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Ignorance: Lessons from the Laboratory of Literature

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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

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 pretty straightforward. Hence, across a broad range of circumstances, prescriptive decision-making approximates rational prescriptions. When outcomes are unknown, however, 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 classified into risk and uncertainty. Risk applies when probabilities are known, as they are at gambling tables, or for insurance companies that have vast amounts of data on individual risks. Uncertainty prevails when even those probabilities are unknown, as they are for virtually all real-life decisions. Some of the best analytical minds of the twentieth century—Frank P. Ramsey, John

Maynard Keynes, John von Neumann, and Leonard Jimmie Savage—grappled with the problem of how individuals should make choices under uncertainty; they formulated axioms and prescriptions for effective decision-making. Toward the end of that century, eminent psychologists Amos Tversky and Daniel Kahneman and those who followed in their footsteps documented the significant and systematic deviations of the decisions of ordinary mortals from the prescriptions of those great mathematical minds.¹ Such deviations are disturbing since those prescriptions are now widely—though not universally—accepted by economists and decision theorists as showing how people should decide.

I. Ignorance

This article addresses situations that we label *ignorance*, states of the world where some possible outcomes are not even able to be identified. Ignorance is hardly a minor category; it permeates our lives in the form of the unknown and the unknowable (Gomory 1995; Zeckhauser 2006). Ignorance is both an enemy and a friend; it imposes big risks, yet offers the possibility of substantial gains. It confronts most of us much of the time, in decisions large and small. What will our intended spouse be like in a decade? What will amaze us on our trip to China? Where will this job lead? One way to recognize the prevalence of ignorance is to look backwards, and to see how many current situations in no way resemble what we imagined possible. Our readers, particularly our mature readers, should reflect on their own lives. Did their careers take mysterious turns? Do their children differ from what they expected in ways they could not have imagined?

¹ Kahneman and Vernon Smith were awarded the Nobel Prize in Economics in 2002. Tversky would have shared it had he not died tragically in 1996.

Few if any of our readers, including seasoned experts, could have envisioned the sudden collapse of the Soviet Union, or the financial meltdown of 2007-8. Yet as the Arab Spring and its aftermath reveal, “surprising” regime collapse often merits contemplation. So too does a profound crisis in the financial world. An unforeseen crisis seems to pounce upon us at least once a decade. Remember the savings and loan crisis of the 1980s and 1990s, the Asian financial crisis of 1997, and the collapse of the high tech bubble starting in 2000, for example. As these events prove, we often proceed in primary ignorance, not contemplating future CADs. As we detail below, even the best attempts by decision theorists, whatever methods they employ, have been unable to dispel that fog of ignorance. Ignorance is at the frontier of decision research: territory that is uncharted, unexplored, and, to date, unmastered, even in textbooks.

Ignorance describes the state of the world when one has moved from uncertainty to conditions where some potential outcomes are unknowable and not merely unknown (Zeckhauser 2006). In such circumstances, decision theory would prescribe 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 some significant possible outcomes cannot be identified. Thus, 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 further methods to deal effectively with the prospect of ignorance, but that is a major challenge that we will leave for another day.

Neither descriptive nor prescriptive decision research directly addresses ignorance. The rational decision paradigm was posited seminally by Savage (1954) and

more accessibly by Raiffa (1968). Economists from Allais (1953) to Ellsberg (1961) have attempted to understand deviations from objective and subjective probability. In the last forty years, Tversky, Kahneman, and their followers have developed an abundance of models of risk preferences based on non-expected utility: Tversky and Kahneman's (1979) "Prospect Theory," Quiggin's (1982) "Theory of Anticipated Utility," and Gilboa and Schmeidler's (1989) "Maxmin Expected Utility" are a few eminent examples. But none of these or related articles address ignorance, much less how individuals should or do respond to it.

Our study of ignorance is not concerned with ignorance situations in which there is a 1% or even a 5% chance of some inconsequential unexpected outcome. Rather, our study pertains to situations having some combination of likelihood and importance that makes the ignorance of those situations worthy of attention. For ignorance to merit such scrutiny, a *Consequential Amazing Development* (CAD) must be possible. CADs will play a prominent role in this essay, as they do in many lives. A Consequential Amazing Development can be bad or good, but it must be an outlier, something that is better or worse than the extreme events in a typical month. *Amazing* implies that even if one thought hard, one could not have contemplated the actual outcome. Thus, applying for and getting a long-shot job is not amazing. By contrast, having someone call you out of the blue to offer you a terrific job would be astounding. We shall assume a non-trivial likelihood of a CAD when we refer to ignorance below.

Decision makers frequently do not recognize their ignorance. Such was arguably the case with the policy examples given above: the collapse of the Soviet Union, the terrorist attacks of 9/11, and the financial meltdown of 2008. Thus, prior to the meltdown,

banks went happily on their way, buying mortgage-backed securities, not imagining what could go wrong. Such events compel us to recognize the sheer power of ignorance in our lives and our inability to identify important possible outcomes.² For instance, scientists warn us that if climate change proves catastrophic in the decades to come, the most damaging element of catastrophe may be some effect not currently contemplated.

These examples illustrate two different types of ignorance. *Primary ignorance* arises when one does not even recognize that one is ignorant. *Recognized ignorance* occurs when one perceives the ignorance, and its implication that important potential outcomes cannot be identified. To be clear, in most situations of ignorance, nothing unexpected happens and no CAD occurs. CADs must be possible although they will rarely be likely.

There is a well-known increase in the challenges to rational decision-making as we move from risk to uncertainty. Regression to the mean and the Law of Large Numbers fly out of the window; “anchoring,” “framing,” and “representativeness” enter the room in their stead. With uncertainty, biases associated with ambiguity come into play, including irrational aversion (Ellsberg 1961) and failure to recognize learning opportunities (Trautmann and Zeckhauser 2013). The irrationality of human behavior in the real world has been well documented. Often the deviations from rationality, though quirky, are surprisingly predictable (Ariely 2008), and counter-intuitive thinking can

² Bazerman and Watkins, in their thought-provoking *Predictable Surprises: The Disasters You Should Have Seen Coming, and How to Prevent Them* (2004), are more optimistic than we are about effectively combating ignorance on public policy concerns. We concur with them that both CADs and “predictable surprises” impose staggering financial and human costs, and are propelled by common decision-making biases.

sometimes counter the misguided decision propensities in response to uncertainty (Mauboussin 2009).³

Ignorance, where the states of the world cannot even be identified, greatly amplifies the challenges to sound decision-making. With primary ignorance, failures are inevitable, because the unaware decision maker does not consider possible consequential outcomes. One could argue, and we will do so below, that a rational decision maker should always consider the possibility of ignorance, thus ruling out primary ignorance. But that is a level of rationality that very few achieve. With recognized ignorance, at least, the rational decision maker can attempt to pursue a robust strategy for an ill-defined situation.⁴

Economists investigating decision-making take one of two approaches:

1. They conduct lab experiments. The most common experiments ask individuals to choose among alternatives in which some form of a chance process, such as drawing a marble from an urn, determines the outcome.
2. They observe real-world decision making, such as how much people save, how they invest their funds, and what jobs they take. They often use data from others.

To our knowledge, neither approach has been used to explore the most distinctive issues that confront decision making under ignorance, and with good reason. First, except

³ Given the biases as to what gets published in the scientific literature, irrational behavior that is unpredictable is much less effectively studied than that which follows some discernible pattern. Similarly, irrational behavior that is difficult to study in laboratory settings or with large data sets is much less well understood. Responses to ignorance fall into both categories.

⁴ In our opening quote, Buffett—though talking about uncertainty not ignorance—implicitly identifies the distinction between primary and recognized ignorance situations. Moreover, he suggests the availability heuristic may play a role in alerting people to uncertainty.

for trivial examples, it would be impossible to recreate or even distill situations of primary ignorance into laboratory settings. To do so would create the paradox of telling participants, “You have really no idea of what is going to happen here; you couldn’t even imagine it.” Merely setting up the experiment would destroy it.⁵ 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 with inconsequential surprises. That you never imagined you would run into your old roommate in the bazaar in Marrakech is not our concern; it is not consequential. An example of an amazing development that is also consequential (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.⁶ Decisions of magnitude involving life choices, decisions about major medical treatments, momentous policy evaluations, would make ideal subjects for studying consequential ignorance. All would be prohibitively costly, most impossibly long-term, and many unethical to reproduce in a laboratory setting. Finally, situations of ignorance frequently take years to play out, which would rule out a conventional lab study. That is because the situations that eventuate, be they the financial crisis or marriage to a chronic drunk, are unforeseen by both researcher and subject when the critical decisions are made.

⁵ This problem is related to the observer effect in physics: observing a phenomenon alters that phenomenon.

⁶ A dramatic literary parallel would be the case in George Orwell’s *Nineteen Eighty-Four* (1949), where Winston Smith discovers O’Brien, his close friend and supporter, has been working for the Thought Police all along. For Smith, this is a CAD that drastically affects the course of his future. Because of O’Brien’s covert betrayal, Winston finds himself arrested, tortured, and brainwashed.

II. Literature as a Decision Laboratory

Our mode of analysis departs sharply from what economists commonly employ. No lab results are presented here, no field studies pursued, no data sets processed. Tests of statistical significance do not appear. The mere nature of the subject calls for an alternative methodology.

Fortunately there is a group of highly perceptive chroniclers of human decision-making who observe individuals and follow their paths, often over years or decades. They are the individuals who write fiction: plays, novels, and short stories describing imagined events and people (or fictional characters). Thousands of these works get written each year; the ones that survive over long periods of time are those that most accurately capture the human condition. The greatest of these writers of fiction, those whose works are used as exemplars below, invariably have deep insights into the way individuals confront decisions, both great and small.⁷ In the *Poetics* (335 BCE/1937), a classical treatise on the principles of literary theory, Aristotle argues that art imitates life. We refer here to Aristotle's idea of *mimesis*, or imitation. Aristotle claims one of art's functions is the representation of reality. "Art" here includes creative products of the human imagination and, therefore, any work of fiction. Indeed, a crevice, not a canyon, separates fact and fiction.

For centuries, authors have attempted to depict situations of ignorance. In Greek literature, Sophocles's King Oedipus and Creon, and Homer's Odysseus all seek the

⁷ A large body of research from the field of evolutionary psychology examines how fictional narratives teach human beings how to navigate their social environment. For example, see Tooby and Cosmides (1990), Oatley (1999), and Scalise Sugiyama (1996, 2001).

forecasting skills of the blind prophet Tiresias who is doomed by Zeus to “speak the truth no man may believe.”

For its status as one of literature’s most enduring love stories, Jane Austen’s *Pride and Prejudice* (1813/2002) begins rather unpromisingly: the hero and the heroine cannot stand each another. The arrogant Mr. Darcy claims Elizabeth Bennet is “not handsome enough to tempt *me*”; Elizabeth offers the equally withering riposte that she “may safely promise . . . *never* to dance with him.” Were we to encounter them after these early skirmishes, we (like Elizabeth and Darcy themselves) would be ignorant of the possibility of an ultimate romance.

In Gustave Flaubert’s *Madame Bovary* (1856/2004), Charles Bovary is a stolid rural doctor who is ignorant of the true character of the woman he is marrying. Dazzled by her youth and beauty, he ends up with an adulterous wife who plunges him into debt. His wife Emma, the titular “Madame Bovary,” is equally ignorant of the true character of her husband. Her head filled with romantic fantasies, she yearns for a sophisticated partner and the glamor of city life, but finds herself trapped in a somnolent marriage with a rustic man.

K., the land surveyor and protagonist of Franz Kafka’s *The Castle* (1926/2009), attempts, repeatedly and unsuccessfully, to gain access to the mysterious authorities of a castle but is frustrated by an authoritarian bureaucracy and by ambiguous responses that defy rational interpretation. He begins and ends the novel (as does the reader) in ignorance.

We issue one caution: in the interests of a compelling narrative, authors are predisposed towards creating interesting characters and placing them in unique situations.

This tendency would suggest a selection bias. For virtually all of us, what we read is more interesting than what we live; CADs are more prevalent in fiction than in everyday life.

Our study of ignorance uses stories and their characters to illustrate the complexities and nuances of decision-making under ignorance. But why stories? Leading social anthropologists such as Claude Lévi-Strauss, James Frazer, Franz Boas, and Donald Brown have argued that there are universal characteristics common to all cultures through time. The fact that literature has, since antiquity, attempted to imitate reality suggests why it is a highly appropriate setting for studying decision making; it is as close as we can get to life itself while living it vicariously and, incidentally, studying it inexpensively. Steven Pinker (1997) remarks, “When we are absorbed in a book ... we get to see breathtaking landscapes, hobnob with important people, fall in love with ravishing men and women, protect loved ones, attain impossible goals and defeat wicked enemies”. The characters in these stories are, as literary scholar Blakey Vermeule (2010) notes, “portable” and “transcend dependence on a specific genre.” “Endowed with an unusual staying power,” they enjoy “tremendous power to circulate, to give people shared stories, and to sponsor discussion about personal and collective values.” Studying ignorance through characters in fiction builds on our affinity for narratives about other people. Stories offer what psychologists Raymond Mar and Keith Oatley (2008) term “simulations of the social world” via abstraction, simplification, and compression, while giving us the pleasure of losing ourselves in the lives of strangers who, in many ways, happen to be similar to us.

The different categories of ignorance would be difficult, perhaps impossible, to reproduce in controlled experiments. The world of fiction, however, offers a promising “laboratory”; authors place characters and construct plots with an eye to ignorance, the essence of real life and also of absorbing story telling. Fiction contains all the features of the real world familiar to us, but it places the characters in hypothetical situations that have consequences only within the scope of the plot. The reader observes and learns, at little economic cost, about human behavior in unforeseen circumstances—what we otherwise call the pleasure of a good story. “[N]ovels, plays ... and stories,” Thomas Schelling (1988) offers, “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.”

Our thesis is that characters in great works of literature reproduce the behavioral propensities of real-life individuals. The reader of classic literature will rarely encounter situations as exciting or as unusual in real life but can, nonetheless, learn much about choice and consequence from them. In a sense, this is why great literature will never get dated: these stories observe the details of human behavior, and present such behavior awash with all the anguish and the splendor that is the lot of the human predicament. As Pinker (1997) notes: “Characters in a fictitious world do exactly what our intelligence allows us to do in the real world. We watch what happens to them and mentally take notes on the outcomes of the strategies and tactics they use in pursuing their goals.” Our conception of fictional characters, broadly construed, is that their experiences represent a constrained optimum. They are chosen to elicit excitement and interest, while maintaining plausibility in the way they make decisions.

Our study of ignorance through the world of fiction leads us to three hypotheses:

1. Ignorance often goes unrecognized.
2. Even when we worry, plan, and prepare for the future while explicitly recognizing our ignorance, CADs will occur.⁸
3. Ignorance constitutes a promising and untapped category for decision research.

But why study ignorance at all? One way to answer might employ the image of life as an ever-changing, three-dimensional maze, with many completely unknown opportunities and pitfalls scattered throughout. Paths continually change course, walls shift, ladders get moved, and tunnels open and shut. Ignorance is not an adversary but a condition of life as adventures beckon, tragedies and setbacks occur, and opportunities arise without warning. Authors represent this fundamental human vulnerability in some of the greatest works of literature.

Army general Macbeth meets three witches who prophesy that he will be Scotland's king. Convinced of the truth of this prediction, despite the absence of evidence, Macbeth revises his conception of the future. He slides rapidly down the slope from uncertainty to ignorance. The contemplated state of the world occurs, but only after he has murdered the reigning king. Further CADs then erupt, one after the other. To keep the throne, he has to commit still more murders. He descends into paranoia, and his ill-begotten kingdom is threatened by civil war. He recognizes his initial ignorance of the price he ultimately has to pay: "Upon my head they placed a fruitless crown."

⁸ The exception would be the author and her fictional world of make-believe. Here real-world rules apply but since the author creates the future, she obviously knows what will develop. Ian McEwan plays with this notion in his novel *Atonement* (2001), in which the narrator Briony Tallis writes a plot that unites and provides a happy ending to the two characters she cruelly separated in real life.

We choose to study ignorance for very practical and compelling reasons. Situations of ignorance are widespread and inevitable. Policy makers, diplomats, and investors tend to make significant errors because much of their training prepares them only for the world of risk and uncertainty, with probabilities that can be estimated. Most lives involve a series of amazements, not just contemplated events. Furthermore, many situations of ignorance are singular occurrences, making it difficult to learn from past mistakes.

Given ignorance, as in any decision situation, we are often best served by thoughtful action or prudent information gathering. Yet, as our studies below show, we frequently act in ways that violate such advice.

III. Attending to Ignorance

The first challenge in grappling with ignorance is to recognize its presence. A person who suffers primary ignorance has usually failed to consider the possibility of CADs. So we start with the suggestion of raising self-awareness. Ask yourself regularly: “Might I be in a state of consequential ignorance here?” If the answer is yes, the next step should be to estimate base rates. That should also be the next step if the starting point is recognized ignorance. You might inquire: “Of all such situations that someone like me has experienced that are roughly like this, how often have they produced CADs?” This is not an easy question to answer. The answer will be totally subjective, and its underpinnings are elusive. It is hard to know what the sample of relevant past experiences has been, how to draw inferences from the experience of others, etc. Nevertheless, it is far better to proceed to an answer, however tenuous, than to simply miss (primary

ignorance) or slight (recognized ignorance) the issue. Unfortunately, the assessment of base rates is challenging and substantial biases are likely to enter.

Biases in computing base rates for CADs. 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 will lead to underestimates of base rates, others to overestimates. Three biases come into play:

- a. Overconfidence. As Alpert and Raiffa (1982) demonstrated, individuals are overconfident when they estimate quantities. Extrapolating from the Alpert-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.
- b. Saliency. Individuals will tend to identify states that are salient, that is, states with which they have some experience or that are otherwise easily brought to mind. If they have ever encountered a similar event x , the availability heuristic (Tversky and Kahneman 1973) will push them to overestimate the likelihood of x -like events when contemplating the future. However, framing will also influence assessments. When x is a CAD, an overestimate results; when not a CAD, an underestimate. Although ordinary outcomes are much more common, CADs are much more salient. This produces a duel of biases.
- c. Selection Bias. In one's store of memories from life, from literature, from historical accounts, and from gossip, there is a strong selection bias to recall or retell events that were surprising or of great consequence. For example, we

might hear and repeat the tale of the man who came home to find a note on the kitchen table that his long-term wife had decided to leave and that he should not to try to find her. If the note said instead that she was at the supermarket and would be back in half an hour, the event would likely never be recounted, much less retold or remembered. Thus, even a subject who was 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.

Our key lesson is that as individuals proceed through life, they should always be on the lookout for ignorance. When they do recognize it, they should try to assess how likely they are to be surprised—in other words, attempt to compute the base rate. In discussing this assessment, we might also employ the term “catchall” from statistics, to cover the outcomes not specifically addressed.⁹

Biases in computing magnitudes for CADs. Ignorance is only important if the expected consequences are significant. Thus, the magnitude of the consequence comes into play in addition to likelihood. The expectation of a CAD is the product of the two. (See section VI on expectations of magnitudes, and the expected value of CADs.)

We leave till another day a discussion of what a rational person should do after she recognizes a situation of ignorance, estimates its base rate of occurrence, and assesses its expected magnitude. She might discover that, in this context, ignorance is a major

⁹ In Bayesian statistics, the ultimate realized outcome must reside within one’s prior beliefs. The catch-all hypothesis is a residual category used to refer to “none of the above” hypotheses, so as to preserve this property.

consideration; then she has to decide what to do. Future investigations will be required in order to provide such an individual with guidance.

IV. Primary ignorance

Ignorance is a venture into unknown territory. Primary ignorance arises when that lack of knowledge is not even recognized. Under primary ignorance, the future seems either knowable or prosaic. One is lulled into proceeding without contemplating what opportunities and dangers lie ahead, and without even recognizing the potential for highly important events.

In literature, through its plots and the lives of characters, authors often demonstrate the measure of human life against ignorance. As we observe from the perch of the reader, we sense a vague unease, a foreboding that the often unaware characters before us face an effective, yet invisible, trickster. Ideally, we can learn from their decisions.

Primary ignorance ruins the life of one of fiction's most famous characters, Anna Karenina. Readers of *Anna Karenina* (1877/2004) know that, in this novel, a train bookends bad news. Anna alights from one train as the novel begins and throws herself under another one as it ends. As she enters the glittering world of pre-Revolutionary Saint Petersburg, Anna catches the eye of the aristocratic bachelor Count Vronsky and quickly falls under his spell. But there is a problem: she is married to the rising politician Karenin, the two have a son Seryozha, and society will not take kindly to the conspicuous adultery of a prominent citizen. Indulging in an extra-marital affair, especially when one's husband is a respected member of society, promotes the likelihood of unpleasant

CADs. But her passion for Vronsky dulls Anna's capacities for self-awareness. She becomes pregnant out of wedlock, a disastrous condition for a woman in nineteenth-century Russia. Anna consistently displays an unfortunate propensity to take action without recognizing that a terrible consequential outcome is possible. That is, she operates in primary ignorance.

Anna demonstrates all the characteristics of primary ignorance. She fails to consider all the possible scenarios that will occur from her impulsive decision making. She risks her marriage with Karenin, a kind if undemonstrative husband, who is willing to forgive and even offers to raise her illegitimate child as his own. Leaving Seryozha with Karenin, she and Vronsky escape to Italy and then to his Russian country estate. Ultimately, she finds that while Vronsky continues to be accepted socially, living his life exactly as he pleases, the door of society slams shut in her face. No one will associate with her and she is insulted as an adulterer wherever she goes. It is only when she is completely isolated socially and cut off from her beloved son that Anna recognizes the dangers of primary ignorance: she risked her family and her reputation for too little. She now reassesses the CAD that occurred: falling in love and becoming pregnant through an extra-marital affair. She realizes she was ignorant of the possible outcomes that jumping headlong into an illicit relationship would bring.

Primary ignorance can prevail in two different ways. First, thoughts of a possible CAD simply do not occur to us, in part because there are no signs of a possible CAD. Second, we may be presented with concrete signs of potential specific CADs but find ways not to see them.

The second way frequently appears in literary works, often in characters' romantic lives. A literary character demonstrates willful cognitive dissonance to justify an infatuation. It is, after all, cognitively burdensome to bear the weight of holding two mutually exclusive (or dissonant) beliefs simultaneously: one that the object of our affection is sublime perfection, the other that he is duplicitous.

Cognitive dissonance facilitates primary ignorance in Jane Austen's *Sense and Sensibility* (1811/2001). The romantic and impulsive Marianne Dashwood falls in love with the debonair John Willoughby. He seemingly reciprocates these feelings, leading her to believe that there is a wedding in their future. Then, her letters to him go unanswered, but her expectations do not dim. But at a London ball, his cold response shows Marianne she has been ignorant all along about his true character. The next day he writes her an excessively formal letter declaring his "affections have been long engaged elsewhere"—making this a CAD in Marianne's life. We later find out he is now engaged to marry Miss Grey, a woman of large fortune. It is only retrospectively after suffering a nearly fatal heartbreak, that Marianne realizes that Willoughby's adulterous and mercenary behavior was always a possibility. She also discovers his philandering past and realizes she had been ignorant and inconsistent in her thoughts about him.

In the 1920s, psychologist Carl Jung discussed the concept of "synchronicity," wherein two or more events that are causally unrelated are experienced and interpreted as connected events that have meaningful significance. For example, a person has a dream that corresponds to a closely related incident in real life; intimate friends have similar experiences or thoughts and we interpret this as "telepathy." Individuals do not like

unpleasant surprises and will do anything to understand and overcome ignorance, a process that sometimes involves repressing that possibility.¹⁰ But does this work?

Great works of literature suggest that it does not. Ignorance afflicts individuals because when CADs are possible, the past may be far from a prologue to critical future events. Situations of ignorance and the CADs they sometimes lead to are often *sui generis*. People turn out much differently from our expectations or their representations. This literary motif, that we have very little knowledge of who a person *really* is, turns up in dozens of plots from antiquity to the present day. They form the crux of the craft of Homer's *Odyssey*, the narratives that constitute Scheherazade's *One Thousand and One Nights*¹¹, rags-to-riches stories from nineteenth-century America¹², wheel-of-fortune accounts from the Middle Ages, fairy tales from seventeenth-century Europe, didactic stories, animal fables, and love stories. Literary characters do not see a pauper and question the likelihood that this is a prince in disguise, as he is so often in Shakespeare's plays and Gilbert and Sullivan operettas. Rather they see a pauper and take him to be just that. The possibility that he is a prince never flickers across their minds. Similarly, a woman disguised as a man—for instance, Portia in Shakespeare's *The Merchant of*

¹⁰ When repression is successful, we turn recognized ignorance into primary ignorance.

¹¹ In *One Thousand and One Nights*, also called *The Arabian Nights*, the daughter of the vizier of King Shahriyar marries the king and escapes the death that was the usual fate of his former wives by telling him a story every night, and interrupting each at a riveting point with a promised continuation the following night. To produce its intended result, each story depends on an unexpected ending and the king's utter amazement at this ending. At the end of a thousand and one such stories, the king is so taken by her gift as a raconteur that he pardons her. One might argue that the king's ignorance (of the power of stories and also of human nature) is what saves her.

¹² Horatio Alger's *Ragged Dick* (1868/1985) is a celebrated example. Going further back, Benjamin Franklin's *Autobiography* (1793/2012) contains distinct characteristics of the rags-to-riches genre.

Venice, whom Shylock calls a “good youth” and “a Daniel come to judgment”—can pass easily as a man without raising suspicion.

In the real world, a contemplated state of the world almost always occurs. This happens because we are able, most felicitously, to entertain the major scenarios that make up perhaps 95% or 98% of the density. Moreover, the outcomes we encounter are mostly positive. This is serendipitous: the future we envisioned and prepared for is one that transpires and is reasonably welcome. If this Pollyannaish world were all, decision theorists would prosper. They would prescribe how to craft subjective probabilities in a world of uncertainty, caution us against behavioral biases, and gather praise when most decision makers were pleased by the outcomes. In addressing their own decisions, the card-carrying Bayesian researchers among us would thrive.

But despite their sophistication, the methods of Jimmie Savage (decision theory) and Harry Markowitz (portfolio optimization) prepare us poorly for the world of ignorance we so often confront. We cannot assign subjective probabilities to states we cannot foresee. We cannot assemble an effective collection of assets using modern portfolio theory, if distributions are fat-tailed and not normal, and if Black Swans make frequent appearances.

CADs, generally unpalatable ones, often jolt us out of the cognitive lassitude of primary ignorance. As Warren Buffett sagely observes, most surprises are unpleasant. A woman marries a man of promise and he turns out to be a drunkard with a gambling problem. We invest in a well-funded terrific new startup and the business goes broke a year hence when its scientific genius runs off with his young assistant, when its lead

venture firm remarkably goes broke, or when three kids from California produce a superior competitive product.

A word of caution: We should be careful not simply to label an unusual extreme outcome, even a tragic outcome, as stemming from ignorance. For example, a swimmer's death by a shark attack is almost the opposite of ignorance. Such an outcome would invariably make the evening news, and be vivid in our imaginations. Few of us venture into the ocean without a brief flash of shark concern going through our minds.

Remember our requirement: Ignorance must be consequential before it becomes a concern. Unimagined events of extremely low probability by themselves fail to meet this standard. But if together they make up a non-trivial probability, say even 1 or 2%, they surely would. At the societal level, something that happens to one person is not consequential ignorance but if dozens were affected it would be. Thus in investigating societal ignorance, independence or dependence of outcomes across individuals becomes significant. Does this surprise matter to one person in a hundred or does it simultaneously affect many?

Few industries exemplify this dependence better than venture capital. Kleiner Perkins Caufield & Byers, the dot-com era symbol of Silicon Valley, was seemingly ahead of the curve in envisioning the future. Its early investments in Amazon, Google, and Netscape defined the technology boom of the 1990s. Kleiner investors in three venture funds the firm raised in 1994, 1996, and 1999—containing Juniper Networks, Amazon, and Google—received astonishing returns. The 1994 fund delivered 32 times

the investors' money, the 1996 fund 17 times, and 1999, six times.¹³ A money tree had been discovered. Investors scrambled to get into the funds of the venture firms. But they were ignorant. Kleiner's funds raised in 2000 and 2004 have been unprofitable. It was not just the isolated collapse of the leader. Venture funds as a whole returned 35.7 percent annually in the decade ending in 2000, but they lost 1.9 percent annually in the decade ending in 2010.

Primary ignorance and the impact of CADs show up constantly in the funding of U.S. start-ups. Research shows that around 75% of startups fail to return investors' capital, leaving venture capitalists to "bury their dead very quietly. ... They emphasize the successes but they don't talk about the failures at all."¹⁴ This is a staggering consequence of primary ignorance. Investors know they might lose it all but never entertain the potential for a fatality rate of 75%. They fail to contemplate many scenarios that lead to disaster, which thus represents what can only be categorized as primary, or unrecognized ignorance.

One might argue that many CADs were of such low probability that they might matter to the one person in one thousand to whom they happen and who is profoundly surprised, but they hardly matter on average. But that logic does not follow. From the standpoint of an individual, any specific meaningful surprise is highly unlikely and thus hardly matters, but in most situations of ignorance there are many such potential surprises that together count a great deal. Moreover, Black Swan events—irregular and unpredictable occurrences of historic significance—happen much more frequently than is

¹³ *New York Times*, May 7 2013. <http://dealbook.nytimes.com/2013/05/07/a-humbled-kleiner-perkins-adjusts-its-strategy/>

¹⁴ *Wall Street Journal*, September 19 2012. <http://online.wsj.com/article/SB10000872396390443720204578004980476429190.html>

believed (Taleb 2007). Thus we believe the first key question is: are people aware that they are in a situation of ignorance?

Primary ignorance traps us into seeing life through smoke and mirrors. The individual proceeds as if merely dealing with a situation of uncertainty; she believes her mental map has the bases covered. On life's smaller decisions primary ignorance may not matter, but it does on the bigger ones. And bigger ones are unlike lead actors; they are neither announced at the outset nor tabulated in the program.

Fyodor Dostoevsky's *Crime and Punishment* (1866/1989) provides a perfect example of decision making under primary ignorance. 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 the murder, her sister Lizaveta enters to his amazement. This is a situation of unrecognized ignorance—he had very precise information she would be elsewhere at the time. In a fit of self-preservation, Raskolnikov murders her too. Following this double murder, he remains immersed in a world of primary ignorance: each decision precipitates a chain of successive and increasingly unanticipated outcomes.

Crime and Punishment is particularly interesting as a study of primary ignorance. Raskolnikov deploys his impressive intelligence to plan the murder, believing, in his ignorance, that he has left nothing to chance. In a series of descriptions not for the squeamish or the faint-hearted, 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 (what is

the precise manner in which he will carry the axe?; what strategies will help him avoid detection) are revealed.

But since Raskolnikov is making decisions under primary ignorance, his determined rationality is tightly “bounded.” 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). The second-guessing, fear, and delirium at the heart of Raskolnikov’s thinking as he struggles to gain a foothold in his inner world show the impact of a cascade of CADs, none predicted, none even contemplated. Raskolnikov anticipated an outcome in which he would dispatch the pawnbroker and slip quietly out of her apartment. He could not have possibly predicted that her sister would show up, a characteristic CAD that challenges what Taleb (2012) calls our “illusion of predictability.”

Two conclusions may be drawn apropos of decision making under unrecognized ignorance: First, we tend to downplay the role of unanticipated events, preferring instead to expect simple causal relationships and linear developments. Second, when we do encounter a CAD, we often counter with knee-jerk, impulsive decisions, the equivalent of Raskolnikov committing a second impetuous murder.¹⁵

V. Recognized ignorance: Biases and heuristics in response

There are two ways that consequential ignorance can be recognized: An individual can contemplate the future and realize that she simply can’t identify some

¹⁵ In the modern day, Aaron Hernandez followed in Raskolnikov’s footsteps, having to murder again. Truth has proved as strange as fiction.

important possible outcomes. Alternatively, a CAD appears and the individual is jolted into reality.

Our study of ignorance is motivated in part by observing humans attempt, as described in literature, to simplify decision making under ignorance by applying well-known heuristics. These mental rules-of-thumb allow decisions to take place expeditiously, bypassing complex cognitive algorithms (Shah and Oppenheimer 2008). We seek to identify decision heuristics that individuals employ within the context of recognized ignorance, a category that frequently defies the application of the standard tools for optimal decision-making. We expect to see these heuristics at work in the real world in decisions as diverse as on investments, medical treatments, and romance. It is our hope that studying ignorance using our proposed methodology will extend current heuristic theories and facilitate research in areas beyond already well-identified deviations from the Expected Utility model.

Our jolted individual now recognizes her ignorance. When this happens, she attempts to control both the past and the future through complex inter-temporal recalculations. Affect, or experiencing risk as feelings, plays a strong role post-recognition (Loewenstein et al. 2001; Slovic et al. 2004). Affect-rich outcomes lead to an overweighting of small probabilities of events that can be imagined and underweighting of large probabilities (Rottenstreich and Hsee 2001). There is a bias in our treatment of ignorance. We ask ourselves, what could go wrong on our trip to China? We think about losing our passport or missing our connecting flight and exaggerate the probability of these possibilities. But a dozen worse events that might happen go unrecognized. Elsewhere, wishful thinking (making future decisions through a combination of emotion

and fantasy) and poor memory for past visceral states has been studied in the context of future behavior (Read and Loewenstein 1998; Loewenstein 2000).

Recognized ignorance spawns its own specific heuristics. They arise in two categories: making peace with the past, and actions taken now.

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Making peace with the past.

Retrospective recollection of contemplation (RRC). Once we recognize ignorance, we attempt to make peace with inconsistent thoughts and attitudes. Retrospective recollection of contemplation (RRC) whitewashes our past ignorance. Though we did not contemplate the CAD that transpired, RRC leads us to erroneously recollect that it was on our menu of possible outcomes. To borrow a metaphor from geography, we believe the CAD was on our mental map of the world, although it was not. RRC is closely related to the hindsight bias (“I knew it all along”) and to cognitive dissonance (Fischhoff and Beyth 1975; Festinger 1957), but is a specific response to the occurrence of a CAD.

Once a CAD, with its salient consequences, has occurred, our emotions cloud our memory. Our reconstituted past alters reality to make sense of our ignorance. RRC makes us creative curators of history. Memories are transformed when “we see through a glass, darkly.” Moving from the words of Apostle Paul to those of poet Percy Shelley, we are reminded that “We look before and after, [a]nd pine for what is not.”

Authors frequently demonstrate RRC in the domain of intimate relationships. Literary characters see before them a blushing haze of imagined bliss, only to discover, after a CAD strikes, that the road ahead led to misery. Post CAD, they recollect,

erroneously, that they had contemplated such an outcome—the partner turns out to be a closet dipsomaniac, the groom reveals himself to be a two-timing cheat—as a possibility.

Frequently we 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, we see but we do not observe. Isabella Linton in Emily Brontë's *Wuthering Heights* (1847/2003) ignores clear evidence and stated warnings about Heathcliff's appalling character, turns a blind eye to these clues to reduce her cognitive dissonance, and elopes with him believing his professions of love are genuine. Immediately after the wedding, a CAD strikes; Heathcliff turns out to be exactly as cautioned—violently abusive, neglectful, and having had designs all along on Isabella's considerable fortune.¹⁶ Isabella then convinces herself she always knew he would turn out like this, because she had seen the evidence in his past behavior. Her ex-post understanding represents an extreme version of RRC. *A priori*, Isabella displayed primary ignorance about her future husband's true character, despite the obvious signs. Worse, her erroneous retrospective recollection was not merely that she contemplated the possibility that Heathcliff would turn out to be an abusive husband, but that she actually knew that he would.

Actions taken now.

1. *Barn door closing.* Barn door closing behavior arises when we have just been astonished, our past ignorance becomes well recognized, and we have a chance for a repeat decision (Patel et al. 1991), albeit in a new environment. We take actions today

¹⁶ Isabella writes this letter in distress shortly after her elopement: "Is Mr. Heathcliff a man? If so, is he mad? And if not, is he a devil? I [...] beseech you to explain [...] what I have married."

that we should have taken yesterday, just as we should have closed the barn door before the horse escaped. After stock market collapses, many investors swear off stocks forever, a strategy captured in the popular expression “Once bitten, twice shy.”

As a decision bias, this memorable metaphor of equine provenance represents an attempt to re-align past with present. The individual looks backward, seeking to contain regret, and attempts to remove reminders of past errors through present choices. Barn door closing is a phenomenon we encounter often in the novels of Jane Austen who “looks at how the relationship between a person’s multiple selves can be more complex than a simple chain of command” (Chwe 2013). In an example that *Pride and Prejudice* readers will recognize instantly, Darcy does everything in his power to mend his relationship with Elizabeth by helping her family when her youngest sister Lydia elopes with the disreputable Wickham, even though Wickham and Darcy have a long history of personal enmity. This is “barn door closing” at its best: remedying the past through present actions.

Although barn door closing is found in the world of finance, it makes little sense there, since prices more or less reflect current expectations. But one might think that it is a good response in the world of social relationships. After all, one would be “mending” the past by improved (or “better”) behavior in the present. But this is often not so. Shakespeare frequently relates this propensity and its limitations. King Lear realizes too late that his past self, full of the self-importance of royal power, has misjudged his genuine daughter Cordelia and given too much credence to his other two daughters, Goneril and Regan and their false professions of filial love. Prospero in *The Tempest* regrets, at the end of the play, having neglected his duties as Duke of Milan in favor of a

life of the mind, which ultimately allowed his jealous brother to depose him. Lady Macbeth urges her husband to cease his regrets on the murder of King Duncan, something they both realize they cannot go back and change: “Things without all remedy / Should be without regard: what’s done, is done.” Barn door closing, whether in life or in fiction, is rarely an adequate response to ignorance when finally recognized.

When ignorance is recognized, any of three common biases may emerge:

1. *Status quo bias.*
2. *Action bias.*
3. *Indecision Bias*

1. *Status Quo Bias* (SQB) leads one to stay the course by “doing nothing or maintaining one’s current or previous decision” (Samuelson and Zeckhauser 1988). A psychological explanation is that errors of commission weigh more heavily than errors of omission (Ritov and Baron 1990, 1992). This bias is reinforced when most outcomes are likely to be bad. A switch in strategy that leads to a bad outcome is more susceptible to blame from others, or indeed oneself, than simply sticking with things as they are and doing equally poorly.

Sophocles’s *Antigone* (441 BCE/1984) illustrates the two claims at the heart of SQB: first, that people prefer to stick to the status quo; second, that they are naturally reluctant to take actions that will require leaving this state. Sophocles’s eponymous heroine has seen her two brothers Polyneices and Eteocles kill each other in an internecine war for the control of the kingdom of Thebes. Thebes’s current ruler, also Antigone’s uncle, Creon regards Polyneices, who involved a foreign army in the struggle for political control of Thebes, as a traitor, and decides to punish him even in death by

denying his body a decent burial per religious rites. He also passes an edict threatening death to anyone who gives Polyneices's body a burial.

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 CADs could result from his edict. Antigone, Creon's niece and future daughter-in-law, decides, at first secretly, to give her brother Polyneices a proper burial. 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, Creon is himself defying the much higher religious authority of the gods. Unfortunately, she is seen and arrested. At this point, Creon orders the execution of Antigone by entombing her alive.

The blind prophet Tiresias (see section II of this essay) warns Creon about the CADs that will follow from his edict. He predicts that if Creon does not permit Polyneices's burial, the gods will curse the kingdom of Thebes and disaster will ensue. Upon this catastrophic forecast, Creon finally recognizes that holding on to his past decisions may not be a good idea. He decides to free Antigone and give Polyneices proper rites of burial. But it is already too late. Antigone has already hung herself, thereby defying Creon's tyranny even in death. Haemon—her fiancé and Creon's son—distraught at Antigone's death, tries to kill his father but accidentally ends up killing himself. Creon's wife, Eurydice, commits suicide upon receiving the news of her son's death.

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; Kahneman and Tversky 1984), the availability heuristic, and the overweighting of errors of commission versus those of omission. For Creon, his current status as Thebes's omnipotent ruler serves as his reference point. Changing his policies about the treatment of a traitor would bring about a readily anticipated—hence readily available—loss of status, as opposed to the gain of being regarded as compassionate. The CADS that actually resulted, by contrast, were obscured from view by his ignorance. Finally, should Creon change his stance and lose authority and influence, he would have committed an error of commission, weighted more heavily, *ceteris paribus*, than doing nothing, and having bad things happen.

2. *Action Bias* (AB) arises when people take actions when standing pat or simply waiting would be preferred in expectation (Patt and Zeckhauser 2000). AB is the converse of SQB. It is likely to operate when most outcomes will be favorable. People seek credit from themselves (as well as others) from taking an action that leads to a good outcome. Often it is not clear what would have happened had they simply stuck with what they had. Thus, the talented new college graduate may venture to a new locale, knowing he will engage in self-congratulation when life there proves attractive.

Emma Woodhouse, the eponymous heroine of Jane Austen's novel *Emma* (1816/2004) is a beautiful and affluent woman who, as the novel begins, has just attended the wedding of her former governess Miss Taylor to a Mr. Weston, two people she introduced. She is quick to take credit for the match and falling prey to the availability heuristic, overestimates her likelihood of future success. She believes that if she becomes

a full-time matchmaker she can create many similar romantic alliances. Emma exhibits strong AB: she likes to affect outcomes when gains are reaped, overestimates the ease of the task, her capabilities, and the likelihood of finding suitable matches (a difficult task especially in the small, socially circumscribed village of Highbury). She is also ignorant of the consequences her meddling might produce. Consequently, Emma's AB imposes losses on the way, most importantly in the lives of other people. Her best friend Harriet Smith, a woman born out of wedlock, gets a marriage proposal from a perfectly eligible, middle-class farmer called Robert Martin. But Emma encourages Harriet to reject this match by suggesting she should aim higher, in this case the local vicar Mr. Elton. Harriet's illegitimacy in eighteenth-century English society means few men will ever offer to marry her. Besides the vicar has no interest in Harriet for reasons Emma never imagined. He has his sights set on Emma and her considerable fortune. Emma is shocked and disgusted by his romantic interest in her. In time, Emma comes to realize how frequently AB clouds her decision making. At the end of the novel, Harriet marries Robert Martin, and they are perfectly happy and clearly well suited. Emma finally comes to see that she is often blind to ignorance, and that the AB of her meddling ways had been misplaced. She concludes she should allow others to make their own choices.

3. *Indecision Bias (IB)* arises when one must choose among alternatives, the future is cloudy, and high-magnitude outcomes are possible. Many individuals get frozen with indecision, putting off till tomorrow what should be decided today, particularly when postponement will not secure new information.¹⁷

¹⁷ That the English language has so many inventive names for this bias—"shilly-shallying," "letting the grass grow under one's feet," "lollygagging," "dilly-dallying," "sitting on the fence"—must surely tell us how common indecision is.

It is perhaps a Zen-like axiom that not taking any action is also a form of action. When individuals recognize their ignorance they frequently respond through complete inaction or a state of being frozen with indecision, a phenomenon we label *indecision bias* (IB). IB is not rooted in the impulse to gather more information; it is, on the contrary, wishful waiting for the situation to resolve itself on its own. At times like this, we might heed President Roosevelt's (1933) words: "[L]et me assert my firm belief that the only thing we have to fear is fear itself—nameless, unreasoning, unjustified terror which paralyzes needed efforts to convert retreat into advance." IB, motivated in part by fear of error, is a fundamental affliction.

The recognition of ignorance accentuates difficulties in decision-making among the already indecisive. Too much positive evidence is required before making the switch from a known to an unknown choice (Trautman and Zeckhauser 2013). Thus IB can prove costly. In a situation of recognized ignorance, often a switch from the status quo or some other action yields information that will prove extremely valuable in repeat-choice situations. Yet individuals vastly underestimate or completely ignore this benefit when the action they take is "unable to decide."

Shakespeare's Hamlet provides a splendid exemplar of IB. He recognizes his ignorance and responds by, well, doing nothing ("To be, or not to be: that is the question"). Hamlet discovers that his uncle, the now King Claudius, murdered Hamlet's father and married his widow (Hamlet's mother). His father's ghost urges Hamlet to avenge his death, 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’s indecision is followed by its opposite, rash action. For example, 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 uncle and his father’s purported murderer. Hamlet rashly runs him through with his sword. Alas, for Hamlet, a CAD strikes again. The man behind the tapestry was Polonius, the Lord Chamberlain, who was eavesdropping harmlessly.

Even when ignorance is recognized—for example, Hamlet receiving the inconceivable news that his uncle murdered his father—the individual may respond with IB. This is behaviorally mystifying. Why, even with our new awareness, do we fail 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 in some sense gets overwhelmed as it seeks to bridge the chasm between reality and expectations. If so, doing nothing is the least cognitively expensive activity, and the one most likely to avoid an error of commission.

VI. Toward Measured Decision Given Ignorance

To develop a fully rational approach to decision making under ignorance will be a task for many folks over many years. Here we offer just a few snippets of what that approach might entail, using the less lofty title of *measured decision*, suggesting doing something reasonable, if not optimal. Two elements have already been stressed:

1. Always be on the lookout for ignorance.

2. Where ignorance might be present, try to assess its base rate. This assessment is intended to sound a warning siren for seriously attending to ignorance. Much of the time it will relieve us from being on high alert, which is draining both emotionally and in terms of cognitive function. Where base rates are *de minimus*, traditional decision procedures are likely to be effective.

When the base rate appears meaningful, you must next assess potential magnitudes, and then you put the two together.

3. Try to assess the expected magnitude should a CAD occur. That task is even harder than assessing the base rate for CADs. You must pull together a variety of CAD experiences from your own life and what you have learned from elsewhere, including the media and literature. You must then calibrate their magnitude, and then extrapolate from that heterogeneous sample to what might happen in a particular future.

First some observations about magnitude. Many CADs will involve payoffs that are not readily assessed on a monetary basis, a birth thought not possible, an unexpected death. Prescriptive decision theory would recommend that vonNeumann-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 100.¹⁸ 0 would be the status quo. Then each CAD outcome would be placed on this scale using traditional lottery procedures. Values above 100 and below $-X$ would be expected.

If we are primarily worried about CADs, and the expected level of ignorance, negative values would be weighted equally with positive values of the same magnitude.

¹⁸ Note, we do not assign the bad outcome a utility value of -100, because it may be hard to think of an outcome with precisely that value.

Thus, we would compute the expected absolute value of a CAD. Note, since these are VN-M utilities, weighting them by probabilities is appropriate.

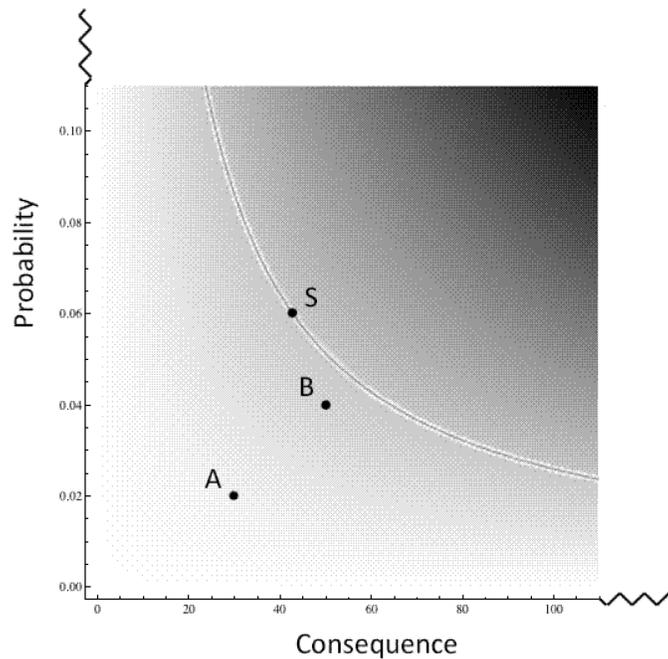
We recognize that this calibration process would be challenging. First, it addresses ignorance, and assessing the magnitude of consequences that we can't even imagine. Second, this process would be afflicted with the availability heuristic. Surely more extreme outcomes would be more easily brought to mind. Third, and cutting in the opposite direction, the world of unforeseen outcomes is dense with fat-tailed distributions. This implies that the average of what we have seen thus far is likely an underestimate of the expectation of what we will see in the future. There is much work here for decision theorists to do.

Posit for the moment that we could identify the distribution of magnitudes for potential CADs. We would then compute their expected value, namely sum the probability times the absolute utility for each potential outcome. Another way to get at the same concept, perhaps an easier cognitive task, would assess the overall likelihood of a CAD and then assess the expected absolute utility of a CAD. Multiplying these two values together would give the same result as the summation procedure.

The figure below shows the outcome of such calculations. It shows the Expected Consequences from Consequential Amazing Developments. Any individual CAD would be represented by a point on the graph. The greater its consequence, the greater its probability, the greater is its contribution. The figure gets darker, the expected consequences of ignorance increase, as we move in a northeasterly direction. The figure shows such two points, A and B. It also shows S, 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 any point on the rectangular hyperbola through S yields the same expected consequences. In essence, this procedure identifies the importance of ignorance.

Expected Consequences from Unidentified States



Posit that we know that consequential ignorance is lurking. How should we respond to it in a deliberate, thoughtful, and considered fashion? 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, and to more information gathering along the way, enabling a switch in strategies if and when early indications of a CAD appeared.¹⁹

¹⁹ We often encounter such decision-making in mystery fiction. Agatha Christie's fictional Belgian detective Hercule Poirot uses a process of gathering information,

Societies—working through the government or mediating institutions, including the market—also must take actions in advance of potential CADs. As 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 have experts, governments, and research organizations qualified to give guidance. A full analysis of how a rational decision maker – whether individual or societal -- should proceed once ignorance is recognized is, as mentioned earlier, a challenging task well beyond this essay.

Nevertheless, once again, literature provides some guidance. We look to the formidable strategist, Greek hero Odysseus. Roman poet Virgil's *Aeneid* identifies Odysseus as the mastermind behind the Trojan Horse, an equine figure made of wood, presented as a gift but concealing Greek warriors intent on the destruction of Troy. Odysseus correctly conjectured that the Trojans would not recognize their ignorance upon receiving a massive gift from their enemy. 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 may well be taken as a recommendation for strategic decision-making under ignorance: It is not that you should be able to foresee the unforeseeable. That is

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). Arthur Conan Doyle's famous detective Sherlock Holmes stresses cognitive flexibility—an 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."

impossible. But you should be able to recognize that you are often in a situation of ignorance even though there are no visible signs.²⁰

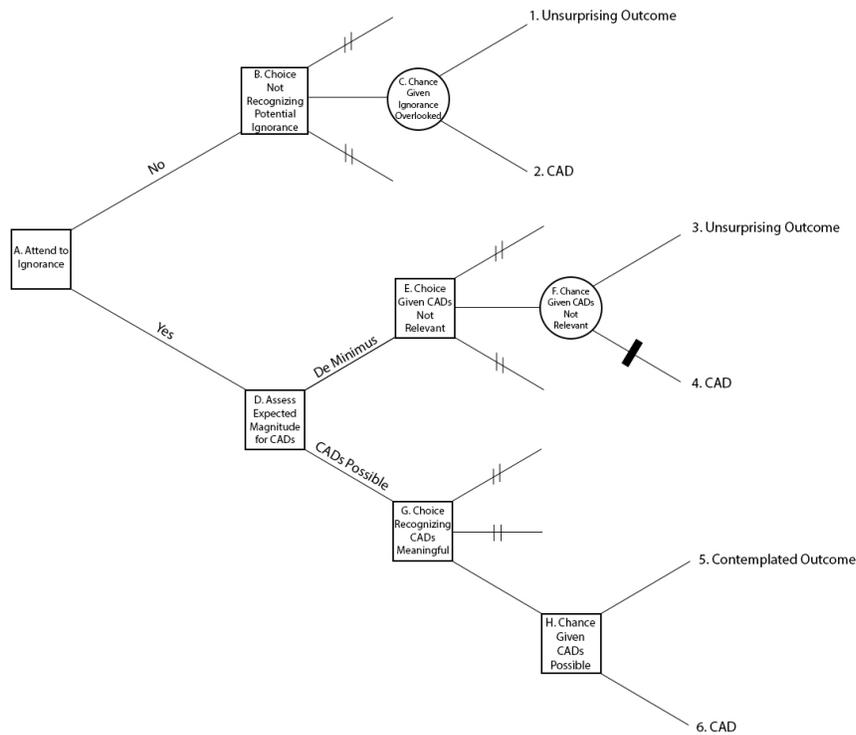
In the *Odyssey*, Homer's epic poem that describes Odysseus' ten-year-long journey home to Ithaca following the destruction of Troy, he is repeatedly faced with situations never encountered in the past—in other words, situations of ignorance. Whether marooned on Calypso's island, blinding the Cyclops Polyphemus, outmaneuvering the enchantress Circe, or, in the final account, proving his identity to his skeptical wife Penelope, Odysseus' adventures reveal measured decision making in the face of ignorance. Can we elevate Odysseus to the status of a rational decision theorist? Quite probably not. Are these situations ones that we might reasonably encounter in the twenty-first century? Almost certainly not. But the larger lesson is that Odysseus has a shrewd capability to recognize situations of ignorance, and to take strategies that would help him get through them. Absent that, he would not have come out alive.

The decision tree below shows the challenge of confronting ignorance. The decision tree below shows the two paths for confronting potential ignorance. The first choice is whether to attend to ignorance. The upper branch, "No", proceeds to primary ignorance. CADs are not considered, though they might arise. The lower branch, "Yes", represents the first step in measured decision. At box D, the decision maker must assess the expected magnitude of CADs. This requires estimating their base rate and then multiplying that rate by the expected magnitude of a CAD should one occur. If the product is *de minimus*, CADs need not be a concern; box E is reached. Given that CADs are meaningful at G, a different choice might be taken, with a tilt toward flexibility. Note

²⁰ The Trojans had another potential warning sign, the prophecy of Cassandra, the daughter of their king, that the horse would be their city's downfall.

that the choices available at nodes B, E and G are the same. At B and E, where choices are made respectively ignoring CADs and knowing they are not a concern, the same middle choice is taken. At G, the lower choice is selected, being more robust against CADs. The ultimate payoffs at 1 and 3 are the same: middle choice and unsurprising outcome. Those payoffs are superior in expectation to the payoff at 5, which though a contemplated (unsurprising) outcome, sacrifices somewhat in choosing the lower branch to protect against CADs. However, the payoff at 6 is well superior in expectation to that at 2, since the choice of the lower branch at H was to protect against CADs. When the tree is folded back, the expected payoff at D, measured decision, is greater than it is at B, primary ignorance.²¹ That is because the decision maker changed actions at D, when CADs were determined to be meaningful. (Had the middle choice been optimal at G, the strategies would be the same throughout, and the expected payoffs for the two branches would be the same.)

²¹ Note, all these payoffs were done in expected values. In some realizations, for example, the payoff at 6 will be below that at 2.



VII. Discussion and Conclusions

Traditional decision theory assumes that the future that arrives will be on our menu of possibilities. CADs are thus chimerical beasts. But as life and our literary examples make clear, consequential amazing developments do happen, to individuals and to societies. Robert Burns warned us against making choices without recognizing their possibility, that is proceeding in ignorance: “The best laid schemes of mice and men often go awry.”²²

²² From Scottish poet Robert Burns’s “To a Mouse, on Turning Her Up in Her Nest with the Plough” (1785), the phrase has been used, memorably, as a title for John Steinbeck’s *Of Mice and Men* (1937). “To a Mouse” is an unlikely but pertinent source for its commentary on ignorance. In these lines, for instance, the poet tells the mouse that people (like mice) suffer from CADs regardless of how well prepared they think they are:

But little Mouse, you are not alone,
In proving foresight may be vain:

Our examples lead to a more sobering conclusion: Proceeding in ignorance is ingrained in the human condition. Not only is it impossible to imagine all future states of the world, or even all future consequential states of the world, but also few of us have a natural inclination to attend to ignorance. Like keeping your eye on the ball in tennis, or leaning downhill in skiing, it is an unnatural skill that has to be learned. To be clear, we cannot learn what outcomes there are that we cannot imagine. But we can learn to expect outcomes that we cannot define. And when they are likely to be consequential, we can lean toward actions that are robust against them.

We recognize decision-making costs, and the costs of contemplating unknowable futures, but still we recommend that folks engage in the following exercise. Ask yourself: Given the situation that I am in, what is the likelihood of something consequential happening that I did not even imagine? And once I have pondered that question, what is the expected magnitude of the consequence of such an event?

If one is leading a prosaic life, and is continuing in the quite normal course of affairs, the probability is likely small, and the expected magnitude is likely small as well when compared to the experience of most leading literary characters. Thus, the ordinary worker with an ordinary family living in ordinary times meets CADs only rarely. But even for them, there are unexpected accidents, deaths, job opportunities, romances, and societal events. Think of the typical Cairene clerk of five years ago, who expected nothing special to happen in the coming years. Now she has seen tumultuous events, multiple times. The typical clerk in a typical city has had a much less exciting five years.

The best laid schemes of mice and men
Go often awry,
And leave us nothing but grief and pain[.]

Nevertheless, as the chroniclers of everyday life, from Jane Austen and Franz Kafka to those who write soap operas, make clear, even everyday folks living in ordinary times experience CADs.²³ They face but frequently fail to attend to ignorance. Consequential amazing developments are well documented in our laboratory: literature. They are a critical element of human existence.

²³ Consider Kafka's *The Metamorphosis* (1915/1996) with its shocking first sentence, a CAD on every level: "As Gregor Samsa awoke one morning from uneasy dreams, he found himself transformed in his bed into a giant bug."

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