantly lower WTP than those who did not (P<0.01). Nothing is proven by these findings, but they do provide reassurance that the data collected signify something real.

A Few Uninteresting Results

In many situations, empirical results that find no significant association between two variables provide important clues about how the world works. But in others, insignificant relationships can simply be the product of noise or measurement error. Given the context of this experiment, insignificant results more likely signify the latter. Due to the untested online survey techniques used and the difficulty of comprehending many of the complex questions asked, I had an *a priori* expectation that every coefficient would be biased towards zero. Consequently, it would be wrong to make too much of regressions that failed to find statistically significant associations.

As a result, I will quickly summarize several lines of inquiry that proved unfruitful without extensive discussion. First, the investigation into unrealistic optimism was not promising. Individuals did demonstrate unrealistic optimism in both measures collected, indicating that they were significantly less likely than their coworkers to be the victim of a workplace fatality (P<0.01), and that they were less

[203] Hammitt & Haninger, "Valuing Fatal Disease and Injury Risks," find a VSL of between $7-10 million depending on model specifications. See Viscusi & Aldy, "The Value of Statistical Life," for the range of published VSL figures. The $7.13 million figure found in my study accords nicely with past research, as evidenced by the fact that it is almost identical to the value of life currently used by the EPA, see Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions," 288.

likely to succumb to a disease epidemic than other Americans of the same age and gender (more than 68% reported having below average risk). These results are in line with previous findings on unrealistic optimism, and therefore are not particularly remarkable in and of themselves.[204] When attempts were made to connect them to the VSL/Age question, no significant association was observed between age and unrealistic optimism, or between unrealistic optimism and WTP for risk reduction. This does not close the door on the possibility that risk perceptions shift with age or influence WTP. But this survey finds nothing to support the claim that differences in risk perceptions between young and old help drive the interaction between age and WTP.

In addition, attempts to associate monetary and non-monetary discount rates with age or WTP proved unsuccessful. Heavy discounting of future rewards was pervasive in subjects' monetary and non-monetary intertemporal choices. However, discount rates did not appear to be meaningfully correlated with any other observed variables, suggesting that participants may not have properly understood or thought about the time preference questions they were asked. Consequently, I have little to add to the extensive literature on time preference, and cannot reasonably use my findings to connect discounting to questions of VSL.

Yet while these attempts uncovered little, two other lines of inquiry provided insights worth discussing.

[204] See, for example, Weinstein, "Unrealistic Optimism about Health Problems."

Happiness, Satisfaction, and WTP

First, the survey data help elucidate the relationship between self-reported wellbeing and willingness-to-pay for risk reductions. As argued in Chapter One, it seems plausible that high levels of wellbeing—and expectations for future flourishing—would be associated with high WTP for risk reductions. Intuitively, enjoying one's life should incline one to pay more to protect it.[205] In order to test this possibility, respondents were asked a variety of questions that measured their current and projected subjective wellbeing. To allow for a better understanding of the dynamics at work, subjects were randomly divided into two conditions, one of which asked about "happiness" while the other investigated "life satisfaction." Traditionally, the first measurement has been considered an "affective" metric, as opposed to the second, which is supposed to promote "cognitive," "global" evaluation of life.[206] Participants were not only asked for current happiness or satisfaction, but also for their projections of wellbeing levels at every ten-year interval from the first decade after their current age until 80 (for example, a 43-year-old in the satisfaction condition would be asked to predict her life satisfaction at ages 50, 60, 70, and 80).

[205] Krupnick et al., 163, hints at this. However, as noted earlier, it is possible that the marginal utility of wealth is higher for happier individuals, which could complicate the relationship between wellbeing and WTP.
[206] See Crooked & Near for a discussion.

Figure 5: Means and standard deviations of current and predicted future levels of happiness and satisfaction (based on a 0-10 scale)

	Happiness	Satisfaction
Current	6.62 (1.87) n=612	6.38 (2.19) n=652
Age 30	7.06 (1.78) n=311	7.77 (1.82) n=377
Age 40	7.01 (1.86) n=473	7.89 (1.76) n=519
Age 50	6.89 (1.89) n=559	7.81 (1.98) n=597
Age 60	6.72 (2.09) n=602	7.66 (2.17) n=637
Age 70	5.54 (2.46) n=611	7.40 (2.41) n=649
Age 80	6.06 (2.51) n=611	7.01 (2.75) n=650
All Future (Average)	6.46 (1.69) n=612	7.51 (1.97) n=652

In order to estimate the impact of wellbeing levels on WTP for mortality risk reduction, two statistical models were employed. The first uses only the subjects' responses to the initial bid question, leaving out the follow-up answers. This helps protect against potential biasing that can occur from the first valuation question influencing responses to the second.[207] In this model, each respondent's answer to the initial payment question is coded as a "1" if they chose the Pesticide Safety System, and a "0" if they did not. The influence of independent variables on the probability that the respondent was willing to pay the initial bid amount is then

[207] For discussion of the potential for bias see Joseph A. Herriges and Jason F. Shogren, "Starting Point Bias in Dichotmous Choice Valuation with Follow Questioning," *Journal of Environmental Economics and Management* 30 (1996) and Anna Alberini, Barbara Kanninen, and Richard T. Carson, "Modeling Response Incentive Effects in Dichotomous Choice Contingent Valuation Data," *Land Economics* 73, no. 3 (1997).

measured through probit regression, with dummy variables for the initial bid size included to control for the obvious effect that the price of the risk reduction has on the probability of purchasing the Pesticide Safety System.[208] The second model uses both the initial payment question and the follow up, generating a WTP interval for each respondent (e.g., an individual who expressed willingness to pay for the risk protection at a price of $250 but not at $500 would be assigned to the interval (250, 500)). These intervals provide the dependent variable for analysis through interval regression.[209] In most cases, the results are highly similar across the two models, helping support the robustness of the findings.

---

[208] The model takes the form $\Pr(A = 1 \mid X) = \Phi(X'\beta)$, where A is a binary response variable equal to 1 if the respondent chose the Pesticide Safety System and 0 if he did not, X is a vector of subject characteristics, Φ is the cumulative distribution function of the standard normal distribution, and β is the coefficient being estimated.

[209] Interval regression followed form $Y = X'\beta + \varepsilon$, where Y is subject WTP recorded as an interval, X is a vector of participant characteristics, β is the coefficient estimated, and ε is the error term.

Figure 6: Regression of WTP onto Happiness and Satisfaction with Demographic Controls

	Probit	Interval Regression	Probit	Interval Regression
Happiness	0.057	18.208		
	[1.98]**	[1.17]		
Satisfaction			0.03	28.003
			[1.26]	[2.02]**
Income	0.061	23.719	-0.052	-41.931
	[1.91]*	[1.34]	[1.62]	[2.30]**
Age	-0.006	-3.349	0	1.508
	[1.22]	[1.22]	[0.03]	[0.51]
Female	0.122	22.599	-0.055	-63.029
	[1.15]	[0.39]	[0.52]	[1.02]
White	-0.011	-4.635	-0.089	-106.604
	[0.08]	[0.06]	[0.72]	[1.48]
Married	0.084	62.089	0.154	59.823
	[0.63]	[0.85]	[1.19]	[0.79]
Children	0.12	32.302	0.266	154.364
	[0.87]	[0.42]	[2.03]**	[1.99]**
Smoker	0.295	59.969	-0.129	-55.495
	[2.34]**	[0.87]	[1.08]	[0.80]
Exercise	-0.179	9.335	0.003	-18.11
	[1.66]*	[0.16]	[0.03]	[0.30]
Ask250	0.125		-0.249	
	[0.87]		[1.72]*	
Ask500	-0.415		-0.352	
	[2.80]***		[2.37]**	
Ask1000	-0.563		-0.826	
	[3.82]***		[5.60]***	
Constant	-0.194	526.284	0.491	725.068
	[0.71]	[3.65]***	[1.89]*	[5.19]***
Observations	612	612	652	652

Absolute value of z statistics in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

The coefficient on happiness is positive in both cases, but only significant in the Probit model.[210] Satisfaction, meanwhile, is significant only under the Interval Regression framework.[211] Therefore, these preliminary results provide weak support for the hypothesis that higher levels of subjective wellbeing lead to higher WTP for risk reductions.

[210] Coefficients in the interval regression model an be interpreted as the increase in mean WTP associated with a 1-point rise in an independent variable, measured in dollars. Coefficients in the probit model, on the other hand, represent the shift in the cumulative normal function of the probability that the respondent was willing to pay for the Pesticide Safety System, measured in Z-scores.

[211] The significant negative coefficient on income in the interval regression model with satisfaction is surprising. However, this can probably be attributed to noise. Conducting regressions on happiness and satisfaction effectively splits the sample in two, since only half of the participants received each type of question. And while income is significant and negative in one satisfaction regression, it is positive and approaching significance ($P<0.10$ in the Probit model) in the happiness regressions. Since income proves to be associated with happiness and with satisfaction in basically the same way, and is insignificant when the whole sample is evaluated at once, it would seem premature to make too much of this one finding.

As noted earlier, though, it is not simply present wellbeing that one would expect to influence WTP—the utility gain from a risk reduction is impacted not just by current life quality, but also by what takes place in the future. Therefore, it is necessary to inspect how projected future happiness and satisfaction interact with WTP as well. This analysis was conducted by using the same regression frameworks as before, while substituting predictions of future happiness and satisfaction for reports of current happiness and satisfaction as independent variables. Due to the large number of different future wellbeing measures, many different individual regressions were conducted to gauge the impact of happiness or satisfaction predictions for a given future age.

Figure 7: Coefficients of projected levels of happiness at future ages generated when each individual prediction was used as a predictor of WTP in the regression frameworks presented in Figure 6.

	Probit	**Interval Regression**
30	.052 (1.22)	23.553 (1.10)
40	.037 (1.14)	16.000 (0.86)
50	.029 (1.00)	14.185 (0.89)
60	-.013 (0.51)	-2.732 (0.19)
70	-.037 (1.74)*	-12.049 (1.02)
80	-.010 (0.48)	-6.993 (0.60)
Average	.006 (0.19)	2.219 (0.13)

*Absolute values of Z-statistics in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%*

Figure 8: Coefficients of projected levels of Satisfaction at future ages generated when each individual prediction was used as a predictor of WTP in the regression frameworks presented in Figure 6.

	Probit	**Interval Regression**
30	.014 (0.37)	35.197 (1.59)
40	.050 (1.49)	46.959 (2.51)**
50	.058 (2.12)**	52.285 (3.34)***
60	.072 (2.98)***	53.065 (3.88)***
70	.088 (4.11)***	56.205 (4.66)***
80	.067 (3.59)***	38.103 (3.57)***
Average	.094 (3.56)***	62.575 (4.18)***

*Absolute value of Z-statistics in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%*

A striking, and pregnant, distinction emerges between the behavior of happiness and satisfaction. Subjects' projections of their future happiness levels have

little influence on their WTP. In both Probit and Interval Regression models, the association between predicted happiness and WTP is consistently insignificant. On the other hand, projected satisfaction—especially at later ages—proves a highly significant predictor of WTP. In both models, respondents' anticipated future satisfaction levels are strongly associated with their WTP (a one-point increase in predicted satisfaction at 70, for example, boosts VSL by about $560,000, according to the Interval Regression model).

What explains this differential behavior? The most likely candidate seems to be the "affective versus cognitive" distinction between happiness and satisfaction discussed earlier. When subjects predict their happiness at an advanced age, they likely consider anticipated day-to-day affective experience—an individual's projection of happiness at age 60 might reveal what he thinks his average day will be like at that point. Projections of life satisfaction, on the other hand, may respond to a more holistic assessment of life quality. A 20-year-old who predicts high levels of life satisfaction at 60 may do so because he thinks that he will lead a worthwhile life between now and then, making his 60-year-old self "satisfied" with what has transpired. Therefore, while anticipated happiness measures a highly speculative projection of a future emotional state, anticipated life satisfaction provides a powerful proxy for how well an individual thinks his life will go in the years to come.

In other words, future satisfaction measures what matters from a WTP standpoint in a way that future happiness does not. Individuals who expect to live good lives—the kind that will make them satisfied at a later age—are particularly interested in not dying prematurely. Consequently, positive expectations, as measured by future satisfaction, lead people to pay more for risk reductions.

The discovery of an association between perceived life quality and WTP leaves open the possibility that divergences between projected and actual future wellbeing could drive observed preferences for risk reduction to deviate from idealized preferences. If projected satisfaction is a determinant of WTP, but such projections are systematically biased, then individuals may under- or over-value risk reductions depending on the direction of their projection error. And as suggested in Chapter One, there is some reason to believe that younger individuals might have unrealistically pessimistic conceptions of their future life circumstances as a result of inaccurate beliefs about the deleterious consequences of aging. If so, this could potentially cause the VSL of the young to be biased downward.

The viability of this argument depends two claims: 1) WTP is related to projected future life quality and 2) The young have overly pessimistic projections of future life quality. While the data from this survey help support the first assertion, they do not back up the second. They do, however, provide interesting insights into how people think their lives will go.

In this sample, current levels of happiness are not significantly associated with age. Neither is satisfaction when it is regressed onto age alone. However, if demographic controls are added, the correlation is negative and significant, suggesting that, all other things being equal, older individuals in this population are less satisfied with their lives. This is not particularly surprising given that many of the older participants in this young sample are in the midst of middle age, which is the nadir of wellbeing according to many studies.[212]

[212] See e.g., Deaton; Blanchflower & Oswald.

What is more interesting is how projections of future happiness and satisfaction behave. The following figures display each age cohort's prediction of the trajectory of their happiness/satisfaction over the rest of their lives:

Figure 9: Current and Projected Happiness for Different Age Cohorts

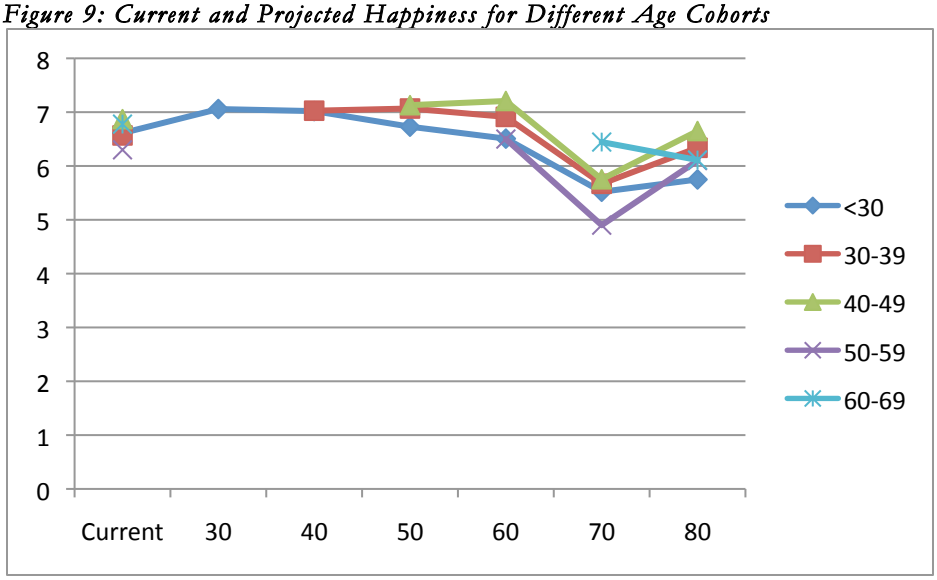
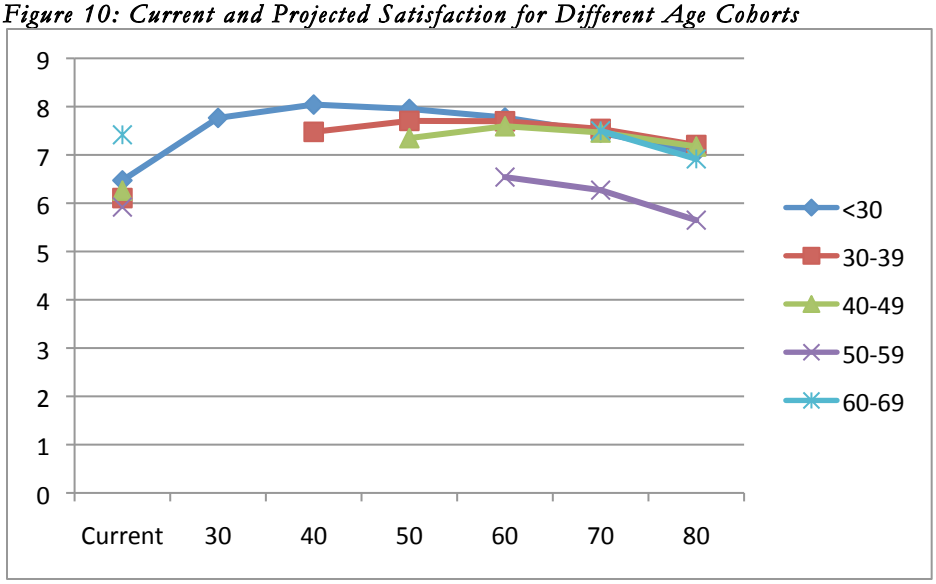


Figure 10: Current and Projected Satisfaction for Different Age Cohorts



The trends are strikingly similar across cohorts: almost all groups appear to anticipate an immediate uptick in wellbeing followed by a gradual decline.[213]

[213] The charts above appear highly cluttered and difficult to read when standard error bars are added. However, the standard errors are small, and therefore most of the movement is statistically significant.

Happiness and satisfaction behave in slightly different ways, though, and therefore are discussed separately.

With regard to happiness, the data weakly suggest that most participants have a negative conception of aging *per se*. In all cohorts, the general trend of future happiness slopes downward from the first prediction to the last. Yet while most foresee a long-term decline, they also predict a short-term rise—every cohort except the oldest anticipates that it will be happier at the next decade mark than it is currently. The distant future may appear worse than the proximate future, but the proximate future seems superior to the present. In all likelihood, this pattern emerges because pessimistic views of aging are tempered by optimism about the future—while the average person believes that aging in general is bad, he still thinks that his future prospects are good.[214] There is fairly little literature on perceptions of distant future wellbeing, but one of the few studies that does attempt to measure long-term expectations comes to a similar conclusion. Lacey et al. find that individuals believe age decreases happiness for the average person, but not for themselves—while their subjects thought the average 30-year-old was happier than the average 70-year-old, they did not believe that they would personally become less happy from 30 to 70.[215] This exceptionalism was evident in my sample as well. In two related questions, participants claimed that age would have a negative effect on the happiness of the average person, but no effect on their own happiness ($P<0.01$). The interplay between individualistic optimism and general pessimism buoys near-term happiness

---

The difference between the 30-39 cohort's prediction of satisfaction at 50 and at 40, for example, is greater than zero, $P<0.05$.

[214] See Shelley E. Talyor and Jonathan D. Brown, "Illusion and Well-Being: A Social Psychological Perspective on Mental Health," *Psychological Bulletin* 103, no. 2 (1988), for a discussion of the pervasive human tendency towards self-serving positivity, and its possible mental health benefits

[215] Lacey et al., 171-172.

projections, but eventually, the latter effect trumps the former, as projections of happiness at the advanced ages of 70 and 80 are lower than current reported happiness for all age groups.

But the victory of age over optimism is not so dramatic, nor does it appear that the young are its principle cause. In fact, there is fairly little evidence here that the young have a worse conception of what is to come than their older counterparts. Once demographic variables are controlled for, projections of happiness at any given future age are unrelated to the current age of the predictor—for example, 30-year-olds and 50-year-olds seem to have more or less the same conception of how happy they will be at 60. Nor is it clear that the young's predictions of happiness at future ages is lower than the current reported happiness of individuals at those ages right now. Respondents under 30, for instance, predict future happiness of 6.73 when they are 50—while average current happiness for subjects between 45 and 55 is only 6.43.

The results for satisfaction are even more dramatic. In this domain, projections for the future are especially rosy, with the optimistic young leading the charge. All age cohorts appear to think they will be more satisfied at older ages than they are now (average future satisfaction is greater than current reported satisfaction, $P<0.01$). In this case, the balance of individual optimism and general pessimism appears slanted in the direction of the former. The distinction between cognitive and affective measurement helps explain this pattern of data. Because questions about future satisfaction induce respondents to consider life holistically, their conception of satisfaction at a future age depends far more on their anticipated accomplishments—which are driven by optimism about the future—than on predictions of affective experience at an advanced age—which are more likely to be influenced by negative

conceptions of aging. The importance of optimism is driven home by the observed relationship between current age and predicted satisfaction at a given future age. For all future ages until 60, there is a strong negative association between age and projected satisfaction ($P<0.05$). In other words, young individuals are more optimistic about satisfaction at a given age than their older counterparts. This may be because unrealistic optimism is easier to sustain in the absence of hard information. For proximate futures, the possibilities are constrained by reality, whereas for distant futures, the only limit is imagination. Therefore, a 30-year-old has a rosier conception of what 50 will be like than a 45-year-old does because he possesses less information that could disconfirm his optimistic priors. This view is supported by the fact that there is no significant association between age and projections of satisfaction at 70 or 80. Those advanced ages are very distant for almost everyone in this survey's young sample, meaning age doesn't have a strong impact on how optimistic a projection can be—since both a 45-year-old and a 30-year-old are quite far away from 80, both can hold comparably improbable fantasies about what will transpire between now and then.

The powerful effects of optimism observed in these results contradict the claim that the young have unrealistically pessimistic assessments of future life quality. In fact, the young appear more enthusiastic about the future than almost anyone else. Therefore, it is hard to conclude that misperceptions of how aging affects wellbeing distort the age/VSL relationship in the manner proposed in Chapter One. Young people may have overly dismal conceptions of aging *per se*, but this bias is outweighed by optimism about their own future prospects. So while projected future satisfaction is a significant predictor of WTP, if anything this might be expected to bias young

VSL *upward*, since it is the young who possess the rosiest visions of what the future will hold.

Priming to Increase Magnitude Sensitivity

This experiment's results also shed light on the role magnitude insensitivity may play in influencing WTP for risk reductions. In Chapter One, I argued that the inability of most individuals to adequately process the connection between the length of a remaining lifespan its value prevents the observed relationship between age and VSL from reflecting fully informed, rational preferences. My claim is effectively that individuals unintentionally ignore highly salient information when valuing risk reductions. If it is true, one might expect behavior to change when people are forced to think about the duration of life and its connection to welfare. Research on scope insensitivity generally finds that individuals are more attuned to magnitude when they evaluate items in comparison to otherwise similar objects of different size.[216] Rinot & Zakay, for example, found that subjects were more sensitive to the duration of aversive sounds when they listened to multiple noises that lasted for different lengths of time.[217] Consequently, it is possible that a manipulation that allowed individuals valuing risk reductions to compare lifespans of different lengths would similarly improve their sensitivity to life's duration.

This is precisely what the scope prime included in the current survey attempted to test. Immediately after the introduction of the valuation question, half of the subjects were asked to report how many more years they expected to live. Following this, the primed subjects were reminded that this prediction represented

[216] See Hsee et al., 236.
[217] Rinot & Zakay, "Attenting to Duration."

the number of years they would lose if they died prematurely from pesticides in their food. Subjects then learned what the average remaining lifespan of a 40-year-old American was—39.9 years—as a point of comparison. Participants were encouraged to compare their projected lifespan to this baseline figure. They were asked whether it would be better to live for the number of additional years they expected to live, or for 39.9 more years, and then if dying prematurely would constitute a greater misfortune for a person with a 39.9 year remaining lifespan or for someone with their remaining lifespan. After this prime, the valuation test proceeded unaltered for both the prime and non-prime groups.

Figure 11: Effect of the Prime

	Probit	Interval Regression
Prime	0.15252	98.639
	[2.12]**	[2.39]**
Ask250	-0.04588	
	[0.46]	
Ask500	-0.35645	
	[3.47]***	
Ask1000	-0.70287	
	[6.87]***	
Constant	0.30833	660.458
	[3.81]***	[21.73]***
Observations	1264	1264

Absolute value of z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

If magnitude insensitivity does infect the process of risk valuation, then this prime should increase WTP, in particular for those who expect to live a long time. Indeed, the scope prime significantly affects WTP for risk reductions. In both models, receiving the prime has a statistically significant ($P<0.05$) positive effect on WTP. The coefficient from the interval regression model implies that the prime increased WTP by around $98, which translates to a VSL increase of approximately $980,000—a non-trivial effect. Therefore, considering the number of years left in life

seems to have made individuals more inclined to purchase risk reductions. The particular way in which this process worked is elucidated by the disparate impact that the prime had on different populations. Among those who expected to live for more than 40 additional years (i.e., longer than the average 40-year-old's remaining lifespan as presented in the prime), receiving the prime had an even stronger positive effect on WTP. The prime increased the VSL of this group by a sizeable $1.27 million. Among those who expected to live for 40 years or less, however, the effect of the prime is close to zero and no longer statistically significant.

Figure 12: Effect of the Prime By Expected Remaining Life Years

	Remaining Life Greater Than 40 Years		Remaining Life 40 Years or Less	
	Probit	Interval Regression	Probit	Interval Regression
Prime	0.193	127.415	0.041	20.846
	[2.48]**	[2.81]***	[0.37]	[0.36]
Ask250	-0.017		0.095	
	[0.16]		[0.75]	
Ask500	-0.365		-0.315	
	[3.27]***		[2.45]**	
Ask1000	-0.662		-0.693	
	[5.99]***		[5.27]***	
Constant	0.293	662.442	0.257	645.943
	[3.46]***	[21.54]***	[2.76]***	[22.54]***
Observations	1087	1087	773	773

Absolute value of z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

The prime increased the WTP of those who believed they had many years of life remaining, while having little impact on those who believed their remaining lifespans were short—in other words, it appears to have made individuals more sensitive to the duration of their future lives. This point is driven home by the fact that there is a highly significant positive association between predicted years of life remaining and WTP ($P<0.01$). Remaining life expectancy was only solicited in the prime condition, so this effect is entirely driven by the fact that subjects who received the prime were more willing to pay to reduce risk if they believed they would live for longer.

Figure 13: Effect of Life Years Remaining

	Probit	Interval Regression
Life Years Remaining	0.012	5.077
	[3.22]***	[2.35]**
Income	-0.032	-25.866
	[1.04]	[1.41]
Age	0.012	5.099
	[1.90]*	[1.35]
Female	0.033	6.813
	[0.32]	[0.11]
white	-0.177	-92.031
	[1.46]	[1.26]
Married	0.082	61.217
	[0.64]	[0.79]
Children	0.29	180.764
	[2.15]**	[2.23]**
Smoke	0.012	-9.875
	[0.10]	[0.14]
Exercise	0.088	53.755
	[0.87]	[0.88]
ask250	-0.311	
	[2.14]**	
ask500	-0.41	
	[2.80]***	
ask1000	-0.831	
	[5.76]***	
Constant	-0.359	393.531
	[1.01]	[1.90]*
Observations	666	666

Absolute value of z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

This is not necessarily the result of the prime—it could be that individuals with more years of life remaining would demonstrate higher WTP whether they were primed or not. (In hindsight it was unfortunate that the survey only solicited predicted life expectancy in the prime condition—it should have been asked in both conditions so the effects could be compared). Yet it is worth noting that in the Hammitt & Haninger contingent valuation study that employs essentially the same risk reduction question, and which contained no prime to increase magnitude

sensitivity, there was no significant effect of predicted remaining life on WTP for an individual risk reduction.[218] Therefore, the combination of evidence suggests that the prime made individuals more responsive to the number of years remaining in their lives.

This does not necessarily imply that the prime helped correct an irrational bias. According to economic theory, length of remaining life is only one of many important factors that should influence WTP for a risk reduction.[219] Therefore, it could be that participants were already adequately sensitive to magnitude, but became overly fixated on it after receiving the prime. It would be unsurprising, for example, to discover that individuals primed to think carefully about fuel efficiency immediately before purchasing a car were pickier about the gas mileage of the car they eventually bought. Yet this would not imply that the fuel prime "improved" decision-making, or that the preferences revealed with the prime were more normatively valid than those demonstrated without it. In fact, it could be that the primed car-buyers focused on gas mileage at the expense of other important attributes, and therefore made worse decisions.

But suppose that car buyers typically paid little attention to fuel efficiency, yet car *owners* reported that gas mileage was one of the most significant determinants of whether they enjoyed their purchase. In that case, we might have good reason to believe that the typical car buyer was inadequately sensitive to gas mileage, and therefore that the fuel prime helped bring his preferences in line with those he would possess under conditions of full information and rationality. This is somewhat analogous to the situation that likely prevails with regard to life duration and WTP.

[218] See Hammitt & Haninger, "Valuing Fatal Risks."
[219] See Hammitt, "QALYs and WTP."

We have compelling evidence that humans are not very good at processing the importance of magnitude in a variety of domains.[220] Meanwhile, our intuitions make it clear that a long life is a significantly more valuable than a short life. Therefore, it seems far more likely that the prime improved rather than impaired decision-making, and that the post-prime, increased-sensitivity results reveal more about idealized individual preferences. While nothing is certain, a compelling case can be made that the increased attention to the number of remaining life-years demonstrated by primed subjects accords more closely to how individuals would behave under conditions of full information and rationality.

Conclusions

None of the results mentioned here is presented as conclusive. The limitations of the survey format employed make any data gathered preliminary in nature—this entire experiment was a first attempt to harness the power of Mechanical Turk to generate a subject pool for a complex task such as contingent valuation. Yet despite these limitations, several meaningful findings emerge from the pattern of data observed.

First, the survey offers encouraging signs about the potential for employing Mechanical Turk for research purposes in the future. Subjects appeared to engage with the test in a reasonable manner, suggesting that they were capable of understanding the material and providing valuable responses. The possibility of gathering a fairly diverse sample capable of handling even complicated

[220] A problem that often infects contingent valuation, see Hammitt & Graham, "Willingness to Pay for Health Protection."

questionnaires cheaply and quickly has useful implications for future social science research.

In addition, the investigation into current and future perceptions of happiness and satisfaction elucidates both how individuals think about risk reductions and what they anticipate for their futures. This survey provides the first known direct evidence of a correlation between commonly used measures of self-reported wellbeing and WTP, supporting the intuitive but thus far untested claim that people who think their lives are going well are more likely to pay to save them. In addition, the results shine some light on the largely unexplored domain of perceptions of distant future wellbeing, suggesting that individuals' pronounced optimism more than offsets their negative view of aging. This, in turn, casts doubt on the claim that the young possess an unrealistically pessimistic conception of what their golden years will hold, and that these misperceptions could bias VSL.

Finally, the data support the possibility that many people fail to properly comprehend the significance of the number of remaining life-years they possess unless explicitly reminded to do so. The power of a simple prime to influence WTP—especially among the young—hints that scope insensitivity plays a key role in risk valuation, which may cause the preferences for risk reduction commonly articulated in contingent valuation and revealed preference studies to deviate from those held by rational, fully informed individuals. Additional research is required to definitively establish how large magnitude insensitivity looms in altering the lifecycle path of VSL, but the preliminary results found here suggest that its distortionary effects are not trivial. As this psychological factor is explored further, our understanding of the relationship between age and VSL might shift dramatically.

CHAPTER 3:
RETHINKING REGULATION

Academics may struggle with how to value individuals of different ages, but God does not. A peculiar passage of the Bible gives very specific instructions on monetizing the lives of young and old: In the Book of Leviticus, Moses is told to "set the value of a male between 20 and 60 at 50 shekels." A man over the age of 60, however, counts for merely 15 (Leviticus, 27:1-7). Had the AARP been around back then, it would have no doubt objected vociferously.

There is something noteworthy about the divine approach: it is entirely unconcerned with what individuals of different ages claim their lives are worth. Instead, it determines value *a priori*, from some preconception of age's effects. This stands in stark contrast to current regulatory practice. Unlike the God of the Hebrews, the United States government bases its approach to the monetization of lives saved through regulation on the premise that "the value of a reduction in mortality risk…is what a person is willing to pay for it."[221] This transforms the question of whose lives should count for more in cost-benefit analysis from a moral dilemma into an empirical one.[222] Value is reduced to willingness-to-pay, implying there is no reason to adjust monetized benefits for age unless differences in WTP between young and old are discovered. Other concerns could still block disaggregation—federal agencies do not use different VSL figures for Caucasians and African-Americans, for example, despite evidence that their WTPs for risk reductions are not the same—but differential WTP is the *sine qua non* of age

[221] Cropper et al., *SAB Advisory,* 10.
[222] More accurately, it makes a set of normative assumptions that turns the rest of the problem into an empirical question. Moral judgment does take place somewhere in the process.

adjustment.[223] Without it, economic theory fails to affirm that it is advisable to save a young person instead of his grandfather, no matter how intuitively appealing this premise appears. Our *a priori* beliefs about the value of risk reductions to different age groups play no role in this type of analysis.

Over the past decade, the failure of empirical evidence to demonstrate that WTP for risk reductions decreases significantly with age has pushed one such *a priori* belief—that there is something fundamentally different about saving the life of a 20-year-old and an 80-year-old—to the margins of government practice. Guided by a firm conviction that "Understanding how willingness-to-pay to reduce risk varies with age will facilitate better prioritization of risk reduction efforts for populations of various ages," agencies have largely settled on methods of monetizing lifesaving benefits that are insensitive to the age of a protected population.[224] Not so long ago, many government cost-benefit analyses made use of two tools that weight the lives of the young more heavily than those of the old: age-adjusted VSL and age-invariant VSLY (albeit usually only in sensitivity analyses).[225] But the tide has turned. In light of the growing empirical consensus that the relationship between age and WTP is inconclusive at best, agencies have largely resigned themselves to the old stalwart of a constant, unadjusted VSL figure for all age groups.[226]

This transition may owe something to the political pressure generated by the 2003 "senior discounting" controversy.[227] But if so, then it is overdetermined. The

---

[223] See W. Kip Viscusi, "Racial Differences in Labor Market Values of a Statistical Life," *Journal of Risk and Uncertainty* 27 (2003): 252, for evidence on lower VSL for African-Americans.
[224] Aldy & Viscusi, "Age Differences in the Value of Statistical Life," 257.
[225] See Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions," for an overview of current practice and its history.
[226] See Cropper et al., *SAB Advisory*; National Academy of Sciences, *Estimating Mortality Risk Reduction and Economic Benefits*, for recent examples of this consensus.
[227] See Viscusi, "The Devaluation of Life," 109-111, for an account of the political backlash.

EPA and other agencies do not begrudgingly accept age-invariant VSL as a political necessity that clashes with their better judgment, but rather embrace it as the normatively correct course of action due to empirical findings and the methodological assumptions that guide their interpretation. As long as stated and revealed preference studies fail to find evidence that the young value their lives significantly more than the old, then the economic theory that governs agency practice will continue to characterize age-adjusted VSL or constant VSLY as improper.

But perhaps this is a time when Uncle Sam should take a page out of Leviticus. In general, there are good reasons for federal regulators to rely on WTP rather than *a priori* convictions when monetizing regulatory benefits—to know the value of things without having to ask is a characteristic of omniscient deities that modern bureaucrats do not share. Yet to employ this method in every situation makes a universal statement about the worthlessness of our intuitions and the reliability of our WTP evidence that may be unwarranted in some cases.

VSL age adjustment is one of these cases. Society's current approach to monetizing risk reductions to different age groups places too little weight on powerful convictions about how the value of a risk reduction is influenced by the age of its beneficiaries, while putting too much stock in the results of revealed preference and contingent valuation studies that are distorted by their subjects' cognitive limitations.

In the two preceding chapters, I have argued that the observed relationship between age and WTP for risk reductions is determined by many factors that have

little normative significance, such as wealth and psychological errors.[228] As a result, there is something fundamentally misguided about the reverence with which it is held in policymaking circles. "Understanding how willingness-to-pay to reduce risk varies with age" only "facilitate[s] better prioritization of risk reduction efforts for populations of various ages" if these populations are capable of accurately evaluating how their age impacts the welfare benefits they receive from reduced risk. Our understanding of the human mind compels us to reject this psychologically dubious premise. WTP is insufficiently responsive to age because of the cognitive limitations of the subjects from whom it is solicited. Due to the incredible complexity of comprehending the welfare difference between life and death, this is a realm in which idealized and revealed preferences diverge, making WTP an extremely poor proxy for welfare.

If the empirical relationship between age and VSL tells us more about human psychology than about the relative value of risk reductions to different age groups, there is no longer a compelling case for allowing it, rather than our *a priori* convictions, to determine the course of federal regulatory policy. Cost-benefit analysis is best understood as a decision procedure that provides an implementable stand-in for maximizing welfare directly, but carries no moral weight of its own.[229] Therefore, there is no reason to base our valuation of risks to different age groups on revealed WTP unless we believe this provides the best available proxy for welfare maximization.

---

[228] More precisely, wealth carries no normative significance assuming the beneficiaries of a risk reduction do not also shoulder its costs. This claim is controversial. It will be elaborated later in this chapter.
[229] See Adler & Posner, *New Foundations of Cost-Benefit Analysis,* 25-61.

It does not. There are readily available alternatives that track welfare far better than the WTP-based status quo. Systems like constant VSLY, which dictate that the value of a person saved decreases dramatically with his age, correspond to our intuitive prior convictions, but not our evidence. Given the strength of the former and weakness of the latter, this is a tradeoff we should be willing to make. As a result, agencies should scale back their focus on observed WTP when evaluating how to treat age in cost-benefit analysis. Rather than rely on a psychologically distorted measurement that signifies little, decisions on how to prioritize risk reduction across age groups should instead reflect our firm and justified *a priori* understanding of how age impacts the value of a prevented fatality.

The Recent History of Age and Monetization

The use of cost-benefit analysis is mandated for all "economically significant" government regulations by executive order.[230] Since a substantial portion of regulatory benefits come from prevented fatalities, this requirement forces a variety of federal agencies to confront the prickly issue of monetizing human lives. In particular, The Office of Management and Budget (OMB), which supervises the administration of CBA for important rules, and the Environmental Protection Agency (EPA), which is responsible for the lion's share of life-saving regulations, have spent the past few decades coming to terms with the problematic questions involved in valuing mortality risks.[231]

---

[230] See Exec. Order No. 12866 (1993), replacing Exec. Order No. 12291 (1981).
[231] See Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions," 283, on the EPA's prominent role in lifesaving regulation.

Not least among these challenges is determining whether the monetized value of life should vary with age. The prevailing solutions to this dilemma have varied over time (and over agency, though here I focus primarily on the EPA due to its prominent position in lifesaving regulation), but the guiding approach—"to use the willingness to pay of the protected population as the guide"—has remained the same.[232] The belief that age adjustment should respond to empirical evidence on how WTP for risk reductions varies over the lifespan played a large role in motivating earlier efforts to make cost-benefit analysis sensitive to age, and also in catalyzing more recent rejections of such adjustment. Nowhere along the line was a concern for welfare as something distinct from WTP evident.

Up until a few years ago, many policymakers and economists advocated against treating all prevented fatalities as equivalent regardless of how long the individuals in question would have lived otherwise. In a 1993 overview of the benefits of the Clean Air Act, the EPA's Science Advisory Board (SAB) recommended that the agency adjust its VSL figures to take into account the number of life-years—instead of just the number of lives—saved by its regulations.[233] Similarly, a 1999 SAB review of EPA's approach to cost-benefit analysis argued for including VSLY sensitivity analyses in benefit calculations.[234] These suggestions did

---

[232] Viscusi, "The Devaluation of Life," 113.

[233] Robert Schmalensee, *Science Advisory Board's Review of the Office of Policy, Planning and Evaluation's (OPPE) and Office of Air and Radiation's (OAR) Progress on the Retrospective and Prospective Studies of the Impacts of the Clean Air Act*, Letter from the Chair, Science Advisory Board's Clean Air Act Compliance Analysis Council, to EPA Administrator Carol M. Browner (1993). This distinction between lives and life-years is particularly significant for the EPA, since many of its regulations disproportionately benefit the elderly, see United States, Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1990-2010*, EPA 410-R-99-001 (1999).

[234] Robert Stavins, *An SAB Report on the EPA Guidelines for Preparing Economic Analyses*, Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Carol M. Browner, EPA-SAB-EEAC-99-020 (1999).

not fall upon deaf ears. Throughout the late 1990s and early 2000s, many EPA publications contained at least some form of analysis that was sensitive to age.[235]

This practice was motivated by a widely held belief that observed VSL was not identical for all age groups. A 2000 EPA Science Advisory Board paper clarifies that the agency was only interested in age because "the theoretically appropriate method is to calculate WTP for individuals whose ages correspond to the affected population."[236] This logic is no different from that which currently leads the EPA to reject age adjustment. Therefore, it is clear that the agency's earlier openness to the practice emerged from the same normative theory it employs now—using WTP as a guide. The different conclusion was purely the result of different empirical evidence.

This is evident in the infamous *Analysis of the Benefits of the Clear Skies Initiative* that sparked the "senior discount" controversy. Here, the EPA justifies its use of a 37% discount for individuals over 70 by stating: "the appropriate way to account for age differences is to obtain the values for risk reductions from the age groups affected by the risk reduction. Several studies have found a significant effect of age on the value of mortality risk reductions expressed by citizens of the United Kingdom."[237] By this logic, if "several studies" had found a significant *positive* effect

---

[235] For examples see United States, Environmental Protection Agency, *Regulatory Impact Analysis--Control of Air Pollution from new Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements*, EPA 420-R-99-023 (1999); United States, Environmental Protection Agency, *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, EPA 420-R-02-022 (2000); United States, Environmental Protection Agency, *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*, 420-R-02-022 (2002).
[236] Robert Stavins, *An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction*, Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Carol M. Browner, EPA-SAB-EEAC-00-013 (2000), 8, cited in Robinson, "How U.S. Government Agencies Value Mortality Risk Reductions," 291.
[237] EPA, *Methodologies for the Benefit Analysis of the Clear Skies Initiative,* 35.

of age on the value of mortality risk reductions instead, then a senior premium would have been justified.

Indeed, once prevailing beliefs on the age/VSL relationship were revolutionized by a flood of new research that contradicted the studies used to justify the EPA's earlier age-adjustments, opinions on practices like age-adjusted VSL and age-invariant VSLY soured.[238] In the wake of the senior discount crisis, OIRA Administrator John D. Graham circulated a memo that advised all agencies to discontinue the use of age-adjustments for VSL.[239] To support his proscription, he cited new studies that failed to identify a significant effect of age on VSL.[240] His memo went on to warn against the use of a constant VSLY figure for all age groups, once again because "economic theory and the available evidence on individual preferences" did not support it.[241] Instead, Graham recommended employing significantly higher VSLY values for senior citizens, thereby undermining some of this metric's ability to differentiate between age groups. Now that empirical evidence no longer supported age adjustment, the practice's days were numbered.

Graham's views were soon codified in the OMB's *Circular A-4*, which still stands as the official federal guideline on how to conduct cost-benefit analysis. Citing "mixed" evidence on the relationship between age and WTP, the document advises against adjusting VSL on the basis of age.[242] Similarly, it encourages higher VSLY for seniors, quoting directly from Graham's memorandum for support. OMB's approach is epitomized by its claim that "regulations with greater numbers of life-

---

[238] The original EPA analysis was based on Jones Lee et al., "The Value of Safety"; Jones-Lee, *The Economics of Safety and Physical Risk*; and Jones-Lee et al., *The Value of Preventing Non-Fatal Road Injuries*.
[239] See Graham, *Benefit-Cost Methods and Lifesaving Rules*.
[240] Specifically, Alberini et al., "Does the Value of Statistical Life Decrease with Age?"
[241] Graham, *Benefit-Cost Methods and Lifesaving Rules,* 1.
[242] OMB, *Circular A-4,* 30.

years extended are not necessarily better than regulations with fewer numbers of life-years extended"—a statement whose intuitive unattractiveness appears lost upon its authors.[243]

More recent analyses follow a similar pattern. In 2007, the EPA's Science Advisory Board recommended that the agency stick with age-invariant VSL. Once again, this judgment was founded in the economic tenet that "the value of a reduction in mortality risk…is what a person is willing to pay for it."[244] Similarly, a 2008 National Academy of Sciences report argued against age adjustment due to "insufficient" empirical evidence that WTP for risk reductions decreases over the lifespan. NAS summed up the current consensus nicely, stating that: "the status quo of using a uniform VSL should be continued until there is sufficient empirical evidence for how WTP for mortality-risk reduction varies with remaining life expectancy."[245]

As the language of these analyses shows, the methodological assumptions of welfare economics have become so ingrained in government practice that many bureaucrats appear to believe that observed WTP provides the ultimate measure of value. Questions of age, at least, are rarely examined through any other lens. The economist W. Kip Viscusi argues that, "What matters from the standpoint of benefit valuation is whether the personal willingness to pay for risk reduction has declined, irrespective of whether a third party government policymaker thinks that people should be willing to pay less for risk reduction if fewer years of life are being

---

[243] OMB, *Circular A-4,* 30.
[244] Cropper et al., *SAB Advisory,* 10.
[245] National Academy of Sciences, *Estimating Mortality Risk and Benefits,* 157.

saved."[246] The third-party government policymakers Viscusi advises have internalized his lesson so well that they make no attempts to do otherwise.

But perhaps federal agencies should spend a little less time investigating how WTP varies with age and a little more considering whether the current WTP-driven approach to age adjustment deserves its pride of place. The theory undergirding current government practice appears willing to embrace the absurd. For example, if it were discovered that 80-year-olds were willing to pay 10 times more for mortality risk reductions than 20-year-olds, then according to the "economic efficiency norm," the lives of 29 college students would be insufficient compensation for the loss of just three octogenarians. A reasonable person might find this conclusion morally preposterous, no matter what results contingent valuation studies uncovered. Therefore, perhaps it's worth asking a question that gets left out of most policy analyses: should the economic efficiency norm dictate the way we think about age adjustments in cost-benefit analysis? There may be some good reasons why it should, but we should consider whether they are really good enough.

The Foundations of CBA

In order to determine how to conduct cost-benefit analysis properly, it is necessary to understand why we conduct cost-benefit analysis in the first place. The procedure has its origins in classical utilitarianism. In *The Principles of Morals and Legislation,* Jeremy Bentham explains how to examine political alternatives through "hedonic calculus"—by which he means literally summing up the pleasures and pains

[246] Viscusi, "The Devaluation of Life," 112.

experienced by all citizens as a result of any proposed government action.[247] According Bentham's theory, if the net happiness created by a proposal is positive, then it should be implemented; if not, then it must be discarded. As the discipline of economics developed, however, many began to doubt the feasibility of measuring pleasures and pains directly in a way that would allow for comparison across individuals.[248] Modern cost-benefit analysis emerges from this difficulty, which it solves by comparing a policy's impact on different people in dollar terms. CBA depends on the concept of an individual's compensating variation for a given proposal—the amount of money that, if taken away from him after the proposal is implemented, would make him indifferent between this outcome and the status quo.[249] A policy P is evaluated by adding up the compensating variations for all relevant individuals affected by P—if the sum is positive, then P passes cost-benefit analysis.

Bentham believed that hedonic calculus was a moral criterion—it could determine whether policies were justified without reference to anything else. It is less clear whether modern CBA enjoys the same status, though, or if it merely gives hints about something else that possesses moral relevance. The direct normative justification for cost-benefit analysis comes from the related concepts of potential Pareto improvement and Kaldor-Hicks efficiency. A proposal is a Pareto improvement if it makes at least one person better off and no one worse off. This

---

[247] Jeremy Bentham, *An Introduction to the Principles of Morals and Legislation* (New York: Hafner Press, 1973), 32.
[248] See for example Robbins, *An Essay on the Nature and Significance of Economic Science*. However, that welfare can be directly measured and compared across individuals is making something of a comeback with the rise of happiness research—see Daniel Kahneman and Robert Sugden, "Experienced Utility as a Standard of Policy Evaluation," *Environmental and Resource Economics* 32 (2005): 161-181.
[249] See Adler & Posner, *New Foundations of Cost-Benefit Analysis*, 12-19, for a good overview of the process.

standard has obvious moral appeal, but at the same time seems overly restrictive—almost no government policies would meet its stringent requirements.[250] The more practical Kaldor-Hicks test was developed by the eponymous economists Nicholas Kaldor and John Hicks in 1939.[251] A proposal is Kaldor-Hicks efficient if those it benefits could make a costless transfer to those it harms that leaves both groups better off, thereby making the resulting outcome a "potential" Pareto improvement.[252] CBA, as traditionally practiced, is directly related to the Kaldor-Hicks test—if a policy passes cost-benefit analysis, then by definition those who gain under it could compensate its losers and still have something left over to spare.[253]

Yet while the concept of Kaldor-Hicks efficiency is appealing in some ways, it lacks the moral force of the Pareto Criterion because the potential compensations it envisions never actually take place.[254] Consequently, there is no guarantee that a policy that passes the Kaldor-Hicks test would increase welfare. Consider, for example, a situation in which a starving man has a glass of milk that a rich tycoon wants to feed to his overweight cat. The starving man indicates that he would give $5—a sizeable chunk of his meager endowment—to keep the milk, while the rich man is willing to pay $100 to pour it in the kitty bowl. Transferring the milk from the

---

[250] See Yew-Kwang Ng, *Social Welfare and Economic Policy* (London: Harvester Wheatsheaf, 1990), 98, for a discussion of just how impractical the Pareto standard is.
[251] See Richard E. Just, Darrell L. Hueth, and Andrew Schmitz, *The Welfare Economics of Public Policy: A Practical Approach to Project and Policy Evaluation* (Cheltenham, UK: Edward Elgar, 2004), 32-48, for a summary of this test.
[252] There is a actually a distinction between the Kaldor test and the Hicks test, as the former requires the winners under a policy to be able to compensate the losers after it takes place, whereas the latter asks whether the losers would be willing to compensate the winners in order for the policy not to be enacted. These tests could, at least theoretically, yield different answers. See T. De Scitovsky, "A Note on Welfare Propositions in Economics," *The Review of Economic Studies* 9, no. 1 (1941): 77-88, for an argument that a proposed policy should be required to pass both.
[253] See Lee S. Friedman, *The Microeconomics of Public Policy Analysis* (Princeton, N.J.: Princeton University Press, 2002), 169, for an argument grounding CBA in Kaldor-Hicks efficiency.
[254] See Adler & Posner, *New Foundations of Cost-Benefit Analysis*, 21-24; Adler, "QALYs and Policy Evaluation," 13-16, for arguments questioning the moral weight of the Kaldor-Hicks standard.

starving man to the cat is Kaldor-Hicks efficient—the rich man could, after the shift, give the poor man anywhere between $5 and $100 and both parties would be better off. But since this compensation never takes place, it is unclear that overall welfare has increased through giving a starving man's nourishment to an already well-fed cat.[255] This admittedly extreme hypothetical shows how the Kaldor-Hicks test may point towards policies that are welfare enhancing, but is not a moral criterion in and of itself. This is not to say that the standard is worthless—if a policy is Kaldor-Hicks efficient, it is likely that it may enhance welfare as well, which is morally relevant—but it does not possess moral weight in and of itself.[256]

In their recent book, *The New Foundations of Cost-Benefit Analysis,* Eric Posner and Matthew Adler offer a more promising way to justify CBA. Under their account, cost-benefit analysis is a welfarist decision-making procedure with no intrinsic moral relevance.[257] Maximizing welfare—understood as satisfying the preferences of idealized spectators over lotteries, as discussed in Chapter One—is the goal of regulation.[258] CBA is only necessary because it would be exceedingly impractical to instruct policymakers to try to accomplish this task directly. Instead, agencies need a readily applicable decision rule that will stand in for welfare maximization.[259] Cost-benefit analysis is useful as such a tool because, if practiced correctly, it can track

---

[255] See Uwe E. Reinhardt, "Reflections on the Meaning of Efficiency: Can Efficiency Be Seperated from Equity?" *Yale Law and Policy Review* 10 (1992): 312-313, for a more humorous example of how perverse outcomes can be Kaldor-Hicks efficient.
[256] See John D. Graham, "Saving Lives through Administrative Law and Economics," *University of Pennsylvania Law Review* 157 (2008): 395-540, for a defense of the Kaldor-Hicks test.
[257] Adler & Posner, *New Foundations of Cost Benefit Analysis*, 62-100. See Donald Hubin, "The Moral Justification of Benefit/Cost Analysis," *Economics and Philosophy* 10 (1994): 169, for a similar argument.
[258] See Harsanyi, "Morality and the Theory of Rational Behavior," 45-60, for an exposition of this conception of overall wefare.
[259] More precisely, Adler & Posner advocate for a "weak welfarist" approach that asserts that "overall welfare is morally relevant, not that it is morally decisive," Adler and Posner, *New Foundations of Cost-Benefit Analysis,* 53. Therefore, other considerations could outweigh the goal of welfare maximization, but in the absence of powerful contravening claims, the promotion of welfare is a legitimate moral criterion.

welfare reasonably well while providing a transparent and implementable way to evaluate policy.

This understanding should inform our conception of how to conduct cost-benefit analysis most effectively. If the goal is to choose the implementable decision-making procedure that is most likely to maximize overall welfare, then we should evaluate particular approaches to cost-benefit analysis on how well they mirror the preferences of idealized spectators, not on whether they accord with the principles of Kaldor-Hicks efficiency.[260]

Why Should We Base Age Adjustment on WTP?

With this in mind, we can ask what method of age-adjustment is most likely to maximize welfare subject to practical constraints. Traditional economic theory suggests that this is accomplished by valuing risks to a particular age group at that group's WTP.[261] Is this claim compelling? If there is no divergence between idealized and observed WTP—meaning individuals' revealed preferences are identical to those

---

[260] Adler & Posner suggest that a standard could be judged on its 1) decision costs 2) accuracy in tracking overall welfare and 3) safeguards against decision-maker opportunism and error Adler & Posner, *New Foundations of Cost-Benefit Analysis,* 62-63.

[261] There is some question as to exactly what is meant by WTP here, though. Adler & Posner, *New Foundations of Cost-Benefit Analysis*, 12, argue that in welfare economics, "preference refers to how people actually rank states of the world, not how they would rank states of the world if they were better informed, more enlightened, or otherwise different." Consequently, willingness to pay represents an agent's actual demonstrated WTP, not the WTP he would have under conditions of perfect information and rationality. Some dispute Adler and Posner's claim, however, and assert that welfare economics looks for preferences that are fully informed, see Kaplow & Shavell, 410, arguing that "this [Adler & Posner's] characterization is inapplicable to proper welfare economic analysis." Similarly, see John D. Graham, "Saving Lives through Administrative Law and Economics," *University of Pennsylvania Law Review* 157 (2008). But regardless, it is clear that in practice, the prescriptions offered by economists involve examining actual revealed WTP amounts, even if the best attempts are made to ensure that these figures reflect the preferences of informed agents. Graham, who argues against the claim that welfare economics accepts uninformed preferences as normatively valid, still asserts that "economists believe that lifesaving preferences based on actual decisions, where an informed worker faces real consequences from her choice, are more informative of genuine preferences than is idle speculation," Graham, "Saving Lives,"387. Economics and cost-benefit analysis trade in actual preferences, not hypothetical, idealized preferences, even if all possible steps are taken to ensure that the two converge, see Friedman, *The Microeconomics of Public Policy Analysis*,

they would hold if they could fully understand the welfare consequences of their actions—then the argument for respecting age-group differences in WTP is strong, at least in certain cases.

In a defense of individuated WTP, Cass Sunstein makes a useful distinction between situations in which the beneficiaries of a regulation bear its costs, and those in which they do not.[262] In the first case, the claims for individuating WTP to the greatest extent possible are extremely compelling. Regulation in this context can be thought of as "forced exchange," as individuals are effectively being made to exchange money for risk protection. Compelling anyone to purchase more or less risk protection than she chooses as optimal produces a welfare loss, assuming that her choices accurately reflect her idealized preferences. Suppose, for example, that 70-year-olds are willing to pay $500 to reduce a 1/10,000 chance of dying, while 30-year-olds are only willing to pay $300. If these observed WTP figures survive idealization, then a 30-year-old is harmed by being forced to pay more than $300 for a risk reduction (or by being required to forgo a risk reduction that costs less than $300), while a 70-year-old benefits from purchasing risk reduction if and only if its cost is under $500. In this case, if policymakers are looking to maximize welfare, they should adopt a lower VSL for a regulation affecting 30-year-olds than for one protecting 70-year-olds as long as the beneficiaries bear the costs. Otherwise, cost-benefit analysis would recommend too much regulatory protection for 30-year-olds and not enough for 70-year-olds. This conclusion is unaltered if the WTP divergence between age groups is caused by the effects of age on the marginal utility of wealth,

[262] Cass R. Sunstein, "Valuing Life: A Plea for Disaggregation," *Duke Law Journal* 54 (2004): 421-439.

since those who benefit from regulation also pay for it, making the affected population's opportunity cost of money a relevant consideration.

The situation is more complicated, however, when one group is forced to pay for another's regulatory protection. This distributive pattern is common in the real world, as the costs and benefits of most important lifesaving regulations do not accrue to the same individuals. The Clean Air Act, for example, tends to benefit some while harming others.[263] And if regulatory beneficiaries don't shoulder one hundred percent of the costs, then perfectly individuated WTP might not provide the welfare-maximizing guide for age adjustment because of the confounding effects of the marginal utility of money.[264] Suppose, for example, that 70-year-olds demonstrate greater WTP for risk reductions than 30-year-olds because they have large accumulated savings and few opportunities to spend them.[265] If a policymaker were considering a regulation that protected, and was paid for by, 30-year-olds, it would be efficient to use a lower VSL value than if contemplating an identical policy for 70-year-olds. But if the costs and benefits are borne by different individuals, then the marginal utility of wealth of the beneficiaries is no longer quite so salient. The high opportunity cost of money for 30-year-olds is a compelling reason to provide them with less risk protection if they are paying for it, but not if someone else is picking up the tab. This argument is powerfully articulated by Pratt & Zeckhauser, who note that individuals with high background risk (i.e., the elderly) will likely demonstrate inflated VSL because their personal opportunity cost of money is low

---

[263] Interestingly, these benefits accrue disproportionately to minorities and the poor, see Matthew E. Kahn, "The Beneficiaries of the Clean Air Act," *Regulation* 21 (2001): 35-38.
[264] See Sunstein, "Valuing Life," 434-437; Adler & Posner, *New Foundations of Cost-Benefit Analysis*, 130-131. Even standard treatments of CBA note this point, see E. J. Mishan, *Cost-Benefit Analysis: An Informal Introduction*, 4th ed. (London: Unwin Hyman, 1988), 200.
[265] These are the exact explanations for high senior VSLY proposed by John Graham in his 2003 memo, see Graham, *Benefit-Cost-Methods and Lifesaving Rules*, 2.

due to the likelihood they will die in the near future (assuming the absence of a particularly powerful bequest motive).[266] However, it would be inefficient for society to prioritize risk reduction efforts for these individuals as a result, because the social opportunity cost of spending on them is no different from the social opportunity cost of spending to protect anyone else.[267]

The natural objection to this sort of reasoning is that adjusting WTP amounts for the marginal utility of wealth is inherently redistributive, and redistribution is better accomplished through the tax system.[268] Yet this claim is not entirely satisfying. Few would argue that society at present has achieved the optimal level of redistribution from a welfarist standpoint, or that such a distribution would even be possible given political constraints.[269] Telling federal agencies to avoid correcting for the effects of the marginal utility of wealth on WTP values because there are hypothetically superior alternatives involving taxes and transfers is not compelling when these alternatives are not politically feasible.[270] When conducting welfarist policy analysis, it makes sense for agencies to consider which of the options actually available to them is most likely to maximize welfare.

Current federal regulatory policy appears to at least implicitly endorse this view, as it is standard practice to refrain from adjusting VSL for income despite

---

[266] See Pratt & Zeckhauser, "Willingness to Pay and the Distribution of Risk and Wealth," 747-763.
[267] For a similar treatment, see Olivier Armantier and Nicolas Treich, "Social Willingness to Pay, Mortality Risks, and Contingent Valuation," *Journal of Risk and Uncertainty* 29 (2004): 7-19.
[268] For arguments to this effect, see Louis Kaplow and Stephen Shavell, "Why the Legal System Is Less Efficient than the Income Tax in Redistributing Income," *Journal of Legal Studies* 23 (1994); David A. Weisbach, "Should Legal Rules Be Used to Redistribute Income?" *University of Chicago Law Review* 70 (2003): 439-440.
[269] See Ronald M. Dworkin, "Is Wealth a Value?" *Journal of Legal Studies* 9 (1980) and Yew-Kwang Ng, "Quasi-Pareto Social Improvements," *American Economic Review* 74 (1984), who claim that society could not be considered close to a welfare-maximizing wealth distribution.
[270] For arguments to this effect, see Sunstein, "Willingness to Pay Versus Welfare," 314-315; Adler & Posner, *New Foundations of Cost-Benefit Analysis,* 144-146.

powerful evidence that WTP for risk reductions displays positive income elasticity.[271] By insisting on constant VSL for all income levels, government agencies effectively correct for the impact of the marginal utility of wealth. Consequently, treating differences in WTP between age groups produced by variations in opportunity costs as normatively significant would seem to violate existing commitments to ignore the impact of material resources on the value of life.[272]

This analysis reveals that if observed WTP survives idealization, then basing VSL age adjustments on the pattern of data that emerges from revealed preference and contingent valuation work is welfare-maximizing as long as the beneficiaries of regulation also bear its costs. If costs and benefits accrue to different individuals, then observed VSL provides a welfare-maximizing guide to age adjustments only in so far as it can be corrected for the impacts of the marginal utility of wealth.

What if Observed WTP Is Inaccurate?

Yet this conclusion assumes that observed WTP does not deviate from idealized WTP—or at least that if it does, these deviations do not systematically vary with age. As argued in the two previous chapters, this is a dubious claim. Humans are not psychologically equipped to take into account the impact of the size of their future lifespan on the welfare benefit of a risk reduction. As a result, there is good reason to believe that the observed interaction between age and VSL lacks normative significance. Once this possibility is acknowledged, it becomes harder to maintain

---

[271] See Aldy & Viscusi, "A Critical Review of VSL Estimates," 36-38, estimate an income elasticity of 0.5-0.6.

[272] Interestingly, John Graham, Administrator of OIRA during the senior discounting controversy, notes this problem in Graham, "Saving Lives through Administrative Law."

that basing the VSL for a particular age group on its revealed WTP for risk reductions is a welfare-maximizing approach.[273]

Suppose 70-year-olds demonstrate higher WTP for a risk reduction than 30-year-olds, but this difference is primarily driven by cognitive errors—neither group properly processes the way in which the length of a future lifespan impacts the welfare loss of dying, and both would behave differently under conditions of full information and rationality. It would therefore be inaccurate to say that employing higher VSL for 70-year-olds necessarily increases welfare. If revealed preferences survive idealization, then requiring anyone to purchase more or less risk protection than he claims to want decreases his wellbeing. But if revealed preferences are not normative, then overriding them can potentially enhance welfare. Therefore, as long as psychological constraints induce observed WTP to diverge from idealized WTP, and these divergences are not independent of age, it seems unlikely that the current data available provide a welfare-maximizing guide for age adjustments.

Perhaps, as the science of measuring WTP improves, these divergences between observed and idealized WTP will shrink. The state of knowledge has advanced considerably over the past decade, and current analyses encourage further research to better understand the relationship between age and VSL.[274] Yet the disconnect between revealed and idealized WTP observed so far may be tied to fundamental features of the human psyche. It is possible that no amount of measurement will be able to compensate for the fact that people are inherently

---

[273] See Matthew D. Adler and Eric A. Posner, "Implementing Cost-Benefit Analysis when Preferences Are Distorted," *Journal of Legal Studies* 29 (2000), for a related discussion of the proper way to "launder" uninformed preferences when conducting CBA.
[274] See for example Cropper et al., *SAB Advisory,* 11; National Academy of Sciences, *Estimating Mortality Risks and Economic Benefits*, 157.

limited in their ability to comprehend the welfare benefits of living the rest of their lives. Regardless, this is only a consideration for tomorrow's policymakers. Even if more accurate measurements could be obtained in the future, this does not erase the fact that currently available data are still plagued by the distorting effects of cognitive errors.

The Implications of Irrationality

Establishing that revealed individual preferences are not welfare maximizing does not directly imply that governments should disregard them. Even if people fail to always act in their self-interest, it is unclear that policy makers can do a better job. John Stuart Mill tells us as much in his classic defense of individual freedom, *On Liberty:*

> With respect of his own feelings and circumstances, the most ordinary man or woman has means of knowledge immeasurably surpassing those that can be possessed by any one else. The interference of society to overrule his judgment and purposes in what only regards himself, must be grounded on general presumptions; which may be altogether wrong, and even if right, are as likely as not to be misapplied to individual cases.[275]

In a more recent, but similarly inclined, analysis, the economist Ed Glaeser argues that individual errors do not justify paternalism, as governments have fewer incentives to correct their mistakes, and are therefore likely to be even more egregiously wrong than private citizens.[276]

Yet the existence of situations in which individuals do not maximize their welfare does suggest that there are at least some cases in which it is possible for

---

[275] John Stuart. Mill, *On Liberty*, ed. Edward Alexander (Peterborough, Ontario: Broadview, 1999), 124.
[276] Edward L. Glaeser, "Paternalism and Psychology," *The University of Chicago Law Review* 73, no. 1 (2007): 133-156.

governments to enhance welfare by overriding revealed preferences.[277] If agents always acted with full information and rationality, then policymakers would be incapable of improving on the recommendations that observed WTP offered for how to monetize regulatory benefits. To the extent that individuals' revealed WTP figures do not survive idealization, however, then policymakers can at least theoretically produce figures that provide a better approximation of idealized preferences and welfare.

In many cases, this might prove impossibly difficult. Cost-benefit analysis is supposed to provide a decision procedure that is accurate, implementable, and relatively immune from the weaknesses of bureaucrats.[278] Valuing benefits at revealed WTP can probably meet these criteria better than any alternative in most situations, even if it fails to provide a perfect proxy for welfare. For example, consider the practice of valuing the benefits of lifesaving regulations using VSL figures derived from revealed- and stated-preference studies. Many of the arguments made for the divergence of actual from idealized WTP in this thesis suggest it would be foolish to believe that the VSL used by policymakers perfectly approximates the idealized value of a prevented fatality for any age group. But this does not mean that the government should adopt an entirely different method of monetizing lifesaving benefits. In order to justify such a step, policymakers would have to develop a

---

[277] Several authors have discussed the new possibilities for welfare-enhancing government regulation in light of new research on human behavior. Jolls et al., "A Behavioral Approach to Law and Economics, 1541 describe their stance as "anti-anti-paternalist." Sunstein & Thaler, "Libertarian Paternalism Is Not an Oxymoron," advocate "libertarian paternalism." Similarly, Camerer et al., "Regulation for Conservatives," 1212, argue for "asymmetric paternalism." All these approaches depend on the fact that individuals often reveal preferences that are not welfare-maximizing. See also Ted O'Donoghue and Matthew Rabin, "Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes," *The American Economic Review* 93, no. 2 (2003): 186-191, for more consideration of the potential for welfare-enhancing paternalism.

[278] Adler & Posner, *New Foundations of Cost-Benefit Analysis*, 62-63.

different, transparent, readily calculable alternative that would be more likely to maximize welfare than VSL calculated from WTP.[279] This task would likely prove exceedingly difficult. Are current WTP figures too high or too low? How would we know? And by how much? It is hard to imagine how a policymaker could provide anything other than an entirely arbitrary answer to these questions, and the opacity of such a system would leave it vulnerable to manipulation by bureaucrats who wanted to promote pro-regulatory or deregulatory agendas.[280]

Suppose the Department of Transportation (DOT) wants to decide how much it is willing to pay for the construction of lifesaving guardrails on federal highways. Published VSL estimates provide an imperfect proxy of the welfare benefit of saving a life. But the DOT has no better alternative to use as a guideline for monetizing prevented fatalities, and therefore should stick with the best available option, WTP-based VSL. But the same considerations should not dictate whether to pay more to build guardrails in the college town of Hannover, New Hampshire, or in the retiree-heavy community of Boca Raton, Florida.

While there are few good ways to determine a baseline figure for the value of life aside from using revealed preference data, VSL age adjustments are not subject to the same constraints. Here, there is a readily available, intuitive way to approach the problem. Common sense does not give much guidance as to what the dollar value of a human life should be, but it does provide clear instructions on how this number should change with age. Risk reductions seem to provide greater welfare to young individuals with long future lifespans than to old people with few years left to

---

[279] Adler, "QALYs and Policy Evaluation," 61-69, suggests the use of QALYs, yet when deciding how to monetize, he still depends in part on WTP evidence.
[280] For a potential real-world example of such manipulation, see Viscusi, "The Devaluation of Life," 113-118.

live. Therefore, we could develop an age adjustment system that reflected this intuitive belief, even if it was not supported by revealed preference evidence.

A Simple Proposal

Consider one approach to age adjustment that reflects our intuitions and is readily implementable within the current policy framework (as evidenced by its frequent use over the past two decades), but is decisively rejected by observed evidence on WTP for risk reductions: age-invariant VSLY.[281] Monetizing mortality risk reductions in terms of years as opposed to lives is appealing because no regulation literally "saves" a single person.[282] Everyone dies sooner or later—the question is just whether it will come sooner, or later.

VSLY is generally calculated from VSL under the assumption that that the value of a life is the sum of the net present value of all its remaining years.[283] As a result, use of a single, unadjusted VSLY figure for cost-benefit analysis is equivalent to implementing a significant, downward age-adjustment on VSL.[284] It increases the benefits estimates for regulations that protect the young—who have many life-years left to live—while driving down the benefits of those that protect the old. Therefore,

---

[281] I am currently proposing use of age-invariant VSLY only as a form of age adjustment. Life-years saved by regulation depend critically on the age of the affected population, but also on other factors, such as its health status or gender. Using VSLY analysis in general would suggest diminishing the value of risk reductions for men or those with chronic medical conditions, which may be normatively undesirable. In my proposal, however, agencies would only modify their assessment of the life-years saved by a regulation based on the age distribution of the beneficiaries, not on any other characteristics, so these problems would be avoided.

[282] See Sunstein, "Lives, Life-Years, and Willingness to Pay," 213, for a similar argument.

[283] The model derives from Michael J. Moore and W. Kip Viscusi, "The Quantity-Adjusted Value of Life," *Economic Inquiry* 26, no. 3 (1988): 369.

[284] Such constant VSLY analysis has featured prominently in sensitivity analyses for many major regulations, such as the EPA's 1997 review of the benefits of the Clean Air Act, see EPA, *The Benefits and Costs of the Clean Air Act, 1970-1990*. Sunstein, "Lives, Life-Years, and Willingness to Pay, 252, provides a long list of regulatory rulings using VSLY.

in order to be justified under economic theory, this practice would require WTP for risk reductions to be strictly and dramatically decreasing in age. Of course, this pattern has not been observed.[285] Based on empirical evidence, it appears that the old are willing to pay significantly more for a life-year than the young. Consequently, OMB and the EPA have unequivocally rejected the use of constant VSLY.[286]

Yet agencies could employ a constant VSLY as a means of distinguishing between regulations that impact different age groups without too many logistical difficulties—in fact, they already have many times before—as long as they were willing to disregard evidence on how WTP changes over the lifespan. This type of practice would clearly fail to meet the requirements of traditional cost-benefit analysis, and would not necessarily generate outcomes that were Kaldor-Hicks efficient. But as argued earlier, we are looking for the simplest way to approximate welfare. And with respect to that standard, constant VSLY might perform surprisingly well.

Conviction versus Evidence: A Welfarist Comparison

Consider two contrasting approaches to the monetization of risk reductions for individuals of different ages. The first bases VSL for a given age group on that age group's WTP for risk reductions. It is favored by economic theory and agency practice. Given current policymakers' interpretation of the empirical evidence on the age/WTP relationship, this approach can be identified with the practice of age-

[285] See Krupnick, "Mortality Risk Valuation and Age," and Aldy & Viscusi, "Age Differences in the Value of Statistical Life."
[286] See OMB, *Circular A-4*, 30 and Cropper et al., *SAB Advisory,* 11.

invariant VSL that has become ubiquitous in recent years.[287] The second is the system of constant VSLY just described. Which one of these proposals better satisfies the requirements for a good welfarist decision-making procedure?

With regard to implementability, the result is likely a draw.[288] Both systems are transparent, have been successfully used in the past, and do not require policymakers to make excessively difficult calculations that would be vulnerable to abuse. The key, therefore, is how the two systems perform at accurately tracking welfare.

As argued earlier, welfare is defined by the preferences of idealized spectators over equiprobability person-state lotteries. Consequently, a system of VSL age-adjustments for cost-benefit analysis does its job in so far as it mirrors the preferences of idealized spectators—in a perfect system, a policy P would generate higher monetized benefits than an alternate policy P* if and only if idealized spectators would prefer the equiprobaility lottery under P to that under P*.[289]

Suppose we had to determine what sort of system would best approximate this ideal before examining how observed WTP varied with age. *A priori,* it would

---

[287] Exactly what sort of age adjustments it recommends depends on which data it employs. Revealed preference studies suggests that VSL follows an inverted-U shape over the lifespan, which would imply that the regulatory benefits of lifesaving should be adjusted upward for the middle-aged relative to everyone else—including the young see Aldy & Viscusi, "Age Differnces in the Value of Statistical Life." Stated preference evidence, however, points to no clear relationship between age and VSL, see Krupnick, "Mortality risk Valuation and Age." While agencies generally rely primarily on revealed preference evidence (21 of the 26 studies used to calculate the EPA's VSL are revealed preference based), their approach to age adjustment seems to take its cues from the assumption that WTP for risk reductions is fairly invariant over the lifespan, see Robinson, "How U.S. Government Agencies Value Mortality Risks."

[288] Interestingly, there are certain types of lifesaving regulations for which it is easier to calculate the number of lives saved, and other types for which it is simpler to calculate the number of life-years saved. See Hammitt, "Valuing Changes in Mortality Risk," 233-234.

[289] Note that this is only the case if we ignore the effects of the marginal utility of money—i.e., assume it doesn't matter to whom the costs of regulation accrue. For the purposes of this analysis, I make this simplifying assumption. As argued earlier, it is appropriate in cases where the beneficiaries of a regulation do not bear its cost, which is true for most important lifesaving policies, and also reflects agency commitments to avoid adjusting VSL for wealth.

appear natural for spectators to value risk reductions in inverse proportion to the age of the protected population. After all, saving a 20-year-old preserves three times as many life-years as saving a 60-year-old life does (assume for simplicity that all individuals live to 80). It would be very strange if idealized spectators did not consider a chance of gaining 60 additional years significantly preferable to an equal chance of gaining 20 years. Therefore, it appears welfare considerations favor some sort of adjustment that makes older lives less valuable than younger ones.

The trickier question is how big this adjustment should be. It seems possible that simply looking at the number of life-years saved undervalues the lives of the old. It is clear that idealized spectators would prefer a policy that saved ten 30-year-olds to one that saved ten 60-year-olds, in no small part because the first alternative adds 500 life-years whereas the second only provides 200. But would they prefer a policy that saved five 30-year-olds to one that protected ten 60-year-olds? The former dominates the latter in terms of life-years, yet it does not seem obviously superior because its benefits are not as widely distributed.[290] At first glance, it appears possible that if idealized spectators were reasonably risk averse, they would prefer the second program, since it offers a greater chance of enjoying at least some benefits.[291] Yet this claim is the product of a misguided interpretation of the equiprobability lottery concept. In Harsanyi's formulation, welfare is determined by spectators' preferences over entire life histories.[292] Therefore, the fact that lifesaving benefits are more widely

---

[290] This is related to the classic criticism of utilitarianism that benefits to one individual cannot truly compensate losses to another due to the separateness of persons, see Robert Nozick, *Anarchy, State, and Utopia* (Oxford: Blackwell, 2003) for the famous "utility monster" *reductio ad absurdum* related to this claim.

[291] See Adler, "QALYs and Policy Analysis," 46-47, for a discussion of risk aversion with respect to life-years.

[292] See Harsanyi, "Morality and the Theory of rational Behavior, 39-63; Weymark, "A Reconsideration of the Harsanyi-Sen Debate," 255-321.

distributed in the second program does not mean that it is favored by equity and risk aversion concerns.

For example, assume there are three people in the world, two of whom are 75 and one of whom is 30. Policy A saves the life of the 30-year-old, whereas Policy B protects the two 75-year-olds. The equiprobability lottery faced by idealized spectators is not: *1/3{live 50 more years, live 0 more years, live 0 more years}* if policy A is implemented versus *1/3{live 0 more years, live 5 more years, live 5 more years}* under policy B. Rather, the relevant alternatives are: *1/3{live 80 years, live 75 years, live 75 years}* and *1/3{live 30 years, live 80 years, live 80 years}*, respectively. Policy B only appears attractive under the first (incorrect) formulation. When the problem is framed properly, it becomes clear that risk aversion might suggest that simply maximizing the number of life-years saved actually *undervalues* the young relative to the old, since a marginal year contributes more welfare if it goes to an individual who has lived a shorter life thus far.[293] Interestingly, this claim fits well with studies of individuals' preferences for public lifesaving programs (not a perfect parallel for the Harsanyi construct, but close), which suggest that most people attach a higher value to the life-years of younger individuals than to those of the elderly.[294]

Therefore, a constant VSLY monetization system, which causes the benefits of a regulation to decrease with the age of those it protects, appears to be far more in line with our *a priori* expectations about the preferences of idealized spectators than a constant VSL system, which treats all lives the same regardless of how many years

---

[293] Counting the life-years of a younger individual more heavily also seems to have some appeal from a fairness perspective, as a person who has lived less appears
more entitled, in a sense, to additional life, see Williams, "Intergenerational Equity: An Exploration of the Fair Innings Argument."
[294] See Dolan et al., "QALY Maximization and People's Preferences"; Cropper et al., "Preferences for Lifesaving Programs."

are left in them. Of course, this claim is purely based on a conjecture about the preferences of idealized, rational spectators (albeit a well-reasoned one). It could be entirely wrong.

In fact, the observed evidence on how WTP for risk reductions varies with age resoundingly suggests that it is. The absence of an observed decline in VSL over the lifespan implies that demonstrated VSLY increases dramatically with age. Therefore, if revealed preference must be respected, then it is incorrect to assert that a policy saving more life-years is necessarily preferable to one saving fewer as long as the two policies protect different age groups. This underlies the government's rejection of constant VSLY—in his 2003 memo, John Graham asserts that "economic theory and the evidence on individual preference do not support a simple VSLY method (i.e., saving 10 life-years is not necessarily more valuable than saving 1 life-year). OMB is concerned that a simple VSLY approach could underestimate benefits significantly when applied to rules that primarily or significantly benefit senior citizens."[295]

Graham's argument is unquestionably valid within the framework of economic theory. But its soundness depends on the assumption that some combination of empirical evidence provides decisive information about welfare. The question that he does not, but should, ask is whether such evidence really must override our intuitive belief that constant VSLY leads CBA to track welfare more accurately than does constant VSL. Basing age adjustment on revealed preference evidence has the advantage of responding to what citizens claim to want. Yet as argued extensively before, what individuals claim to want may, at times, be only

[295] Graham, *Benefit-Cost Methods and Lifesaving Rules,* 1-2.

loosely associated with what actually promotes their welfare. Years of research provide considerable information about how observed WTP for risk reductions varies with age, but this does not conclusively show how idealized WTP behaves over the lifespan. It only gives clues, not answers.

Policymakers should synthesize prior conceptions with new evidence in accordance with the dictates of Bayesian inference.[296] Consequently, revealed preference evidence should update, but not necessarily override, intuitive prior conceptions. The decision of which to privilege depends on the reliability of each.

Consider the case of a child about to embark upon a long-distance car trip. You ask the boy whether he wants to use the bathroom and he tells you "no." In this situation, you have a prior belief—children with small bladders rarely make it through long car rides without needing to use the bathroom, so it is likely that this child would, in fact, be well-served by a trip to the restroom. You also have some contradictory revealed preference evidence—the child claims that it is not in his best interest to use the toilet. But very few people (and even fewer parents) would conclude that the child is better off skipping the bathroom trip. The evidence provided by the small boy's insistence that he doesn't need to go might influence one's conception of what constitutes his true self-interest, but it seems far more likely that the child is mistaken about what promotes his welfare than that your well-founded prior conception is misguided.

Children are different from adults most of the time—but perhaps not all the time. As Camerer et al. write, "behavioral economics extends the paternalistically

---

[296] Bayes's Theorem tells us how to combine prior probabilities with new information. See Adler, "QALYs and Policy Evaluation," 54-56 for a discussion of Bayesian updating with regard to risk policy. See José M. Bernardo and Adrian F. M. Smith, *Bayesian Theory* (Chichester: Wiley, 2000), for an overview of Bayesian statistics.

protected category of 'idiots' to include most people at predictable times."[297] Even adults do not always know what will maximize their welfare, and therefore we should not always dismiss well-justified prior conceptions about what a person would choose under conditions of full information and rationality simply because he tells us otherwise.[298]

This logic applies directly to the question of monetizing risk reductions. Here we have a prior belief—that risk reductions protecting the young generate more welfare than those guarding the old—and contravening empirical evidence—old individuals do not demonstrate lower WTP for risk reductions than their younger counterparts. When we synthesize these two pieces of information to form a concept of what the preferences of idealized spectators would look like, we must carefully consider how heavily to weigh each input.

There are very good reasons to have faith in our prior conviction. It is hard to explain why the welfare benefit of a mortality risk reduction would not be intimately related to the number of life-years it saved. And as noted earlier, the possibility of risk aversion and diminishing marginal utility of living actually compels us to give more weight to younger years relative to older ones, suggesting that saving the 40-year expected remaining lifespan of a 40-year-old might, if anything, generate

---

[297] Camerer et al., "Regulation for Conservatives," 1218.

[298] This may seem to violate respect for individual autonomy. Sunstein, "Valuing Lives: A Plea for Disaggregation," 401, for example, claims that valuing lifesaving benefits at WTP can be justified on autonomy grounds, independent of welfare. However, Sunstein believes—correctly—that this argument is primarily applicable when regulation amounts to forced exchange. Most regulatory policies instead concern situations in which one group pays for another's benefits, and it is less clear whether autonomy concerns are valid here. A person may have some deontological right to determine how much to spend on his own safety, even if his choice is not welfare-maximizing. But who has a right to determine how much society spends on his safety? When policymakers determine a system of VSL age-adjustment, it does not violate anyone's autonomy if the adjustments are not based on WTP data, except in the rare cases in which individuals shoulder all the costs of their own regulatory protection. And even in those instances, there is active debate on whether the satisfaction of non-ideal preferences really constitutes autonomy and deserves respect, see Sunstein & Thaler, "Libertarian Paternalism Is not an Oxymoron," 1167.

more than twice the welfare benefit of protecting the 20 remaining years of a 60-year-old.

Meanwhile, there are many reasons to be suspicious of the information provided by revealed preference evidence, which is likely driven by a combination of marginal utility of money effects and cognitive limitations—neither of which impact the welfare gain produced by lifesaving. A cocktail of high background risks, increased wealth, and diminished spending opportunities lowers the marginal utility of money for older individuals, inducing them to spend more on risk reductions. In cases where people do not bear the entire cost of their risk protection—which is true most of the time—this effect is purely distortionary, inducing society to overspend on the elderly.[299] And even in the rare cases in which beneficiaries do shoulder the entire cost of risk protection themselves, relying on the effects of the marginal utility of wealth to prioritize risk reductions to different groups goes against the government's stated commitment to avoid adjusting VSL for income.[300]

Even more damning is the presence of psychological factors that distort the age/VSL relationship. Cognitive limitations prevent people from truly comprehending the impact that their age has on the welfare benefit of a risk reduction. Consequently, it is not at all surprising that observed VSL does not decline with age—given our understanding of the psychological processes that take place when individuals value mortality risks, it would almost be more remarkable if it did. As a result, revealed preference evidence cannot be considered a reliable guide to how much welfare different age groups derive from lifesaving.

---

[299] See Pratt & Zeckhauser, "Willingness to Pay and the Distribution of Risk and Wealth."
[300] See Robinson, "How U.S. Government Agencies Value Mortality Risks," 291-292, for current agency practice. See Graham, "Saving Lives through Administrative Law," for a discussion of the implications of this.

In sum, it seems far more attractive to trust our powerful intuitive convictions than our shaky WTP evidence. We are forced to conclude that the lifetime pattern of WTP we observe is not all that different from the child telling us he doesn't need to use the bathroom—given our understanding of the cognitive errors influencing this new evidence, it shouldn't shake our solid prior conception of the welfare maximizing course of action.

This is not to say that constant VSLY is necessarily the monetization approach that causes CBA to most accurately track welfare while still remaining practical. There could be other alternatives that would mirror the preferences of idealized spectators even more closely. But this simple proposal does appear superior to the status quo, even in light of contravening revealed preference evidence. If government cost-benefit analysis looks to maximize welfare, then it should monetize lives saved using something closer to constant VSLY than constant VSL. The current approach, which is willing to allow age adjustment only in so far as it is supported by revealed preference evidence, does not promote welfare as effectively, and should be discarded accordingly.[301]

[301] It could be argued that even if constant VSLY promoted welfare more effectively than constant VSL, such a system would still be morally impermissible because it fails to treat all lives the same, effectively discriminating against the elderly. This argument fails to consider two crucial facts. First, while constant VSLY may not treat everyone's life in the same manner, constant VSL does not treat everyone's life-years equivalently, instead valuing those of the old at a premium. Since life "saving" is really just life extension, it is unclear that the "injustice" of treating lives differently is worse than the comparable inequity of differentiating between life-years. Second, the claim of discrimination fails to note that age is inherently symmetrical—everyone who was old was once young. Therefore, every person who is harmed by a constant VSLY system at one point in their lives was benefited at an earlier time (excluding the first generation of seniors after the policy change). See Sunstein, "Lives, Life-Years, and Willingness to Pay," 216-222, for elaborations of these arguments.

A New Approach to Regulation

In his famous essay, "The Methodology of Positive Economics," Milton Friedman argues that the plausibility of a model's assumptions is unimportant as long as it generates valid predictions.[302] But in this case, that is not entirely true. We care not just about how VSL varies with age, but also about *why* it varies with age. It means something very different if observed patterns of VSL over the lifetime are the product of rational calculation or cognitive errors. Once we recognize that the latter play a large role in determining how individuals of different ages value risk reductions, our approach to monetizing regulatory benefits should not be the same.

Policymakers largely have yet to grasp this. As a result, the current federal agency approach, which eschews age adjustment on account of WTP evidence, fails to promote welfare as effectively as it could. By ignoring sound, easily implementable convictions about what types of risk reductions generate greater benefits in favor of revealed preference data that provide little information about the idealized preferences of fully rational, informed spectators, it places the tenets of economic theory over the pursuit of welfare.

This is a crucial error. Government cost-benefit analysis should be understood as a welfarist decision-making procedure that looks to track overall welfare as closely as possible while still remaining practical. Many alternative approaches to benefit monetization, such as constant VSLY, accomplish this goal more effectively than the status quo. One of these systems should be adopted in

[302] Milton Friedman, "The Methodology of Positive Economics," in *Essays in Positive Economics* (Chicago: University of Chicago Press, 1953), 3-42.

place of continued reliance on an age-invariant VSL figure that obscures the important distinctions between risk reductions for populations of different ages. Until this happens, government agencies will continue to misallocate lifesaving resources in the thrall of an illusion about how people behave and what constitutes their true best interest.

CONCLUSION
THE VALUE OF PRICE

After its brief foray into the spotlight during the senior discounting controversy of 2003, VSL managed to stay out of the media for a while (federal regulatory policy usually doesn't make for good newspaper copy). But it emerged back into the public eye five years later, once again as a result of some peculiar manipulations at the EPA. The agency usually boosts its VSL estimates over time to reflect inflation and gains in per capita income. In the summer of 2008, however, EPA's value of life mysteriously dropped by about $1 million. The agency asserted that it was correcting its figures, which had previously been too high, but the rest of the world smelled a rat.[303] "By reducing the value of human life, which is really a devious way of cooking the books, the perceived benefits of cleaning up the air seem less," complained Frank O'Donnell, an environmental advocate from Clean Air Watch.[304]

But for many the concern was more metaphysics than deregulation. Senator Barbara Boxer, who would sponsor a bill to prevent the value of statistical life from ever being lowered again, released a public statement that asserted "EPA may not think that Americans are worth all that much, but the rest of us believe the value of an American life to our families, our communities, our workplaces and our nation is no less than it ever has been."[305] Boxer implies that there is something fundamentally pernicious about decreasing VSL, independent of its consequences for regulatory

---

[303] See Viscusi, "The Devaluation of Life," 113-121, for an account of the controversy.
[304] David A. Fahrenthold, "Cosmic Markdown: EPA Says Life Is Worth Less," *Washington Post*, July 19, 2008, sec. A.
[305] U.S. Senate Committee on Environment and Public Works, "Boxer Statement on EPA Decision to Lower Human Life," press release, http://epw.senate.gov/public/index.cfm?FuseAction=Majority.PressReleases&ContentRecord_id=22250f94-802a-23ad-4b6d-c5aab7b77cd8&Region_id=&Issue_id= (accessed March 1, 2010).

policy. Based on her description, one imagines that EPA's bureaucrats had somehow managed to singlehandedly degrade the quality of our families, communities, workplaces, and nation through their VSL chicanery.

This reaction reveals the fundamental disconnect between how economists and non-economists think about VSL. In common parlance, "value" is associated with inherent worth. Consequently, for most people, policies that determine the "value of life" have a moral significance that agency bureaucrats often miss. This goes a long way towards explaining what makes senior discounting particularly controversial. Many seniors found the EPA's age adjustments sinister because they felt that the government was downgrading their moral status—a point driven home by the literature distributed at Listening Tour protests asserting that the EPA's discounting policy rendered seniors "worth 3/5 of a person."[306]

It also provides guidance for moving forward. If the EPA and other agencies ever want to account for age in their cost-benefit analyses, they need to discover how to do it without incurring the wrath of the AARP. The answer is better marketing. Trudy Ann Cameron, a contingent valuation researcher from the University of Oregon, recently published an article in the Association of Environmental and Resource Economists newsletter that persuasively argues for scrapping the term "value of statistical life."[307] In its place, she offers a concept pioneered by the economist Ronald Howard: the micromort.[308] A micromort is simply a 1 in 1 million probability of death. Since lives are priced by multiplying out WTP for small risk

---

[306] Scryzki, "Under Fire, EPA Drops the 'Senior Death Discount.'"
[307] Trudy A. Cameron, "The Value of a Statistical Life: [They] do not think it means what [we] think it means," *AERE Newlsetter* 28 (November 2008): 36-38.
[308] See Ronald A. Howard, "On Fates Comparable to Death," *Management Science* 30 (1984): 407-422 and Ronald A. Howard, "Microrisks for Medical Decision Analysis," *International Journal of Technology Assessment in Health Care* 5 (1989): 357-370 for a discussion of micromorts.

reductions, micromorts can be monetized by simply leaving out the second step. The ultimate effect is the same, but the terminology is much less loaded (it's hard to imagine a "devaluation of the micromort" getting a lot of press).

Shifting regulatory focus from lives to life-years would also go a long way towards making age-adjustment palatable. While senior discounting generated considerable controversy, VSLY- or QALY-based analysis has been practiced by many agencies for years, but never drawn much public scrutiny, despite the fact that its impact on regulation—promoting risk reductions for the young over those for the old—is comparable.[309] This suggests that age-adjustment is politically feasible as long as it is presented in the right manner. The "value of a life-year" does not carry the same connotations as the "value of life." It avoids the troubling appearance of determining the moral status of persons, and therefore can achieve the same regulatory outcomes as VSL adjustment with far less controversy. Also, while senior discounting appears to violate equality norms by valuing some people's lives more than others, constant VSLY frames the question in a more favorable light, emphasizing the importance of counting each person's life-years as equal.

At its heart, the problem with age-adjustment is one of presentation, not content. In the midst of the 2003 crisis, economist Allan Krupnick claimed that "If you ask people on the street whether they prefer a policy that saves the life of a young person or an elderly person, I think most people, including the elderly, would save the young person."[310] In fact, Krupnick's hypothetical "person on the street" has been consulted on this matter before, and it appears that she does indeed prefer

---

[309] See Sunstein, "Lives, Life-Years, and Willingness to Pay," 252, for a history of VSLY use. Adler, "QALYs and Policy Evaluation," 58-59, summarizes instances of QALY analysis.
[310] Tierney, "Life: The Cost-Benefit Analysis."

saving the young. Studies consistently find that subjects dramatically favor lifesaving programs targeted at the young over those affecting the elderly.[311] Therefore, the public is not concerned with the regulatory impact of senior discounting so much as its unsavory metaphysical connotations. As long as agencies can get around this problematic confusion—through the use of micromorts or VSLY, for example—citizens might embrace, rather than denounce, age-adjustment.

It is important to recognize that agencies could find a way to differentiate between age groups in cost-benefit analysis without spawning a public outcry, because, according to the arguments put forth in this thesis, this "could" implies a corresponding "should." Currently, bureaucrats and the economists who advise them take observed WTP evidence as the final word in how to treat age when valuing life. This practice is buttressed by an economic approach that asserts that the value of a good is defined by willingness to pay. As a result, agencies are unwilling to promote protecting the young over the old as long as empirical evidence fails to show a significant negative association between age and WTP for risk reductions.

This consensus should be reexamined. This thesis has shown how a number of psychological phenomena likely influence the way in which individuals value risk reductions, and that the net effect of these behavioral biases is to drive the VSL of the young downward. In particular, insensitivity to the duration of remaining life appears to throw a wedge between observed and idealized WTP for risk reductions. Consequently, the shape of the age/VSL curve is distorted by human cognitive limitations, undermining its informative value for anyone primarily concerned with welfare.

---

[311] See for example Dolan et al., "QALY Maximization and People's Preferences" and Cropper et al., "Preferences for Lifesaving Programs."

This conclusion is bolstered by the evidence gathered from my original online survey research. I conducted one of the first empirical examinations of how psychological factors influence the relationship between age and WTP, and uncovered several interesting results. First, my findings encourage optimism about the possibility of using Amazon's Mechanical Turk and other online labor markets as an effective tool for future social science research, even if it involves complex tasks. In addition, my results demonstrate a positive association between WTP and perceptions of future satisfaction—a connection that, though intuitive, has never before been tested. My findings do not ultimately support the hypothesis that unrealistically pessimistic conceptions of aging among the young drive their VSL downward. However, they do provide new information about how people expect their wellbeing to change over the lifespan, suggesting that individual-specific optimism about future prospects tends to trump generally negative beliefs about aging *per se*.

Yet while the mispredictions hypothesis was not supported, the results from the scope prime did bolster the claim that individuals may be inadequately sensitive to the magnitude of their future lifespans when contemplating risk reductions. This possibility, which Chapter One conjectured might be the single most important cognitive determinant of the age/VSL relationship, has profound implications for how to interpret the lifetime pattern of WTP. If individuals are generally insensitive to one of the most salient characteristics of aging—shrinking remaining life expectancy—then it seems unlikely that the observed relationship between age and VSL can tell us much about how idealized preferences for risk shift over the lifespan.

These arguments about cognitive limitations support a fundamental reassessment of the way age is treated in federal agency practice. Cost-benefit analysis should be conducted so as to most effectively maximize welfare while still remaining practical. WTP evidence suggests that this can be accomplished through use of age-invariant VSL, but our *a priori* beliefs about the greater value of risk reduction for the young tell us otherwise, and advocate for alternative solutions like constant VSLY. Therefore, we must decide what is more likely to be accurate: our reasoned convictions or our empirical evidence. Policymakers and economists have consistently picked the second. But given the context, they choose unwisely.

There are powerful, intuitive reasons to believe that more welfare—as understood through the preferences of idealized spectators—is generated by saving younger rather than older individuals. Meanwhile, the empirical evidence that militates against these intuitions is distorted by cognitive errors and wealth effects that have no relation to welfare. While the tenets of economics still command us to go with WTP over conviction, reason respectfully disagrees. Policymakers should recognize that the observed lifetime pattern of VSL is shaped by the complementary forces of wealth effects and psychological errors, both of which serve to obscure the fact that the absolute welfare benefit of a risk reduction declines with age. They should prioritize risk reductions for the young accordingly.

Therefore, the answer to the question posed in the title of this thesis is: No—the price is wrong. And more importantly, the entire process used to determine the price is wrong (at least with respect to age adjustment). The economic theory that guides regulatory policy's approach to age rests on deeply problematic assumptions about human behavior. Once these flaws are revealed, the model's recommendations

lose their appeal. Policymakers must adapt to this new understanding rather than cling to a dead dogma.

Frank Ackerman and Lisa Heinzerling, outspoken critics of monetizing prevented fatalities, argue in their book, *Priceless,* that calculating the value of life leads to a world in which we know the price of everything and the value of nothing.[312] What they miss is that we price life precisely because we do know what is valuable: having the most welfare-enhancing regulatory policies possible. But the current system of age adjustment falls short of this goal. It misallocates resources with real, and often fatal, consequences, because it prioritizes evidence produced by human fallibility over convictions formulated by human reason. This is not a wise tradeoff. We should shift our approach to age adjustment so that the way we price achieves the things we value.

[312] Ackerman & Heinzerling, *Priceless*: *On Knowing the Price of Everything and the Value of Nothing.*

REFERENCES

Ackerman, Frank, and Lisa Heinzerling. *Priceless: on knowing the price of everything and the value of nothing*. New York: New Press, 2004.

Adler, Matthew, and Eric A. Posner. "Happiness Research and Cost-Benefit Analysis." *Journal of Legal Studies* 37 (June 2008): 253-92.

Adler, Matthew D., and Eric A. Posner. "Implementing Cost-Benefit Analysis when Preferences Are Distorted." *Journal of Legal Studies* 29 (2000).

Adler, Matthew D., and Eric A. Posner. *New Foundations of Cost-Benefit Analysis*. Cambridge, Mass.: Harvard University Press, 2006.

Adler, Matthew D. "QALYs and Policy Evaluation: A New Perspective." *Yale Journal of Health Policy, Law, and Ethics* 6, no. 2 (2006): 1-92.

Adler, Matthew D. "Risk, Death and Harm: The Normative Foundations of Risk Regulation." *Minnesota Law Review* 87, no. 5 (2003): 1293-445.

Alberini, Anna, Alistair Hunt, and Anil Markandya. "Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study." *Environmental and Resource Economics* 33 (2006): 251-64.

Alberini, Anna, Barbara Kanninen, and Richard T. Carson. "Modeling Response Incentive Effects in Dichotomous Choice Contingent Valuation Data." *Land Economics* 73, no. 3 (1997): 309-24.

Albernini, Anna, M. Cropper, A. Krupnick, and N. Simon. "Does the Value of Statistical Life Vary with Age and Health Status? Evidence from the U.S. and Canada." *Journal of Environmental Economics and Management* 48 (2004): 769-92.

Aldy, Joesph E., and Seamus J. Smyth. *A Numerical Model of the Value of LIfe*. RFF Discussion Paper 07-09. 2007.

Aldy, Joseph E., and W. Kip Viscusi. "Adjusting the Value of a Statistical Life for Age and Cohort Effects." *The Review of Economics and Statistics* 90, no. 3 (August 2008): 573-81.

Aldy, Joseph E., and W. Kip Viscusi. "Age Differences in the Value of Statistical Life: Revealed Preference Evidence." *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007): 241-60.

Anderson, Elizabeth. *Value in ethics and economics*. Cambridge, Mass.: Harvard University Press, 1993.

Anon. ""Ask A Silly Quesiton...": Contingent Valuation of Natural Resources Damages." *Harvard Law Review* 1981 (1992): 1984-990.

Argyle, Michael. *The Psychology of Happiness*. London: Routledge, 2001.

Arias, Elizabeth. "United States Life Tables, 2004." *National Vital Statistics Reports* 56, no. 9 (2007).

Ariely, Dan. "Combining Experiences over Time: the Effects of Duration, intensity Changes, and On-Line Measurements on Retrospective Pain Evaluations." *Journal of Behavioral Decision Making* 11 (1998): 19-45.

Armantier, Olivier, and Nicolas Treich. "Social Willingness to Pay, Mortality Risks, and Contingent Valuation." *Journal of Risk and Uncertainty* 29 (2004): 7-19.

Arrow, Kenneth, Robert Solow, E. E. Leamer, R. Radner, and H. Schuman. *Report of the NOAA Panel on Contingent Valuation*. Report. 1993.

Baron, Jonathan, and Joshua Greene. "Determinants of Insensitivity to Quantity in Valuation of Public Goods: Contribution, Warm Glow, Budget Constraints, Availability, and Prominence." *Journal of Experimental Psychology: Applied* 2, no. 2 (1996): 107-25.

Baron, Jonathan. "Biases in the Quantitative Measurement of Values for Public Decisions." *Psychological Bulletin* 122, no. 1 (1997): 72-88.

Bate, Roger. *Pick A Number: A Critique of Contingent Valuation and its Application in Public Policy*. Report. Competitive Enterprise Insitute, 1994.

Bateman, Ian J., Richard T. Carson, Brett Day, Michael Hanemann, and Nick Hanley. *Economic valuation with stated preference techniques: a manual*. Cheltenham: Elgar, 2002.

Becker, Gary. "The Economic Approach to Human Behavior." In *Foundations of the Economic Approach to Law*, edited by Avery Wiener. Katz, 6-11. New York: Oxford University Press, 1998.

Bentham, Jeremy. *An Introduction to the Principles of Morals and Legislation*. New York: Hafner Press, 1973.

Bernardo, Jose? M., and Adrian F. M. Smith. *Bayesian Theory*. Chichester: Wiley, 2000.

Berns, Gregory S., David Laibson, and George Loewenstein. "Intertemporal Choice: Toward an Integrative Framework." *Trends in Cognitive Science* 11 (2007): 482-88.

Beshears, John, James J. Choi, David Laibson, and Brigitte C. Madrian. "How Are Preferences Revealed?" *Journal of Public Economics* 92, no. 8-9 (August 2008): 1787-794.

Bishai, David M. "Does Time Preference Change with Age?" *Journal of Population Economicsq* 17, no. 4 (December 2004): 583-602.

Blanchflower, David G., and Andrew J. Oswald. "Is Well-Being U-Shaped over the Life Cycle." *Social Science and Medicine* 66 (2008): 1733-749.

Brickman, Phillip, Dan Coates, and Ronnie Janoff-Bulman. "Lottery Winners and Accident Victims: Is Happiness Relative?" *Journal of Personality and Social Psychology* 36 (1978): 917-27.

Brink, David O. "Prudence and Authenticity: Intrapersonal Conflicts of Value." *The Philosophical Review* 112, no. 2 (April 2003): 215-45.

Camerer, Colin F., and Teck-Hua Ho. "Violations of the Betweeness Axiom and Nonlinearity in Probability." *Journal of Risk and Uncertainty* 8, no. 2 (1994): 167-96.

Camerer, Colin, Samuel Issacharoff, Ted O'Donoghue, and Matthew Rabin. "Regulation for Conservatives: Behavioral Economics and the Case for 'Asymmetric Paternalism'" *University of Pennsylvania Law Review* 151, no. 3 (January 2003): 1211-254.

Cameron, Trudy A. "The Value of a Statistical Life: [They] do not think it means what [we] think it means." *AERE Newlsetter* 28 (November 2008): 36-38.

Campbell, Angus, Philip E. Converse, and Willard L. Rodgers. *The Quality of American Life: Perceptions, Evaluations, and Satisfactions*. New York: Russel Sage Foundation, 1976.

Carstensen, Laura L., Derek M. Isaacowitz, and Susan T. Charles. "Taking Time Seriously: A Theory of Socioemotional Selectivity." *American Psychologist* 54, no. 3 (1999): 165-81.

Carstensen, Laura L., M. Psupathi, U. Mayr, and J. Nesselroade. "Emotion Experience in Everyday Life across the Adult Life Span." *Journal of Personality and Social Psychology* 79 (2000): 644-55.

Chabris, Christopher F., David Laibson, Carrie L. Morris, Jonathon P. Schuldt, and Dmitry Taubinsky. "Individual Laboratory-Measured Discount Rates Predict Field Behavior." *Journal of Risk and Uncertainty* 37 (2008): 237-69.

Charles, Susan T., Chandra A. Reynolds, and Margaret Gatz. "Age-Related Differences and Change in Positive and Negative Affect over 23 Years." *Journal of Personality and Social Psychology* 80, no. 1 (2001): 136-51.

Chesnut, L. G., R. D. Rowe, and W. S. Breffle. *Economic Valuation of Mortality Risk Reduction: Stated Preference Approach in Canada*. Report. 2004.

Ciriacy-Wantrup, Siegfried V. "Capital Returns from Soil Conversation Practices." *Journal of Farm Economics* 29 (1947): 1181-196.

Corso, Phaedra S., James K. Hammitt, and John D. Graham. "Valuing Mortality Risk Reduction: Using Visual Aids to Improve the Validity of Contingent Valuation." *Journal of Risk and Uncertainty* 23 (2001): 165-84.

Cowen, Tyler, and Derrick Parfit. "Against the Social Discount Rate." In *Justice between age groups and generations*, edited by Peter Laslett and James S. Fishkin, 144-62. New Haven: Yale Press, 1992.

Crooker, Karen J., and Janet P. Near. "Happiness and Satsifaction: Measures of Affect and

Cognition?" *Social Indicators Research* 44, no. 2 (1998): 195-224.

Cropper, Maureen L., Sema K. Aydede, and Paul R. Portney. "Preferences for Life Saving Programs: How the Public Discounts Time and Age." *Journal of Risk and Uncertainty* 8 (1994): 243-65.

Cropper, Maureen. *SAB Advisory on EPA?s Issues in Valuing Mortality-risk Reduction. Memorandum from the CHair, Science Advisory Board, and the Chair, Environmental Advisory COmmittee, to EPA Adminstrator Stephen L. Johnson*. Report no. EPA-SAB-08-001. 2007.

De Scitovsky, T. "A Note on Welfare Propositions in Economics." *The Review of Economic Studies* 9, no. 1 (1941): 77-88.

Deakin, Julia, Michael Aitken, Trevor Robbins, and Barbara J. Sahakian. "Risk Taking During Decision-Making in Normal Volunteers Changes with Age." *Journal of the International Neuropsychological Society* 10 (2004): 590-98.

Deaton, Angus. "Income, Health, and Well-Being around the World: Evidence from the Gallup World Poll." *Journal of Economic Perspectives* 22, no. 2 (Spring 2008): 53-72.

Deshazo, J.R., and Trudy A. Cameron. Mortality and Morbidity Risk Reduction: An Empirical Life Cycle Model of Demand with Two Types of Age Effects. 2004. MS, University of California at Los Angeles.

Desvouges, W., R. Johnson, R. Dunford, K. Boyle, S. Hudson, and K. Wilson. *Measuring Non-Use Damages Using Contingent Valuation: An Experimental Evaluation Accuracy*. Research Triangle Institute Monograph 92-1. 1992.

Diamond, Peter A., and Jerry A. Hausman. "Contingent Valuation: Is Some Number Better than No Number?" *Journal of Economic Perspectives* 45 (1994): 49-52.

Dickens, William T. "Assuming the Can Opener: Hedonic Wage Estimates and the Value of Life." In *The new hedonics primer for economists and attorneys*, edited by John O. Ward and Thomas R. Ireland. Tucson, AZ: Lawyers & Judges Pub., 1996.

Diener, Ed, Derrick Wirtz, and Shigehiro Oishi. "End Effects of Rated Life Quality: The James Dean Effect." *Psychological Science* 12, no. 2 (2001): 124-28.

Diener, Ed, Eunkook M. Suh, Richard E. Lucas, and Heidi L. Smith. "Subjective Well-Being: Three Decades of Progress." *Psychological Bulletin* 125, no. 2 (1999): 276-302.

Dolan, Paul, Rebecca Shaw, Aki Tsuchiya, and Alan Williams. "QALY Maximization and People's Preferences: A Methodological Review of the Literature." *Health Economics* 14, no. 2 (2005): 197.

Donohue, John J. "Why We Should Discount the Views of Those Who Discount Discounting." *Yale Law Journal* 108 (1998).

Dorman, Peter. *Markets and mortality: economics, dangerous work, and the value of human life*. Cambridge

[England]: Cambridge University Press, 1996.

Dunn, Elizabeth W., Lara B. Aknin, and Michael I. Norton. "Spending Money on Others Promotes Happiness." *Science* 319 (2008): 1687-688.

Dunning, David, Chip Heath, and Jerry M. Suls. "Flawed Self-Assessment: implications for Health, Education, and the Workplace." *Psychological Science in the Public Interst* 5, no. 3 (2004): 69-106.

Dworkin, Ronald M. "Is Wealth a Value?" *Journal of Legal Studies* 9 (1980): 191.

Earley, Pete. "What's a Life Worth." *Washington Post*, June 9, 1985, Magazine sec.

Ehrlich, Isaac, and Yong Yin. "Explaining Diversities in Age-Specific LIfe Expectancies and Values of LIfe Saving: A Numerical Analysis." *Journal of Risk and Uncertainty* 31, no. 2 (2005): 129-62.

Elster, Jon, and John E. Roemer, eds. *Interpersonal Comparisons of Well-being*. Cambridge [England]: Cambridge University Press, 1991.

Evans, Mary R., and V. Kerry Smith. "Do we Really Understand the Age-VSL Relationship?" *Resource and Energy Economics* 28 (2006): 242-61.

Exec. Order No. 12291, 3 C.F.R. (1981).

Exec. Order No. 12866, 3 C.F.R. (1993).

Fahrenthold, David A. "Cosmic Markdown: EPA Says Life Is Worth Less." *Washington Post*, July 19, 2008, sec. A.

Field, Barry C. *Environmental Economics: An Introduction*. 2nd ed. New York: McGraw-Hill, 1997.

Fordyce, Michael W. "A Review of Research on the Happiness Measures: A Sixty-Second Index of Happienss and Mental Health." *Social Indicators Research* 20 (1988): 355-381.

Frederick, Shane, George Loewenstein, and Ted O'Donoghue. "Time Discounting and Time Preference: A Critical Review." *Journal of Economic Literature* 40 (June 2002): 351-401.

Fredrick, Shane. "Time Preference and Personal Identity." In *Time and decision: economic and psychological perspectives on intertemporal choice*, edited by George Loewenstein, Daniel Read, and Roy F. Baumeister, 89-113. New York: Russell Sage Foundation, 2003.

Frey, Bruno S., and Alois Stutzer. *Happiness and economics: how the economy and institutions affect well-being*. Princeton, N.J.: Princeton University Press, 2002.

Friedman, Lee S. *The microeconomics of public policy analysis*. Princeton, N.J.: Princeton University Press, 2002.

Friedman, Lee S. *The microeconomics of public policy analysis*. Princeton, N.J.: Princeton University Press, 2002.

Friedman, Milton. "The Methodology of Positive Economics." In *Essays in Positive Economics*, 3-43. Chicago: University of Chicago Press, 1953.

Gilbert, Daniel T., Elizabeth C. Pinel, Timothy D. Wilson, Stephen J. Blumberg, and Thalia P. Wheatley. "Immune Neglect: A Source of Durability Bias in Affective Forecasting." *Journal of Personality and Social Psychology* 75, no. 3 (1998): 617-38.

Gilbert, Daniel T. *Stumbling on Happiness*. New York: A.A. Knopf, 2006.

Glaeser, Edward L. "Paternalism and Psychology." *The University of Chicago Law Review* 73, no. 1 (2007): 133-56.

Graham, John D. *Benefit-Cost Methods and Lifesaving Rules, Memorandum to the President?s Management Council, Office of Mangement and Budget*. 2003.

Graham, John D. "Saving Lives through Administrative Law and Economics." *University of Pennsylvania Law Review* 157 (2008): 395-540.

Green, Leonard, Astrid F. Fry, and Joel Myerson. "Discounting of Delayed Reward: A Life-Span Compoarison." *Psychological Science* 5, no. 1 (January 1994): 33-36.

Hahn, Robert, and Scott Wallsten. "Who's Life is Worth More? (And Why Is It Horrible to Ask?)." *Washington Post*, June 1, 2003, Final ed., Outlook sec.

Hahn, Robert W., and Cass R. Sunstein. "A New Executive Order for Improving Federal Regulation? Deeper and Wider Cost-Benefit Analysis." *University of Pennsylvania Law Review* 150, no. 5 (May 2002): 1489-552.

Hammitt, James K., and John D. Graham. "Willingness to Pay for Health Protection: Inadequate Sensitivity to Probability?" *Journal of Risk and Uncertainty* 8 (1999): 33-62.

Hammitt, James K., and Kevin Haninger. "Valuing Fatal Risks to Children and Adults: Effects of Disease, Latency, and Risk Aversion." *Journal of Risk and Uncertainty* 40, no. 1 (February 2010): 57-83.

Hammitt, James K., and Kevin Haninger. "Willingness to Pay for Food Safety: Sensitivity to Duration and Severity of Illness." *American Journal of Agricultural Economics* 89, no. 5 (2007): 1170-175.

Hammitt, James K. "QALYs Versus WTP." *Risk Analysis* 22, no. 4 (2002): 985-1001.

Hammitt, James K. "Valuing Changes in Mortality Risk: Lives Saved Versus Life Years Saved." *Review of Environmental Economics and Policy* 1, no. 3 (Summer 2007): 228-40.

Hanemann, Michael, John Loomis, and Barbara Kanninen. "Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation." *American Journal of Agricultural Economics* 73, no. 4 (November 1991): 1255-263.

Harbaugh, William T., Kate Krause, and Lise Versterlund. "Risk Attitudes of Children and Adults: Choices over Small and Large Probability Gains and Losses." *Experimental Economics* 5 (2002): 53-84.

Harsanyi, John C. "Morality and the Theory of Rational Behavior." In *Utilitarianism and beyond*, edited by Amartya Sen and Bernard A.C. Williams. Cambridge: Cambridge University Press, 1982.

Hausman, Daniel M. "The Impossibility of Interpersonal Utility Comparisons." *Mind* 104, no. 415 (July 1995): 473-90.

Helweg-Larson, Marie, and James A. Shepperd. "Do Moderators of the Optimistic Bias Affect Personal or Target Risk Estimates? A Review of the LIterature." *Personality and Social Psychology Review* 5, no. 1 (2001): 74-95.

Herriges, Joseph A., and Jason F. Shogren. "Starting Point Bias in Dichotmous Choice Valuation with Follow Questioning." *Journal of Environmental Economics and Management* 30 (1996): 112-31.

Hicks, John R. "The Foundations of Welfare Economics." *The Economic Journal* 49, no. 196 (December 1939): 696-712.

Horton, John J., and Lydia B. Chilton. *The Labor Economics of Paid Crowdsourcing*. Working paper. Harvard University, 2010.

Howard, Ronald A. "Microrisks for Medical Decision Analysis." *International Journal of Technology Assessment in Health Care* 5 (1989): 357-70.

Howard, Ronald A. "On Fates Comparable to Death." *Management Science* 30 (1984): 407-22.

H.R. Res. 2673, 108th Cong. (2004) (enacted).

Hsee, Christopher K., Yuval Rottenstreich, and Zhixing Xiao. "When Is More Better? On the Relationship between Magnitude and Subjective Value." *Current Directions in Psychological Science* 14, no. 4 (2005): 234-37.

Hubin, Donald. "The Moral Justification of Benefit/Cost Analysis." *Economics and Philosophy* 10 (1994).

Ipeirotis, Panos. "Mechanical Turk: The Demographics." A Computer Scientist in Business School. Weblog entry posted March 19, 2008. http://behind-the-enemy-lines.blogspot.com/2008/03/mechanical-turk-demographics.html (accessed January 14, 2010).

Itoaka, Kenshi, Alan Krupnick, Makoto Akai, Anna Alberini, and Nathalie Simon. *Age, Healht, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey in Japan*. RFF Discussion Paper 05-34.

Johannesson, Magnus, and Per-Olov Johansson. "Quality of Life and the WTP for an Increased Life Expectancy at an Advanced Age." *Journal of Public Economics* 65 (1997): 219-28.

Johansson, Per-Olov. "On the Definition and Age-Dependency of the Value of Statistical Life." *Journal of Risk and Uncertainty* 25, no. 3 (2002): 251-63.

Jolls, Chrstine, Cass R. Sunstein, and Richard Thaler. "A Behavioral Approach to Law and Economics." *Stanford Law Review* 50, no. 5 (May 1998): 1471-550.

Jones-Lee, Michael, M. Hammerton, and P. Phillips. "Valuing the Prevention of Non-Fatal Road Injuries: Contingent Valuation Versus Standard Gambles." *Oxford Economic Papers* 47 (1995): 676-95.

Jones-Lee, Michael W., G. Loomes, D. O'Reilly, and P.R. Phillips. "The Value of Preventing Non-Fatal Road Injuries: Findings of a Willingness-to-Pay National Sample Survey." *TRY Working Paper, WP SRC2* (1993).

Jones-Lee, Michael W., M. Hammerton, and P. R. Phillips. "THe Value of Safety: Results of a National Sample Survey." *Economic Journal* 95 (1985): 49-72.

Jones-Lee, Michael W. *The Economics of Safety and Physical Risk*. Oxford: Basil Blackwell, 1989.

Jones-Lee, Michael W. *The Value of Life.: An Economic Analysis*. Chicago: University Of Chicago Press, 1976.

Jorm, A.F. "Does Old Age Reduce the Risk of Anxiety and Depression? A Review of Epidemiological Studies Across the Adult Life Span." *Psychological Medicine* 30 (2000): 11-22.

Just, Richard E., Darrell L. Hueth, and Andrew Schmitz. *The welfare economics of public policy: a practical approach to project and policy evaluation*. Cheltenham, UK: Edward Elgar, 2004.

Kahn, Matthew E. "The Beneficiaries of the Clean Air Act." *Regulation* 21 (2001): 34.

Kahneman, Daniel, and Alan B. Kreuger. "Developments in the Measurement of Subjective Well-Being." *Journal of Economic Perspectives* 20, no. 1 (Winter 2006): 3-24.

Kahneman, Daniel, and Jack L. Knetsch. "Valuing Public Goods: The PUrchase of Moral Satisfaction." *Journal of Environmental Economics and Management* 22 (1992): 57-70.

Kahneman, Daniel, and Richard H. Thaler. "Utility Maximization and Experienced Utility." *Journal of Economic Perspectives* 20, no. 1 (Winter 2006): 221-34.

Kahneman, Daniel, and Robert Sugden. "Experienced Utility as a Standard of Policy Evaluation." *Environmental and Resource Economics* 32 (2005): 161-81.

Kahneman, Daniel, Barbara L. Fredrickson, Charles A. Schrieber, and Donald A. Redelmeier. "When More Pain Is Preferred to Less: Adding a Better End." *Psychological Science* 4, no. 6 (1993): 401-05.

Kahneman, Daniel, Ilana Ritov, and David Shckade. "Economic Preferences or Attitude Expressions? An Analysis of Dollar REsponses to Public Issues." *Journal of Risk and Uncertainty* 19, no. 1 (1999): 203-35.

Kaplow, Louis, and Stephen Shavell. "Why the Legal System Is Less Efficient than the Income Tax in Redistributing Income." *Journal of Legal Studies* 23 (1994).

Kaplow, Louis, and Steven Shavell. *Fairness Versus Welfare*. Cambridge, MA: Harvard University Press, 2002.

Kassam, Karim S., Daniel T. Gilbert, Andrew Boston, and Timothy D. Wilson. "Future Anhedonia and Time Discounting." *Journal of Experimentla Social Psychology* 44 (2008): 1533-537.

Kilka, MIchael, and Martin Weber. "What Determines the Shape of the Probability Weighting Function under Uncertainty." *Management Science* 47, no. 12 (December 2001): 1712-726.

Kittur, Aniket, Ed H. Chi, and Bongwon Suh. *Crowdsourcing User Studies with Mechanical Turk*. Working paper. Palo Alto Research Center, 2008.

Kniesner, Thomas J., W. Kip Viscusi, and James P. Ziliak. "Life-Cycle Consumption and the Age-Adjusted Value of Life." *Contributions to Economic Analysis and Policy* 5, no. 1 (2006).

Kreuter, Matthew W., and Victor J. Strecher. "Changing Inaccurate Perceptions of Health Risk: Results from a Randomized Trial." *Healthy Psychology* 14, no. 10 (1995): 56-63.

Krupnick, Alan, Anna Alberini, Maureen Cropper, N. O'Brien, R. Goeree, and M. Heintzelman. "Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents." *Journal of Risk and Uncertainty* 24, no. 2 (2002): 161-86.

Krupnick, Alan. "Mortality Risk Valuation and Age: Stated Preference Evidence." *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007): 261-82.

Lacey, Heather P., Dylan M. Smith, and Peter A. Ubel. "Hope I Die before I Get Old: Mispredicting Happiness across the Adult Lifespan." *Journal of Happiness Studies* 7 (2006): 167-82.

Laibson, David. "Golden Eggs and Hyperbolic Discounting." *Quarterly Journal of Economics* 112, no. 2 (May 1997): 443-77.

Laux, Fritz L. "Addiction as a Market Failure: Using Rational Addication Results to Justify Tobacco Regulation." *Journal of Health Economics* 19 (2000): 421-37.

Layard, Richard. *Happiness: Lessons from a New Science*. New York: Penguin Press, 2005.

Loewenstein, George, and David Schkade. "Wouldn't It Be Nice? Predicting Future Feelings." In *Well-being: the foundations of hedonic psychology*, edited by Daniel Kahneman, Ed Diener, and Norbert Schwarz. New York: Russell Sage Foundation, 1999.

Loewenstein, George F., Elke U. Weber, Christopher K. Hsee, and Ned Welch. "Risk as Feelings." *Psychological Bulletin* 127, no. 2 (March 2001): 267-86.

Loewenstein, George, Ted O'Donoghue, and Matthew Rabin. "Projection Bias in Predicting Future Utility." *Quarterly Journal of Economics* 118, no. 4 (November 2003): 1209-248.

Loomes, Graham, and Lynda McKenzie. "The Use of QALYs in Health Care Decisionmaking." *Social Science and Medicine* 28 (1989): 299.

Madey, Scott F., and Rowena Gomez. "Reduced Optimism for Perceived Age-Related Medical Conditions." *Basic and Applied Social Psychology* 25, no. 3 (2003): 213-19.

Manton, Kenneth G. "Mortality and Morbidity." In *Handbook of Aging and the Social Sciences*, edited by Robert H. Binstock and Linda K. George, 64-89. 3rd ed. San Diego: Academic Press, 1990.

Mather, Mara, and Laura L. Carstensen. "Aging and Motivated Cognition: The Positivity Effect in Attention and Memory." *Trends in Cognitive Science* 9, no. 10 (October 2005): 496-501.

Mather, Mara, Turhan Canli, Tammy English, Sue Whitfield, Peter Wais, Kevin Ochsner, John D.E. Gabrieli, and Laura L. Carstensen. "Amygdala Responses to Emotionally Valenced Stimuli in Older and Younger Adults." *Psychological Science* 15, no. 4 (2004): 259-63.

McClure, Samuel M., David I. Laibson, George Loewenstein, and Jonathan D. Cohen. "Seperate Neural System Value Immediate and Delayed Monetary Rewards." *Science* 306 (2004): 503-06.

McKenna, F. P. "It Won't Happen to Me: Unrealistic Optimism or Illusion of Control?" *British Journal of Psychology* 84 (1993): 39-50.

Meng, Ronald. "Compensating Differences in the Canadian Labour Market." *Canadian Journal of Economics* 22, no. 2 (1989): 413-24.

Mill, John Stuart. *On Liberty*. Edited by Edward Alexander. Peterborough, Ontario: Broadview, 1999.

Mishan, E. J. *Cost-benefit analysis: an informal introduction*. 4th ed. London: Unwin Hyman, 1988.

Mishan, E.J. "Evaluation of Life and Limb: A Theoretical Approach." *Journal of Political Economy* 79, no. 687 (1971): 695-705.

Moore, Michael J., and W. Kip Viscusi. "The Quantity-Adjusted Value of Life." *Economic Inquiry* 26, no. 3 (1988): 369.

Morewedge, Carey K., Karim S. Kassam, Christopher K. Hsee, and Eugene M. Caruso. "Duration Sensitivity Depends on Stimulus Familiarity." *Journal of Experimental Psychology: General* 138, no. 2 (2009): 177-86.

Morris, Jill, and James K. Hammitt. "Using Life Expectancy to Communicate Benefits of Health Care Programs in Contingent Valuation Studies." *Medical Decision Making* 21 (2001): 468-78.

Mroczek, Daniel K., and Christian M. Kolarz. "The Effect of Age on Positive and Negative Affect: A Developmental Perspective on Happiness." *Journal of Personality and Social Psychology* 75, no. 5 (1998): 1333-349.

National Academy of Sciences. *Estimating mortality risk reduction and economic benefits from controlling ozone air pollution*. Washington, D.C.: National Academies Press, 2008.

Ng, Yew-Kwang. "Quasi-Pareto Social Improvements." *American Economic Review* 74 (1984): 1033.

Ng, Yew-Kwang. *Social Welfare and Economic Policy*. London: Harvester Wheatsheaf, 1990.

Ng, Yew-Kwang. "The Older the More Valuable: Divergence between Utility and Dollar Values of LIfe as One Ages." *Journal of Economics* 55, no. 1 (1992): 1-16.

Nozick, Robert. *Anarchy, State, and Utopia*. Oxford: Blackwell, 2003.

O'Donoghue, Ted, and Matthew Rabin. "Doing It Now or Later." *The American Economic Review* 89, no. 1 (March 1999): 103-24.

O'Donoghue, Ted, and Matthew Rabin. "Studying Optimal Paternalism, Illustrated by a Model of Sin Taxes." *The American Economic Review* 93, no. 2 (2003): 186-91.

Parfit, Derek. *Reasons and Persons*. Oxford: Clarendon, 1984.

Perloff, L. S., and B. K. Fetzer. "Self-Other Judgments and Perceived Vulnerability to Victimization." *Journal of Personality and Social Psychology* 50 (1986): 502-10.

Pigou, Arthur C. *Economics of welfare*. London: Macmillan, 1929.

Pontin, Jason. "Artificial Intellignece, with Help from the Humans." *New York Times*, March 25, 2007.

Portney, Paul R. "Housing prices, health effects, and valuing reductions in risk of death." *Journal of Environmental Economics and Management* 8 (1981): 72-78.

Pratt, John W., and Richard J. Zeckhauser. "Willingness to Pay and the Distribution of Risk and Wealth." *The Journal of Political Economy* 104, no. 4 (August 1996): 747-63.

"Public Listening Sessions | Aging Initiative | US EPA." U.S. Environmental Protection Agency. http://www.epa.gov/aging/listening/index.htm (accessed March 1, 2010).

Rawls, John. *A Theory of Justice*. Cambridge: Harvard University Press, 1971.

Read, Daniel, Gerrit Antonides, Laura Van den Ouden, and Harry Trienekens. "Which is Better: Simultaneous or Sequential Choice." *Organizational Behavior and Human Decision Processes* 84, no. 1 (2001): 54-70.

Redelmeier, Donald, and Daniel Kahneman. "Patients Memories of Painful Medical Treatments: Real-Time and Retrospective Evaluations of Two Minimally Invasive Procedures." *Pain* 116 (1996): 3-8.

Reinhardt, Uwe E. "Reflections on the Meaning of Efficiency: Can Efficiency Be Seperated from Equity?" *Yale Law and Policy Review* 10 (1992).

Revesz, Richard L., and Laura J. Lowenstein. "Anti-Regulation under the Guise of Rational Regulation: The Bush Administration's Approaches to Valuing LIves in Environmental Cost-Benefit Analyses." *Environmental Reporter* 34, no. 10954 (2003).

Rinot, M., and D. Zakay. *Attending to Duration*. Technical paper. Tel Aviv University, Department of Psychology, 1999.

Robbins, Lionel. *An Essay on the Nature and Significance of Economic Science*. London: Macmillan, 1952.

Robinson, Lisa. "How U.S. Government Agencies Value Mortality Risk Reductions." *Review of Environmental Economics and Policy* 1, no. 2 (Summer 2007): 283-99.

Robinson, Lisa. *Valuing Mortality Risk Reductions in Homeland Security Regulatory Analysis, prepared for U.S. Customs and Border Patrol, Department of Homeland Security*. Report. 2008.

Ross, Joel, Andrew Zaldivar, Lilly Irani, and Bill Tomlinson. Who Are the Turkeres? Worker Demographics in Amazon Mechanical Turk. 2009. MS, University of California, Irvine.

Rottenstreich, Yuval, and Christopher K. Hsee. "Money, Kisses, and Electric Shocks: On the Affective Psychology of Risk." *Psychological Science* 12, no. 3 (May 2001): 185-90.

Samuelson, Paul. "A Note on Measurement of Utility." *Review of Economic Studies* 4 (1937): 155-61.

Scharff, Robert L., and W. Kip Viscusi. *Heterogeneous Rates of Time Preference and the Decision to Smoke*. Working paper no. 08-31. Vanderbilt University Law School, 2008.

Schelling, Thomas C. "The Life You Save May Be Your Own." In *Problems in public expenditure analysis. Papers presented at a conference of experts held Sept. 15-16, 1966*., edited by Samuel B. Chase, 127-62. Washington: Brookings Institution, 1968.

Schkade, David, and Daniel Kahneman. "Does Living in California Make People Happy? A FOcusing Illusion in Judgments of Life Satisfaction." *Psychological Science* 9 (1998): 340-46.

Schmalensee, Robert. *Science Advisory Board's Review of the Office of POlicy, Planning and Evaluation's (OPPE) and Office of Air and Radiation's (OAR) PRogress on the Retrosepctive and Prospective Studies of the Impacts of the Clean Air Act*. Letter from the Chair, Science Advisory Board's Clean Air Act Compliance Analysis Council, to EPA Administrator Carol M. Browner. 1993.

Schreiber, Charles A., and Daniel Kahneman. "Determinants of the Remembered Utility of Aversive Sounds." *Journal of Experimental Psychology: General* 129 (2000): 27-42.

Scrzycki, Cindy. "Under Fire, EPA Drops the 'Senior Death Discount'" *Washington Post*, May 13, 2003, Final ed., Financial sec.

Seelye, Katherine Q., and John Tierney. "E.P.A. Drops Age-Based Cost Studies." *New York Times*, May 7, 2003, Late ed., sec. A.

Shepard, Donald S., and Richard J. Zeckhauser. "Survival Versus Consumption." *Management Science* 30, no. 4 (1984): 423-39.

Shiell, Alan, and Lisa Gold. "Contingent Valuation in Health Care and the Persistence of Embedding Effects without the Warm Glow." *Journal of Economic Psychology* 23 (2003).

Shrader-Frechette, Kristin S. *Environmental justice: creating equality, reclaiming democracy*. Oxford: Oxford University Press, 2002.

Sidgwick, Henry. *The Methods of Ethics*. Indianapolis: Hackett, 1981.

Simon, Herbert. "Rationality in Psychology and Economics." *Journal of Business* 59 (1986): 209-24.

Simonson, Itamar. "The Effect of Purchase Quantity and Timing on Variety-Seekign Behavior." *Journal of Marketing Research* (May 1990): 150-62.

Smith, Adam. *An inquiry into the nature and causes of the wealth of nations*. Edited by Jonathan B. . Wight. Petersfield: Harriman House, 2007.

Smith, Adam. *The Theory of Moral Sentiments*. Edited by Knud Haakonssen. Cambridge: Cambridge University Press, 2002.

Smith, V. Kerry, Mary F. Evans, Hyun Kim, and Donald H. Taylor. "Do the 'Near' Elderly Value Mortality Risks Differently?" *Review of Economics and Statistics* 86, no. 1 (2004): 423-29.

Snow, Rion, Brendan O'Connor, Daniel Jurafsky, and Andrew Y. Ng. "Cheap and Fast--But Is It Good? Evaluating Non-Expert Annotations for Natural Language Tasks." In *Proceedings of the 2008 Conference on Empirical Methods in Natural Language Processing*, 254-63. 2008.

Soman, Dilip, George Ainslie, Shane Frederick, Xiuping Li, John Lynch, Page Moreau, Andrew Mitchell, Daniel Read, Alan Sawyer, Yaacov Trope, Klaus Wertenbroch, and Gal Zauberman. "The Psychology Intertemporal Discounting: Why Are Distant Events Valued Differently from Proximal Ones." *Marketing Letters* 16, no. 3 (2005): 347-60.

Standage, Tom. *The Mechanical Turk: The True Story of the Chess-Playing Machine that Fooled the World*. London: Penguin, 2003.

"Statement Of Christine Todd Whitman | Aging Initiative | US EPA." U.S. Environmental Protection Agency. http://www.epa.gov/aging/listening/2003/balt_ctw.htm (accessed March 09, 2010).

Stavins, Robert. *An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Redcution*.

Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Carol M. Browner. EPA-SAB-EEAC-00-013. 2000.

Stavins, Robert. *An SAB Report on the EPA Guidelines for Preparing Economic Analyses*. Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Carol M. Browner. EPA-SAB-EEAC-99-020. 1999.

Sumner, Leonard W. *Welfare, happiness, and ethics*. Oxford: Clarendon Press, 1996.

Sunstein, Cass R., and Arden Rowell. "On Discounting Regulatory Benefits: Risk, Money and Intergenerational Equity." *University of Chicago Law Review* 74, no. 1 (2007): 171-208.

Sunstein, Cass R., and Richard H. Thaler. "Libertarian Paternalism Is Not an Oxymoron." *The University of Chicago Law Review* 70, no. 4 (Autumn 2003): 1159-202.

Sunstein, Cass R. "Cognition and Cost-Benefit Analysis." In *Cost-benefit analysis: legal, economic, and philosophical perspectives*, edited by Matthew D. Adler and Eric A. Posner, 223-67. Chicago: University of Chicago Press, 2001.

Sunstein, Cass R. "Congress, Constitutional Moments, and the Cost-Benefit State." *Stanford Law Review* 48, no. 2 (January 1996): 247-309.

Sunstein, Cass R. "Lives, Life-Years, and Willingness to Pay." *Columbia Law Review* 104, no. 1 (January 2004): 205-52.

Sunstein, Cass R. "Valuing Life: A Plea for Disaggregation." *Duke Law Journal* 54 (2004): 385-445.

Sunstein, Cass R. "Willingness to Pay Versus Welfare." *Harvard Law and Policy Review* 1 (2007): 303-30.

Talyor, Shelley E., and Jonathan D. Brown. "Illusion and Well-Being: A Social Psychological Persepctive on Mental Health." *Psychological Bulletin* 103, no. 2 (1988): 193-210.

"Tampa, FL Listening Session | Aging Initiative | US EPA." U.S. Environmental Protection Agency. http://www.epa.gov/aging/listening/2003/tampa.htm (accessed March 1, 2010).

Thaler, Richard, and Sherwin Rosen. "The Value of Saving a Life: Evidence from the Labor Market." In *Household production and consumption: conference on household production and consumption, Washington, D.C. 1973.*, edited by Nestor E. Terleckyj, 265-302. New York: Columbia University press, 1975.

Tierney, John. "Life: The Cost-Benefit Analysis." *New York Times*, May 18, 2003, Late ed., Week in Review sec.

Tversky, Amos, and Daniel Kahneman. "Advance in Prospect Theory: Cumulative Representation of Uncertainty." *Journal of Risk and Uncertainty* 5 (1992): 297-323.

United Nations Development Programme. *Human Development Report 2003*. 2003.

United States. Enivironmental Protection Agency. *Regulatory Impact Analysis--Control of Air Pollution from new MOtor Vehicles: Tier 2 MOtor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements*. EPA 420-R-99-023. 1999.

United States. Environmental Protection Agency. *Final Regulatory Support Document: Control of Emissions from Unregulated Nonroad Engines*. 420-R-02-022. 2002.

United States. Environmental Protection Agency. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehical Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA 420-R-02-022. 2000.

United States. Environmental Protection Agency. *Technical Addendum: Methodologies for the Benefit Analysis of the Clear Skies Initiative*. 2002.

United States. Environmental Protection Agency. *The Benefits and Costs of the Clean Air Act, 1970-1990*. Washington, D.C., 1997.

United States. Environmental Protection Agency. *The Benefits and Costs of the Clean Air Act, 1990-2010*. EPA 410-R-99-001. 1999.

United States. Office of Managment and Budget. *Circular A-4*. 2003.

Urry, Heather, Jack Nitschke, Kim Dalton, Corrina Mueler, Melissa Rosenkranz, Carol Ryff, Burton Singer, and Richard Davidson. "Making a Life Worth Living." *Psychological Science* 15, no. 6 (2004): 367-72.

U.S. Senate Committee on Environment and Public Works. "Boxer Statement on EPA Decision to Lower Human Life." Press release. http://epw.senate.gov/public/index.cfm?FuseAction=Majority.PressReleases&ContentRecord_id=22250f94-802a-23ad-4b6d-c5aab7b77cd8&Region_id=&Issue_id= (accessed March 1, 2010).

"U.S. Treasury - Daily Treasury Yield Curve." United States - Department of The Treasury - Homepage. http://www.ustreas.gov/offices/domestic-finance/debt-management/interest-rate/real_yield.shtml (accessed March 08, 2010).

Van Houtven, George, Michell B. Sullivan, and Chris Dockins. "Cancer Premiums and Latnecy Effects: A Risk Tradeoff Approach for Valuing Reductions in Fatal Cancer Risks." *Journal of Risk and Uncertainty* 36 (2008): 179-99.

Varey, Carol, and Daniel Kahneman. "Experiences Extended across Time: Evaluation of Moments and Episodes." *Journal of Behavioral Decision Making* 5 (1992): 169-85.

Velleman, J. David. "Well-Being and Time." In *The Metaphysics of death*, edited by John Martin Fischer, 327-57. Stanford, Calif.: Stanford University Press, 1993.

Viscusi, W. Kip, and Joni Hersch. "The Mortality Cost to Smokers." *Journal of Health Economics* 27

(2008): 943-58.

Viscusi, W. Kip, and Joseph E. Aldy. "Labor Market Estimates for the Value of Statistical Life." *Journal of Environmental Economics and Management* 53, no. 3 (May 2007): 377-92.

Viscusi, W. Kip, and Joseph E. Aldy. "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World." *Journal of Risk and Uncertainty* 27, no. 1 (2003): 5-76.

Viscusi, W. Kip, and William N. Evans. "Utility Functions that Depend on Health Status: Estimates and Economic Implications." *The American Economic Review* 80, no. 3 (June 1990): 353-74.

Viscusi, W. Kip. *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. New York: Oxford University Press, 1992.

Viscusi, W. Kip. "Racial Differences in Labor Market Values of a Statistical Life." *Journal of Risk and Uncertainty* 27 (2003).

Viscusi, W. Kip. "Rational Discounting for Regulatory Analysis." *University of Chicago Law Review* 74, no. 1 (2007): 209-46.

Viscusi, W. Kip. "The Devaluation of Life." *Regulation and Governance* 3 (2009): 103-27.

Viscusi, W. Kip. "The Value of Risks to Life and Health." *Journal of Economic Literature* 31, no. 4 (December 1993): 1912-946.

Viscusi, W. Kip. "Value of LIfe." In *The New Pagrave Edition of Economics*, edited by Steven N. Durlaufe and Lawrence E. Blume. 2nd ed. New York: Palgrave Macmillan, 2008. http://www.dictionaryofeconomics.com/article?id=pde2008_V000005 (accessed March 6, 2010).

Von Neumann, John, and Oskar Morgenstern. *Theory of Games and Economic Behavior*. Princeton: Princeton University Press, 1947.

Weinstein, Neil D. "Unrealistic Optimism about Susceptibility to Health Problems: Conclusions from a Community-Wide Sample." *Journal of Behavioral medicine* 10, no. 5 (1987): 481-500.

Weisbach, David A., and Cass R. Sunstein. "Symposium on Intergenerational Equity and Discounting." *University of Chicago Law Review* 74, no. 1 (2007): 1-3.

Weisbach, David A. "Should Legal Rules Be Used to Redistribute Income?" *University of Chicago Law Review* 70 (2003): 439.

Weymark, John A. ""A Reconsideration of the Harsanyi-Sen Debate on Utilitarianism." In *Interpersonal Comparisons of Well-Being*, edited by Jon Elster and John E. Roemer. Cambridge [England]: Cambridge University Press, 1991.

Williams, Alan. "Intergenerational Equity: An Exploration of the 'Fair Innings' Argument." *Health Economics* 6 (1997): 117-32.

Wilson, Timothy D., and Daniel T. Gilbert. "Affective Forecasting: Knowing What to Want." *Current Directions in Psychological Science* 14, no. 3 (2005): 131-34.

Wilson, Warner. "Correlates of Avowed Happiness." *Psychological Bulletin* 67 (1967): 294-306.

Wu, George, and Richard Gonzalez. "Curvature of the Probabiltiy Weighting Function." *Management Science* 42 (1996): 1676-690.

Yang, Yang. "Social Inequalities in Happiness in the United States, 1972 to 2004: An Age-Period-Cohort Analysis." *The American Sociological Review* 73 (April 2008): 204-26.

Zeckhauser, Richard, and Cass R. Sunstein. "Dreadful Possibilities, Neglected Probabilities." In *The irrational economist: making decisions in a dangerous world*, edited by Erwann Michel-Kerjan and Paul Slovic, 116-24. New York: Public Affairs, 2010.

Zeckhauser, Richard J., and W. Kip Viscusi. "Discounting Dilemmas: Editors' Introduction." *Journal of Risk and Uncertainty* 37 (2008): 95-106.

Appendix: Online Survey Questionnaire