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Grappling with Ignorance: Frameworks from Decision Theory, Lessons from Literature

Abstract: Benefit-cost analysis (BCA), a discipline best known for guiding policy choices, can also guide personal decisions. In either application, traditional BCA tallies benefits and costs using market values or willingness to pay. When future outcomes are uncertain, as they are across a wide array of situations, BCA must call as well on the methods of decision analysis. Thus, von Neumann–Morgenstern utilities, subjective probabilities, and sequential decision strategies are brought into play.

Traditional decision analysis distinguishes between risk and uncertainty. With risk, the probabilities of possible outcomes are known; with uncertainty, those outcomes are known, but not their probabilities. We introduce the concept of ignorance: a third, less tractable category. With ignorance, even the possible outcomes of decisions cannot be identified. Ignorance takes particular importance when high payoffs are associated with these unidentified outcomes, as is often the case. We identify such outcomes as *consequential amazing developments* (CADs). In the policy realm, the 2008 financial meltdown or the Arab Spring would represent a CAD. For an individual, a CAD might be that one's secure tenured position had been inexplicably terminated, or that one's trusted business partner had long been shuttling corporate secrets to a competitor. We distinguish between *unrecognized* and *recognized* ignorance. In the latter category, we identify specific cognitive biases that impair decision making.

Consequential ignorance cannot be studied in a controlled laboratory setting, since its payoffs are high, its time delays often long, and merely introducing the subject would tend to give away the game. Thus we develop a descriptive understanding of ignorance drawing on great works of literature, from antiquity to the present day, positing that skilled writers understand how humans make decisions and respond to unanticipated outcomes. Shakespearean examples would be Hamlet's ignorance of his father's killer, and Macbeth's lack of awareness of the tragic ramifications following his actions to seize the Scottish crown.

Following this descriptive analysis, we turn to prescription. We draw on decision analysis to develop a formula for calculating consequential ignorance; it

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incorporates the expected magnitudes and assessed base rates for CADs. Finally, we propose a decision-analytic framework for measured decision making, given ignorance. Our recommended approach explicitly recognizes decision-making costs, and thus proposes when to use quick and intuitive as opposed to more deliberative approaches to decision, or the labels Kahneman has popularized as System 1 and System 2.

Studying ignorance through literature has important implications for BCA. Given the potential for ignorance, there are two key goals for prudent decision making. First, steps should be taken to recognize when ignorance might be present. Second, efforts should be made not to respond in a suboptimal fashion when ignorance is anticipated or when a CAD springs upon us. Great literature can provide the equivalent of widespread life experience, and can help a decision maker reach both goals. At its heart, this essay represents a benefit-cost approach to dealing with ignorance. Numerous connections to BCA are made throughout.

Keywords: benefit-cost; CAD; decision theory; ignorance; lessons from literature; System 1 and System 2.

JEL classifications: D80; D03; D78; D84; H43.

1 Ignorance and CADs

Of course, the immediate future is uncertain; America has faced the unknown since 1776. It's just that sometimes people focus on the myriad of uncertainties that always exist while at other times they ignore them (usually because the recent past has been uneventful).

– Warren Buffett, *To the Shareholders of Berkshire Hathaway Inc.*, 2012

Benefit-cost analysis (BCA) provides a rational template for making difficult decisions. The discipline is best known for applications to policy decisions, helping us answer such questions as: (a) Where should we set the speed limit to trade off accident risk versus travel time? (b) How much should we spend on the community center valuing recreational and other benefits against costs? (c) How much Tamiflu should the United States stockpile given the possibility that it will protect citizens against a new strand of avian flu? However, the discipline is equally useful when applied to the domain of personal decisions, for example: (a) Should I take the new job that has been offered in Atlanta, given the uncertainties of a new job, a new city, and the potential for new friends and a new life? (b) Should I proceed with the back operation, which Dr. R strongly recommends, but Dr. S believes to be too risky? (c) Should I marry Louisa, despite her shortcomings, given her strengths particularly in complementing me?

Benefit-cost analysis brings two strengths in addressing such questions. First, it provides an overarching methodology for dealing with challenging lines of inquiry. Thus, for policy decisions, it finesses a variety of deep questions on interpersonal comparison by recommending that benefits and costs be tallied in dollar terms, usually employing market prices where available and willingness to pay where not.¹ Second, it makes the analyst, whether for policy or personal decisions, stop and think, for example to identify possible outcomes and estimate how likely they are, identify the consequential attributes, and then consider alternatives – in short, diagnosis before therapy. Third, to qualify the second advantage, it even tells us to consider the marginal benefits of not thinking further about marginal benefits; BCA is readily cast aside when deciding whether to order the chicken or the lasagna.

Decision theory enabled BCA to take a great leap forward. It could now be applied to areas where there were significant uncertainties, as there are in all the problems discussed above. It is no surprise that the policy analysis/systems analysis movement in government was born in a small office in the Defense Department, home of the so-called Whiz Kids, where the uncertainties confronting the underlying problems were massive.² It then spread to the Department of Health, Education, and Welfare (DHEW), also a realm of significant uncertainties, and then around the government. The early successes of policy analysis/systems analysis in addressing highly uncertain issues came not so much because it provided finely calibrated answers, but rather because many current policies were so far from optimal.³

The observation that motivates this essay is that many of the most important decisions that society and individuals take involve grappling with massive uncertainties. Indeed, often potential outcomes are not even identified at the time a decision is taken. If so, decision makers are not treading the well-marked path of the early years of BCA, as employed, say, by the Corps of Engineers. Rather, they are wandering into a foggy future. In the terminology of this essay, they are confronting ignorance.

Let us mention some representative policy examples. The gravest policy problem for the United States in the latter half of the 20th century was how to confront the Soviet Union, given that tens of millions of lives would be lost in a nuclear exchange. Yet the collapse of that empire in 1991, despite massive intelligence expenditures, was an unforeseen event. A decade later, the West's new foreign

¹ One of the most delicate subjects is valuing lives, and BCA provides a way to proceed. See Viscusi (2014). Benefit-cost analysis also provides techniques for thinking about distribution, but that subject is beyond this essay.

² The early Bible of the policy analysis movement was the book *The Economics of Defense in the Nuclear Age* (1960). Its coauthor Charles Hitch was the Assistant Secretary of Defense (1961–1965) who established and oversaw the first office of policy analysis in the government.

³ Zeckhauser worked briefly in the policy analysis offices in both the Department of Defense and DHEW. In the latter, his assignment was to prepare a white paper on the allocation of resources to biomedical research, a topic where uncertainties are massive.

policy challenge, terrorism, announced itself with the 9/11/2001 attack. The lead policy challenge of the current century, the 2007–2008 financial meltdown and economic doldrums that followed, massively surprised policy makers. So too did the swift rise of Islamic State of Iraq and Syria (ISIS), perhaps the most appalling example of contemporary terrorism. Looking forward, climate change and measures to confront it will surely unfold in ways that are not presently foreseen as possibilities. Ignorance challenges the techniques of traditional BCA, broadly considered, on many of the really consequential policy problems.

How does society do when planning for catastrophes? From viral pandemics, such as Ebola, to cyberattacks, such as the late-2014 Sony hacks, contemporary society is repeatedly confronted with unanticipated disruptions that call for pre-emptive forestalling. Rodin (2014) proposes the concept of a “resilience dividend.” She suggests that resilience is built when institutions capitalize on the learning that occurs on the heels of a catastrophe. Ways to do this include nurturing and improving new, more robust systems and strengthening social ties to preemptively prepare for future catastrophes. One way forward is through private–public partnerships, such as the 2013 initiative titled “Rebuild by Design,” organized collectively by the Department of Housing and Urban Development and the Rockefeller Foundation – headed by Rodin – in the wake of Hurricane Sandy in 2012. It is a \$1 billion “National Disaster Resilience Competition, which is aimed at encouraging local businesses, community development organizations, nonprofits, and local and state governments to rethink how cities plan in the face of a growing number of natural disasters,” thereby addressing disruptions before they occur. Rose et al. (2007) note that a dollar spent on a Federal Emergency Management Agency (FEMA) hazard mitigation grant produces four dollars of benefits – a significant return on public dollar expenditures.

Ignorance, unfortunately, compounds the challenge of building resilience in anticipation of disasters, in this realm of unimagined disasters. Perhaps the most consequential example looking forward is climate change. Many climate scientists believe that if the world does confront a climate-induced catastrophe, the major loss is likely not to come from one of the prime dangers identified today. But the same two major lessons apply: experience from past disasters is instructive. Planning in advance, including expenditures to build resilience, can substantially reduce later losses. Alas, that is not the way that individuals or societies naturally engage ignorance.

This essay investigates why individuals, whether choosing for themselves or in some organization on behalf of others, decide poorly when grappling with ignorance, and provides a framework that will enable them to choose more effectively. Its focus is on decision making, as opposed to BCA itself. Unless the bedrock – effective decisions for BCA – is sound, the structure on top is at risk.

Economists, psychologists, and decision theorists try to distill the ways in which people in the real world make decisions. When outcomes are known, decision making is fairly straightforward. Hence, across a broad range of circumstances, decision making approximates rational prescriptions. However, when outcomes are unknown, grave difficulties intrude. People choose poorly, at least as judged from the standpoint of the well-developed prescriptive theories built on Bayesian decision and expected utility. Unknown outcomes can be further described as involving risk or uncertainty. Risk applies when probabilities are known, as they are at gambling tables or for insurance companies that have vast amounts of actuarial data on individual risks. Uncertainty prevails when even those probabilities are unknown, as they are for virtually all real-life decisions.

The rational decision paradigm was posited seminally by Savage (1954) and more accessibly by Raiffa (1968). Decision theory has emphatically modeled itself on the expected utility (EU) approach, which requires that a probability and a utility be attached to each potential outcome. The behavioral decision approach, building on the work of economist Maurice Allais and psychologists Daniel Kahneman and Amos Tversky, and those who followed in their footsteps, documents significant and systematic deviations of the decisions of ordinary individuals from the prescriptions of rational decision theory. Such deviations prove to be significant when important possible outcomes are uncertain.

This article examines situations in which the decision maker does not or cannot even identify important possible outcomes. These situations are characterized by what we label *ignorance*: a state beyond uncertainty, in which potential outcomes are both unknown and unknowable (Gomory, 1995; Zeckhauser, 2006). In such circumstances, traditional decision theory, and by extension systematic policy analysis, prescribes that one should contemplate the future, identify what might happen, attach probabilities, and make the best possible choice. But such efforts are hardly feasible with ignorance, since what actually happens may not be one of the possibilities contemplated. Worse yet, as we detail below, decision makers are often unaware that they are choosing in ignorance. Prescriptive decision theory therefore needs to extend its horizons to deal effectively with the prospect of ignorance. Our analysis identifies a path forward for such decisions, building on the approach of rational decision theory. We will highlight preliminary steps along that path.

Ignorance is consequential to both the individual and society, making it imperative to engage in a systematic effort to improve decision making under conditions of ignorance. Errors in underappreciating ignorance lead people to marry incompatibly, save imprudently, and legislate injudiciously. Neither descriptive nor prescriptive decision research at present directly addresses ignorance. We perceive two general categories of ignorance. *Primary ignorance* arises when one does not

even recognize that one is ignorant. *Recognized ignorance* describes a situation in which one perceives one's ignorance and becomes aware that important potential outcomes are not being contemplated.

This article introduces the concept of *consequential amazing development* (CAD), which can be a bad or a good occurrence. To be consequential, a CAD must be better or worse than the extreme events in a typical month. To be amazing, it must lie beyond the decision maker's horizon of contemplation. We pause for a moment to define what a CAD *is not*. A CAD is not simply an outlier or a black-swan-style event, such as a precipitous drop in the stock market or a windfall in a lottery. Such outcomes could have been contemplated. Being challenged to a duel to the death would today be considered a CAD, but in seventeenth-century France it would be an outlier yet perfectly within the realm of contemplation.⁴ Further, a CAD is a subjective, not an objective, designation; it is judged from the standpoint of the individual affected.

We classify CADs into three categories. *Deep* CADs are striking and seemingly impossible developments that could not possibly have been contemplated. However, some CADs could or should be contemplated. *Conventional* CADs are those that are not readily contemplated, but which could have been conjectured with cognitive effort. *Blindered* CADs are developments that could have been envisioned but were not, generally due to a combination of visceral emotions and wishful thinking. Such forces act in the manner of blinders on a horse, blocking out the consideration of possible outcomes. In short, cognitive effort potentially can transform conventional and blindered CADs into contemplated outcomes, whereas such an effort would be futile where deep CADs are concerned. CADs are also classified in terms of scope: *broad* and *narrow*. Much of our discussion is addressed to CADs that strike one or a few individuals, or what we label as *narrow* CADs. Unexpectedly falling in love or being cheated by one's long-term trusted business partner would be representative examples. *Broad* CADs, on the other hand, affect large swaths of society. The collapse of the Soviet Union, the 9/11 attacks, and the Arab Spring, none of which was an outcome contemplated even by experts, would qualify as broad CADs. Though broad CADs are probably most relevant for policy, many narrow CADs lead to the personal catastrophes that call for safety net measures.

A systematic study of ignorance, beyond simply a descriptive understanding, is challenging for several reasons. First, ignorance defies extrapolation from statistical

⁴ D'Artagnan, the protagonist of *The Three Musketeers* by Dumas (1844/1995), was challenged three times in a 24-hour period. A note about in-text citations – When citing literary and philosophical texts that were written a few centuries ago, we include two dates within parenthesis: the original publication date followed by the current edition cited. The reference list cites only the current edition.

study, the favorite instrument in the forecaster's toolkit. When unpredictable events occur, such as the events in Ukraine in early 2014, they are usually unique occurrences. Additionally, although potential CADs are many, actually occurring CADs are few. Most potential CADs are never even contemplated. These factors make it extremely difficult to estimate the base rate for CADs in any particular situation, yet such estimates could give fair warning and allow for preparation. Moreover, these statistical challenges are complemented by behavioral biases. For example, when contemplating the future, people tend to be limited by the parameters of what they have already seen or experienced.

The Office of Management and Budget (OMB) Circular A-4 (2003) provides guidance to federal agencies on the best practices apropos of regulatory analysis. The circular's section titled "Treatment of Uncertainty" notes with some perspicacity: "In some cases . . . uncertainty may be so large that you can only present alternative scenarios without assessing the relative likelihood of each scenario quantitatively. . . . In such cases, you might present results from a range of plausible scenarios, together with any available information that might help in qualitatively determining which scenario is most likely to occur." It is not a large step from this recommendation to the observation that some consequential scenarios may be beyond conjecture. In short, many policy analyses would benefit from a discussion of CADs.

The remainder of this essay is structured as follows. Section 2 delves into our methodology: we study ignorance predominantly through the decisions of literary characters for reasons explained there. Section 3 elaborates on and provides examples of different categories of CADs. Section 4 identifies biases and heuristics that affect choices under ignorance. Section 5 moves beyond description to propose strategies for grappling with ignorance. Discussion and conclusions follow in Section 6.

Although much of our analysis is descriptive, it leads to four prescriptive recommendations that we return to in Section 5:

1. *Build intellectual capital.* Appreciate the importance of ignorance. Build intellectual capital as a means to grapple with it. Such capital-building measures would include retrospective studies of ignorance, extending BCA methods to grapple with ignorance, and reading about ignorance more generally.⁵
2. *Scan for potential CADs.* Scan choice situations inexpensively to assess if CADs lurk. This assessment, which may identify the potential for CADs, though not their nature, is intended to sound a warning to attend seriously to ignorance. Much of the time an inexpensive scan will spare us from

⁵ See for example, Gross and McGoey (2015). The paper by Roy and Zeckhauser (2015) in that volume, though addressed to a significantly different audience, makes a number of the points made here.

cognitively draining processes. Where base rates appear insignificant, traditional decision procedures are appropriate.

3. *Devote attention after a positive scan.* When the potential for CADs appears meaningful, devote attention to assess it. Ignorance is of importance when the product of the estimated likelihood for CADs times their expected magnitude is substantial.
4. *Adjust choices given ignorance.* If ignorance is substantial, institute changes that will diminish the likelihood or consequences of potential CADs.

2 Literature as a decision lab

We study ignorance through literature, drawing on some of the world's best-known stories. Why literature? The answer is that the traditional methods by which economists study decision making, namely laboratory experiments and empirical observations based on economic incentives, are ill-equipped to study ignorance. To distill situations of primary ignorance into laboratory settings would create the paradox of telling participants, "You have no idea of what is going to happen here; you couldn't even imagine it." Merely setting up the experiment would destroy it.⁶ Second, situations involving ignorance and its consequences often involve long stretches of time, which are hard to accommodate in a laboratory. Third, we are concerned with CADs, not inconsequential surprises. An example of a CAD would be the discovery that one's trusted business partner has been secretly stealing industrial secrets for an arch competitor over many years.⁷ Decisions of magnitude involving life choices, major medical treatments, or momentous policy evaluations would all make ideal subjects for studying consequential ignorance. All would be prohibitively costly, most long term, and many unethical to reproduce in a laboratory setting.⁸

We share Elster's (2007) perspective that it is necessary "to inculcate skepticism toward two common lines of reasoning in the social sciences": first, regarding the social sciences' continued reliance on consequences rather than motivations for

⁶ This problem is related to the observer effect in physics: observing a phenomenon alters that phenomenon.

⁷ A dramatic literary parallel occurs in Orwell's *Nineteen Eighty-Four* (1949), where the main protagonist Winston Smith discovers that his close friend and supporter O'Brien has been working for the Thought Police all along. For Smith, this is a deep CAD that drastically affects the course of his future. Due to O'Brien's covert betrayal, Winston finds himself arrested, tortured, and brainwashed.

⁸ Today's internal review boards (IRBs) would never approve of an experiment such as Milgram's famous study (1963) in which individuals believed they were delivering dangerous electric shocks to others. Moreover, the code of conduct among economists does not permit the use of deception in experiments.

explaining behavioral patterns; and second, as he states with iconoclastic zeal, “I now believe that rational-choice theory has less explanatory power than I used to think,” a shift in belief shared by much of the economics profession. Literature, in contrast with the hypothesis-driven, sanitized world of economic experiments, frequently portrays fictional characters in plausible situations steeped in what Elster terms “the fog of uncertainty that surrounds most important decisions.” These characters – imaginary men and women, but whose behaviors are distilled from real-world observations – often dwell in ignorance and subsequently get buffeted by CADs.⁹ Studying ignorance and CADs through literature has five great virtues:

1. *Scope*. Literature provides a rich available universe of decisions. Important decisions, whether in the real world or in fiction, usually confront uncertainty. Research reveals that exposure to literary fiction reduces our need for “cognitive closure” or discomfort with uncertainty, and leads to more sophisticated and creative metacognition; as Djikic, Oatley and Moldoveanu (2013) observe, “exposure to literature may offer a pedagogical tool to encourage individuals to become more likely to open their minds.”
2. *Experiential reality*. Stories enable us to get inside the heads of literary characters to experience the world as they do, reproducing their ignorance and reporting on the CADs that dramatically affect their lives. Stories are the central mechanism through which the human mind encodes reality.¹⁰ Reading about the diverse decision-making styles of literary characters enables us to expand the horizon of our own thinking about decision making.
3. *Cultural learning*. Stories disseminate cultural learning via symbol, metaphor, and analogy, often through the cautionary tales of literary characters. Weber and Johnson (2008) observe: “Individuals who live in cooperative groups with the ability to communicate information in symbolic form can use the experience of others not just by direct observation, but also receive it in condensed form.” From Aesop’s *Fables* to Zola’s *Rougon-Macquart* novels, writers present descriptive insights about decision making by depicting how literary characters choose creatively.
4. *Anticipation*. Literary narratives demonstrate that ignorance is commonplace and that CADs arise seemingly from nowhere. Literature has the potential to

⁹ CADs also provide some of the most riveting plots in literary fiction. Consider the central plot of Márquez’s *Love in the Time of Cholera* (1988) in which Florentino Ariza decides to wait for “fifty-one years, nine months, and four days” for Fermina Daza after she marries another, more socially suitable man. Or, consider the plot of any Jeffrey Archer novel, with the story line inevitably built around personal vendettas and corporate double-dealing.

¹⁰ See, for instance, the work of psychologist Bruner (2002), who suggests that we “cling to narrative models of reality and use them to shape our everyday experiences” and of literary theorist Boyd (2009), who argues, “Minds exist to predict what will happen next.”

teach the reader the importance of anticipating possible CADs when making decisions that affect critical life areas such as education, employment, and marriage. Literary scholars such as Miall (1995) argue for the positive role of readerly anticipation in constructing narrative meaning. This essay's authors observe that anticipation and expectation are also seminal to the decision-making process.

5. *Contemplation*. Reading narrative fiction exercises the imagination in contemplating and envisioning CADs; it can be used as a strategy for developing one's contemplation "muscles." Vigilant contemplation is difficult to achieve, yet it is a critical ingredient for dealing effectively with ignorance.

Literature mirrors life. Writers work within a rich tradition, going back to Plato and Socrates, that investigates how human beings perceive reality. Book VII of Plato's *Republic* (380 BCE/1992) contains the famous "allegory of the cave," which posits that we live in a world of ignorance and that we find cognitive comfort in such ignorance because it is all we have ever believed, erroneously, to be the nature of reality. The central argument of Aristotle's *Poetics* (335 BCE/1997) is that *mimesis*, or the imitation of reality, is one of the central functions of art.¹¹ Roman poet Horace goes further and, in *Ars Poetica* (19 BCE/1926), makes the case for literature as learning for life. He asserts, "My advice to one who is trained in representation is to look to life and manners for his model [...]." We notice an overlap: economists and psychologists run controlled experiments, examine behavioral phenomena, or investigate large quantities of data – strategies seeking to distill information that illuminates real choices. Similarly, authors depict literary characters making decisions under the very same conditions of interest to this essay: ignorance, amazement, and consequence. Literary characters, from Cervantes's Don Quixote to Dashiell Hammett's Sam Spade, confront problems not encountered before, find themselves in the midst of events impossible to predict, and discover they are in situations that are both specific and novel. This is the quintessence of ignorance.

We are not the first social scientists to stand on the shoulders of giants in the humanities. Elster, for instance, seamlessly integrates a rich cornucopia of philosophical, political, and literary thought from sources as varied as Aristotle, Tocqueville, Montaigne, Rochefoucauld, and Proust in his sophisticated retelling of rationality in the seminal works, *Ulysses and the Sirens* (1979) and *Explaining Social Behavior: More Nuts and Bolts for the Social Sciences* (2007). We share his belief that "the dialog with the past can be immensely fruitful," and that thinkers and writers often inform, if not influence directly, some of "the most decisive advances in social science over the last fifty years" by titans of economics such

¹¹ "Art" here refers broadly to creative products of the imagination and not merely to visual art such as paintings.

as Thomas Schelling, Kenneth Arrow, and Daniel Kahneman and Amos Tversky. Besides, as Elster (2007) argues eloquently, if skeptically, “Inventing ingenious mathematical models [may be] a well-paid activity” but the obsession with larger and more sophisticated data sets, the preoccupation with conducting more and yet more regression analyses, and positing empiricism as the ne plus ultra of intellectual achievement in the social sciences only serve to conceal what he describes as a “hard obscurantism.” In other words, there is more than one way to tell the story of human behavior.

For centuries, human beings have used stories to portray the real world mimetically, as a condensed version of life. Stories offer what psychologists Mar and Oatley (2008) term “simulations of the social world” via abstraction, compression, and simplification, while giving readers the pleasure of losing themselves in the lives of strangers who, in many ways, share their cognitive and behavioral characteristics. Recent work in literary studies proposes that literary fiction helps readers understand the human mind (Turner, 1996; Oatley et al., 2012). Schelling (1988) distills it best: “Novels, plays . . . and stories give the reader . . . a stake in the outcome. . . . The characteristic that interests me is the engrossment [,] the participation, the sense of being in the story or part of it, caring, and wanting to know.” English lexicographer Johnson (1752) remarks in *Rambler No. 4* that the writer’s “task . . . arise[s] from . . . accurate observation of the living world.” Abrams (1953) in *The Mirror and the Lamp*, a classic text on literary theory, posits that literature provides a mirror for society, a looking glass reflecting the social life and mores of the real world.

Literary fiction leads us into truly interesting territory in terms of complex decision making with idiosyncratic variables. Authors convey tremendous amounts of information involving psychological insight and probability judgment on the high side, and blind ignorance on the low, with literary characters placed in situations involving decisions with insufficient information to identify what might happen. The interstices between literary fiction and game theory have been explored in recent works by Brams (2003, 2011) and Chwe (2013). Brams (2003), in *Biblical Games*, draws from a deep well of Old Testament stories, applying game theory to choice situations such as Adam and Eve’s decision about the apple, Abraham’s decision to slaughter Isaac, Moses and his reluctant leadership, among others. Blending Biblical interpretation with game theoretic models is a challenging endeavor, and Brams’s work, despite being erudite is also accessible. In this essay, we have followed his lead by reading literary fiction close to the bone – avoiding textual interpretation and reinterpretation unless crucial, focusing instead on the stories and what they illustrate about ignorance.

In marrying game theory with both literary analysis and Biblical exegesis, Brams (2011) persuasively argues that such disciplinary give-and-take can work both ways: game theorists can discover new applications for these frameworks, while literary scholars can learn how game theoretic principles drive narrative efficacy. A nuanced proponent of rational-choice theory, he claims that literary characters do not “transcend their own rationality,” but that “rationality . . . perfectly well explains the choices of most characters we find compelling in literature.” As behavioral decision researchers, we posit the answer lies somewhere in between: literary characters, like the human actors they are based on, are largely rational but are also frequently driven by the twin engines of cognitive biases and heuristics.

Literature often depicts situations where a CAD unexpectedly occurs and unfolds its unsuspecting victims. The people who are struck by CADs are ordinary men and women – people who resemble us in their behavior and thinking. Literature, with its narratives threaded through with the unknown and the unknowable, provides material for critical self-contemplation and the development of alternative methodologies, both of which are necessary for training in anticipating CADs. For our purposes, fiction frequently depends on unpredictable narrative arcs and the ignorance of the characters involved. Plots and subplots stretch out over long periods of time – a sufficient horizon for examining CADs.

Learning about ignorance through literature has important implications for optimal decision making. Once the concept of ignorance becomes a part of the decision-theoretic discourse, decision scientists can develop methods and train decision makers to cope with it. The greater our understanding of ignorance and CADs, the more improved will be our recognition of and responses to these phenomena.

3 Categories of CADs

In Section 1, we categorized CADs according to two dimensions: their impact and the potential they had for prior contemplation. Here we use literary examples to delve into these categories more fully.

Broad CADs. *Broad* CADs influence society as a whole; they are panoramic in scope. Financial crises, political revolutions, and wars would qualify as broad CADs, as exemplified in Dickens’s portrayal of the French Revolution in *A Tale of Two Cities* (1859/1970). Based in late-eighteenth-century Paris and London, the two cities of the title, the novel examines a society that is subjected to extraordinary and unimagined events, in the form of Robespierre’s Reign of Terror with its scenes of rampant mob violence. The novel has many memorable characters who adapt

differently to the broad CAD represented by the French Revolution. In particular, readers remember Dr. Manette, who was imprisoned in the Bastille for 18 years and now retains a tenuous grip on his sanity by cobbling shoes; Madame Defarge, who sits quietly with her knitting as her victims, many of whose names she has encoded into her work, are dragged to their deaths on the guillotine; and Sydney Carton, the morally lax English lawyer who sacrifices his own life to save that of the husband of the woman he (Carton) loves.

Narrow CADs. Narrow CADs have an impact on one or a few individuals. In Austen's *Pride and Prejudice* (1813/2002), one of literature's most famous love stories begins rather unpromisingly: the hero and the heroine cannot stand each other. The arrogant Mr. Darcy claims Elizabeth Bennet is "not handsome enough to tempt *me*," while Elizabeth offers the equally withering riposte that she "may safely promise . . . *never* to dance with him." Both are ignorant of the possibility of a future romance and have no idea that their lives will be overtaken by a surprising development: they fall in love, wed, and start a seemingly compatible marriage.¹²

Whether CADs are broad or narrow, a major concern is whether they might have been conjectured prior to their occurrence. In this respect, we return to our three categories of CADs: deep, conventional, and blindered.

Deep CADs could not possibly be contemplated by the human mind. They are truly reference independent: in other words, we have nothing against which to compare a deep CAD. Dostoevsky's *Crime and Punishment* (1866/1989) provides a perfect example of a deep CAD. In the novel, Raskolnikov is a cerebral law student, struggling to survive amidst desperate poverty. He has planned, deliberately and carefully, to murder a cantankerous old pawnbroker named Alyona Ivanovna. While he is still in her apartment after having killed her, her sister Lizaveta enters, to his amazement. This is a situation of primary ignorance, or ignorance of one's ignorance; he had very precise information that she would be elsewhere at the time. In a fit of self-preservation, Raskolnikov murders her as well.

These double murders become a deep CAD in Raskolnikov's life. In planning the pawnbroker's murder, he deploys his impressive intelligence, believing, in his ignorance, that he has left nothing to chance. In a series of descriptions that reveal, at a deeper level, our cognitive search for order even amidst ambiguity, the murderer's thoughts are laid bare as he plans the deed. We read about his skills in strategic inference and his powers of prediction about where and how he will corner his victim; his tactics at developing complementary skills (the precise manner in which he will carry the axe and the strategies that will help him avoid detection)

¹² Chwe, in his insightful work *Jane Austen, Game Theorist* (2013), observes that "Austen's strategically thoughtful people try to be self-critically aware of potential bias[es]" in their behavior. Yet, such self-awareness is often no match for ignorance.

are revealed. Yet none of this extensive planning proves helpful. Nor is this a case of biased decision making; there is simply no way Raskolnikov could have contemplated that his victim's sister would show up at that precise moment, overturning all his plans, culminating in a deep CAD of a double murder. Raskolnikov anticipated an outcome in which he would kill the pawnbroker and slip quietly out of her apartment. He instead experiences a deep CAD that challenges what Taleb (2012) calls our "illusion of predictability."

"Someone must have been telling lies about Josef K., for without having done anything wrong he was arrested one fine morning." With these words, we are plunged into the nightmare world (termed today as *Kafkaesque*) of Kafka's posthumous novel *The Trial* (1925/1992). Josef K, a conscientious bank employee experiences a deep CAD that ends his life. He is arrested one morning, charges are never revealed, and, ultimately, he is executed.

Josef K's questions about his unfortunate, if illogical, situation are never answered by the authorities. But upon closer analysis, his behavior illustrates how the mind works upon encountering a deep CAD; he "construct[s] a simplified model of the real situation in order to deal with it; . . . behaves rationally with respect to this model, [but] such behavior is not even approximately optimal with respect to the real world" (Simon, 1957). His second-guessing, fear, and vague sense of guilt as he struggles to gain a mental foothold express the impact of deep CADs – none predicted, none even contemplated.

We use the Greek mythological figure of King Oedipus as our final example of a deep CAD. His fate demonstrates the invisible but forbidding boundary that separates the present from our knowledge of the future – knowledge that is questionable, unreliable, and frequently chimerical. Son of Theban king Laius and his wife Jocasta, the infant Oedipus is abandoned to die on Mount Cithaeron by his father, after an oracle warns Laius that his own son will kill him. But Oedipus is ultimately saved and later adopted by Corinthian king Polybus and his wife Merope. The adult Oedipus, ignorant of his parentage, eventually returns to Thebes, the land of his birth. His ignorance allows him to take two consequential actions he would never have considered had he understood their implications. First, he murders Laius in a freak, rage-fueled incident (unaware that he is committing patricide). Then he marries Jocasta, not knowing she is his mother. Both are deep CADs. Oedipus and Jocasta have four children: daughters Antigone and Ismene, and sons Polynices and Eteocles. Oedipus ultimately discovers the entire truth of his personal history. Jocasta commits suicide and Oedipus blinds himself. Captured by Greek tragedian Sophocles in his play *Oedipus the King* (429 BCE/1982), Oedipus depicts how ignorance can be neither "domesticated" nor controlled when deep CADs occur.

Deep CADs teach us something useful while also destabilizing our existing understanding of risky choice. Randomness in the world – a dramatic drop in the stock market, an implausibly hot summer – is readily imagined. However, unique events without hint or precedent – being arrested for unknown crimes, learning that one’s love object is one’s mother – beyond defying conjecture, often have significant reverberations.

Literary fiction points to two conclusions about deep CADs. First, we tend to downplay the role of unanticipated events, preferring instead to expect simple causal relationships and reasonably linear developments. Second, when we do encounter a deep CAD, we often respond with knee-jerk, impulsive decisions, the equivalent of Raskolnikov committing a second impetuous murder.

Conventional CADs are contemplated only rarely by decision makers, but conceivably could be conjectured with some cognitive effort. Tolstoy’s *War and Peace* (1869/1996) depicts Napoleon’s invasion of Russia (1812) through the experiences of five aristocratic families.¹³ Tolstoy’s Kutuzov is overweight, old, one-eyed, and an army “lifer” with seemingly obsolete tactics – in brief, the very antithesis of his enemy, the dashing military strategist Napoleon. That he is appointed commander-in-chief to lead the Russian army against Napoleon seems, at first, laughable.

But Napoleon’s invasion of Russia develops into a conventional CAD that the French military leader could have easily predicted had he not underestimated Kutuzov or the impact of the weather. Kutuzov has a brilliant understanding of military strategy. He is a tactical innovator who has incorporated line formation techniques from the French Revolutionary wars. Kutuzov knows that the enemy is motivated by a narrow set of attributes – arrogance, a God complex (the term *Napoleon complex* is anachronistic but apt), vaingloriousness – underlying his political choices, that later prove to be the French emperor’s undoing. Kutuzov, although a much decorated war general, eschews egoism in favor of psychology, realism, and timing. In an engagement with the Russian army, the French suffer 70,000 casualties in the Battle of Borodino in September 1812. Following the Battle of Maloyaroslavets in October 1812, Napoleon is forced to retreat in the face of a harsh winter, with his severely depleted army.

Blinded CADs should be contemplated as potential outcomes, but they are not envisioned because strong emotions often overpower balanced foresight. Just as blinders constrain a horse’s field of vision, so too can strong feelings limit an individual’s perceptions of the future.

¹³ Tolstoy’s Kutuzov was based on real-life figure General Mikhail Illarionovich Kutuzov (1745–1813), who retired in 1802 but was recalled to direct the Russian military against Napoleon, first in 1805 (Battle of Austerlitz) and then in 1812 (Battle of Borodino). See Bellamy (2001).

Tolstoy's *Anna Karenina* (1877/2004) enters the glittering world of pre-Revolutionary Saint Petersburg. She catches the eye of the aristocratic bachelor Count Vronsky and quickly falls under his spell. But there are problems. She is married to the rising politician Karenin, they have a son Seryozha, and society will not take kindly to a woman's conspicuous adultery. Although Anna has qualms about dancing with Vronsky at a ball – she is a married woman and he is an attractive single man – she quickly capitulates to his pursuit. Infatuated, she is “blinded” to the CADs that lie in wait. These quickly appear in the form of her husband's discovery of her adultery, her pregnancy with an illegitimate child, and the social stigma and isolation she eventually suffers. From the very start of the affair, Anna's passion for Vronsky and her hedonistic attitude toward life dull her capacity for self-awareness and her ability to contemplate likely future developments. She gives birth out of wedlock, a disastrous condition for a woman in nineteenth-century Russia. She abandons her marriage to Karenin, a kind if undemonstrative husband who is willing to forgive her and even offers to raise her illegitimate child as his own. Vronsky and Anna escape to Italy and then to his Russian country estate. Ultimately, she finds that, while he continues to be accepted socially and to live his life exactly as he pleases, she is banished from society. No one will associate with her, and she is insulted as an adulterer wherever she goes. She realizes she has made a terrible mistake only when fearsome CADs rain down upon her – she loses her husband, her son, and her social status. Ultimately, Anna apprehends that she risked her family and her reputation for too little. It is only toward the end of the novel that Anna realizes she has suffered from the blinded CADs that jumping headlong into an illicit relationship would cause.

Anna's experience illustrates the categorization (above) that, when blinded CADs threaten, the individual should have been able to contemplate such outcomes. The wise counsel of a relative or tales from literature could have provided fair warning. Shrewd strategists take advantage of the blinders on others. Roman poet Virgil's *Aeneid* (19 BCE/2007) identifies the hero Odysseus as the mastermind behind the Trojan Horse, a giant figure made of wood, presented to Troy as a “parting gift” by the Greeks, who feign departure after losing the Trojan War. The horse contains Greek warriors who ultimately emerge and enable the destruction of Troy. Odysseus correctly conjectures that the rejoicing Trojans would be flattered, and blinded, by the impressive gift from the retreating enemy, presumably left behind as a peace-making concession of defeat. The idea that warriors might reside inside the wooden horse, and the possibility that the Greek ships would quickly return, never enters their thoughts. Virgil's famous phrase “Timeo Danaos et dona ferentes” (“I fear the Greeks, even those who come bearing gifts”), with its sense of quiet foreboding, and the remarkable gift itself from the enemy should have alerted the Trojans, but

they neither take pains to foresee given the unprecedented circumstances, no doubt blindered in part by their egoism. Catastrophically, they fail to recognize that they are in a situation of ignorance.¹⁴

4 Cognitive biases and heuristics

This essay's major goal is to motivate readers to attend to ignorance, in their personal lives and in their academic studies. Alas, a variety of cognitive biases may intrude when people are attempting to assess or grapple with ignorance. In two recent books, *Simpler: The Future of Government* (2013) and *Valuing Life* (2014), law professor and former Office of Information and Regulatory Affairs (OIRA) administrator Cass Sunstein, combines insights from behavioral economics with cost-benefit analysis to demonstrate how the power of cognitive biases may be harnessed toward improving regulation.

Recommendations 2 and 3 (see Section 1: Ignorance and CADs) state that we should “scan for potential CADs” and “devote attention after a positive scan.” Essentially, we recommend estimating the likelihood (or base rate) for CADs in choice situations. Unfortunately, estimating the base rate of outcomes that we cannot identify is a challenging process, and substantial biases are likely to enter. If ignorance is not recognized, its base rate is implicitly set at zero – an extreme underestimate. If it is recognized, we believe that individuals will encounter dueling biases, some leading to underestimates of base rates, others to overestimates. However, knowledge of these biases may make them easier to counter.

Three biases come into play in assessing primary ignorance. These same biases may also explain why we miss some CADs that could be contemplated:

1. *Overconfidence*. As Alpert and Raiffa (1982) demonstrate, individuals are overconfident when they estimate quantities. Extrapolating from the Alpert and Raiffa results, which have been replicated thousands of times, if we ask individuals to identify states of the world they can envision for the future, they will overestimate the amount of density for which they account. This leaves less space for CADs, thereby leading to an underestimate.
2. *Salience*. Individuals tend to identify states that are salient – that is, states with which they have some prior experience, or those that are otherwise easily brought to mind. If they have encountered event *x*, the availability heuristic (Tversky & Kahneman, 1973) or the related recognition heuristic (Goldstein

¹⁴ The Trojans had another, albeit vague, potential warning of a deep CAD: the prophecy of Cassandra, daughter of their King Priam, that the horse would be their city's downfall.

& Gigerenzer, 2002) pushes them to overestimate the likelihood of x -like events when contemplating the future. The nature of x affects the level of magnification. If it is a CAD it will be highly salient. Thus when x is a CAD, availability and salience will complement one another. A much more dramatic overestimate will result than when x is an ordinary event.

3. *Selective attention.* In one's store of memories from life, literature, history, and anecdotal gossip, there is a strong selective tendency to recall or retell events that were either surprising or of great consequence. For instance, we might hear and repeat the tale of the man who came home to find a note on the kitchen table stating that his wife of many years had left and that he should not try to find her. If, instead, the note said that she was at the supermarket and would return in half an hour, the event would likely never be recounted, much less retold or remembered. Thus, even a subject who is not vulnerable to the availability heuristic would, by merely drawing upon a memorable story, overestimate the likelihood of a CAD. Such tales told preferentially about events with consequences of great magnitude reflect and produce a selection bias.

Understanding these biases is part of the effort of building intellectual capital (Recommendation 1). Unfortunately, even when ignorance is recognized, it is often dealt with ineffectively. We identify two primary biases that influence the responses to recognized ignorance, and illustrate these with literary examples.

Status quo bias (SQB) leads one to stay the course by “doing nothing or maintaining one's current or previous decision” (Samuelson & Zeckhauser, 1988). One prominent psychological explanation is that errors of commission weigh more heavily than errors of omission (Ritov & Baron, 1990, 1992). Potential blame, whether from oneself or others, reinforces this disparity. Thus, SQB is particularly potent when we are faced with the potential for unfavorable CADs.

Sophocles's *Antigone* (441 BCE/1982) illustrates the two claims at the heart of SQB: first, people prefer to adhere to the status quo; second, they are reluctant to take actions that will require leaving this state. Sophocles's eponymous heroine has seen her two brothers Polynices and Eteocles kill each other in an internecine war for the control of the kingdom of Thebes. Thebes's current ruler Creon, who is also Antigone's uncle, regards Polynices, who involved a foreign army in the struggle for political control of Thebes, as a traitor, and decides to punish his dead nephew by denying Polynices's body a decent burial. Creon also passes an edict threatening death to anyone who buries the body.

Although Creon's instinct as a ruler is understandable – he wants to safeguard his political authority against foreign dissidents – he is proceeding in ignorance. He does not envisage that his edict could stimulate CADs. Antigone, Creon's niece

and future daughter-in-law, decides, at first secretly, to give her brother Polynices a proper burial according to Greek religious tradition. Then, when Creon's soldiers disinter the corpse, she defies Creon a second time by reburying the body. Antigone is convinced that, while she may be defying Creon's authority, he is defying a much higher divine authority. Unfortunately, she is seen and arrested. At this point, Creon orders the execution of Antigone by entombing her alive.

The blind prophet Tiresias warns Creon about the CADs that will follow from his edict. He predicts that if Creon does not permit Polynices's burial, the gods will curse the kingdom of Thebes and disaster will ensue. Hearing this catastrophic forecast, Creon finally recognizes his ignorance. He then decides to free Antigone and permit her to bury her brother. But it is too late. Antigone has already committed suicide, thereby defying Creon's tyranny in death. Her fiancé Haemon, who is also Creon's son, distraught at Antigone's death, tries to kill his father but accidentally kills himself. Creon's wife, Eurydice, commits suicide upon receiving the news of her son's death. Thus, a series of deep CADs destroy Creon's family. The dramatic irony and the tragedy lie in the fact that, had Creon not upheld the status quo so rigidly, he might have saved his family.

Creon demonstrates the dangers of SQB under ignorance. Antigone's defiance was certainly impossible to foresee in a woman in a patriarchal society. Creon is reluctant to change his established position as the all-powerful ruler of Thebes. Such a preference for the status quo, a potentially risky choice for Creon, may be explained as a disastrous combination of loss aversion (Thaler, 1980; Tversky & Kahneman, 1991), the availability heuristic, and the overweighting of errors of commission versus those of omission. For Creon, his current position as the omnipotent ruler of Thebes serves as his reference point, and he weighs all threats to this status quo in terms of absolute, not relative, losses. Thus, he perceives Antigone's request to bury her dead brother as an unqualified threat to his authority, not a relatively small gesture to concede to a bereaved sister. Finally, Creon's SQB is motivated by the conviction that, if he lost authority and influence as a result of this concession to Antigone, he would have committed an error of commission, weighted more heavily than doing nothing.

Indecision bias (IB) arises when one must choose among alternatives, the future is cloudy, and consequential outcomes are possible. When individuals recognize their ignorance, they are frequently frozen with indecision and in a state of complete inaction. IB differs from SQB in that it is characterized by the evasion of a decision, perhaps while waiting for something ill defined to happen, rather than by the choice to do nothing.

Recognizing ignorance accentuates difficulties in decision making among the already indecisive, who frequently require too much positive evidence before

making the switch from a choice with known probabilities to one where they are unknown (Trautmann & Zeckhauser, 2013). The latter choice offers learning opportunities that would otherwise be foregone.

We encounter IB in its full glory in Beckett's existential drama, *Waiting for Godot* (1956). On a country road, tramps Vladimir and Estragon wait endlessly for the arrival of the mysterious Godot, who continually defers arrival, while sending word that he is on his way. A rational choice would be to leave, but Vladimir and Estragon continue to wait. They pass the time in rambling conversations on mundane topics and in meaningless banter with two other characters, Lucky and Pozzo. Twice, a boy brings news that Godot will arrive tomorrow. At the end of the play, Vladimir and Estragon discuss their miserable lot in life and consider hanging themselves. And yet they continue to wait. The stage directions make their indecision clear. At the end of the final act, Estragon asks, "Well, shall we go?" to which Vladimir replies, "Yes, let's go." The stage direction reads: "They do not move."

If ignorance is not recognized, most often nothing happens. Decision makers are not alerted to their inability to contemplate outcomes. They float on gently down the stream of life, oblivious to the CAD that lurks around the bend. Sometimes, however, a CAD does occur. Then IB may intrude, as well, despite the fact that past ignorance is now obvious.

Shakespeare's play *Hamlet* (1603/2005) is possibly the most famous literary exemplar of IB. Hamlet responds to a deep CAD – his father's murder by poisoning – by doing nothing ("To be, or not to be: that is the question"). Hamlet is warned by his father's ghost that Hamlet's uncle, the now King Claudius, murdered him (Hamlet's father) and married his widow (Hamlet's mother). The ghost urges Hamlet to seek revenge, but Hamlet spends much of the play frozen with indecision – now contemplative, now apparently insane. He spends more time debating what he is going to do and pondering whether the ghost was genuine. He "confess[es] he feels himself distracted/But from what cause . . . will by no means speak." His friend Guildenstern observes that Hamlet "with a crafty madness, keeps aloof/. . . [avoiding] confession/Of his true [mental] state." To make matters worse, Hamlet breaks his indecisiveness only to pursue its opposite – rash action. For example, while confronting his mother Queen Gertrude in her bedchamber, Hamlet hears a noise behind the tapestry and simply assumes the man hiding there is King Claudius – his father's purported murderer. Hamlet rashly runs the man through with his sword. Alas, for Hamlet, another CAD has occurred. The man behind the tapestry was Polonius, the Lord Chamberlain, who had been eavesdropping harmlessly.

Even when people recognize their ignorance after a CAD – for instance, Hamlet receives the unprecedented news that his uncle is his father's murderer – they

may respond with IB.¹⁵ This is behaviorally troubling. Why do people fail, even with new awareness, to revise probabilities and utilities, which would enhance the relative appeal of some actions and diminish that of others? We speculate that, when struck by a CAD, the brain is cognitively overwhelmed as it seeks to bridge the chasm between reality and expectations. Doing nothing seems the least cognitively challenging activity and the one most likely to avoid an error of commission. Seeking such cognitive “comfort” is no small matter when we have seen our world upended by a CAD.

We now identify two additional biases that play distinctive roles after a CAD has occurred. Having failed to even contemplate such an outcome, people who now attempt to confront the future fall prey to particular decision heuristics, which we explore using literary examples.

Retrospective recollection of contemplation (RRC) arises when people who have proceeded in ignorance later attempt to make peace with past failures. Retrospective recollection of contemplation whitewashes the past. Although the victims had not contemplated the CAD that transpired, though with a conventional CAD they might have and with a blindered CAD they should have, RRC leads them to recollect erroneously that it was on their menu of possible outcomes. To borrow a metaphor from geography, people tend to recollect that the CAD was on their mental map of the world, although it nowhere appeared. RRC is closely related to the hindsight bias (“I knew it all along”) and to cognitive dissonance (Fischhoff & Beyth, 1975; Festinger, 1957), but it is a specific response to the occurrence of a CAD.

The CAD stirs emotions, and the emotions cloud memories. The recollected past is reconstituted to repress or submerge evidence of ignorance. Retrospective recollection of contemplation makes people creative curators of their history. Authors frequently demonstrate RRC in the domain of intimate relationships when literary characters suffer blindered CADs. After the CAD, the characters erroneously recollect that they had contemplated such an outcome. This is true to life; frequently people fail to draw inferences from the presence of cognitive clues that, more carefully noticed, would be markers for ignorance. To paraphrase Sherlock Holmes’s frequent admonition to Watson, people see but do not observe.

Isabella Linton in Brontë’s *Wuthering Heights* (1847/2003) ignores clear evidence and warnings about Heathcliff’s appalling character, turns a blind eye to these

¹⁵ While we see Hamlet’s behavior as an illustration of IB, Brams (2011), in contrast, examines Hamlet as an actor both rational and strategic, and observes that there is, to cite Polonius, a “method” to Hamlet’s “madness.” Hamlet’s two strategies, according to Brams, are *to reveal* or *not reveal* his knowledge of Claudius’s guilt. Not revealing buys time, enabling Hamlet to secure more evidence and keep himself safe from the vindictiveness of an already suspicious Claudius. We posit that Hamlet is rational for the most part, but when under extreme and highly unusual conditions, is subject to powerful biases.

clues to reduce her cognitive dissonance, and elopes with him, believing his professions of love are genuine. Immediately after the wedding, a blindered CAD occurs; Heathcliff turns out to be exactly as cautioned. He is violently abusive, neglectful, and has had designs all along on Isabella's considerable fortune – qualities she earlier ignored, blindered by the rosy glow of infatuation. Isabella then convinces herself that she has always known that he would turn out like this because she has seen the evidence in his past behavior. Her belated understanding represents an extreme version of RRC. Before the wedding, Isabella displays primary ignorance about her future husband's true character, despite the obvious signs. Yet, her flawed retrospective recollection is not merely that she has contemplated the possibility that Heathcliff would turn out to be an abusive husband, but that she had actually known that he would.

Barn door closing behavior, a metaphor of equine provenance, applies to prospective behavior when one has just recognized one's ignorance and encounters a chance at a similar decision, albeit in a new environment. (See Patel, Zeckhauser & Hendricks, 1991, who apply the concept to investors who make choices today that they should have made yesterday, just as one should have closed the barn door before the horse bolted.) When a negative CAD occurs, decision makers attempt to rectify the past by doing what they should have done in the past.

In Dickens's *Great Expectations* (1861/1996), the eccentric and rich Miss Havisham is jilted by her fiancé, the villainous Compeyson, moments before their wedding. Miss Havisham then develops a hypervigilance against opportunistic men, something that would have served her well in the past but is fairly useless now. She saunters around her decrepit mansion, Satis House, in a faded wedding dress, keeps the eerie remnants of her wedding day undisturbed, including a moldering wedding cake and clocks stopped at twenty minutes to nine – all visual reminders of her past error in judgment. She methodically trains her ward Estella to be habitually cruel to all men lest they take advantage of her.

Miss Havisham's behavior exemplifies barn door closing behavior. As she looks backward, she seeks to contain postdecision regret and makes attempts to remove reminders of past errors through present choices, as with her training of Estella.¹⁶ Miss Havisham's choices appear logical to her. However these choices represent a fusion of fact and fantasy – the desire for vindication merging with the fantasy of a fiancé who will return and release her from a perpetual state of waiting. Miss Havisham is an elegiac portrait of a heart grown bent and broken, haunted by a past CAD.

¹⁶ Weber and Johnson (2008) define regret as the “unfavorable comparison between what was received and what could have been received with a different (counterfactual) action under the same state of the world.” For more on regret theory, see Loomes and Sugden (1982) and Bell (1982).

Barn door closing is closely related to what Schelling (1984), and Ainslie and Haslam (1992) call the precarious and complex relationship between dual selves, one myopic and one farsighted. The myopic agent may have committed a strategically poor decision in allowing the metaphorical horse to bolt, but the well-meaning, farsighted agent will rectify poor past behavior by closing the barn door. Alas, when the myopic agent gets back in charge, the barn door swings open again.

5 Grappling with ignorance

How should we grapple with ignorance? At the outset, we should admit that no strategy is likely to be fully or nearly fully satisfactory. The challenge is simply too great when we are threatened with CADs, and their identity cannot even be defined. Thus, we seek a second-best solution, with the expectation that conscious anticipation of ignorance situations and the contemplation of possible approaches to it can improve outcomes.

We recommend a two-pronged strategy that incorporates the four recommendations presented in Section 1. First, we suggest building intellectual capital by acquainting ourselves with the general problem at hand. Further, we reflect on the lessons presented in this essay. We adjust these lessons, given our own experiences and thought patterns. We learn to extrapolate from life stories, including those from literature where fictional characters often proceed in ignorance. Our goal: thinking about ignorance and CADs becomes as habitual for us as thinking intuitively about probabilities (all skills required in many realms for wise decision making or for effective BCA).

Second, we utilize this intellectual capital on a daily basis to grapple with ignorance. Such cognitive processes require the expenditure of mental energy, an expensive commodity, and one that benefit-cost requires taking into account. If, at every decision point, we find ourselves asking, “Am I at nontrivial risk for a CAD?” it would take a week just to get through a day. Thus, we suggest a second-best approach: Do a cheap scan for ignorance using fast and intuitive thinking, or what psychologists label System 1 (Stanovich & West, 2000; Kahneman, 2003, 2011). This will quickly reveal that for almost all choice situations – what color of shirt to wear, which way to proceed in the museum – ignorance need not be a concern. This scanning, accompanied by beneficial criteria that are acquired over time, should enable us to identify when CADs might be lurking, which is precisely when ignorance should be a concern.

Possible criteria for concern would be that the decision could have major consequences, that the situation is completely unfamiliar, or that the context is complex

and multilayered, making outcomes hard to predict. We should be particularly alert when our emotions are running high, which is also when blindered CADs present the greatest risk. (The Trojans and their horse meet most of these criteria.) When criteria of this sort tip us off to potential ignorance and to the fact that the base rate for CADs may be high, it is time to bring the slow and deliberate reasoning of System 2 into play. System 2 brings superior contemplation. It is better at confronting ignorance, but it is expensive to employ in terms of time and effort. In short, to employ the mind's resources in a cost-effective manner, we employ Systems 1 and 2 strategically and parsimoniously. Essentially, we recommend using decision theory and BCA to develop a metastrategy for confronting ignorance.

Often, the mere recognition of ignorance will change our choices. Recognizing that our emotions are high and that a blindered CAD may lurk, we may choose to delay a life decision, such as getting married. For some decisions, we might opt for a more flexible strategy, for example, taking a visiting position at a university that has given us an attractive offer rather than resigning our current post to take the offer. For such consequential decisions, we might also seek counsel from others. In some instances, we may be able to take actions that reduce the likelihood of a CAD, including a former conventional or blindered CAD that has appeared on our radar screen. Such changed choices entail costs if no CAD occurs, but these costs may be worth paying once we recognize the meaningful probability of a CAD, and the expected costs incurred if we do not change.

Analytic tools are often most helpful when they are hardest to employ. Knowledge of decision theory and its cousins cost-benefit and cost-effectiveness analysis is of modest value when shopping at the supermarket, but that knowledge can be of great value when dealing with a complex medical decision or an elaborate R&D undertaking, even if we employ only the theory's basic approach. Thus, we are effectively proposing a decision-theoretic, consequence tallying approach to ignorance. We employ the less lofty title of *measured decision* to suggest doing something reasonable, if not 100% optimal.

First, we make some observations about magnitude. Many CADs will involve consequences that are not readily assessed on a monetary basis: a marriage rent asunder or a betrayal by one's adult child. Prescriptive decision theory would recommend that von Neumann–Morgenstern (VN–M) utilities be employed. First, a very good reference outcome would be established at 100 and a very bad one at $-X$, where X is a number on the order of magnitude of 100.¹⁷ Zero would be the status quo. Then each CAD outcome would be placed on this scale using traditional lottery procedures. Values below 100 and above $-X$ would be expected.

¹⁷ Note: We do not require that the bad outcome get a utility value of exactly -100 , because it may be hard to identify an outcome with precisely that value.

If the concern is about CADs and the assessment of ignorance, negative values would be weighted equally with positive values of the same magnitude. Thus, we would compute the expected absolute value of a CAD. Note that, since these are VN–M utilities, weighting them by probabilities is appropriate. We recognize that this calibration process would be a challenging assessment of the magnitude of consequences that you often cannot even identify. However, making a crude estimate is better than simply not considering the problem, a lesson well known to benefit-cost practitioners.

Figure 1 illustrates the outcome of such calculations. It shows the expected consequences of CADs. Any individual CAD would be represented by a point on the graph. The greater its consequences and the greater its probability, the greater is its importance. The figure gets darker and the expected consequences of ignorance increase as we move in a northeasterly direction. The figure shows two points, A and B, each representing a CAD. It also shows their aggregate contribution to ignorance. Point S is computed by adding together the two points' probabilities and computing the expected value of their consequences. Note that any point on the rectangular hyperbola through S yields the same expected consequences. In essence, this procedure identifies the significance of the ignorance these CADs create.

We posit that we know that consequential ignorance is lurking. How should we respond to it in a deliberate and thoughtful manner? How should we take a measured decision? The conscientious decision maker should ponder which possible actions would be most favorable against potential CADs. This would produce a tilt toward more flexible and diversified strategies. One way to gain flexibility is to delay a response while gathering more information, thus enabling a switch in strategies if and when early indications of a CAD appear.¹⁸

Societies – working through the government or mediating institutions, including the financial markets – must also take actions in advance of potential CADs. As the examples cited above suggest, many of the most serious problems that we recognize today were hardly conceived of two decades ago. Societies should have some advantages over individuals, in that they include experts, governments, and

¹⁸ Readers often encounter such decision making in detective fiction. Christie's fictional Belgian detective, Hercule Poirot, uses a process of gathering information, forming hypotheses, and adapting to new evidence as it emerges, in stories such as *The Murder of Roger Ackroyd* (1926) and *Murder on the Orient Express* (1934). Doyle's famous detective Sherlock Holmes in *The Adventure of the Crooked Man* (1894/1993), stresses cognitive flexibility, or the openness to allowing the previously unknowable to become evident when one starts from a point of ignorance: "You know my methods, Watson. There was not one of them which I did not apply to the inquiry. And it ended by my discovering traces, but very different ones from those which I had expected."

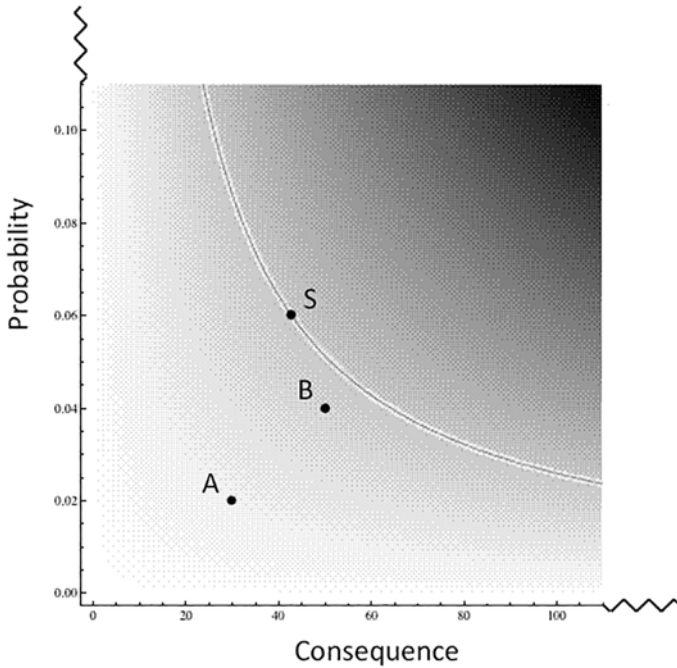


Figure 1 Expected consequences from unidentified states.

research organizations qualified to give guidance. But they also have disadvantages, such as having to work through bureaucratic and political processes.

Figure 2 illustrates our recommended approach after capital has been built to understand ignorance and CADs. The illustration employs hypothetical numerical values. We assume that an individual first employs System 1 to scan potentially important decisions, and that the scan shows 10% of decisions to have CAD potential.¹⁹ Those 10% are then addressed by System 2. In half of the instances (5%), System 2 determines that CADs do threaten. System 2 then adjusts choices. The expected utility payoffs are these: normal outcome, 1000; CAD outcome, 0; CAD outcome with an adjusted choice, 400;²⁰ and normal outcome with an adjusted

¹⁹ We simplify by assuming that the capital-building step imposes negligible cost on a decision when amortized over the individual's lifetime, and that System 1 scanning is effectively costless, not unlike looking both ways before crossing the street. We scale the top outcome to 1,000, not the more conventional 100, to reduce decimals. All calculations are carried through without rounding. However, the values at nodes in the decision tree are rounded to the nearest tenth.

²⁰ Some CAD outcomes may be favorable, which presents no problem since this is an expected utility.

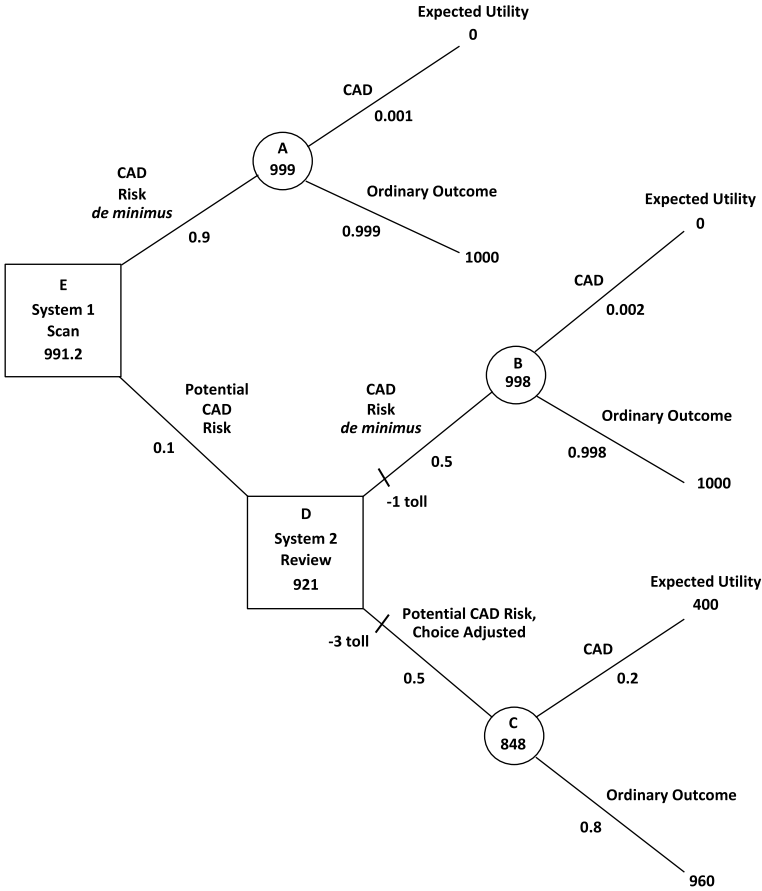


Figure 2 Grappling with ignorance.

choice, 960.²¹ The CAD occurrence probability is 0.1% when System 1 finds it insignificant, 0.2% when System 1 alerts but System 2 finds it insignificant,²² and 20% when System 2 assesses a threat and the choices are adjusted. A System 2 review has a utility cost of 1 initially, and an additional 2 if CAD risk is identified and choice is adjusted.

²¹ If it were known that a CAD would not occur, it would be better not to adjust one’s choice.
²² Even though System 2 is much more thorough than System 1, it is screening decisions preselected for high CAD risk. Hence, there is the 0.2% probability here versus 0.1% when System 1 finds an insignificant risk.

If ignorance is neglected, there is a 0.021 chance of a CAD. No choice will be adjusted, and the expected utility will be $0.021 * 0 + 0.979 * 1000 = 979$. On the decision tree, expected utilities – computed by folding back – are shown at each choice or chance node. If ignorance is grappled with, as shown in box E, expected utility is 991.2. Grappling cuts the expected cost of CADs by 58%, from $1000 - 979 = 21$ to $1000 - 991.2 = 8.8$.

The techniques illustrated by Figures 1 and 2 are templates for guidance, what individuals might do ideally. They are intended to play much the role that decision trees play for ordinary decisions. In practice, though they are unlikely to be fully deployed, understanding their underlying principles should help to improve decisions.

6 Discussion and conclusions

Midway in our life's journey
I found myself in a dark forest
For the straight path had been lost.²³

Thus begins the first canto of Dante's *Inferno* (1314/1994), one of three parts of his larger work *Divine Comedy*. It is also a perfect coda to our examination of ignorance. Dante, and, by allegorical extension, every individual, finds himself proceeding in darkness, lost due to his ignorance. Dante meets the ghost of the Roman poet Virgil who guides him personally on a journey into the nine circles of Hell. Each circle represents a cardinal sin, or what we might today describe as “very bad decision making.” As Dante hears stories from the many notorious sinners who populate each circle, we learn what to the medieval mind was an object lesson in metaheuristics: “This is the path you want to avoid if you want good outcomes in life. When confronted by situations never before encountered, this is what you should do instead.”²⁴

These lines from Dante lead to a sobering conclusion: proceeding without recognizing ignorance is ingrained in the human condition. “Dark forest[s]” are our collective destiny. Some possible future state of the world cannot be conjectured, not even all future consequential states. And some that could be conjectured will not be, since few of us have a natural inclination to attend to ignorance. As with keeping one's eye on the ball in tennis or leaning one's weight downhill in skiing,

²³ Our translation.

²⁴ We concede this is an unorthodox reading of Dante's text; but in doing so, we are following in the rich interpretive tradition of Dante scholars who have discovered layers of meaning within the *terzina* of *Divine Comedy*.

staying alert to ignorance is an unnatural skill that has to be learned. To be clear, we cannot foresee deep CAD outcomes that we cannot imagine. But careful thought can reveal conventional CADs, and, if we monitor our own emotions, blindered CADs as well. Moreover, we can learn when to expect consequential outcomes that we cannot contemplate, much less predict. And when we do, we can lean toward choices that incur a cost but offer some protection against CADs.

Our recommendations for grappling with ignorance recognize the decision-making costs of envisioning an unknowable future and of possibly adjusting actions. This leads to the following recommendation. As we proceed through life, we should regularly ask ourselves: “Given the situation that I am in, is there a reasonable likelihood of a CAD?” In straightforward decisions of low consequence, rely on System 1’s thrifty and expedient intuition. In decisions of higher consequence – for instance, should I take the gamble of moving to California to work for a startup? – turn to the slow-and-steady but cognitively expensive System 2.

How can systematic policy analysis contribute to our efforts to anticipate CADs? It can analyze them not as isolated, solitary events – although they surely have those elements – but rather as constituents of broader categories.²⁵ In this recommendation about CADs, we draw a parallel with Lévi-Strauss’s concept of the “mytheme”: the primal and irreducible element of a myth that, while meaningless in isolation, becomes meaningful in relation to other mythemes.²⁶ Thus, we suggest that in future research, decision scholars search for essential, unifying features that lie at the heart of categories of CADs and then use this information inductively and inferentially to create effective strategies for dealing with CADs. Ultimately, this will promote a study of ignorance as a totality, instead of as a circus of enervating occurrences that defy “the best laid plans of mice and men.” When a CAD does occur and your mind struggles to construct meaning after the strike of a thunderbolt, push toward rationality. Seek to remove yourself mentally from the choice-outcome analysis by taking the perspective of an emotionally neutral outsider.

In sum, our overarching recommendation is that in anticipating and confronting CADs, replace naïve complacency and reflexive responses with focused attention and analytic processes.

²⁵ See Kahneman and Lovallo (1993), who note: “[D]ecision makers are excessively prone to treat problems as unique, neglecting both the statistics of the past and the multiple opportunities of the future. In part as a result, they are susceptible to two biases, which we label isolation errors: their forecasts of future outcomes are often anchored on plans and scenarios of success rather than on past results, and are therefore overly optimistic; their evaluations of single risky prospects neglect the possibilities of pooling risks and are therefore overly timid.”

²⁶ For more on Lévi-Strauss’s methodology of myth analysis, see “The Structural Study of Myth” (1955).

The most consequential problems facing us as a polity and as individuals often involve ignorance and thus the potential for CADs. Benefit-cost analysis has made great contributions in the past by bringing a well-developed methodology to confront problems that raise the challenge of many hard-to-value attributes going to different groups of individuals, possibly on an uncertain basis. But it has not grappled without the challenge of unidentified outcomes.

Benefit-cost analysis must break fresh ground to deal with ignorance. It must develop new tools, new modes of investigation, and new ways of thinking, if it is to confront problems at the societal level such as coping with climate change, terrorism, and previously unforeseen diseases, and at the personal level such as: should I tackle graduate school, should I take the position in the overseas locale? Ignorance will always be with us, and will often be consequential. These problems and their myriad cousins merit the vigilant assessment that only BCA can provide.

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