Pascal's Wager

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1   Pascal's Wager and the Origins of Decision Theory: Decision-Making by Real Decision-Makers

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Philosophers approach Pascal's Wager with an initial impression that it is "too good to be true" (Hájek, 2003). That gives them permission to indulge a professional disposition to invent "what-ifs" involving gods with strange motivations, arbitrary distributions of probabilities and payoffs, and calculations with hyperreals and infinitesimals.

Risk analysts involved in actual decision-making, such as safety engineers for nuclear power plants, cannot allow themselves such intellectual luxuries. Serious decision theory keeps to realistic ranges of possibilities and associated risks. As Pascal and his interlocutors knew, choice of religion is equally serious. The person faced with that choice has an obligation to avoid frivolity.

A survey of Wager-like thinking before Pascal is useful. It shows how ingrained into real religious thinking the decision-theoretic considerations of the Wager are. The idea of the Wager applies much more widely than to the particular choice of options and payoffs that Pascal describes. As we will see later, the same applies, though differently, to the present-day situation.

1 Pre-Pascalian Versions of the Wager

Arguments with a broad similarity to Pascal's Wager are traditional in both popular and learned religion (Ryan, 1945). No doubt the "worth a shot" or "insurance policy" aspect to religion has always been part of its appeal, as well as a source of the lukewarmness in faith that can so exasperate the zealous. The Christian apologist Arnobius, about 300 CE, is probably the first to express the argument in a form that recognizably involves the rationality of a decision

in a case of doubt. His reasoning involves doubt, rewards, and decision in response to the doubt and rewards, but not exactly probability:

> There can be no proof of things still in the future. Since, then, the nature of the future is such that it cannot be grasped and comprehended by any anticipation, is it not more rational, of two things uncertain and hanging in doubtful suspense, rather to believe that which carries with it some hopes, than that which brings none at all? For in the one case there is no danger, if that which is said to be at hand should prove vain and groundless; in the other there is the greatest loss, even the loss of salvation, if, when the time has come, it be shown that there was nothing false in what was declared. [Arnobius, 300 CE, 2.4; 1907–1911, p. 434]

That is more generic than Pascal's version, and so directs attention to the core of the argument, as well as showing its adaptability. As often noted, the reasoning has the same form as the "precautionary principle" applied to such cases as global warming. A twenty-first century "Arnobian" might argue: "there is no danger [in carbon reduction, even if some inconvenience] if that which has been said to be at hand [about the risks of climate change] should prove vain and groundless; in the other there is the greatest loss, even the loss of [much of the world's dry land], if, when the time has come, it can be shown that there was nothing false in what was declared." That suggests that reasoning of a Pascalian nature is commonly taken to be sound, in cases of genuine risks.

The generic nature of Arnobius's argument, expressing common hopes, should be kept in mind when we consider whether objections to the details of Pascal's argument carry over to more general versions.

The comparison of choosing religion to a bet and the infinite payoff of choosing religion, both ideas that are important in Pascal's version, were added by William Chillingworth in his 1638 book *The Religion of Protestants a Safe Way to Salvation*. Chillingworth also uses the language of probability, which Pascal avoids but which has been commonly used since. He writes:

> For who sees not that many millions in the world forego many times their present ease and pleasure, undergo great and toilsome labours, encounter great difficulties, adventure upon great dangers, and all this not upon any certain expectation, but upon a probable hope of some future gain and commodity, and that not infinite and eternal, but finite and temporal? Who sees not that many men abstain from many things

they exceedingly desire, not upon any certain assurance, but a probable fear, of danger that may come after? What man ever was there so madly in love with a present penny, but that he would willingly spend it upon any little hope, that by doing so he might gain a hundred thousand pounds? And I would fain know, what gay probabilities you could devise to dissuade him from this resolution. And if you can devise none, what reason then or sense is there, but that a probable hope of infinite and eternal happiness, provided for all those that obey Christ Jesus, and much more a firm faith, though not so certain, in some sort, as sense or science, may be able to sway our will to obedience, and encounter with all those temptations which flesh and blood can suggest to avert us from it? [Chillingworth, 1840 [1638], pp. 430–31; Franklin, 2001, p. 250]

For later reference, we should note Chillingworth's observation that Wager-like reasoning typically works with large finite payoffs. The infinity of religious payoffs is not essential.

The closest parallel to Pascal's Wager in earlier work occurs in the 1637 book *On the Immortality of the Soul*, by Antoine Sirmond, one of the Jesuits most severely attacked in Pascal's *Provincial Letters*. Sirmond's version contains very explicit balancing of risks and rewards. As in Arnobius, but unlike in Pascal, much play is made of the downside risk of eternal damnation:

Without favouring one party or the other, let us suppose there were nothing decided in the matter, and that it were problematic and equally doubtful on either side ... There is no man of good sense who would not rather lose a day or an hour of his pleasures than risk an eternity of happiness, or who would not choose to endure in the present a pinprick for a quarter of an hour, rather than put himself in danger of a torment which would have neither moderation of its rigour, nor limit to its duration. Compare the goods of this life with those to be feared or hoped for in the next, if there is a next life, and you will find there is no more proportion between the terms of this comparison than there is between the stakes and the rewards of this choice. What will happen to the man of vice? He prefers to play for the present than to attend to the future. And if the future deals with him otherwise than he thinks, if his soul finds itself taken on leaving the body, and finds itself existing in the midst of the sufferings it will have deserved, what will be his condition? Truly to have inherited an eternal evil for a moment of the pleasures of

which this life has delivered the enjoyment; to have lost eternal happiness that could have been bought at the price of a little pain in the exercises of several virtues contrary to his humour. Will he not reason, and tell himself thereafter: if I die completely when I quit this earthly coil, my lot will be to have avoided the evils of this life, and to have embraced its goods, as far as I could. In addition, I have naught either to fear or to hope, beyond the experience of sixty or a hundred years or so, that will be the most that will roll past me. If, on the contrary, I were to find after death a land where one lives longer than one does here, I would see myself condemned to torments intolerable in their gravity and infinite in duration. I would feel myself excluded from a state happy in proportion, full of all sorts of goods, and assured for eternity. What then is to be done? [Sirmond, 1637, pp. 456–61, quoted in Blanchet, 1919, pp. 628–30; Franklin, 2001, pp. 251–52]

Sirmond considers the objection that what is in the present is certain, while the supposed future life is only a prospect. He replies: "It is true that certainty in the present is worth more than uncertainty in the future, as long as there is some proportion between the two. But when it is a matter of eternal life or death, how can there be any comparison with a temporal life or death?" There is a Latin edition of Sirmond's book, which generally agrees with the French edition but goes further in comparing the choice between religion and "the world" to a game of chance:

No-one is a man of truly sound mind, who with a not unequal partner, wants to play dice or ball or any kind of game, such that if he wins, he gains a penny, while if not, he loses a most flourishing and opulent and everlasting kingdom ... However long and happy the space of this life may be, while ever you place it in the other pan of the balance against a blessed and flourishing eternity, surely it will seem to you, if the weight of things be known, that the pan will rise on high even as if you were to weigh a penny against the weight of gold of the most splendid kingdom ... [Sirmond, 1635, pp. 390–92, quoted in Blanchet, 1919, pp. 633–34]

Examining these versions in conjunction with Pascal's thus allows us to extract certain features which might not be so clear if we focused solely on Pascal's text. They include the adaptability of the Wager to more generic spaces of choices, the importance of downside risks, and the applicability of the Wager when payoffs are large but finite.

2 Pascal and the Decision Theoretic Perspective

The strength of Pascal's own version of his Wager is its focus on the decisions of a real agent. It is not about probabilities and payoffs in an abstract Platonic space of pure reasons and disembodied probabilities, but about the decisions faced by a person in doubt in the Paris of 1660 (and by extension, the decisions faced by other real persons in different religious contexts).

That already explains why some of the simpler objections to the Wager are misconceived. It is no use arguing that belief is not a matter of decision so that one cannot decide to believe in God. Pascal is well aware of that and his conclusion is strictly about action: "taking holy water, having masses said, and so on." The point of those actions is not to gradually deceive oneself into belief, either. Pascal, the radical Jansenist skeptical of free will, has no time for free actions leading to belief. In his view, faith is a gratuitous and undeserved gift of God, and the most one can do is to remove the obstacles to the action of divine grace – even that is doubtfully compatible with the rigorous determinism of Jansenism. Pascal certainly does not believe in salvation through pretending to believe, or acting "as if" religion is true – that is exactly what he criticized Sirmond for, when Sirmond had argued that one might be saved with good works "as if" one passionately believed in God but without inwardly doing so (Elster, 2003).

Nor is it any use complaining about the moral tone of the Wager. The Wager has often been obscured by a caricature of itself: "Being base and greedy, we want lots of goodies in this life and, if possible, the next. So we are prepared to give up some pleasures now, on the off chance of a lot more later, if our eye to the main chance makes it look worth our while. Since the loot on offer is infinite, even a small chance of raking it in makes it worth a try to grovel to any deity that might do what we want" (Franklin, 1998). Voltaire makes a bid for the high moral ground in saying, "That article seems a bit indecent and childish; that notion of gambling, of losses and winnings, does not suit the gravity of the subject" (Voltaire, 1961 [1778], p. 123). Possibly for this reason, the Wager has been almost as unpopular in religious circles as it has been in atheist ones. It is all beside the point. The motives anyone has for adopting an argument's conclusion have no bearing on the logical validity of the argument. That is the point of classifying *ad hominem* arguments as fallacies. Pascal's strict decision-theoretic approach bypasses any such complaints. An agent – in his time or ours – faces a forced bet, and so is obliged to consider the payoffs. He may take advice from his psychoanalyst on his motives if he wishes, but that will not affect what he hears from his philosophical adviser.

Pascal has the answer. "You must play." Having admitted that, it is time to consider the options, the probabilities and the payoffs.

3 The Range of Options (of a Real Agent)

Proponents of a Pascalian wager argument, including Pascal, are inclined to represent the religious options as two: theirs versus the rest (or often, theirs versus atheism). They would say that, wouldn't they? Others may be skeptical. "An imam could say as much as Pascal," as Diderot (1875 [1746], p. 167) quite rightly said, and a modern perspective may well see a considerably wider range of religious options as having some initial credibility.

That has often been claimed as a serious weakness of the Wager. Flew says, "The central and fatal weakness of this argument as an argument is that Pascal assumes, and has to assume, that there are only two betting options" (Flew, 1976, p. 66).

That cannot be right, since decision theory applies to any spectrum of hypotheses, with any distribution of probabilities across them, and with any set of payoffs. Whether Pascal's reasoning applies in some wider setting than the one he assumes remains to be seen. Perhaps the differences when the spectrum of options is wider are inessential to the argument, perhaps not. The applicability of the Wager to different spaces of options cannot be ruled out beforehand.

So, for a real agent contemplating the choice of religion, what is the spectrum of options?

That is for the agent to say. As for any real decision problem, the agent has a (typically narrow) range of options that are genuine, or really on the table, or realistically under consideration. For one thing, a real agent has only limited cognitive power and so can only feasibly manage a few options. But even apart from that, any case requiring decision has to constrain attention to those options that are in some sense realistic. In risk analysis and criminal trials, for example, risks have to be initially divided into genuine and fanciful. In evaluating the guilt of the accused in court as "beyond reasonable doubt," scenarios where he might be innocent have to be sorted into those genuinely probable and those merely possible to think up. In Lord Denning's famous statement,

> Proof beyond reasonable doubt does not mean proof beyond a shadow of a doubt. The law would fail to protect the community if it permitted fanciful possibilities to deflect the course of justice. If the evidence is so

strong against a man as to leave only a remote possibility in his favour which can be dismissed with the sentence "Of course it is possible but not in the least probable," the case is proved beyond reasonable doubt; nothing short will suffice. [Denning, 1947]

That is what decision in real life is like. It should be the same for decision in choice of religion.

It is a stock example in Philosophy 101 that the hypothesis of there being an elephant in the next room is a logical possibility, but should have no effect on anyone's action as it is a bare possibility and has no reasons in its favor. Similar points are made endlessly when discussing demon or vat skepticism: it is usually said that though logical possibilities, they need not be taken seriously as there are no reasons for them. Mere possibilities that one is wrong, or that some theory one has not investigated or heard of is right, do not impel the reasonable person to any action.

It is a pity then that when philosophers come to consider Pascal's Wager, those wise strictures are thrown out the window. Philosophers are the very ones eager to invent merely possible hypotheses that are alleged to show that Pascal has not taken into account the correct space of hypotheses.

Thus Bartha explains the common reasoning, "If we are prepared to assign positive probability to one deity, why stop there? Suppose that each of these deities offers an infinite reward to believers" (Bartha, 2016). Oppy (1991) invites us to consider, for each positive integer n, the hypothesis that there are "n deities (all much like the Christian God) who reward all and only those people who believe that there are n deities who are much like the Christian God." Other versions of the "many gods" objection exist, no doubt infinitely many.

It seems one could just as well consider merely possible religions, not just actual ones. Could not any would-be prophet whip up a structure of hopes of infinite future rewards and punishments, and barter them for tithes in the present? And perhaps one should consider such hypotheses as that God punishes especially severely those who hypocritically assume the forms of religion as a cover for greed. An uncommitted skeptic, in particular, is one who will consider a larger than average range of possibilities, including ones that promise punishment for belief and/or rewards for intellectual honesty (Cargile, 1966).

None of that impacts Pascalian reasoning. One can consider, suppose, invent, or imagine all the hypotheses one likes. Those "philosopher's fictions"

(Jordan, 2006, p. 75) have no impact on the decisions of a real decision-maker and the range of options he has for serious consideration (argued at length in Jordan, 1994b).

It remains to be explained exactly what distinguishes solid and realistic hypotheses, which must go in the decision matrix, from fanciful and speculative ones that can be ignored. That is traditionally expressed by assigning non-zero "probability" to the realistic ones. That shifts the problem to the meaning of probability in decision theory, to which we turn in the next section.

What Pascal's Wager looks like in the context of a range of options that is more attuned to the epistemic situation of contemporary agents will be considered later.

A final question is whether Pascal fairly stated the range of options confronting the decision-maker to whom he was addressing his argument, the "man of the world" of 1660 – as Rescher puts it, "the ordinary, self-centred, 'man of the world' preoccupied with his own well-being and his own prudential interests … the glib worldly cynic – the free-thinking *libertin* of his day, the sort of persons who populated the social circle in which Pascal himself moved prior to his conversion" (Rescher, 1985, pp. 26–27). That is of historical interest, but also of philosophical interest in raising the general question of honesty in stating the range of options.

The answer is no. Pascal's two stated options are the "Catholic" one and the atheist one. But the informed Parisian audience well knew – as much as anything through Pascal's vigorous polemic in the *Provincial Letters* – that there were really two Catholic options, Jansenist and Jesuit, which differed on a question directly relevant to the Wager. The Jesuits such as Sirmond and the moral theologian Antonio Escobar y Mendoza, very laxly in Pascal's view, did not believe that wagering against God necessarily resulted in the loss of salvation, since good works performed with a good intention might suffice for salvation. That threatened to give the action of wagering against God also an infinite payoff. Thus Pascal had to spend time ridiculing the Jesuits so that their position could be ruled out from the start: "Ridiculous to say that an eternal reward is offered for morals *à la* Escobar" (L692/S571). Not everyone in 1660 agreed, or should have agreed.

4 The Grounded-Subjective Nature of the Probabilities in the Wager

There is a dilemma. To be relevant to decision theory of an agent, the probabilities involved must be actually held by the agent, so in some sense

subjective. On the other hand, if they are disconnected from what the evidence really implies, anyone can think what he likes and construct "probable" religious beliefs to suit himself. In particular, Pascal's Wager only has purchase if the probability of God is really (in some sense) greater than zero. So the probabilities involved must be in some way objective. The problem then is to say in what way the probabilities are subjective and in what way objective. (Or is the combination impossible?)

Saying that the relevant probabilities are subjective does not have to mean that anything goes. Three parallels will make it clear. According to Catholic moral theory, one has an absolute obligation to obey one's conscience, but also an obligation to inform that conscience (to conduct "due diligence," as is said in the legal world). So one must follow one's own (subjective) views, but one is at fault if those views are culpably ill-informed (Catholic Church, 1992, pars 1783–1793). Or again, the utilitarian who is required to calculate the probable future utility of his actions needs this probability to be subjective (since that is all that he knows) but informed (so that a self-serving but crazy distribution of probabilities does not serve as an excuse for wrong action) (Smart, 1986, p. 31). The same applies to more practical cases such as deciding which risks to a nuclear power plant justify spending money on precautions. The probabilities of those risks must be entertained in the mind of the planner and dependent on his beliefs, but also must be grounded in the evidence available. Risk committees in nuclear power plants do not employ philosophers to expatiate on the "many catastrophes objection" as to why no precautions are worthwhile – they get on with addressing those risks they know about which have, to their knowledge, a real chance of being realized.

The combination of subjectivity and objectivity of the probabilities in such cases is not hard to understand. It is just a special case of the general need of knowledge and opinion to be in a reasoner's mind yet grounded in the evidence available to the reasoner.

Action, like conscience, is serious. It requires the beliefs on which it is grounded to be serious too.

That explains why the probabilities of fanciful theories, such as those considered in the last section, can be rightly regarded as zero and hence need not appear in the decision-maker's payoff matrix. Mere possibilities dreamed up by inventive philosophers do not provide the decision-maker with any reasonable ground for believing them, and he cannot assign non-zero probability to them. Hence his grounded subjective probabilities for them can and ought to remain at zero. They could acquire a non-zero

probability if someone found a half-way reasonable argument for one of them. But their role in the many-gods objection was exactly to appear as mere possibilities.

It is true that if the probabilities are subjective though grounded, a zero probability for God may in some circumstances be reasonable. If someone grows up with only atheist indoctrination, for example in the old Soviet Union, and has never thought to take seriously the possibility of God, they do not have, subjectively, any substantial reason actually available to assign the theistic hypothesis in general a non-zero probability. Oppy (1991) does defend that position as reasonable on more normal background knowledge. But a brief amount of thinking should call that into question. "Non-zero" is a very low bar, and the mere knowledge that debate continues among apparently intelligent people in philosophical journals about classical arguments for the existence of God ought to be sufficient to clear it. (The difference between that and demon skepticism is instructive: the latter is not defended as a real possibility, even by those impressed by the traditional skeptical arguments, while the former is. Attempts by some atheists to assert a symmetry between the Christian god and the Flying Spaghetti Monster and thus assign zero probability to each are no better; they are frivolous just because everyone knows at least second-hand the seriousness of standard theistic arguments.)

It is still problematic whether a non-zero probability should be assigned to the more specific theistic hypothesis that is needed for the argument of Pascal's Wager to gain traction, namely that there exists a God who offers an infinite reward dependent on the response of the decision-maker. Pascal reasonably regards that as obvious for his interlocutor, the "man of the world" of 1660. Again, what it means for a contemporary informed person will be considered later.

5 The Payoffs (for a Real Agent)

Payoffs, like options and their probabilities, must be in the mind of the decision-maker if they are to have any effect on decisions. That has not always been kept in mind in the discussion on Pascal's Wager. That applies especially to the meaning of "infinite" payoffs.

Pascal does not draw a payoff matrix, but the one that translates his text is laid out in Table 1.1.

Before discussing the meaning of "infinite gain," which is crucial to the Wager, we consider briefly some other aspects of the matrix.

Table 1.1 Pascal's Wager

		States of the world	
		God exists	God does not exist
	Subjective probability	Non-zero p	$1 - p$
Actions	**Wager for God**	Infinite gain	Inconvenience in life
	Wager against God	Misery	Worldly pleasures

On Pascal's religious views, neither of the payoffs in the first column are in fact certain, if one wagers as indicated. Far from it. Wagering for God gives a chance for God's grace to act, but one still may be mired in sin, or be outside the number of the elect to whom God freely chooses to grant salvation. On the other hand, if one wagers against God, there is still some chance that things will work out positively later and one will scrape home with a deathbed repentance. That may make the expected outcomes of each action harder to calculate and compare, but it depends on what is said about infinity.

The outcome "misery" was played up by earlier writers like Arnobius and Sirmond. They mean by it eternal punishment and plainly intend that the Wager be seen as a threat as much as a promise. Pascal avoids calling attention to that, for reasons that remain unclear. Diderot suggests (1875 [1746], p. 167) that "eternal," said of punishments, is a mistranslation of a Hebrew word that merely means "long-lasting," and it may be doubted whether the difference could be clear in the minds of ancient writers.

The outcomes "inconvenience in life" and "worldly pleasures" come from the fact that wagering for God will require some lifestyle adjustments, such as renouncing sinful pleasures and spending time in prayer, while "worldly pleasures" may continue to be enjoyed by one who decides not to wager on God. One should not forget also the cognitive inconvenience of having to seriously think oneself into a religious point of view, which many find painful – perhaps especially philosophers, trained as they are in a professional skepticism. Pascal allows it to be understood that "inconvenience" is a negative and "worldly pleasures" a positive, but that is a concession to the point of view of his interlocutor, the "man of the world" (again revealing how the Wager must be understood as aimed at a decision-maker with a particular point of view). Pascal himself does not really believe that, as he thinks that a life of virtue and prayer would be better absolutely speaking than one mired in sinful pleasures (even if it should prove that both ended with death). He argues:

> But what harm will come to you from taking this course [committing to God]? You will be faithful, honest, humble, grateful, doing good, a sincere, true friend. It is true you will not enjoy noxious pleasures, glory and good living. But will you not have others? I tell you that you will gain even in this life ... [L418/S680]

Similar reasoning plays an important role in the recent defenses of the Wager by Rota (2016a, pp. 58–63; 2016b), which are addressed to those who are already seriously considering Christian commitment. That is worth arguing, when a real decision-maker is addressed. It also simplifies the decision problem because the strategy of wagering for God is then "super-dominant," as is said in decision theory: it is the best strategy in *every* state of the world.

However, it is widely agreed that the reasonableness or otherwise of Pascal's Wager hinges mainly on the "infinite gain" promised to one who wagers on God, in the case where God does exist.

Recent discussion has often been conducted by philosophers whose main interest in Pascal's Wager is in infinite decision theory, rather than its application to choice of religion. They have taken a rather crude and uncritical understanding of Pascal's "infinity" and identified it with the mathematicians' ∞, a number or quasi-number that satisfies such simple formulas as $\infty + \infty = \infty$ and $100 \times \infty = \infty$. That allows the deployment of colorful mathematical technologies like infinitesimals and extended reals and the mounting of extended objections involving, for example, "mixed strategies" (the strategy "Toss a fair coin: heads, you wager for God; tails, you wager against God" will have a payoff $\frac{1}{2} \times \infty = \infty$ and so will be as good as simply wagering on God) (Hájek, 2012b; Bartha, 2016).

That is plainly disconnected from what faces real decision-makers. If confronted by the choice of "99 percent chance of infinite gain" versus "1 percent chance of infinite gain," it would be excessively fundamentalist about infinitary arithmetic to conclude that $0.99 \times \infty = 0.01 \times \infty = \infty$, and hence that the bets are equally good.

Schlesinger (1994, p. 90, supported in Bartha, 2016) suggests, "In cases where the mathematical expectations are infinite, the criterion for choosing the outcome to bet on is its probability." That is reasonable as it is a straightforward extension to the infinite case of the answer for a fixed finite payoff. If infinitary arithmetic gets in the way of that, one might better conclude that the whole idea of modeling Pascal's "infinite gain" by the mathematical ∞ is misconceived.

The same conclusion can be reached by recalling the importance in modern decision theory of utility functions. To account for the fact that $100 is of much greater concern to a poor person than to a rich person, a "utility function" is commonly assumed which translates from actual money outcomes to "what it's really worth" to the decision-maker involved. The utility function discounts large monetary sums to an assumed psychological weight. The discounting is necessary to correctly model the weight of the outcome in the real considerations of the decision-maker. The utility alone plays a role in the decision matrix.

If we now ask what "infinite gain" means for a real decision-maker, with the usual human mind with finite computational resources, it is unclear whether it should be called literally infinite at all. Perhaps a finite mind can only include a finite utility of an actually infinite outcome. Whether that is true or not, the promised infinite gain is a long way off, spread over an infinite period, and its discounted present value may well be finite. Clergy are always complaining about the difficulty of extracting from the faithful finite sums of money in return for the infinite good in prospect, suggesting a widespread heavy discounting in psychological reality. That degree of discounting might be put down to irrationality through a lack of imagination. But many even after serious thought would agree that "I would not, for every chance no matter how small for eternal bliss, cut off my arm, or suffer stupefaction or madness," (or allow someone I care about to suffer serious harm) (Sobel, 1996, p. 42). At some point, the smallness of the probability of the payoff renders it near-fanciful, implying that the payoff is not really taken to be infinite.

We can take our lead from Chillingworth's observation above that the reasoning of the Wager works in ordinary life in cases of finite payoffs. A more realistic model of the utility of Pascal's "infinite gain" would be a finite but enormous payoff HUGE. It is a number very far beyond the utility of the ordinary goods of life, but is not infinite. Half of HUGE is not equal to HUGE (though HUGE + 1 is indistinguishable from HUGE – indistinguishability being the correct notion of equality for psychological entities – agreeing with Pascal's remark that "Unity added to infinity does not increase it at all ... by adding a unit it does not change its nature" (L418/S680). Since a finite mind is barely able to distinguish between HUGE and the really infinite, a payoff of HUGE is as motivating as a payoff of infinity. Again, it must be emphasized that a utility is a quantity in the mind of a decision-maker, where it can act to motivate. (Similar considerations lead to Bartha's (2007) approach of primitive relative utilities.)

Table 1.2 Pascal's Wager with HUGE Payoff

	God exists	God does not exist
Subjective probability	Non-zero p	$1 - p$
Wager for God	HUGE	Small finite
Wager against God	Negative	Small finite

Hájek (2003) argues that a proposal of that kind would offend against a literal understanding of some of Pascal's sayings, such as "The finite is annihilated in the presence of the infinite, and becomes pure nothingness" and that the wagerer for God "gains all," with its implication of maximality. That may be so, but Pascal is a propagandist fond of hyperbolic expression. The real decision-maker will reasonably be left cold by such considerations as that two eternal lives might be better than one (or $2 \times$ HUGE > HUGE). Just as $2 billion is no more motivating than $1 billion (for the ordinary person) although the sums differ in reality, that difference is not relevant to the utility in the mind of the decision-maker contemplating the Wager.

The payoff matrix of Pascal's Wager, in the case where "infinite gain" is modeled by HUGE is then (simplifying also the payoffs to their quantitative essentials) as laid out in Table 1.2.

In the bottom-left cell of Table 1.2, where one wagers against God and he exists, a negative payoff of some magnitude is reasonable as the rare case of a deathbed conversion will not balance the overall expected large negative: the situation will be something like "1 percent of HUGE after a deathbed conversion summed with 99 percent of negative HUGE otherwise." It can be seen in any case that even a small positive finite value – or even a moderate positive one, less than HUGE – would not affect the conclusion; perhaps that goes some way toward explaining Pascal's avoiding discussing the matter.

With that matrix, Pascal's reasoning is still sound. The Wager is a good bet. It is true that one might wonder whether HUGE is really big enough to balance a sufficiently small probability for the hypothesis "God exists." It may well not be enough to balance a strictly infinitesimal probability, but what about a very small finite one? Since we are envisaging real decision-makers, that can be regarded as a genuine possibility and left for the decision-maker to say. Is his grounded subjective probability for "God exists" really small enough to render nugatory the product of it with HUGE, when all due allowance is made for the cognitive difficulty of comprehending HUGE? In the end, that is for the decision-maker to decide, honestly.

Philosophers may find that a less exciting conclusion than the "all or nothing" version of the Wager with real infinities that they are accustomed to, but real decision-makers may be less concerned.

6 The Adaptability of the Wager to Different Spectra of Options

Convenient as it may be to quarantine Pascal's disturbing thought to the Paris of 1660, that is not correct. Pascal is pursuing decision theory, so his rhetoric is addressed to real agents, namely "men of the world" in the Paris of 1660. The editors of the Port-Royal edition of the *Pensées* added on his behalf: "This chapter addresses only a certain kind of person ... The author claims merely to show that by their own principles and by the pure light of reason they should judge it to their advantage to believe" (Thirouin, 1991, p. 168). For those persons, as for Pascal, there were just those two options – that is, the spectrum of religious theories to which they attached grounded subjective non-zero probability consisted of just Catholicism and atheism (give or take, as we have seen, some different interpretations of Catholicism).

For other people, such as Muslims and contemporary post-Christian intellectuals, the range of credible options is different. That does not mean that the Wager loses its force. It just means it has to adapt to the range of subjective reasonable non-zero probabilities that different agents actually have.

If someone in the early twenty-first century faces a different range of options from the Parisian of 1660, that does not make the Pascalian game-theoretic perspective irrelevant. On the contrary, the richer the choice of options considered reasonable, the more the need for careful calculation. (Just as with nuclear power plants, the more risks there are with some chance of being realized, the more work needed to calculate where money should be spent on precautions.) Perhaps, like the Jesuits, we take more seriously than Pascal the idea that if God has all the goodness claimed for him, then "he's a good fellow, and 'twill all be well." Or perhaps a kind of lowest-common-denominator of religions attracts us more than any particular faith. Or perhaps in the chaos of the post-modern global village, there are as many reasonable distributions of opinions as there are people. It doesn't matter. The essential point is that decision theory applies in the first instance to the reasonable subjective probabilities of any real agent. Pascal got under the skin of the worldly, by understanding what options were serious ones for them;

Table 1.3 Contemporary Wager

	Materialist atheism	Sect of parents	Amorphous spirituality	...	Advaita Vedanta	Mormon	...
Subjective probability	0.7	0.1	0.1	...	0.01	0.005	...
Wager for	Worldly pleasures	HUGE	Oneness with nature?		Nothingness	HUGE	
Wager against	Unknown until investigation	Negative	Pleasures/ suffering?		Many cares, few pleasures	Suboptimal afterlife	

to that extent, but only to that extent, his argument is *ad hominem* and does not survive the cultural context of Louis XIV's France. Whatever options are serious ones for us, Pascal's approach applies to them – unless we can attribute zero probability to the sum of all theistic and perhaps pantheistic options (which as explained above, is not easy).

The payoff matrix for a contemporary Western educated person might have many columns, looking something like that laid out in Table 1.3. The initial subjective probabilities will depend on the evidence the person happens to have grown up with; that is inevitable.

In the modern context, the result of accepting the Wager would again be action, but not necessarily the action that Pascal envisages. It would more likely be a serious investigation of the claims of religion in general.

7 Information Foraging Decisions

Pascal imagined at least in outline not only decision theory itself, but also one of the more subtle aspects of it, namely, how to decide on action in case of uncertainty as to how much more information one should acquire.

Pascal is masterful on the folly of not examining religion because its claims are uncertain on present evidence. In a remark leading up to the Wager, he says "An heir finds the deeds of his house. Will he say, perhaps, that they are false, and not bother to examine them?" (L823/S664) The action indicated in case of uncertain information about a possible large reward is: investigate the evidence to see if it firms up.

An animal foraging for food provides a well-understood analogy. An animal is faced with a choice of committing to a search for food in some

direction, based on current knowledge, or postponing commitment in the hope that gathering further information instead will lead to a better decision (Nishimura, 1992; Lawes and Perrin, 1995). There is a trade-off between exploitation and exploration. In cases where the current alternatives have little evidence for them – they lack "weight of evidence" (in the sense of Keynes, 1921, ch. 6), the probabilities of the alternatives are not robust – it is likely that a little further evidence will drastically change them. So if such evidence can be gathered at low cost, it is worthwhile to do so.

These considerations apply equally well to intellectual foraging, in such paradigm cases as computer programs to play chess (Frey, 1983). The problem there is to use some quick-and-dirty heuristics to decide which of the huge number of possible sequences of moves and counter-moves are worth calculating further, before deciding which move to actually make. Similar issues arise with finding relevant information on the internet; for example, finding an optimal hotel in an unfamiliar city using a hotel booking site which gives information on price, star-rating, location, and so on. We all have intuitive strategies on how to home in on likely candidates without wasting too much time on dead ends, strategies which can be formalized (Pirolli, 2007).

It is the same with foraging in the space of worldviews, in the light of the very partial information I have on them. Given the wealth of alternatives, I must decide on the basis of current knowledge not so much which to commit to, as which to investigate further. How much evidence must be collected is itself something that must be judiciously appraised, in the light of the time to be wasted in blind alleys, the prospects of success somewhere else, and my estimated capacity to understand and critically evaluate theories. And the payoffs, if the theory being investigated were to turn out to be true.

The process would of course be a dynamic one. Having chosen a religious position to investigate and reached a conclusion, I would update my (now better founded) subjective probability of it and hence of all the other options. Standard Bayesian methods of updating probabilities may be appropriate, but there is more to it than simply collecting new facts as in evaluating a doubtful historical thesis. As with a change in philosophical views, new understandings are more important than new facts. If some religion looks worth investigating, it will require intellectual efforts to understand the point of it, discussions with believers, perhaps prayer. Bartha (2012) suggests updating on the basis of relative utilities, iterating until equilibrium is reached. The question of how to proceed is

a complex one; the considerations here suggest it is a problem worth intensive study.

For a contemporary seeker after truth with normal rationality, curiosity, and easy access to information on almost any aspect of any worldview, information foraging just is the decision that a modern version of Pascal's Wager would recommend.