Appendix: Answer Key

Chapter 1

Exercise 1.1 (a) Descriptive. (b) Normative. (c) Descriptive.

Exercise 1.3 (a) 100. (b) $400,000. (c) $242 (see Section 8.2).

Chapter 2

Exercise 2.1 (a) fBn. (b) nBf. (c) nBn.

Exercise 2.2 {Afghanistan, Albania, Algeria, Andorra, Angola, ..., Zimbabwe}. Any order is fine, but the curly brackets are part of a correct answer. Notice that if you were to spell it out, this would be a pretty long list.

Exercise 2.3 (a) In all likelihood: d $\succcurlyeq$ r. (b) In all likelihood: r $\succcurlyeq$ d.

Exercise 2.7 (a) Intransitive, incomplete. (b) Transitive, incomplete. (c) Transitivity depends on whether we consider half-siblings; either way, it is incomplete. (d) Intransitive, incomplete. (e) Transitive, incomplete. (f) Transitive, incomplete. (g) Transitive, incomplete.

Exercise 2.8 If the enemy of your enemy is not your enemy, then "is the enemy of" is intransitive.

Exercise 2.9 (a) Transitive, complete. (b) Transitive, incomplete. (c) Transitive, incomplete. (d) Transitive, incomplete.

Exercise 2.10 (a) Transitivity implies that if apples are at-least as good as bananas, and bananas are at least as good as starvation, then apples are at least as good as starvation; that if starvation is at least as good as bananas, and bananas are at least as good as apples, then starvation is at least as good as apples; and so on. (b) Completeness implies that either apples are at least as good as bananas or bananas are at least as good as apples, but also that apples are at least as good as apples, and that bananas are at least as good as bananas.

Exercise 2.13 Assume that $x \succcurlyeq y$ & $y \sim z$. The fact that $y \sim z$ implies that $y \succcurlyeq z$. Given that $x \succcurlyeq y$ & $y \succcurlyeq z$, it follows that $x \succcurlyeq z$.

Exercise 2.14 Here are the complete proofs.

(a)	1. $x \sim y \,\&\, y \sim z \,\&\, z \sim p$	by assumption
	2. $x \sim z$	from (1), by transitivity of $\sim$
	3. $x \sim p$	from (1) & (2), by transitivity of $\sim$
	$\therefore x \sim y \,\&\, y \sim z \,\&\, z \sim p \rightarrow x \sim p$	QED □

(b)	1. $x \sim y \,\&\, y \sim z \,\&\, z \sim p$	by assumption
	2. $x \succcurlyeq y \,\&\, y \succcurlyeq x$	from (1), by definition of $\sim$
	3. $y \succcurlyeq z \,\&\, z \succcurlyeq y$	from (1), by definition of $\sim$
	4. $z \succcurlyeq p \,\&\, p \succcurlyeq z$	from (1), by definition of $\sim$
	5. $x \succcurlyeq z$	from (2) & (3), by transitivity of $\succcurlyeq$
	6. $x \succcurlyeq p$	from (4) & (5), by transitivity of $\succcurlyeq$
	7. $z \succcurlyeq x$	from (2) & (3), by transitivity of $\succcurlyeq$
	8. $p \succcurlyeq x$	from (3) & (7), by transitivity of $\succcurlyeq$
	9. $x \sim p$	from (6) & (8), by definition of $\sim$
	$\therefore x \sim y \,\&\, y \sim z \,\&\, z \sim p \rightarrow x \sim p$	QED □

Exercise 2.17 Here is the complete proof of Proposition 2.16(i). What this exercise calls the first part is lines (2)–(4).

1.	$x \succ y \,\&\, y \succ z$	by assumption
2.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (1), by definition of $\succ$
3.	$y \succcurlyeq z \,\&\, \neg z \succcurlyeq y$	from (1), by definition of $\succ$
4.	$x \succcurlyeq z$	from (1) and (2), by transitivity of $\succcurlyeq$
5.	$z \succcurlyeq x$	by assumption, for proof by contradiction
6.	$y \succcurlyeq x$	from (3) and (5), by transitivity of $\succcurlyeq$
7.	$\bot$	from (2) and (6)
8.	$\neg z \succcurlyeq x$	from (5)–(7), by contradiction
9.	$x \succ z$	from (4) and (8), by definition of $\succ$
$\therefore$	$x \succ y \,\&\, y \succ z \rightarrow x \succ z$	QED □

Exercise 2.18 Assume, for proof by contradiction, that "is the enemy of" is in fact transitive. That means that whenever A is the enemy of B, and B is the enemy of C, A must be the enemy of C. But assuming that the enemy of the enemy of a person is his or her friend, that is impossible. Therefore, "is the enemy of" is not transitive.

Exercise 2.19 Here is the proof:

1.	$x \succ x$	by assumption
2.	$x \succcurlyeq x \,\&\, \neg x \succcurlyeq x$	from (1), by definition of $\succ$
3.	$\bot$	from (2)
$\therefore$	$\neg x \succ x$	QED □

Exercise 2.20 Here is the complete proof:

1.	$x \succ y \,\&\, y \succcurlyeq z$	by assumption
2.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (1), by definition of $\succ$
3.	$x \succcurlyeq z$	from (1) and (2), by transitivity of $\succcurlyeq$
4.	$z \succcurlyeq x$	by assumption, for proof by contradiction
5.	$y \succcurlyeq x$	from (1) and (4), by transitivity of $\succcurlyeq$
6.	$\bot$	from (2) and (5)
7.	$\neg z \succcurlyeq x$	from (4)–(6), by contradiction
8.	$x \succ z$	from (3) and (7), by definition of $\succ$
$\therefore$	$x \succ y \,\&\, y \succcurlyeq z \rightarrow x \succ z$	QED □

Exercise 2.21 See below:

(a)

1.	$x \succ y$	by assumption
2.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (1), by definition of $\succ$
3.	$x \succcurlyeq y$	from (2), by logic
$\therefore$	$x \succ y \rightarrow x \succcurlyeq y$	QED □

(b)

1.	$x \succ y$	by assumption
2.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (1), by definition of $\succ$
3.	$\neg y \succcurlyeq x$	from (2), by logic
$\therefore$	$x \succ y \rightarrow \neg y \succcurlyeq x$	QED □

(c)

1.	$x \succcurlyeq y$	by assumption
2.	$y \succ x$	by assumption, for proof by contradiction
3.	$y \succcurlyeq x \,\&\, \neg x \succcurlyeq y$	from (2), by definition of $\succ$
4.	$\bot$	from (1) & (3)
5.	$\neg y \succ x$	from (2)–(4), by contradiction
$\therefore$	$x \succcurlyeq y \rightarrow \neg y \succ x$	QED □

(d)

1.	$x \succ y$	by assumption
2.	$x \sim y$	by assumption, for proof by contradiction
3.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (1), by definition of $\succ$
4.	$x \succcurlyeq y \,\&\, y \succcurlyeq x$	from (2), by definition of $\sim$
5.	$\bot$	from (3) & (4)
6.	$\neg x \sim y$	from (2)–(5), by contradiction
$\therefore$	$x \succ y \rightarrow \neg x \sim y$	QED □

(e)

1.	$x \sim y$	by assumption
2.	$x \succ y$	by assumption, for proof by contradiction
3.	$x \succcurlyeq y \,\&\, y \succcurlyeq x$	from (1), by definition of $\sim$
4.	$x \succcurlyeq y \,\&\, \neg y \succcurlyeq x$	from (2), by definition of $\succ$
5.	$\bot$	from (3) & (4)
6.	$\neg x \succ y$	from (2)–(5), by contradiction
$\therefore$	$x \sim y \rightarrow \neg x \succ y$	QED □

(f)	1. $\neg x \succcurlyeq y$	by assumption	
	2. $x \succcurlyeq y \vee y \succcurlyeq x$	by completeness	
	3. $y \succcurlyeq x$	from (1) & (2), by logic	
	$\therefore \neg x \succcurlyeq y \rightarrow y \succcurlyeq x$	QED	□
(g)	1. $\neg x \succcurlyeq y$	by assumption	
	2. $x \succcurlyeq y \vee y \succcurlyeq x$	by completeness	
	3. $y \succcurlyeq x$	from (1) & (2), by logic	
	4. $y \succ x$	from (1) & (3), by definition of $\succ$	
	$\therefore \neg x \succcurlyeq y \rightarrow y \succ x$	QED	□
(h)	1. $\neg x \succ y$	by assumption	
	2. $\neg\ (x \succcurlyeq y \ \&\ \neg y \succcurlyeq x)$	from (1), by definition of $\succ$	
	3. $\neg x \succcurlyeq y \vee y \succcurlyeq x$	from (2), by logic	
	4. $y \succcurlyeq x$	from (3), by part (f) above	
	$\therefore \neg x \succ y \rightarrow y \succcurlyeq x$	QED	□

Exercise 2.22 Begin by assuming what is to the left of the arrow, in this case $x \sim y \ \&\ y \sim z$. Then, on a separate line, assume (for a proof by contradiction) the opposite of what you are trying to prove; that is, assume that $x \succ z$. Finally, derive a contradiction.

Exercise 2.23 (**a**) Begin by assuming that $\neg x \succcurlyeq y$ and that $\neg y \succcurlyeq z$. Apply Proposition 2.21(g) twice to get $y \succ x$ and $z \succ y$. Transitivity will yield $z \succ x$, which by Proposition 2.21(b) gives you the result $\neg x \succcurlyeq z$. (**b**) Begin by assuming that $\neg x \succ y$ and that $\neg y \succ z$. Proposition 2.21(h) applied twice, transitivity, and 2.21(c) will give you the result.

Exercise 2.24 The answer is, of course, that $f^+ \succ c$. Begin by assuming that $f \sim c \ \&\ f^+ \succ f$. You need to prove two things: that $f^+ \succcurlyeq c$ and that $\neg c \succcurlyeq f^+$. After using the definitions of indifference and strict preference, the first part follows by transitivity of weak preference. For the second part, assume (for a proof by contradiction) that $c \succcurlyeq f^+$.

Exercise 2.25 A rational person is indifferent. Because $c_1 \sim c_2 \ \&\ c_2 \sim c_3$, Proposition 2.14 implies that $c_1 \sim c_3$. Because, in addition, $c_3 \sim c_4$, the same proposition implies that $c_1 \sim c_4$ and so on. Ultimately, you will find that $c_1 \sim c_{1000}$. QED.

Exercise 2.26 Assume that $x \succ y \ \&\ y \succ z \ \&\ z \succ x$. Apply the definition of strict preference a few times, and a contradiction is immediate.

Exercise 2.27 Assume that $x \succcurlyeq y \ \&\ y \succcurlyeq z \ \&\ z \succcurlyeq x$, Use the transitivity of weak preference and the definition of indifference to establish that $x \sim y \ \&\ y \sim z \ \&\ z \sim x$.

Exercise 2.28 See Figure A.1.

Exercise 2.30 The new menu would be {nothing at all, soup, salad, chicken, beef, soup-and-chicken, soup-and-beef, salad-and-chicken, salad-and-beef}.

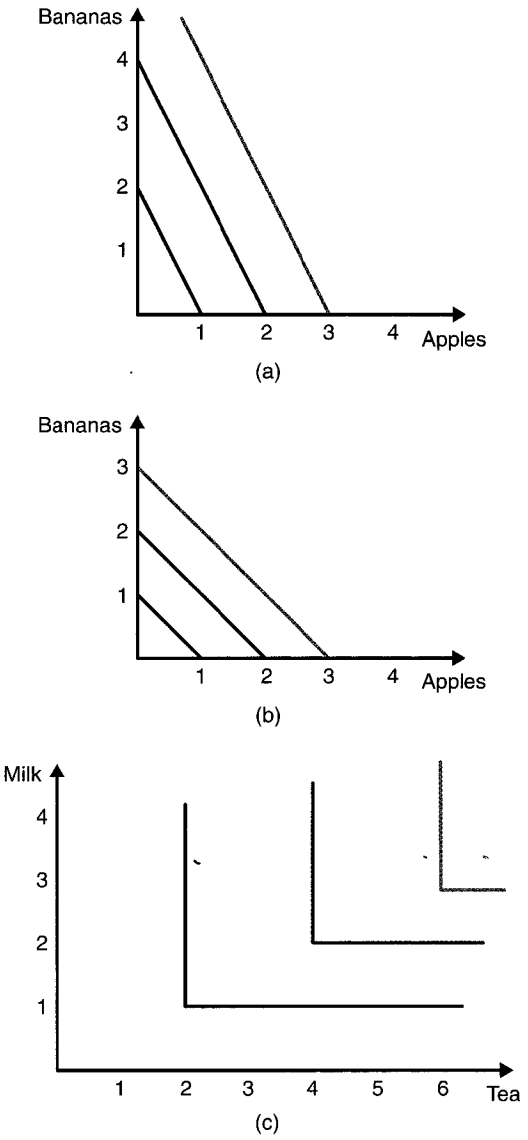
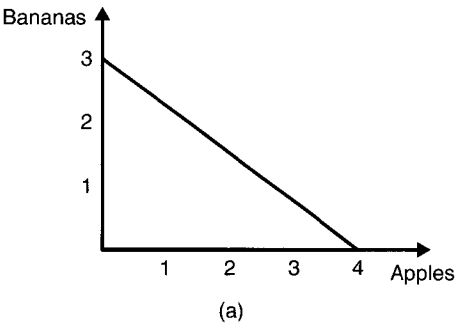
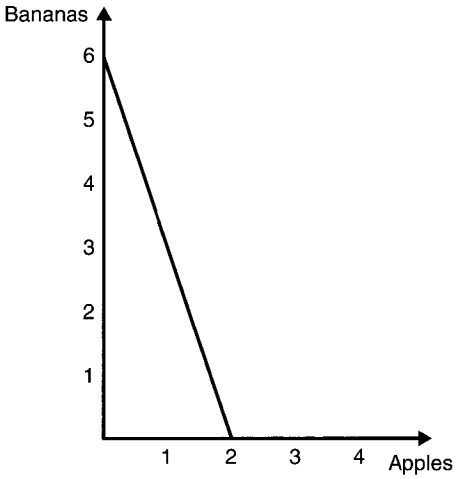


Figure A.1 Indifference curves

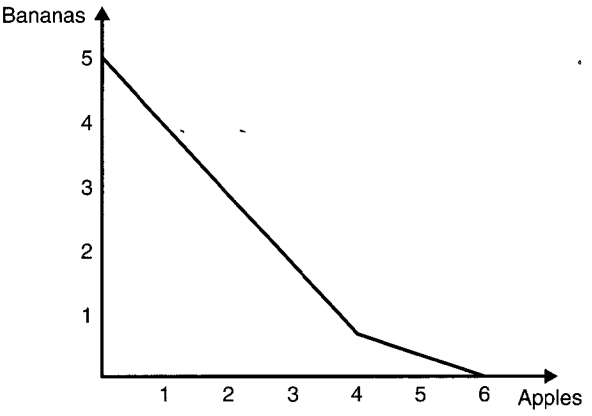
Exercise 2.31 See Figure A.2.



(a)



(b)



(c)

Figure A.2 Budget lines

Exercise 2.35 In order to prove this proposition, you need to do two things. First, assume that $x \sim y$ and prove that $u(x) = u(y)$. Second, assume that $u(x) = u(y)$ and prove that $x \sim y$. Here is the complete proof:

1.	$x \sim y$	by assumption
2.	$x \succcurlyeq y \;\&\; y \succcurlyeq x$	from (1), by definition of $\sim$
3.	$u(x) \geq u(y) \;\&\; u(y) \geq u(x).$	from (2), by definition of $u(\cdot)$ (twice)
4.	$u(x) = u(y)$	from (3), by math
5.	$u(x) = u(y)$	by assumption
6.	$u(x) \geq u(y) \;\&\; u(y) \geq u(x)$	from (5), by math
7.	$x \succcurlyeq y \;\&\; y \succcurlyeq x$	from (6), by definition of $u(\cdot)$ (twice)
8.	$x \sim y$	from (4) and (8), by definition of $\sim$
$\therefore$	$x \sim y \Leftrightarrow u(x) = u(y)$	QED $\square$

Exercise 2.36 (a) Neoclassical economic agents are assumed to be "rational"– which is used in a technical sense quite different from that of "intelligent" and "analytic" in everyday speech – and there is no assumption that they are selfish. Classical economic agents, like those who appear in the work of Adam Smith (see Section 1.2) are not assumed to be rational, intelligent, analytic, or selfish – although they may be on occasion. (b) The notion that money makes people happy is no part of fundamental economic theory. To the extent that people prefer more money to less, we can say that money gives them utility. But the concept of utility has no essential connection to happiness.

Exercise 2.37 See Table A.1.

Table A.1 Properties of weak preference, indifference, and strong preference

	Property	Definition	$\succcurlyeq$	$\sim$	$\succ$
(a)	Transitivity	$xRy \;\&\; yRz \rightarrow xRz$ (for all x, y, z)	✓	✓	✓
(b)	Completeness	$xRy \vee yRx$ (for all x, y)	✓		
(c)	Reflexivity	xRx (for all x)	✓	✓	
(d)	Irreflexivity	$\neg xRx$ (for all x)			✓
(e)	Symmetry	$xRy \rightarrow yRx$ (for all x, y)		✓	
(f)	Anti-symmetry	$xRy \rightarrow \neg yRx$ (for all x, y)			✓

Exercise 2.38 (a) "is not married to" (b) "is married to." (c) both. (d) neither. (e) neither.

Exercise 2.39 Omitted.

Exercise 2.40 (a) She violates completeness. (b) He violates transitivity. (c) It violates completeness.

Chapter 3

Exercise 3.1 (a) See Figure A.3. (b) $1000. (c) $1000.

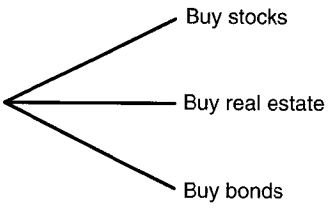


Figure A.3 Investment problem

Exercise 3.3 (a) See Figure A.4.

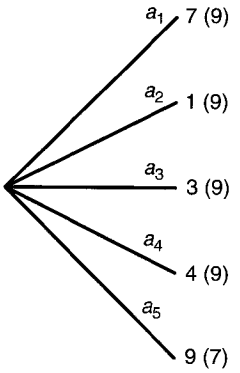


Figure A.4 Opportunity costs

Exercise 3.6 The answers will depend on your preferences, but they could be (a) the most fulfilling relationship you could have instead, (b) the course of study that excites you most, and (c) the most satisfying activity you could engage in instead of sleeping in the morning.

Exercise 3.7 For highly paid people, the opportunity cost of mowing lawns, etc., is greater.

Exercise 3.10 You may be ignoring the fact that there are better things you could spend $60 on, including a $10 meal and 50 dollars' worth of other fun or useful things.

Exercise 3.11 If a person is willing to do "whatever it takes" to attain some goal, that means he or she is willing to ignore all opportunity costs – which is irrational.

Exercise 3.13 Not necessarily: if another, even more successful campaign to boost revenue were available to you at the time, it would have been irrational to invest in the advertising campaign.

Exercise 3.14 No: military action is associated with huge explicit and implicit costs, which are often underestimated by its advocates.

Exercise 3.17 See Figure A.5.

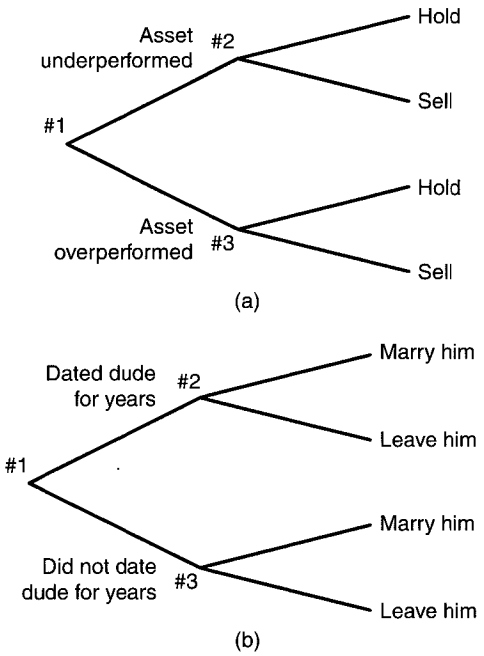


Figure A.5 Sunk costs, again

Exercise 3.19 The difference between the cheese you manage to throw away and the one you do not is that the former is not associated with a sunk cost, whereas the latter is.

Exercise 3.20 Sign up for the course at the public university. The tuition already paid to the liberal arts college is a sunk cost.

Exercise 3.27 (**a**) You would want to put it in area B. (**b**) Before.

Exercise 3.28 (**a**) Show a property that is not in as good shape as and even farther from the office than the first property, but which is still in better shape than the second property. (**b**) Show a property that is in even worse shape and slightly farther from the office than the second property, but which is still closer to the office than the first property.

Exercise 3.29 If the third-party politician C promises neither higher nor lower taxes but massive cuts to public services, he will be asymmetrically dominated by A, as intended.

Exercise 3.30 (**a**) Choose a wingman or wingwoman who is less desirable than you are along all relevant dimensions, but who beats each competitor

along at least one dimension. (**b**) You want your wingman or wingwoman to fall in the 8–9 range (exclusive) both with respect to attractiveness and intelligence. (**c**) He or she thinks you are less desirable than he or she is along all relevant dimensions.

Exercise 3.31 You would need to sell a vehicle that is super-fast and super-unsafe: something like a rocket-propelled bicycle.

Exercise 3.32 The third-party politician must promise even lower taxes, and even greater cuts to public services than politician A.

Exercise 3.36 From the point of view of the waitress without a car, the value of getting one is the value of going from 0 to +1. In terms of value, this amounts to going from $v(0) = 0$ to $v(+1) = 0.5$. The change, therefore, is $v(+1) - v(0) = 0.5$. From the point of view of the waitress with a car, the value of losing one is the value of going from 0 to −1 cars. In terms of value, that amounts to going from $v(0) = 0$ to $v(-1) = -2$. The change, then, is $v(-1) - v(0) = -2 - 0 = -2$. The total change for a person experiencing the gain *and* the loss is $0.5 + (-2) = 0.5 - 2 = -1.5$. This amounts to a loss of 1.5 units of value, leaving her worse off than she was before the sequence of events took place.

Exercise 3.37 In value terms, gaining \$6 and losing \$4 amounts to a change in value terms of $v(+6) + v(-4) = 3 - 8 = -5$. In value terms, that is as bad as suffering a loss of \$2.5, since $v(-2.5) = -5$, in spite of the fact that you are left with \$2 more than you had at the outset.

Exercise 3.38 (**a**) In terms of deviations from a reference point of \$0, the drop in price corresponds to a drop from +1 to 0. In value terms, that corresponds to a drop from $v(+1) = 0.5$ to $v(0) = 0$. So the change in value is $v(0) - v(+1) = 0 - 0.5 = -0.5$. (**b**) In terms of deviations from a reference point of \$1, the drop in price corresponds to a drop from 0 to −1. In value terms, that corresponds to a drop from $v(0) = 0$ to $v(-1) = -2$. So the change in value is $v(-1) - v(0) = -2 - 0 = -2$. (**c**) With a reference point of \$0, you experience a loss of 0.5 units of value; with a reference point of \$1, you experience a loss of 2 units of value. Since a loss of 2 is worse than a loss of 0.5, using a reference point of \$1 makes you feel worse than a reference point of \$0.

Exercise 3.39 (**a**) Given her reference point of \$12, Alicia thinks of the price drop from \$17 to \$12 as a change from +5 to 0. The change in value terms is $v(0) - v(+5) = 0 - 2.5 = -2.5$, meaning a loss of 2.5. (**b**) Given her reference point of \$17, Benice thinks of the price drop as a drop from 0 to −5. The change in value terms is $v(-5) - v(0) = -10 - 0 = -10$, meaning a loss of 10. (**c**) Given her reference point of \$10, Charlie thinks of the price drop as a change from +7 to +2. The change in value terms is $v(2) - v(7) = 1 - 3.5 = -2.5$, meaning a loss of 2.5. (**d**) Benice is most disappointed.

Exercise 3.40 (**a**) 50. (**b**) 200. (**c**) The net effect is −150. (**d**) Bad.

Exercise 3.41 (**a**) Alex thought of the \$2 as a foregone gain, so for him the absolute value of the \$2 was 1. Mathematically, the change in value can be

computed as $v(0) - v(+2) = 0 - 2/2 = -1$. (**b**) Bob thought of the \$2 as a loss, so for him the absolute value of the \$2 was 4. Mathematically, the change in value can be computed as $v(-2) - v(0) = -4 - 0 = -4$. (**c**) Bob.

Exercise 3.42 To people who do not bring their own mugs the discount seems like a foregone gain, whereas a penalty would feel like an actual loss. Since foregone gains are easier to stomach, customers are less likely to be alienated this way.

Exercise 3.43 A person who does not expect a raise would experience $v(+5)$. A person who does expect a raise would experience $v(-5)$. See Figure A.6 for a graphical representation of the difference.

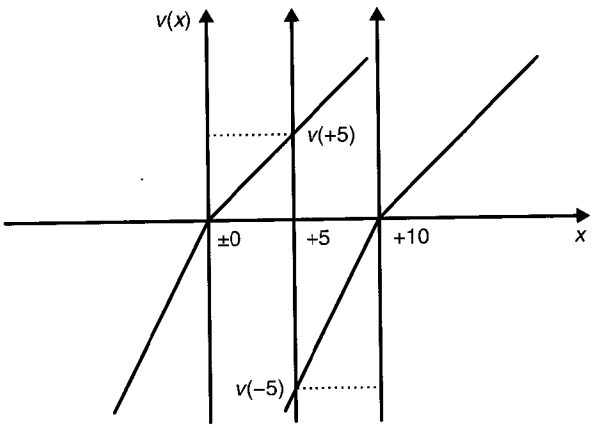


Figure A.6 The raise

Exercise 3.44 (**a**) $v(+93 - 75) = v(+18) = 9$. (**b**) $v(+67 - 75) = v(-8) = -16$. (**c**) The theory would suggest that you should set low expectations and perform well.

Exercise 3.45 The theory would suggest that you should surround yourself with low-paid people and make a lot of money.

Exercise 3.47 See Figure A.7.

Exercise 3.48 (**a**) Status quo bias would entail that Europeans would tend to favor the European system while Americans would tend to favor the American system. The bias is driven by loss aversion. For Europeans, the loss of government-provided health care would not be outweighed by the gain in disposable income; for Americans, the loss of disposable income would not be outweighed by the gain in government-provided health care. (**b**) See Figure A.8. (**c**) Loss aversion suggests that after adaptation has occurred, Americans would be unwilling to give up the new system, and the opposition party would find it difficult to engineer a return to the old one.

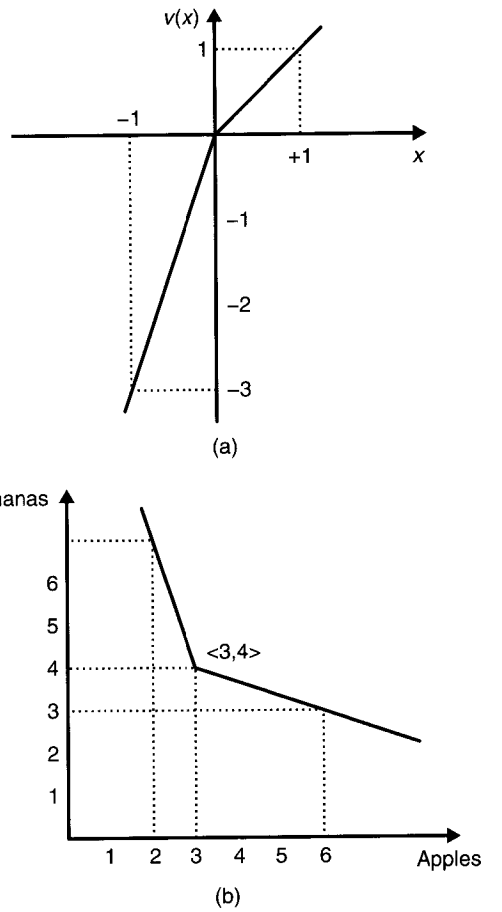


Figure A.7 Value function and indifference curve

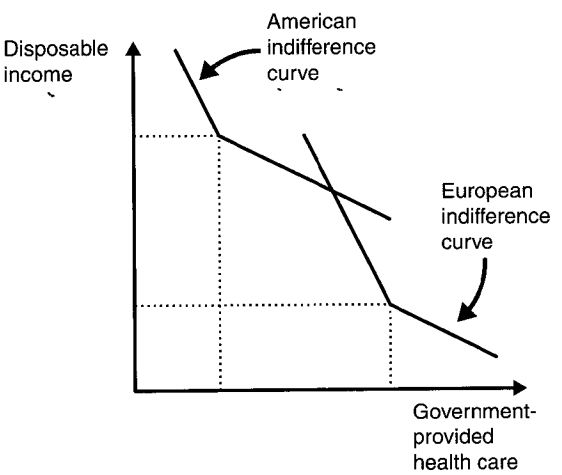


Figure A.8 Health care systems

Exercise 3.49 Loss aversion/status quo bias makes it very difficult to take money or other benefits away from people.

Exercise 3.50 (**a**) Once a program is enacted, loss aversion will make the beneficiaries of that program extremely averse to canceling it. This example also illustrates the concept of status quo bias. (**b**) The sunset provision is supposed to shorten the lifespan of temporary programs, since simply letting legislation expire is easier than taking positive action to cancel it.

Exercise 3.54 Assume that the emperor computed the number of grains of rice that he would owe the inventor during the first n days, where n is a number considerably less than 64, used that number as an anchor, and insufficiently adjusted the number upwards.

Exercise 3.55 Advertise it as being sharply reduced from an original, even higher price.

Exercise 3.56 The answer is (**b**) $10. The answer is the value to you of going to the Dylan concert ($50) minus what you would have to pay to go ($40). Only 21.6 percent of the professional economists in the study got the answer right, which is particularly embarrassing if you reflect on the fact that they could have done better had they simply picked their answers randomly.

Exercise 3.57 The conclusion overlooks the opportunity costs of making money. In real life, all things are not equal: if you decide to do something like work more to increase your income, there is an opportunity cost in terms of foregone leisure, time with family and friends, and so on. As you work and earn more and more, the marginal benefit of money will go down, and you will ultimately hit a point where you are better off switching to leisure. Working more than that is working too much.

Exercise 3.58 The receptionist might be unfamiliar with the sunk-cost fallacy, which is another reason people who just purchased a one-week pass come back for more.

Exercise 3.59 The sunk-cost fallacy, again.

Exercise 3.60 See Figure A.9.

Exercise 3.61 (**a**) If Tim returned the phone, he would go from $v(0) = 0$ to $v(-1) = -3$, meaning that he would experience a loss of 3 units of value. (**b**) If Bill were to pick up a phone, he would go from $v(0) = 0$ to $v(+1) = 1$, meaning that he would experience a gain of 1 units of value. Bill's foregone gain when he does not pick up a phone, then, is 1. (**c**) Because Tim's loss in value terms would exceed Bill's foregone gain, Tim is more likely to end up the owner (proud or not) of the new iPhone.

Exercise 3.62 (**a**) When the price went from $7 to $4, in terms of deviations from his reference point, Larry went from ± 0 to -3. In terms of value, therefore, he went from $v(0) = 0$ to $v(-3) = -9$, meaning that he experienced a loss of 9 units of value. (**b**) When the price went from $7 to $4, in terms of

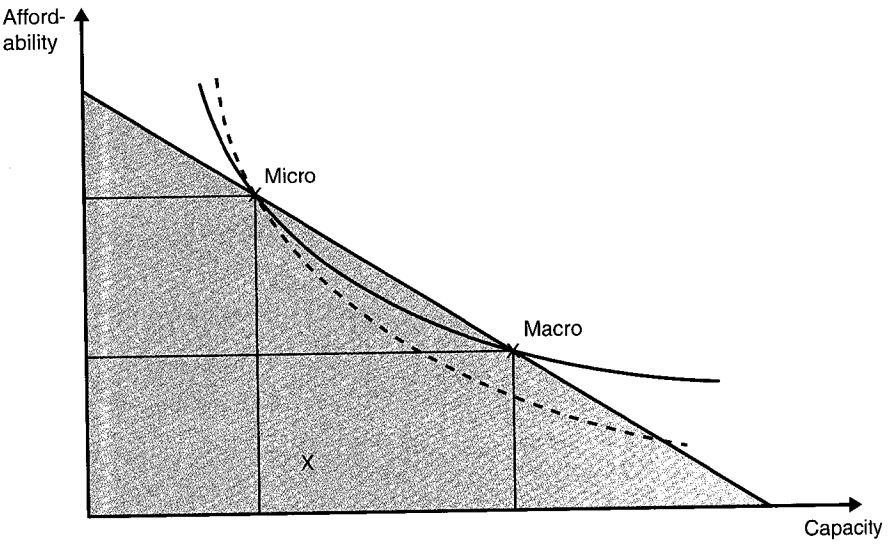


Figure A.9 Pear Corporation hijinks

deviations from her reference point, Janet went from +3 to ±0. In terms of value, then, she went from $v(+3) = 3/3 = 1$ to $v(0) = 0$, meaning that she experienced a loss of 1 unit of value. (c) Larry is more disappointed. Note that the difference is that Larry views the decline in stock price as a loss, whereas Janet views it as a foregone gain.

Exercise 3.63 Loss aversion makes the gain of *what you might become* seem small relative to the loss of *what you are* – prompting people to forgo the former in order to avoid the latter, even when they acknowledge that it would be better to act differently.

Exercise 3.64 The aspiration treadmill.

Exercise 3.65 (a) Sunk-cost fallacy. (b) Anchoring and adjustment. (c) Loss aversion. (d) Sunk-cost fallacy. (e) Failure to consider opportunity costs. (f) The compromise effect.

Chapter 4

Exercise 4.8 1/52. Whatever card you pick the first time around, you have a 1/52 chance to pick the same card again the second time.

Exercise 4.9 You can apply the rule only when the outcomes in question are equally likely, and there is no reason to think that is true here.

Exercise 4.10 The outcome space is reduced to {GB, GG} and the probability is 1/2.

Exercise 4.11 (a) {BBB, GGG, BBG, GGB, BGB, GBG, BGG, GBB}. (b) {GGG, BBG, GGB, BGB, GBG, BGG, GBB}. (c) 1/7. (d) {GGG, GGB, GBG, BGG}. (e) 1/4.

Exercise 4.12 (a) {W/W, W/W, R/R, R/R, W/R, R/W}. (b) {W/W, W/W, W/R}. (c) 1/3.

Exercise 4.13 (a) {W/W, W/W, B/B, B/B, R/R, R/R, R/W, W/R}. (b) {B/B, B/B}. (c) 1. (d) {R/R, R/R, R/W}. (e) 1/3.

Exercise 4.14 The analysis of this problem is not completely uncontroversial, but it is fairly widely agreed that the probability is 1/3.

Exercise 4.16 (c) and (d).

Exercise 4.17 4/52 = 1/13.

Exercise 4.21 It is equally likely: the probability is 1/36 either way.

Exercise 4.22 (d).

Exercise 4.23 Not independent.

Exercise 4.24 Because there are two (mutually exclusive) ways for the dots to add up to eleven, the answer is 1/36 + 1/36 = 1/18.

Exercise 4.25 (a) 1/52 * 1/52 = 1/2704. (b) 1/13 * 1/13 = 1/169.

Exercise 4.26 (a) 1/6 * 1/6 = 1/36. (b) (1 − 1/6) * (1 − 1/6) = 25/36. (c) 1/6 * (1 − 1/6) + (1 − 1/6) * 1/6 = 10/36. (d) 1 − (1 − 1/6) * (1 − 1/6) = 11/36.

Exercise 4.27 It would be a mistake because you would be applying the OR rule to two outcomes that are not mutually exclusive.

Exercise 4.28 The answer is:

$$\frac{6}{49} * \frac{5}{48} * \frac{4}{47} * \frac{3}{46} * \frac{2}{45} * \frac{1}{44} = \frac{1}{13{,}983{,}816}$$

This amounts to about 0.000,000,07. So, if you were to play once a year, on the average you would win once every 13,983,816 years. If you played once per day, given that there are 364.25 days in a year, on the average you would win once every 268,920 years.

Exercise 4.30 If people assess the value of the ticket by using the amount that can be won as an anchor and adjusting downwards, insufficient adjustment would imply that they overestimate the value of the ticket. If, in addition, people assess the probability of winning by using the probability of picking the first number correctly as an anchor and adjusting downwards, insufficient adjustment would imply that they overestimate the probability of winning.

Exercise 4.31 (a) Pr(H|T) means "The probability that the patient has a headache given that he or she has a tumor," whereas Pr(T|H) means "The probability that the patient has a tumor given that he or she has a headache." (b) The probabilities are clearly different. In general, we should expect that $\Pr(H|T) > \Pr(T|H)$.

Exercise 4.33 You already know the answer is one in four, since there are four aces in a deck of cards and the ace of spades is one of them. But you can compute the answer using Definition 4.31 as follows:

$$\Pr(\mathbf{A}\spadesuit|\mathbf{A}) = \frac{\Pr(\mathbf{A}\spadesuit\&\mathbf{A})}{\Pr(\mathbf{A})} = \frac{\Pr(\mathbf{A}\spadesuit)}{\Pr(\mathbf{A})} = \frac{1/52}{4/52} = 1/4$$

Exercise 4.35 $\Pr(\mathbf{A}\spadesuit_1\&\mathbf{A}\spadesuit_2) = \Pr(\mathbf{A}\spadesuit_1) * \Pr(\mathbf{A}\spadesuit_2|\mathbf{A}\spadesuit_1) = 1/52 * 0 = 0.$

Exercise 4.38 (a) Assume that $\Pr(A|B) = \Pr(A)$, then use Proposition 4.34 to derive $\Pr(B|A) = \Pr(B)$. (b) Assume that $\Pr(B|A) = \Pr(B)$, then use Proposition 4.32 to derive $\Pr(A\&B) = \Pr(A) * \Pr(B)$. (c) Assume that $\Pr(A\&B) = \Pr(A) * \Pr(B)$, then use Proposition 4.34 to derive $\Pr(A|B) = \Pr(A)$.

Exercise 4.40 (a) See Figure A.10. (b) The probability that your patient dies within the year is

$$\Pr(D) = \Pr(D|A) * \Pr(A) + \Pr(D|B) * \Pr(B) = 4/5 * 1/3 + 1/5 * 2/3 = 2/5.$$

Exercise 4.41 The probability is

$$\Pr(P) = \Pr(P|E) * \Pr(E) + \Pr(P|\neg E) * \Pr(\neg E) = .90 * .60 + .50 * .40 = .54 + .20 = .74$$

Exercise 4.43 The answer is

$$\Pr(A|D) = \frac{\Pr(D|A) * \Pr(A)}{\Pr(D|A) * \Pr(A) + \Pr(D|B) * \Pr(B)} = \frac{4/5 * 1/3}{4/5 * 1/3 + 1/5 * 2/3} = 2/3.$$

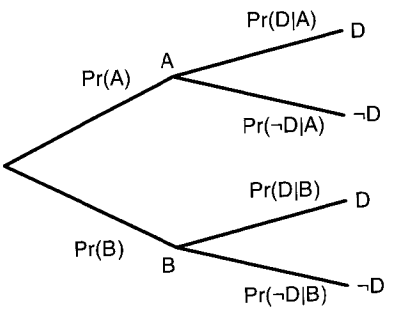


Figure A.10 Cancers A and B

Exercise 4.44 The probability that your test was easy given that you passed is

$$\Pr(E|P) = \frac{\Pr(P|E) * \Pr(E)}{\Pr(P|E) * \Pr(E) + \Pr(P|\neg E) * \Pr(\neg E)} = \frac{.54}{.74} \approx .73.$$

Your friend is probably right.

Exercise 4.45 (**a**) $1/4 * 1/6 = 1/24$. (**b**) $3/4 * 2/3 = 6/12 = 12/24$. (**c**) $1/24 + 12/24 = 13/24$. (**d**) $(1/24)/(13/24) = 1/13$. Good news!

Exercise 4.46 (**a**) The probability assigned to the hypothesis goes from 1/2 to 2/3 after the first trial. (**b**) It goes from 2/3 to 4/5 after the second trial.

Exercise 4.47 Given the way we have defined H and E for the purposes of this exercise, $\Pr(E|H)$ is now zero, since a coin with two heads cannot come up tails. Therefore, the posterior probability will equal 0 no matter the prior:

$$\Pr(H|E) = \frac{0 * \Pr(H)}{0 * \Pr(H) + 0.5 * \Pr(\neg H)} = 0.$$

Exercise 4.48 The outcomes are dependent, but not mutually exclusive.

Exercise 4.49 The answer is $(1/25{,}000)^3 = 1/15{,}625{,}000{,}000{,}000$. So if Langford gambles on undoctored machines three times a year, he could expect to win once every 15,625,000,000,000 years. Notice, though, that the probability that the machines were doctored given that he won does not necessarily equal the probability that he would win given that the machines were not doctored.

Exercise 4.50 The supposed reason is that economists (who tend to be highly numerate) tend not to gamble, which is a big problem in a hospitality industry heavily dependent on gambling revenue.

Exercise 4.51 (**a**) $\left(\frac{1}{2}\right)^{20} \approx 0.000{,}001$. (**b**) $\left(\frac{2}{3}\right)^{20} \approx 0.0003$. (**c**) $\left(\frac{4}{5}\right)^{20} \approx 0.01$. All-male editorial boards of that size are unlikely to result from a purely random process.

Exercise 4.52 (**a**) $0.250^3 \approx 0.016$. (**b**) $(1-0.250)^3 \approx 0.42$. (**c**) $3 * 0.250 * (1-0.250)^2 \approx 0.42$. (**d**) $1 - (1 - 0.250)^3 \approx 0.58$.

Exercise 4.53 (**a**) Because there are 26 letters in the alphabet, the probability is $(1/26)^8 = 1/208{,}827{,}064{,}576 \approx 0.000{,}000{,}000{,}005$. (**b**) The probability that any one letter will *not* spell out the vulgarity is $1 - 1/208{,}827{,}064{,}576 = 208{,}827{,}064{,}575/208{,}827{,}064{,}576$. So the probability that at least one of the letters will spell out the vulgarity is $1 - (208{,}827{,}064{,}575/208{,}827{,}064{,}576)^{100} \approx 0.000{,}000{,}000{,}5$. That is a little higher, but not much.

Exercise 4.54 Note that there are $2^{10} = 1024$ different ways to answer ten true/false questions. So: (**a**) 1/1024. (**b**) 1/1024. (**c**) 1/1024. (**d**) 10/1024. (**e**) 11/1024.

Exercise4.55 (a)1/2.(b)1/2.(c)$(1/2)^{10} = 1/1{,}024$.(d)$1-(1/1{,}024) = 1023/1024$.

Chapter 5

Exercise 5.1 If you do put all of your eggs in one basket, the events "Egg 1 breaks," "Egg 2 breaks," etc., would not be independent – which is bad if you want to make sure that some eggs remain whole.

Exercise 5.2 (a) You want them to be independent. (b) They would be dependent.

Exercise 5.3 The sellers want you to think you are more likely to win if you buy a ticket in this particular location. Thus, they hope (and perhaps expect) that you will take the outcomes "A previous ticket sold here was a winner" and "A future ticket sold here will be a winner" not to be independent, when in fact they are.

Exercise 5.4 People assume that triples of bad things – such as the three deaths – are dependent, when in fact they are not.

Exercise 5.5 (a) 1/256. (b) 1/2.

Exercise 5.6 The outcome 4-3-6-2-1 will seem more representative, and therefore more likely.

Exercise 5.7 (a) 1/10,000. (b) 1/100.

Exercise 5.8 1/25,000.

Exercise 5.13 The answers to all these questions are given by the expression $1 - (7/10)^t$, where t is the number of hours. So: (a) 0.51. (b) Approximately 0.66. (c) Approximately 0.97. Notice that under these circumstances, it is highly likely that you will come across at least one tornado during a 10-hour hike.

Exercise 5.14 The probability of a flood in any given year is 1/10. So: (a) 0.81. (b) 0.18. (c) 0.19. (d) Approximately 0.65.

Exercise 5.15 The probability of having no attack on any given day is $1 - 0.000{,}1 = 0.999{,}9$. There are $365.25 * 10 = 3652.5$ days in ten years. So the probability of at least one attack in ten years is $1 - (0.999{,}9)^{3652.5} \approx 0.306 = 30.6$ percent.

Exercise 5.16 (a) Approximately 0.08. (b) Approximately 0.15. (c) Approximately 0.55. (d) Approximately 0.98.

Exercise 5.17 Imagine that you line up the 30 students in a row. The first student can be born on any day of the year, and the probability of this happening is 365/365; the probability that the second student does not share a birthday with the first is 364/365; the probability that the third student does not share a birthday with either of the first two is 363/365; and so on, until you get to the 30th student: the probability that this student will not share a birthday with any of the

other 29 students is 336/365. So the probability you are looking for is 365/365 * 364/365 * ... 336/365 ≈ 29.4 percent. Thus, in a class this size, the probability that at least two students share a birthday is quite high: about 70.6 percent.

Exercise 5.18 (a) Approximately 0.634. (b) Approximately 0.999,96.

Exercise 5.19 (a) The probability of a catastrophic engine failure is p. (b) The probability of a catastrophic engine failure is $1 - (1 - p)^2 = 2p - p^2$. To see why this is so, refer to Figure A.11. (c) The single-engine plane. Notice that when p is small, p^2 will be so small as to be negligible. If so, the twin-engine plan is virtually twice as likely to experience a catastrophic engine failure as the single-engine plane! (d) Now, the probability of a catastrophic engine failure is p^2.

	Non-Failure	Failure
Non-Failure	(1–p)²	(1–p)*p
Failure	p*(1–p)	

Figure A.11 The private jets

Exercise 5.21 Because the base rate in men is extremely low, the test would not be diagnostic.

Exercise 5.22 Let B mean "The cab is blue," and let P mean "The witness says that the cab is blue." Here is the equation that produces the right answer:

$$\Pr(B|P) = \frac{8/10 * 15/100}{8/10 * 15/100 + 2/10 * 85/100} \approx 41\%$$

Notice that, in spite of the fact that the witness is relatively reliable, the cab that was involved in the accident is more likely to be green than blue

Exercise 5.23 The answer is given by this equation:

$$\frac{75/100 * 20/100}{75/100 * 20/10 + 25/100 * 80/100} \approx 43\%$$

Exercise 5.24 The answer is given by this equation:

$$\frac{1/1000 * 90/100}{1/1000 * 90/100 + 10/1000 * 10/100} \approx 47\%$$

Exercise 5.25 The probability is:

$$\frac{\frac{10}{10{,}000{,}000} * \frac{999}{1000}}{\frac{10}{10{,}000{,}000} * \frac{999}{1000} + \frac{9{,}999{,}990}{10{,}000{,}000} * \frac{1}{1000}} \approx 0.001 = 0.1\%$$

Exercise 5.26 (a) 98/1,000,000,000. (b) 19,999,998/1,000,000,000. (c) $98/20{,}000{,}096 \approx 0.000005 = 0.0005$ percent. (d) No.

Exercise 5.27 In Kabul the base rate is likely to be higher, and this might make the test diagnostic.

Exercise 5.28 The correct answer is C.

Exercise 5.30 If, for whatever reason, you manage to acquire a reputation for being smart, honest, diligent, and cool, you can ride that wave for a long time: confirmation bias means that people will continue to think of you in that way even if you do not always act the part. If, by contrast, people start thinking of you as stupid, dishonest, lazy, or uncool, the reputation will be very difficult to get rid of: confirmation bias means that whatever you do is liable to be interpreted as supporting that view.

Exercise 5.32 Books with titles of that kind will largely be read by people who already believe that the liberal mob/the Christian right are destroying America. Then, confirmation bias will set in and further support the readers' preexisting convictions.

Exercise 5.34

(a) $$\Pr(T|H) = \frac{\Pr(H|T) * \Pr(T)}{\Pr(H|T) * \Pr(T) + \Pr(H|\neg T) * \Pr(\neg T)}$$

$$= \frac{99/100 * 1/10{,}000}{99/100 * 1/10{,}000 + 1/10 * 9999/10{,}000} \approx 0.001.$$

(b) $$\Pr(F|G) = \frac{\Pr(G|F) * \Pr(F)}{\Pr(G|F) * \Pr(F) + \Pr(G|\neg F) * \Pr(\neg F)}$$

$$= \frac{95/100 * 999/1000}{95/100 * 999/1000 + 5/100 * 1/1000} \approx 0.99996.$$

Exercise 5.35 Given that the optometrist mainly sees contact users without problems, an image of a healthy user is most available to her. Given that the ophthalmologist mainly sees users with problems, an image of an unhealthy user is most available to him. Insofar as the two are prone to the availability bias, the optometrist is likely to underestimate, and the ophthalmologist to overestimate, the probability of developing serious problems as a results of wearing contacts.

Exercise 5.37 If people are more likely to remember cases when meteorologists' predictions were off, which is likely, the availability heuristic will cause people to think meteorologists are more poorly calibrated than they really are.

Exercise 5.39 Hindsight bias.

Exercise 5.40 The Dunning–Kruger effect.

Exercise 5.41 The heuristics-and-biases program says heuristics are largely functional and only sometimes lead to bias, which is a far cry from saying that people are irredeemably stupid or hopelessly lost.

Exercise 5.42 $Pr(HHH) = (2/3)^3 = 8/27$ whereas $Pr(HHT) = (2/3)^2(1/3) = 4/27$. It is best to bet on HHH.

Exercise 5.43 Since we are talking about overestimating the probability of a conjunction – the fact that the first member is male AND the second member is male AND so on – the person may have committed the conjunction fallacy.

Exercise 5.44 (**a**) 0.04. (**b**) 0.64. (**c**) 0.36. (**d**) Approximately 0.67.

Exercise 5.45 (**a**) 0.072. (**b**) 0.092. (**c**) 0.164. (**d**) Approximately 0.439. (**e**) The base-rate fallacy.

Exercise 5.46 This problem is in effect the same as Exercise 5.22, so the answer is the same: approximately 41 percent.

Exercise 5.47 (**a**) Let T mean that a person is a terrorist and M mean that a person is Muslim. Based on the figures provided, I assume that $Pr(T) = 10/300{,}000{,}000$; that $Pr(M|T) = 9/10$; and that $Pr(M|\neg T) = 2/300$. If so:

$$Pr(T|M) = \frac{\frac{10}{300{,}000{,}000} * \frac{9}{10}}{\frac{10}{300{,}000{,}000} * \frac{9}{10} + \frac{299{,}999{,}990}{300{,}000{,}000} * \frac{2}{300}} \approx 0.000{,}005 = 0.0005\%$$

(**b**) Obviously, there are many more dangerous things for Juan Williams to worry about. But if the image of a Muslim terrorist is particularly available to him, he would be prone to exaggerating the probability that a random Muslim would fall in that category.

Exercise 5.48 ...confirmation bias.

Exercise 5.49 Representativeness.

Exercise 5.50 The affect heuristic.

Exercise 5.51 (**a**) Confirmation bias would make Schumpeter more likely to remember and give weight to cases that support his hypothesis than cases that do not. (**b**) Assuming episodes where Schumpeter performed well in the three domains are particularly salient to him, availability bias would cause him to exaggerate the likelihood of a good performance. (**c**) An overconfident Schumpeter would be wrong more often than he thinks when it comes to his abilities in various domains. (**d**) The conjunction fallacy would cause him to overestimate the probability of the conjunction cI am the greatest economist in the world" AND "I am the best horseman in all of Austria" AND "I am the greatest lover in all of Vienna."

Exercise 5.52 (a) Confirmation bias. (b) Disjunction fallacy. (c) Availability bias. (d) Base-rate neglect. (e) Availability bias. (f) Conjunction fallacy. (g) Hindsight bias. (h) Availability bias.

Chapter 6

Exercise 6.1 (a) A maximin reasoner would purchase the warranty. (b) A maximax reasoner would not.

Exercise 6.2 (a) C. (b) A. (c) B. The risk-payoff matrix is Table A.2.

Table A.2 Risk-payoff matrix

	S_1	S_2
A	2	0
B	1	1
C	0	4

Exercise 6.5 See Figure A.12.

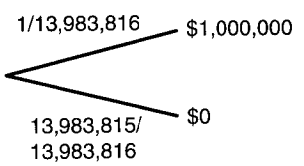


Figure A.12 Lotto 6/49 Tree

Exercise 6.8 (a) $EV(A) = 1/2 * 10 + 1/2 * 0 = 5$. (b) $EV(R) = 4$.

Exercise 6.10 See Table A.3.

Exercise 6.11 (a) The expected value is $1/5 * (-\$30) = -\$6$. (b) Yes.

Exercise 6.13 $3.50.

Table A.3 Roulette payoffs

Bet	Description	Payout	Pr(win)	Expected Value
Straight Up	One number	\$36	1/38	\$36/38
Split	Two numbers	\$18	2/38	\$36/38
Street	Three numbers	\$12	3/38	\$36/38
Corner	Four numbers	\$9	4/38	\$36/38
First Five	0, 00, 1, 2, 3	\$7	5/38	\$35/38
Sixline	Six numbers	\$6	6/38	\$36/38

First 12	1–12	\$3	12/38	\$36/38
Second 12	13–24	\$3	12/38	\$36/38
Third 12	25–36	\$3	12/38	\$36/38
Red		\$2	18/38	\$36/38
Black		\$2	18/38	\$36/38
Even		\$2	18/38	\$36/38
Odd		\$2	18/38	\$36/38
Low	1–18	\$2	18/38	\$36/38
High	19–36	\$2	18/38	\$36/38

Exercise 6.14 (a) \$400,020. (b) Open the boxes. (c) \$150,030. (d) Take the sure amount.

Exercise 6.16 (a) $-5/-100 = 1/20$. (b) $-5/-10 = 1/2$.

Exercise 6.18 The answer is 1/1,000,000.

Exercise 6.19 $p = -79/-325 \approx 0.24$

Exercise 6.23 (a) $EU(\text{R}) = u(4) = 4^2 = 16$. (b) $EU(\text{A}) = 1/2 * u(10) + 1/2 * u(0) = 1/2 * 10^2 + 1/2 * 0^2 = 50$. (c) You should accept the gamble.

Exercise 6.24 (a) About 0.000,07. (b) 1. (c) The dollar.

Exercise 6.25 (a) $EU(\text{A}) = 1/3 * \sqrt{9} = 1$. $EU(\text{B}) = 1/4 * \sqrt{16} = 1$ $EU(\text{C}) = 1/5 * \sqrt{25} = 1$. Choose either one. (b) $EU(\text{A}) = 1/3 * 9^2 = 27$. $EU(\text{B}) = 1/4 * 16^2 = 64$. $EU(\text{C}) = 1/5 * 25^2 = 125$. Choose C.

Exercise 6.26 (a) (i) $EV(\text{G}) = 1/4 * 25 + 3/4 * 1 = 7$. (ii) $EU(\text{G}) = 1/4 * \sqrt{25} + 3/4 * \sqrt{1} = 2$. (b) (i) $EV(\text{G}^*) = 2/3 * 7 + 1/3 * 4 = 6$. (ii) $EU(\text{G}^*) = 2/3 * \sqrt{7} + 1/3 * \sqrt{4} \approx 2.43$.

Exercise 6.27 (a) See Figure A.13(a). (b) See Figure A.13(b). (c) $EU(\neg\text{S}) = 0$. (d) $EU(\text{S}) = 0.85 * 10 + 0.10 * (-2) + 0.05 * (-10) = 7.8$. (e) Have the operation.

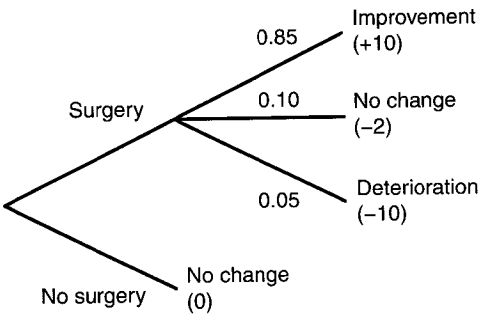
Exercise 6.28 (a) See Figure A.14. (b) The expected utility of going home is $3/4 * 12 + 1/4 * (-2) = 8.5$. The expected utility of staying put is $2/3 * 9 + 1/3 * 3 = 7$. Thus, you should go home, in spite of the possibility that your aunt might show up.

Exercise 6.29 There are many ways to complete this exercise, but the important result is that B is the rational choice no matter what.

Exercise 6.31 (a) $p = 1/2$. (b) $p = 3/4$. (c) $p = 2/3$.

Exercise 6.33 In this case, $EU(\text{A}) = 1/2 * 3^2 + 1/2 * 1^2 = 5$, whereas $EU(\text{R}) = 2^2 = 4$. So you should definitely accept the gamble.

Exercise 6.34 (a) Risk prone. (b) Risk averse. (c) Risk prone. (d) Risk averse. (e) Risk prone. (f) Risk neutral. (g) Risk prone.



(a)

	Improvement	No change	Deterioration
S	10	−2	−10
¬S	0	0	0

(b)

Figure A.13 Hearing loss

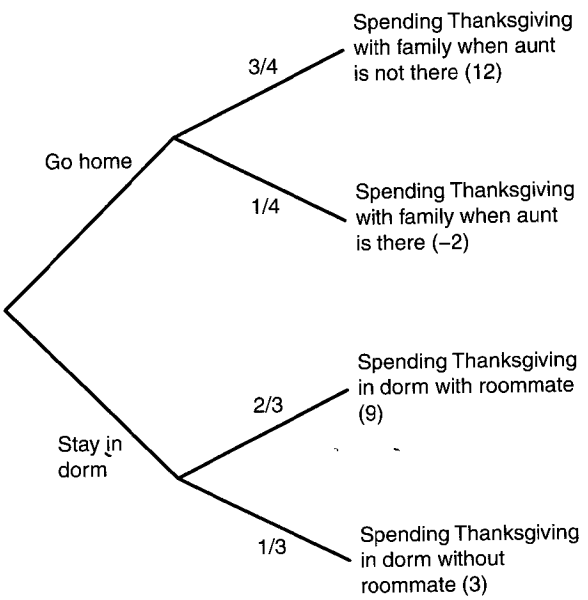


Figure A.14 Thanksgiving indecision

Exercise 6.36 See Figure A.15.

Exercise 6.38 $\sqrt{5}$.

Exercise 6.39 (**a**) The utility of \$4 is 2. The expected utility of G is 3/2. The certainty equivalent is 9/4. Choose \$4. (**b**) The utility of \$4 is 16. The expected utility of G is 21. The certainty equivalent is $\sqrt{21}$. Choose G.

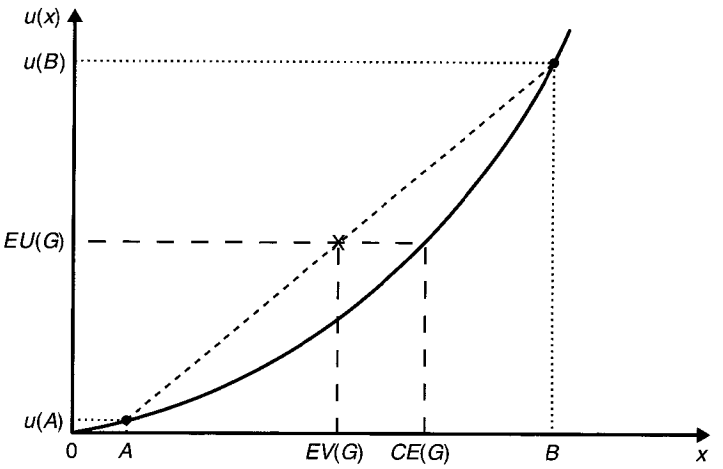


Figure A.15 Finding the certainty equivalent, cont.

Exercise 6.40 (a) The expected value of the gamble is 1.75. (b) The expected utility is 5/4. (c) The certainty equivalent is 25/16. (d) $p = 1/2$.

Exercise 6.41 (a) The expected utility is 5/2. (b) The certainty equivalent is 25/4. (c) The probability is 1/8. (d) You are risk averse.

Exercise 6.42 Approximately 0.000,000,49 cents.

Exercise 6.44 (a) The boxes. (b) The fixed amount. (c) $118,976.

Exercise 6.45 (a) $EU(\mathrm{B}) = 3$. (b) $EU(\mathrm{R}) = 4$. (c) Press the red button.

Exercise 6.46 Nowhere does the theory say that people perform these calculations in their heads – for the obvious reason that doing so would be impossible or prohibitively slow.

Chapter 7

Exercise 7.4 The value of ± 0 is still $v(\pm 0) = 0$, but the value of -10 is $v(-10) = -2\sqrt{|-10|} = -2\sqrt{10} \approx -6.32$. Thus, the absolute difference is $|v(-10) - v(\pm 0)|$ $|-6.32 - 0| = 6.32$. The value of -1000 is $v(-1000) = -2\sqrt{|-1000|} = -2\sqrt{1000} \approx -63.25$; the value of -1010 is $v(-1010) = -2\sqrt{|-1010|} = -2\sqrt{1010} \approx -63.56$. Hence, the absolute difference is $|v(-1010) - v(-1000)| \approx |-63.56 - (-63.25)| = 0.31$. The absolute difference between $v(\pm 0)$ and $v(-10)$ is much greater than the absolute difference between $v(-1000)$ and $v(-1010)$.

Exercise 7.5 The difference between $v(+10)$ and $v(+15)$ is $v(+15) - v(+10) = \sqrt{15/2} - \sqrt{10/2} \approx 0.50$. The difference between $v(+120)$ and $v(+125)$ is $v(+125) - v(+120) = \sqrt{125/2} - \sqrt{120/2} \approx 0.16$. The difference between $v(+10)$ and $v(+15)$ is much greater than than the difference between $v(+120)$ and $v(+125)$. Thus, an S-shaped value function can in fact account for the observed behavior.

Exercise 7.6 This problem can be analyzed using Figure 7.3 on page 156. Jen is risk averse because she takes "no animals saved" to be her reference point. Joe is risk prone because he takes "no animals lost" to be his reference point.

Exercise 7.8 (a) Omitted. (b) $v(\text{A}) = 1/2 * \sqrt{1000/2} \approx 11.18$. (c) $v(\text{B}) = \sqrt{500/2} \approx 15.81$. (d) $v(\text{C}) = 1/2 * (-2)\sqrt{1000} \approx -31.62$. (e) $v(\text{D}) = -2\sqrt{500} \approx -44.72$.

Exercise 7.9 (a) The value of the gain is $v(+4) = \sqrt{+4/2} = \sqrt{2} \approx 1.41$ and the value of the loss is $v(-4) = -2\sqrt{|-4|} = -2*2 = -4$. In absolute terms, the loss is greater than the gain. (b) Relative to a \$0 reference point, \$0 is coded as ±0, \$2 as +2, and \$4 as +4. The value of the sure thing is $v(+2) = \sqrt{+2/2} = 1$. The value of the gamble is $1/2 * v(\pm 0) + 1/2 * v(\pm 4) = \sqrt{\pm 0/2} + 1/2 * \sqrt{\pm 4/2} \approx 0.71$. The person prefers the sure amount. (c) Relative to a \$4 reference point, \$0 is coded as –4, \$2 as –2, and \$4 as ±0. The value of the sure thing is $v(-2) = -2\sqrt{|-2|} = -2\sqrt{2} \approx -2.83$. The value of the gamble is $1/2 * v(-4) + 1/2 * v(\pm 0) = 1/2 * (-2)\sqrt{|-4|} + 1/2 * (-2)\sqrt{|\pm 0|} = -2$. The person prefers the gamble.

Exercise 7.10 (a) Relative to a \$1 reference point, \$1 is coded as ±0, \$2 as +1, and \$5 as +4. The value of the sure thing is $v(+1) = \sqrt{1/2} \approx 0.71$ and the value of the gamble $1/2 * v(\pm 0) + 1/2 * v(+4) = 1/2 * \sqrt{\pm 0/2} + 1/2 * \sqrt{+4/2} = 1/2 * \sqrt{2} \approx 0.71$. The person is indifferent. (b) Relative to a \$5 reference point, \$1 is coded as –4, \$2 as –3, and \$5 as ±0. The value of the sure thing is $v(-3) = -2\sqrt{|-3|} = -2\sqrt{3} \approx -3.46$. The value of the gamble is $1/2 * v(-4) + 1/2 * v(\pm 0) = 1/2 * (-2)\sqrt{|-4|} + 1/2 * (-2)\sqrt{|\pm 0|} = 1/2 * \sqrt{4} = -2$. The person prefers the gamble.

Exercise 7.11 The analysis in this section says that people are more risk prone when they are in the realm of losses. Assuming people who are made to feel poor end up feeling like they are in the realm of losses, the analysis suggests that they should be more likely to choose lottery tickets – which is exactly what the researchers found.

Exercise 7.12 (a) $v(+48+27) = v(+75) = \sqrt{75/3} = 5$. (b) $v(+48) + v(+27) = \sqrt{48/3} + \sqrt{27/3} = 7$. (c) It is better to segregate.

Exercise 7.14 (a) Chances are you would make fewer purchases. (b) The arrangement would encourage you to segregate your losses but integrate your gains, which would simultaneously increase the pain of paying for your stuff and reduce the enjoyment you would derive from it.

Exercise 7.15 The procedure encourages travelers to segregate the costs, which is likely to make them feel worse about the expenditure than they would if they were integrated.

Exercise 7.16 (a) $v(-144-25) = v(-169) = -3\sqrt{169} = -39$. (b) $v(-144) + v(-25) = -3\sqrt{144} + (-3)\sqrt{25} = -51$. (c) It is better to integrate.

Exercise 7.17 The advertisement is supposed to make you buy more books by encouraging you to integrate the costs. Because the books are different, you are less likely to integrate them.

Exercise 7.18 (a) You should encourage voters to integrate: "You're still taking home \$900k!" (b) You should encourage voters to segregate: "You made \$1M! That money is yours! The government is taking \$100k of your money!"

Exercise 7.19 (a) $v(-9 + 2) = v(-7) \approx -5.29$. (b) $v(-9) + v(+2) = -5$. (c) It is better to segregate.

Exercise 7.21 (a) You must ignore the column marked B. (b) You must ignore the columns marked P and R.

Exercise 7.22 The choice pattern (1a) and (2a) is excluded, as is the choice pattern (1b) and (2b).

Exercise 7.24 A strict preference for A over B entails that $EU(\text{A}) > EU(\text{B})$, which means that $1 * u(30) > 0.80 * u(45)$. Divide each side by four, and you get $0.25 * u(30) > 0.20 * u(45)$. A strict preference for D over C entails that $EU(\text{D}) > EU(\text{C})$, which means that $0.20 * u(45) > 0.25 * u(30)$. But this is inconsistent.

Exercise 7.26 Being ambiguity averse, you would rather bet on the fair coin.

Exercise 7.27 Since the probabilities are *most* ambiguous in game 3, you would be *least* likely to bet on that game.

Exercise 7.28 (a) Donner is ambiguity prone. (b) Assuming he considers himself competent at real-estate investing, his attitudes are compatible with the competence hypothesis.

Exercise 7.33 The value of a dollar for sure is $\pi(1)\, v(1) = v(1)$, given that $\pi(1) = 1$. The value of the lottery is $\pi(1/1000)\, v(1000)$. If $v(\cdot)$ is S-shaped, $v(1000) < 1000 * v(1)$. But given that $\pi(x) > x$ for low probabilities, $\pi(1/1000) > 1/1000$. If $\pi(1/1000)$ is *sufficiently* greater than $1/1000$, the value of the lottery will exceed the value of the dollar.

Exercise 7.34 (a) 1000. (b) 1018. (c) 1030. (d) Invest in stocks. (e) Invest in bonds.

Exercise 7.35 The value of the status quo is $v(0) = 0$. The value of the gamble is $v(\text{G}) = 1/2 * \sqrt{10/2} + 1/2 * (-2)\sqrt{|-10|} = 1/2\sqrt{5} - \sqrt{10} \approx -2.04$. You would reject the gamble in favor of the status quo.

Exercise 7.36 (a) By segregating expenditures, you will feel the loss of money more intensely, which can lead to reduced spending. (b) The term is mental accounting. (c) One problem is that you might overspend in one category and underspend in another, violating fungibility.

Exercise 7.37 (a) Silver lining. (b) Mental accounting. (c) Competence hypothesis. (d) Certainty effect. (e) Ambiguity aversion.

Chapter 8

Exercise 8.3 See Table A.4.

Table A.4 Cost of credit

Credit-card offer	$1,000	$100	$10,000
Silver Axxess Visa Card	$247.20	$67.92	$2,040.00
Finance Gold MasterCard	$387.50	$263.75	$1,625.00
Continental Platinum MasterCard	$248.20	$68.92	$2,041.00
Gold Image Visa Card	$213.50	$53.75	$1,811.00
Archer Gold American Express	$296.50	$118.75	$2,074.00
Total Tribute American Express	$332.50	$168.25	$1,975.00
Splendid Credit Eurocard	$294.50	$94.25	$2,297.00

Exercise 8.5 $r = 0.20 = 20$ percent.

Exercise 8.8 (a) \$105. (b) \$162.89. (c) \$1146.74.

Exercise 8.9 (a) \$8664.62. (b) 8603.62. (c) 14,104 percent. (d) Just don't do it.

Exercise 8.12 (a) 1.00, 0.30, 0.04, and 1.34. (b) Choose d. (c) Choose a.

Exercise 8.13 The grasshopper's delta is lower than the ant's.

Exercise 8.14 (a) Low. (b) High. (c) High. (d) Low. (e). High.

Exercise 8.15 (a) The impartial spectator's delta is one. (b) Ours is much lower.

Exercise 8.17 To figure out when you would be indifferent, set up this equation $-1 = \partial * (-9)$ and solve for $\partial = 1/9$. You would (weakly) prefer one stitch just in case $\partial \geq 1/9$.

Exercise 8.18 (a) The curve would be steeper. (b) The curve would be flatter.

Exercise 8.19 (a) $\delta = 1/3$. (b) $\delta = 3/4$. (c) $\delta = 1/2$. (d) $\delta = 3/4$.

Exercise 8.20 (a) 2/3. (b) 1. (c) 1/2.

Exercise 8.21 (a) $\partial = 1$. (b) $\partial = 0$. (c) $\partial = 0.5$.

Exercise 8.23 The table would look like Table A.5, and $\delta = 80/609$.

Exercise 8.24 Young people discount the future too much – that is, their delta is too low – to put much weight on what happens 30–40 years hence.

Exercise 8.25 (a) People with higher discount factors tend to have higher credit scores. (b) People with higher discount factors are more likely to save for the future and better at managing debt, which means that they are more creditworthy.

Exercise 8.26 (a) $\delta = 1/(1+i)$, meaning that $r = i$. (b) $\delta = 1/\sqrt{(1+i)}$.

Table A.5 Time discounting

	$t = 0$	$t = 1$
a	81	16
b	1	625

Chapter 9

Exercise 9.2 (a) $1 + 1/3 * 1 * 3 + 1/3 * 1^2 * 9 = 5$. (b) $1 + 1 * 2/3 * 3 + 1 * (2/3)^2 * 9 = 7$. (c) $1 + 1/3 * 2/3 * 3 + 1/3 * (2/3)^2 * 9 = 3$.

Exercise 9.4 (a) U^{Thu}(**a**) = 8 and U^{Thu}(**b**) = 10; on Thursday, you would choose **b**. U^{Wed}(**a**) = 6.67 and U^{Wed}(**b**) = 8.33; on Wednesday, you would choose **b**.
(b) U^{Thu}(**a**) = 8 and U^{Thu}(**b**) = 2; on Thursday, you would choose **a**. U^{Wed}(**a**) = 1.33 and U^{Wed}(**b**) = 0.33; on Wednesday, you would choose **a**.
(c) U^{Thu}(**a**) = 8 and U^{Thu}(**b**) = 6; on Thursday, you would choose **a**. U^{Wed}(**a**) = 4 and U^{Wed}(**b**) = 6; on Wednesday, you would choose **b**.
(d) U^{Thu}(**a**) = 8 and U^{Thu}(**b**) = 4; on Thursday, you would choose **a**. U^{Wed}(**a**) = 2.67 and U^{Wed}(**b**) = 2.67; on Wednesday, you would be indifferent between **a** and **b**.

Exercise 9.5 (a) 8 and 4. (b) 12 and 6. (c) 3 and 1. (d) 3 and 6. (e) Benny. (f) Benny.

Exercise 9.6 (a) 2/3. (b) 3/4.

Exercise 9.7 (a) $\beta = 3/4$ and $\delta = 2/3$. (b) $x = 4.5$.

Exercise 9.8 $\beta = 4/5$ and $\delta = 1/2$.

Exercise 9.9 Wicksteed is indifferent at $\beta = 1/8$. If he does *not* reach for the blanket, β can be no greater than that, so $\beta \leq 1/8$.

Exercise 9.11 (a) If you are an exponential discounter, from the point of view of $t = 0$, you choose between U^0(**a**) = 3, U^0(**b**) = 5, U^0(**c**) = 8, and U^0(**d**) = 13. Obviously you prefer **d**, and because you are time consistent, that is the movie you will watch.
(b) If you are a naive hyperbolic discounter, from the point of view of $t = 0$, you choose between U^0(**a**) = 3, U^0(**b**) = $1/2 * 5 = 2.5$, U^0(**c**) = $1/2 * 8 = 4$, and U^0(**d**) = $1/2 * 13 = 6.5$. Thus, you will skip the mediocre movie and plan to see the fantastic one. From the point of view of $t = 1$, you choose between U^1(**b**) = 5, U^1(**c**) = $1/2 * 8 = 4$, and U^1(**d**) = $1/2 * 13 = 6.5$. You will skip the good movie, still planning to see the fantastic one. From the point of view of $t = 2$, you choose between U^2(**c**) = 8, and U^2(**d**) = $1/2 * 13 = 6.5$. You watch the great movie, foregoing the opportunity to see the fantastic one.
(c) If you are a sophisticated hyperbolic discounter, you know that you would be unable to skip the great movie at $t = 2$ and that you consequently will not

get to watch the fantastic movie. You also know that from the point of view of $t = 1$, your only realistic options would be $U^1(\mathbf{b}) = 5$ and $U^1(\mathbf{c}) = 1/2 * 8 = 4$. Consequently, you would watch the good movie. From the point of view of $t = 0$, then, your only realistic options are $U^0(\mathbf{a}) = 3$ and $U^0(\mathbf{b}) = 1/2 * 5 = 2.5$, meaning that you will watch the mediocre movie.

Exercise 9.12 (**a**) 8. (**b**) 13. (**c**) 4. (**d**) 12.33.

Exercise 9.14 Less pleasant.

Exercise 9.15 Given that the episode represented by a solid line has higher peak utility than the episode represented by a dashed line, and that the two have the same end utility, the person would favor the former over the latter.

Exercise 9.16 Assuming the college years contain great peak experiences and end on a high note, e.g., with a wonderful graduation ceremony, the peak–end rule will make people remember those years with great fondness. This is true even if there are long periods of tedium or worse.

Exercise 9.18 Projection bias.

Exercise 9.19 (**a**) People overestimate the degree of variety they will want when eating the food, and consequently diversify too much. (**b**) People tend to be hungry when selecting their foods, and project their current hunger onto their future self, although the future selves will get progressively less hungry as they eat. (**c**) People in a hot, hungry state cannot fully empathize with their future, less hot and hungry state.

Exercise 9.20 Gilbert could question the validity of the numbers. But assuming they are correct, he would say (1) principal, then (2) executive chef, and then (3) loan officer. Unless you are yourself Gilbert, you know more about you than Gilbert does. But he thinks you are so bad at "simulating" future experiences that your knowledge does not translate into any kind of advantage.

Exercise 9.21 (**a**) 16/3 and 4. (**b**) 8 and 6. (**c**) 4 and 2. (**d**) 4 and 6. (**e**) Yves. (**f**) Ximena.

Exercise 9.22 (**a**) Refrain in youth and in middle age, but hit in old age. (**b**) Refrain in youth but hit in middle and old age. (**c**) Hit throughout.

Exercise 9.23 Several answers might be correct, but underprediction of adaptation certainly is one: we think being a prisoner, etc., is much worse than it is because we fail to anticipate the extent to which prisoners adapt to their conditions.

Exercise 9.24 (**a**) Hyperbolic discounting. (**b**) Choosing not to choose. (**c**) Preference over profiles. (**d**) Hyperbolic discounting. (**e**) Hyperbolic discounting. (**f**) Preference over profiles. (**g**) Choosing not to choose. (**h**) Misprediction or miswanting.

Chapter 10

Exercise 10.5 (a) ⟨U, L⟩ and ⟨D, R⟩. (b) ⟨U, L⟩. (c) ⟨U, R⟩.

Exercise 10.10 Suppose that Player I plays U with probability p and Player II plays L with probability q. (a) There is an equilibrium in which $p = q = 1/3$. (b) There is an equilibrium in which $p = 1/2$ and $q = 1$.

Exercise 10.11 Suppose that Player I plays U with probability p and Player II plays L with probability q. (a) There are two equilibria in pure strategies, ⟨U, L⟩ and ⟨D, R⟩, and a mixed equilibrium in which $p = 4/5$ and $q = 1/5$. (b) There are no equilibria in pure strategies but a mixed equilibrium in which $p = q = 1/2$. (c) There are two equilibria in pure strategies, ⟨U, L⟩ and ⟨D, R⟩, but no equilibria in mixed strategies.

Exercise 10.13 (a) The payoff matrix is given in Table A.6. (b) In the unique Nash equilibrium, both players randomize with probability 1/3, 1/3, and 1/3 (cf. Example 11.6 on pages 250–251).

Table A.6 Rock-paper-scissor payoff matrix

	R	*P*	*S*
R	0, 0	0, 1	1, 0
P	1, 0	0, 0	0, 1
S	0, 1	1, 0	0, 0

Exercise 10.16 This game has two Nash equilibria in pure strategies, ⟨S, ¬S⟩ and ⟨¬S, S⟩, and a mixed equilibrium in which each player plays S with probability 1/3.

Exercise 10.17 This game has two Nash equilibria in pure strategies, ⟨D, D⟩ and ⟨H, H⟩, and a mixed equilibrium in which each player plays D with probability 1/3.

Exercise 10.20 Yes.

Exercise 10.21 (a) This game has three Nash equilibria in pure strategies: ⟨U, L⟩, ⟨M, M⟩, and ⟨D, R⟩. (b) ⟨U, L⟩ and ⟨M, M⟩, but not ⟨D, R⟩, are trembling-hand perfect.

Exercise 10.25 The unique subgame-perfect equilibrium is ⟨D, RL⟩. That is, Player II plays R at the left node and L and the right node, and (anticipating this) Player I plays D.

Exercise 10.26 (a) In the unique subgame-perfect equilibrium, players always Take. (b) No.

Exercise 10.27 You would predict that economics majors would defect more frequently than non-majors, and that the economics majors therefore would do worse when playing against each other than non-majors would. Empirical evidence supports the prediction.

Chapter 11

Exercise 11.3 In a subgame-perfect equilibrium, a utilitarian Player II will accept any offer, since to her any division is better than ($0,$0). Because a utilitarian Player I would actually prefer ($5,$5) to any other outcome, that is the division that he will propose.

Exercise 11.4 See Table A.7 for the actual games played by (**a**) egoists, (**b**) utilitarians, (**c**) enviers, and (**d**) Rawlsians. The answers are: (**a**) ⟨D, D⟩, (**b**) ⟨C, C⟩ and ⟨D, D⟩, (**c**) ⟨D, D⟩, and (**d**) ⟨C, C⟩ and ⟨D, D⟩.

Table A.7 Social preferences

	C	D
C	4,4	0,5
D	5,0	3,3

(a) Egoists

	C	D
C	8,8	5,5
D	5,5	6,6

(b) Utilitarians

	C	D
C	0,0	−5,5
D	5,−5	0,0

(c) Enviers

	C	D
C	4,4	0,0
D	0,0	3,3

(d) Rawlsians

Exercise 11.7 Rawlsian preferences.

Chapter 12

Exercise 12.1 (**a**) ban; (**b**) nudge; (**c**) ban; (**d**) nudge; (**e**) incentive; (**f**) ban.

Exercise 12.2 The intervention simply changes the default option from French fries to apple slices.

Exercise 12.3 The "Bloomberg ban" is not a nudge because it interferes with the freedom of choice of rational and informed customers who want to buy large sodas.

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