

Notes

This book has extended endnotes on the web at how-emotions-are-made.com, providing additional scientific details, commentary, and stories about the construction of emotion and related topics.

Many of the printed endnotes include a web link to heam.info (example: heam.info/malloy). These links are shortcuts to the appropriate pages at how-emotions-are-made.com.

Introduction:

The Two-Thousand-Year-Old Assumption

1. *“sacrificed their lives protecting students”*: See the video and transcript at heam.info/malloy.
2. *by chance or by custom*: Tracy and Randles 2011; Ekman and Cordaro 2011; Roseman 2011.
3. *newspaper articles that discuss emotion*: From a study by my lab; see heam.info/magazines. *emoticons inspired by Darwin’s writings*: Sharrock 2013. See also heam.info/facebook-1.
4. *through “emotion analytics”*: See references at heam.info/analytics-1. *“team chemistry” from facial expressions*: ESPN 2014. See also heam.info/bucks. *training on the classical view*: Until recently, the FBI National Academy offered a training course based on Paul Ekman’s research.
5. *a product of human agreement*: Searle 1995.
6. *cost taxpayers \$900 million*: Government Accountability Office 2013. SPOT’s reincarnation, called HIDE (Hostile Intent Detection and Evaluation), may be consistent with newer evidence; see heam.info/spot-1.
7. *men . . . with fatal consequences*: This differential treatment persists even when physicians are told that women are at high risk of a heart attack (Martin et al. 1998; Martin et al. 2004).
8. *and hundreds of coalition forces*: Triandis 1994, 29.

1. *The Search for Emotion's "Fingerprints"*

1. *they feel anxious*: Higgins 1987.
2. *I described as emotional granularity*: The discovery of emotional granularity inspired a new domain of emotion research; see heam.info/granularity-1.
3. *part of universal human nature*: This book has had tremendous influence in psychology; see heam.info/darwin-1.
4. *small muscles on each side*: Tassinari et al. 2007.
5. *sadness, and happiness*: Ekman et al. 1969; Izard 1971; Tomkins and McCarter 1964.
6. *that best matches the face*: E.g., Ekman et al. 1969; Izard 1971. *face best matches the story*: E.g., Ekman and Friesen 1971. This is called the "Dashiell" method, after its inventor, the psychologist John Dashiell (1927).
7. *(language) to posed faces*: Ekman and Friesen 1971; Ekman et al. 1987. *expected emotion words and stories*: Ekman et al. 1969; Ekman and Friesen 1971. For an overview of the research program with the Fore of New Guinea, see Russell 1994. *such as Japan and Korea*: Russell 1994; Elfenbein and Ambady 2002.
8. *diagnostic fingerprints of emotion*: "The strongest evidence for distinguishing one emotion from another comes from research on facial expressions. There is robust, consistent evidence of a universal facial expression for anger, fear, enjoyment, sadness and disgust" (Ekman 1992, 175–176).
9. *how much, and how often*: Tassinari and Cacioppo 1992. *each muscle during each emotion*: Calculations control for random movements, or movements during a non-emotional comparison period.
10. *pleasant versus unpleasant feeling*: Cacioppo et al. 2000.
11. *facial movements as they occur*: Ekman and Friesen 1984. FACS was adapted from a method first developed by Swedish anatomist Carl-Herman Hjortsjö in 1969; see heam.info/FACS. *consistently match the posed photos*: Matsumoto, Keltner, et al. 2008. There are hundreds of published studies on emotional expressions, but this research was able to report only twenty-five studies where spontaneous facial movements were measured. Only half of those using FACS coding found that these movements matched the expected configurations, whereas all of those using a more relaxed version of FACS found a match. All found evidence supporting the claim that people make spontaneous facial movements during emotion matching the expected facial expressions. See heam.info/FACS.
12. *learn rules of social appropriateness*: The classical view calls them "display rules" (Matsumoto, Yoo, et al. 2008). *the two situations was indistinguishable*: Camras et al. 2007. The FACS method in this study was specially designed for babies (Oster 2006). For more on infant emotions, see heam.info/infants-2. *seeing facial movements at all*: Babies show cultural differences as well; see heam.info/camras-1.
13. *to offending smells and tastes*: Their facial movements have also been linked to non-emotional factors such as gaze direction, head position, and respiration (Oster 2005). *from the basic emotion method*: See heam.info/newborns-1. Nor do infants have distinctive cries for each emotion; see heam.info/newborns-2.
14. *disgust rather than anger*: Aviezer et al. 2008.
15. *asked actors to portray them*: Silvan S. Tomkins and Robert McCarter (1964) created the photos by drawing on earlier photos taken by the French neurologist Guillaume-

- Benjamin-Amand Duchenne, who was cited in Darwin ([1872] 2005); see also Widen and Russell 2013.
16. *emotion experts — accomplished actors*: This work was conducted by my former graduate student and now postdoctoral fellow Maria Gendron. *to match written scenarios*: Schatz and Ornstein 2006.
 17. *her brow is slightly knitted*: Sadly, Ms. Leo's publicist declined my request to reproduce this instructive photograph.
 18. *to improve your peripheral vision*: Susskind et al. 2008.
 19. *instruments of social communication*: Fridlund 1991; Fernández-Dols and Ruiz-Belda 1995. *the same each time*: Barrett 2011b; Barrett et al. 2011. *has a diagnostic facial expression*: For evidence on whether non-human primates are similar to humans in their expressions, see heam.info/primates-1. For evidence on whether people blind since birth make facial expressions, see heam.info/blind-2.
 20. *the journal Science in 1983*: Ekman et al. 1983. *in the autonomic nervous system*: The autonomic nervous system controls the body's internal organs, such as the heart, the lungs, etc. It is part of the peripheral nervous system (in contrast to the brain and spinal cord, which are considered the central nervous system). (*a measure of sweat*): Also known as an electrodermal response or a galvanic skin response; see heam.info/galvanic-1.
 21. *to move particular facial muscles*: A second task was used as well; see heam.info/recall-1.
 22. *can be evoked this way*: Facial muscles may move during emotion perception; see heam.info/faces-2.
 23. *surprise, and disgust*: Some of these results were unsurprising and others a mystery; see heam.info/body-1.
 24. *target emotions from these instructions*: Levenson et al. 1990, Study 4. *when these studies were conducted*: Barsalou et al. 2003. See heam.info/simulation-1. *the Minangkabau of West Sumatra*: Levenson et al. 1992. These experiments not only established reliability but also improved specificity, supporting the classical view. *than the Western subjects did*: It is not clear that the African subjects shared the same Westernized emotion concepts; see heam.info/sumatra-1.
 25. *and other bodily functions*: See heam.info/body-4. *[no] bodily changes that distinguished emotions*: Distinctions were of affect only; see heam.info/body-2. *exactly the same film clips*: Kragel and LaBar 2013; Stephens et al. 2010.
 26. *22,000 test subjects*: This work was conducted by my former graduate student Erika Siegel as her Ph.D. dissertation. Siegel et al., under review. *emotion fingerprints in the body*: For details on these meta-analyses, see heam.info/meta-analysis-1.
 27. *No, they don't*: Some versions of the classical view are designed to explain this variation; e.g., classical appraisal theories (chapter 8) propose that a person has to evaluate the situation in a particular way to trigger anger. See heam.info/appraisal-1. *body for its own sake*: The sympathetic and parasympathetic nervous systems are together called the autonomic nervous system. They evolved to support your body's movement (e.g., so you don't faint when you stand up). It is well known that sympathetic activity is mobilized for the metabolic demands associated with actual movement behavior (cardio-somatic coupling; Obrist et al. 1970) or expected conditions (e.g., supra-metabolic activity; Obrist 1981). See also heam.info/threat-1. *an angry person's physiological response*: Kassam and Mendes 2013; Harmon-Jones and Peterson 2009.

28. category involves different bodily responses: Test subjects reported feeling a given emotion (e.g., sadness) at a time when the experimenter expected it but were measured as having a variety of bodily responses. *not uniformity, is the norm*: See [heam.info/variation-1](#).
29. thinking, *which was proposed by Darwin*: Darwin (1859) 2003. *in abstract, statistical terms*: Mayr 2007. *able to identify one*: The average size of the American family in 2015 was 3.14 people (U.S. Census Bureau 2015).
30. *they'd avoided before the surgery*: Klüver and Bucy (1939) called this “psychic blindness”; see [heam.info/kluver-1](#).
31. *no strong feelings of fear*: Adolphs and Tranel 2000; Tranel et al. 2006; Feinstein et al. 2011. *difficulty identifying them as fearful*: Adolphs et al. 1994.
32. *learn to fear new objects*: Bechara et al. 1995.
33. *and hear fear in voices*: Adolphs and Tranel 1999; Atkinson et al. 2007. SM also had difficulty seeing fear in scenes only when they contained faces; see Adolphs and Tranel 2003. SM’s difficulties have other explanations not related to fear; see [heam.info/SM-1](#). *even without her amygdalae*: SM could perceive fear in faces under some circumstances; see [heam.info/SM-2](#).
34. *very different profiles regarding fear*: Becker et al. 2012. *compensating for her missing amygdalae*: Ibid. See also [heam.info/twins-1](#).
35. *results have been similarly variable*: In general, studying emotion via brain lesions is problematic; see [heam.info/lesions-1](#).
36. *can produce the same outcome*: Edelman and Gally 2001. Degeneracy even applies to an individual experience of emotion; see [heam.info/degeneracy-1](#).
37. *anterior insula and early visual cortex*: Whenever scientists speak of an “increase” in brain activity, it always means an increase relative to some control. For brevity, I do not write “relative to some control” throughout the text. Also, a phrase like “increased brain activity” is a simplification. Scientifically speaking, brain imaging (specifically functional magnetic resonance imaging, or fMRI) measures changes in magnetic fields, which come from changes in blood flow, which are themselves linked to changes in neural activity. I will continue to speak of increases and decreases in “activity” as a convenient shorthand. See [heam.info/fMRI](#). *linked to visual cortex*: Moriguchi et al. 2013. *an example of degeneracy*: More details about the study are at [heam.info/degeneracy-2](#).
38. *serve more than one purpose*: Barrett and Satpute 2013. The philosopher Mike Anderson calls them multi-use, meaning multipurpose (Anderson 2014). *to many different mental states*: One to many also exists at the level of individual brain regions, e.g., Yeo et al. 2014.
39. *related to firing neurons*: fMRI is much like an MRI that you might receive at a doctor’s office, with a few tweaks. See [heam.info/fMRI](#).
40. *viewed faces with neutral expressions*: Breiter et al. 1996.
41. *triggering “fear” stimulus*: Fischer et al. 2003.
42. *not seen it before*: This effect was first observed by Dubois et al. (1999); see [heam.info/novelty](#). *them in brain-imaging experiments*: Somerville and Whalen 2006. *the brain locus of fear*: An early experiment on fear followed a similar trajectory; see [heam.info/amygdala-1](#).
43. *fingerprints once and for all*: This work was completed as a Ph.D. dissertation by Kristen A. Lindquist, a former graduate student in my lab (Lindquist et al. 2012).

44. fingerprint for any single emotion: For more details on our meta-analysis, see [heam.info/meta-analysis-2](#). (*a brain network*): Touroutoglou et al. 2015. *stimulate individual neurons with electricity*: Guillory and Bujarski 2014. *such as monkeys and rats*: Barrett, Lindquist, Bliss-Moreau, et al. 2007. See [heam.info/stimulation-1](#).
45. *pretty tricky to pull off*: Levenson 2011.
46. *to the environment or context*: This variability is not infinite, of course, but constrained by the patterns that are possible in the body and available in one's culture. For evidence that emotions have no vocal signatures and hormone signatures, see [heam.info/vocal-1](#). Two papers from my lab illustrate different patterns of brain activity within an emotion category: Wilson-Mendenhall et al. 2011, and Wilson-Mendenhall et al. 2015.
47. *mathematical average for the norm*: Clark-Polner, Johnson, et al., in press. Pattern classification is misapplied in the search for emotion fingerprints; see [heam.info/pattern-1](#).
48. *brain-imaging studies of emotion*: Wager et al. 2015.

2. Emotions Are Constructed

1. *We will call it simulation*: Barsalou 1999; Barsalou 2008b. As is typical in science, different psychologists have called this mental feat by different names, depending on their research interests. Examples are “perceptual inference” and “perceptual completion” (Pessoa et al. 1998), “embodied cognition,” and “grounded cognition.”
2. *with a hint of sweetness*: Sensory neurons also fire during motion, and motor neurons during sensation; e.g., Press and Cook 2015; Graziano 2016. *using sensory and motor neurons*: Barsalou 1999.
3. *gagged from the simulated smell*: Simulation explains how ancient Greeks saw gods and monsters in the stars; see [heam.info/simulation-2](#).
4. *not reactions to it*: For a review, see Chanes and Barrett 2016.
5. *what a “Bee” is*: Barsalou 2003, 2008a.
6. *because they're useful or desirable*: For a similar analogy, see Boghossian 2006.
7. *(assuming you enjoy salmon)*: Yeomans et al. 2008.
8. *the defendant cannot be trusted*: Danziger et al. 2011.
9. *an emotion on the spot*: My experience in the coffee shop was typically Jamesian; see [heam.info/coffee](#). *the theory of constructed emotion*: In my academic papers, I called it the “Conceptual Act Theory of Emotion.” Thank goodness for editors.
10. *in a bunch of blobs*: Scientists call this “affective misattribution”; see [heam.info/affect-9](#). *using the same manufacturing process*: Some cultures lack emotion concepts and instead experience physical illness; you'll learn this in chapter 7.
11. *and, of course, emotion*: For references on construction, see [heam.info/construction-1](#).
12. *of changes in their environment*: Freddolino and Tavazoie 2012; Tagkopoulos et al. 2008.
13. *and act in the world*: For the various incarnations of social construction, see Hacking 1999. *depending on your social role*: Harré 1986.
14. *states like cognitions and emotions*: See more on these philosophers at [heam.info/construction-2](#). “*such processes variously combined*”: James 1884, 188. *on the context surrounding them*: Schachter and Singer 1962. The famous Schachter and Singer experiment is described at [heam.info/arousal-1](#). *the mechanism and its product*: William James and Wilhelm Wundt, founding fathers of psychology, were skeptical of emotion

- organs; see heam.info/james-wundt. *emotions and how they work*: For other examples of new psychological construction theories, see chapters in Barrett and Russell 2015; LeDoux 2014, 2015. *distinct from cognitions and perceptions*: The roots of construction stretch back further into mental philosophy; see heam.info/construction-3.
15. *treated you in a certain way*: The gross wiring of the brain comes from ancient Hox genes that are conserved in all vertebrate animals, even fish, but human activity influences the microwiring of a brain that incorporates experiences for later use (Donoghue and Purnell 2005). *your future experiences and perceptions*: Mareschal et al. 2007; Karmiloff-Smith 2009; Westermann et al. 2007.
 16. *population of unique individuals*: James wrote, “There is no limit to the number of possible different emotions which may exist, and why the emotions of different individuals may vary indefinitely, both as to their constitution and as to objects which call them forth” (1894, 454).
 17. *time spent chilling the dough*: See heam.info/chocolate-1 for some revealing examples.
 18. *sugar, and salt*: Barrett 2009.
 19. *participate at any given time*: Marder and Taylor 2011.
 20. *in for a difficult time*: Imagine trying to reverse-engineer a croissant by tasting one; see heam.info/croissant. Problems with reverse engineering are a clue that you are dealing with emergence (Barrett 2011a), i.e., that a system has properties beyond the sum of its components. See also heam.info/emergence-1.
 21. *and expert bakers know this*: This is called the “norm of reaction” in genetics; see heam.info/holism-1.
 22. *greater robustness for survival*: Whitacre and Bender 2010; Whitacre et al. 2012. *computational power of the brain*: Rigotti et al. 2013; Balasubramanian 2015. *a flexible mind without fingerprints*: Degeneracy is a prerequisite for natural selection; see heam.info/degeneracy-3.
 23. *time of day at which they are eaten*: Cupcakes and muffins are both snacks, however. And banana bread, which is a breakfast food and a dessert, is virtually identical to a banana muffin or cupcake except for the shape.
 24. *your body metabolizes it differently*: Crum et al. 2011.
 25. *perceptions exist within the perceiver*: By contrast, it is possible to measure how “accurately” a person detects a facial muscle movement because these movements can be measured electrically as you saw in chapter 1. See also Srinivasan et al., in press.

3. The Myth of Universal Emotions

1. *U.S. Open tennis finals*: For a similar example, see Barrett, Lindquist, and Gendron 2007. Also see Aviezer et al. 2012. For more details, see heam.info/aviezer-1.
2. *make meaning from the image*: A similar phenomenon occurs with the McGurk Effect, in which when someone speaks to you, what you see (mouth movements) influences what you hear (the sounds you perceive); see heam.info/mcgurk.
3. *fearful, and so on*: You even need knowledge of a person to recognize him in different photos; see heam.info/faces-4.
4. *world can recognize from birth*: E.g., Izard 1994.
5. *of the time on average*: In the basic emotion method, choosing the expected emotion word is called “accuracy,” which is a misnomer; see heam.info/bem-1. *about 72 percent of the time*: Russell 1994, table 2. See heam.info/bem-2.
6. *the results were even lower*: See, e.g., Widen et al. 2011.

7. *certain emotions and not others*: See [heam.info/priming-1](#). This process is called priming: It's like when someone says, "Try not to think of a white bear"; see [heam.info/wegner-1](#). "screaming in terror": For a fascinating example of simulation, see Gosselin and Schyns 2003. *the posed faces they see*: This study was conducted by my former graduate student Maria Gendron for her master's thesis (Gendron et al. 2012). *use the basic emotion method*: You can experience this priming yourself by listening to music backward; see [heam.info/stairway](#).
8. *impair emotion perception even more*: This study was conducted by my former graduate student Kristen Lindquist for her undergraduate honors thesis (Lindquist et al. 2006).
9. *lasts less than one second*: You can temporarily deactivate your own emotion concepts in the same way; see [heam.info/satiate-1](#). *yes/no decisions were incorrect*: Test subjects literally see faces differently depending on which concepts are called to mind by the emotion words provided in an experiment; see [heam.info/gendron-1](#).
10. *that was meaningful to them*: Lindquist et al. 2014. All test subjects sorted the faces by the feeling being depicted, and all were confident that the people in the same pile felt exactly the same way. Patients were also asked to sort the photos by actor to make sure they could understand and carry out our instructions. *sadness pile, and so on*: In other experiments, the patients produced random piles; see [heam.info/dementia-1](#). *pleasant versus unpleasant feeling*: We studied three patients in this sample; see [heam.info/dementia-2](#).
11. *who exhibit low emotional granularity*: Widen, in press; see [heam.info/widen-1](#). *that infants picked up on*: Caron et al. 1985. This phenomenon is called "toothiness"; see [heam.info/teeth-1](#).
12. *posed stereotypes are supposedly displaying*: Subjects do even worse when viewing real, spontaneous facial movements during emotional experiences, rather than the posed photos of the basic emotion method. Agreement is quite abysmal (Crivelli et al. 2015; Naab and Russell 2007; Yik et al. 1998).
13. *cognitive psychologist Debi Roberson*: Roberson et al. 2005. Roberson has shown that people do not perceive colors in a universal way; for more on whether color categories are universal, see [heam.info/color-1](#). *in Opuwo, northern Namibia*: See [heam.info/himba-1](#).
14. *didn't look like Himba tribespeople*: Lacking any Himba in Massachusetts, we had to construct this photo set carefully; see [heam.info/himba-2](#). *mixtures of the remaining faces*: Gendron et al. 2014b. *inferring mental states or feelings*: Vallacher and Wegner 1987. *to give evidence of universality*: In an additional experiment, we provided emotion words to guide the sorting task. The resulting piles looked a bit more like the results we would get with the basic emotion method but not dramatically so. See Gendron et al. 2014b.
15. *of photos of posed faces*: Sauter et al. 2010. Sauter's procedure is described at [heam.info/sauter-1](#). *that emotion perception was universal*: Several others have replicated Sauter et al.'s findings (Laukka et al. 2013; Cordaro et al. 2016). *rather than "happy"*: Gendron et al. 2014a. See [heam.info/himba-3](#) for more details.
16. *in the story was feeling*: "Each participant was asked, after each story, how the target person was feeling, in order to ensure that the participant had understood the story correctly" (Sauter et al. 2015, 355). Sauter et al. have called this extra step a "manipulation check"; see [heam.info/himba-4](#). "in their own words": Sauter et al. 2015,

- 355 (emphasis added). *the corresponding English emotion concepts*: Gendron et al. 2014a.
17. *the better match for sadness*: Himba participants had to “explain the intended emotion in their own words, before they proceeded to the experimental trials for that story” (Sauter et al. 2015, 355). That is, all the trials were delivered one right after the other, in what scientists call a “block” of trials; see heam.info/himba-4.
 18. *invention of the Middle Ages*: Trumble 2004, 89. *became more accessible and affordable*: Jones 2014. *“heavily freighted with significance”*: Beard 2014, 75. See also heam.info/smile-1. *happiness is simply not universal*: Smiles mean different things in different cultures (Rychlowska et al. 2015); see heam.info/smile-2.
 19. *“that conforms to Ekman”*: Fischer 2013.
 20. *used the basic emotion method*: People worldwide can perceive pleasant versus unpleasant feeling in experiments that don’t use the basic emotion method; see heam.info/valence-2.
 21. *Trobriand Islands in New Guinea*: Crivelli et al. 2016.
 22. *provided strong evidence for universality*: For a summary, see Russell 1994; Gendron et al. 2014b. *still claiming it as fact*: To read about the key condition, see Norenzayan and Heine 2005.
 23. *“something the Fore didn’t do”*: Ekman 2007, 7. *a set of facial movements*: Kudos to the social psychologist Robert Zajonc, who pointed out the embedded assumptions in the word “expression.” *of certain Japanese emotion concepts*: For examples, see heam.info/japanese-1. *emotions as transactions between people*: Lutz 1980; Lutz 1983.
 24. *catalogued many of the concerns*: Russell 1994.
 25. *hypothetical substance called luminiferous ether*: Firestein 2012, 22.
 26. *in the face, body, and voice*: The project began with one intrepid young psychologist, David Cordaro; see heam.info/cordaro.

4. The Origin of Feeling

1. *and displeasure feel qualitatively different*: Pleasure and displeasure are like a sixth sense; see heam.info/pleasure-1. *waking moment of your life*: Every human language that has been studied has words for “feels good” and “feels bad” (Wierzbicka 1999). Words in a variety of human languages also connote good and bad (Osgood et al. 1957). Findings like these have led psychologists like J. A. Russell to claim that valence and arousal properties are universal (Russell 1991a). See heam.info/pleasure-2.
2. *and your immune system*: Your body is a confusing array of “systems”; see heam.info/systems-1.
3. *the brain operated similarly*: The roots of this analogy run deep; see heam.info/stimulus-1.
4. *awaiting a jump-start*: Walløe et al. 2014; see heam.info/neurons-1. *continue from birth until death*: E.g., Llinás 2001; Raichle 2010; Swanson 2012.
5. *called intrinsic networks*: Yeo et al. 2011. Some of these networks are in your brain at birth, and others develop in the first few years of your life, as you interact with the physical and social environments (e.g., Gao et al. 2009; Gao, Alcauter, et al. 2014; Gao, Elton, et al. 2014). *producing the same basic function*: Marder and Taylor 2011; Marder 2012. It is best to think about function at the network level rather than the

- module/hub level. See [heam.info/network-1](#). *discoveries of the past decade*: See [heam.info/intrinsic-1](#).
6. *called simulation in chapter 2*: Intrinsic activity is also called default mode activity and the resting state; see [heam.info/resting-1](#).
 7. *a dark, silent box*: This observation is somewhat different than that offered by Fred Rieke (1999) and others, that the brain itself is a black box that only has access to its own states. *smells, and other sensations*: Bar 2007.
 8. *your brain makes predictions*: Clark 2013; Hohwy 2013; Friston 2010; Bar 2009; Loehmann and Deneve 2011.
 9. *brain's primary mode of operation*: Memory works similarly; see [heam.info/memory-1](#).
 10. *skull but explain it*: Clark 2013; Hohwy 2013; Deneve and Jardri 2016. *would be a visual prediction*: If you can taste the apple (is it tart or sweet?), then neurons in taste cortex have changed their firing patterns as a gustatory prediction. If you hear the crunch of biting into an apple and feel the juice dribbling down your chin, then neural firing in auditory cortex and somatosensory cortex has also changed as auditory and somatosensory predictions.
 11. *intent about moving your body*: Wolpe and Rowe 2015. "*illusion of free will*": Entertaining books on the illusion of free will are at [heam.info/free-1](#).
 12. *connection in every waking moment*: Koch et al. 2006. Sensory input that reaches your brain from the outside world is incomplete; see [heam.info/vision-1](#). *interconnections than it could maintain*: Sterling and Laughlin 2015; Balasubramanian 2015.
 13. *Only a small fraction*: In the bottom figure, the arrows are not meant to imply that predictions are carried from a single neuron to V1. More details on this example are at [heam.info/vision-2](#).
 14. *the signal represents intrinsic activity*: Raichle 2010. This intrinsic activity is metabolically expensive; see [heam.info/expensive-1](#).
 15. *baseball in a typical game*: On a regulation-sized baseball diamond, you have about 688 milliseconds to move into position, unless you are a professional baseball player, in which case you have more like 400 milliseconds. See [heam.info/baseball-1](#).
 16. *Prediction makes the game possible*: Ranganathan and Carlton 2007. This is also true for basketball; see Aglioti et al. 2008. *using your past experience*: Locating objects in space and preparing to act on them more heavily involves the dorsal part of your visual system; it transmits prediction error from the world a bit faster than the ventral part of the visual system, which is more important for conscious seeing (Barrett and Bar 2009). See [heam.info/dorsal-1](#). *and you catch it*: Your brain initiates your catch well before you consciously see the ball in the predicted location. You become aware of your intention to move your arm at about the same time as you become aware of seeing the ball in its current location, however, so it seems as if you see the ball and then move your arm to catch it. See [heam.info/ventral-1](#).
 17. *sensory input of mashed carrots*: Another example might be inattentive blindness; see [heam.info/blind-1](#).
 18. *influencing and constraining each other*: Chanes and Barrett 2016. There is evidence in studies with rats that taste works by prediction, but currently there are no experiments in humans; my examples in chapter 2 of my daughter's gross foods birthday party and the salmon ice cream experiment demonstrate both olfactory (smell) and gustatory (taste) predictions in action.
 19. *prediction and sensory input*: Carhart-Harris et al. 2016; Barrett and Simmons 2015; Chanes and Barrett 2016. See [heam.info/LSD](#).

20. *and changes your blood pressure*: Along with your autonomic nervous system, your brain commands two other systems within the body that make physical movements possible. Your endocrine system regulates your metabolism, ions (like sodium), etc., through hormones, and your immune system protects your body against disease. See [heam.info/interoception-7](#). *remember, is called interoception*: Interoception was originally defined by Sir Charles Scott Sherrington; for a readable and comprehensive update, see Craig 2015; [heam.info/interoception-1](#).
21. *that is noisy and ambiguous*: Interoceptive information is noisy and ambiguous; see [heam.info/interoception-2](#). *of movements inside your body*: Barrett and Simmons, 2015.
22. *heart pounding in your chest*: Even an inflamed organ might not produce a sensation; see [heam.info/interoception-3](#). Self-reports of bodily sensations rarely correspond to actual sensitivity; see [heam.info/interoception-6](#). *experience these sensations with precision*: See [heam.info/interoception-2](#).
23. *be an instance of emotion*: Scientists still don't understand why intense interoceptive sensations are sometimes experienced as physical symptoms and other times as emotions.
24. *hearing, and other senses*: Kleckner et al., under review. The interoceptive network is made up of two overlapping networks that go by many other names, depending on the interests of the scientists who named them; see [heam.info/interoception-12](#). *your body in the world*: Interoception is actually a whole-brain process anchored in this network; see [heam.info/interoception-9](#).
25. *and the default mode network*: Many studies seem to show that the default mode and salience networks work in opposition: a brain can be in an internal mode, with the default mode network "activated" and the salience network "deactivated" (meaning one is sending more signal than during the rest period and the other is showing less), or the brain can be in an external mode with the opposite pattern. This opposition is an analysis artifact. The two networks can work together or in opposition. For a detailed list of cortical and subcortical regions in the interoceptive network, see [heam.info/regions-1](#).
26. *called your primary interoceptive cortex*: For more on the primary interoceptive cortex, see [heam.info/interoception-10](#).
27. *simulated in the usual way*: Barrett and Simmons 2015. Every other intrinsic network in the brain overlaps with the interoceptive network in at least one of its regions (van den Heuvel and Sporns 2013). So the interoceptive network doesn't create all of its predictions by itself; see [heam.info/interoception-11](#).
28. *a budget for your body*: Scientists call this budget-balancing act "allostasis" (Sterling 2012). See [heam.info/allostasis-1](#).
29. *region within the interoceptive network*: These regions are called "limbic" and include the amygdala; the nucleus accumbens and the rest of the ventral striatum; the anterior, mid, and posterior cingulate cortices; the ventromedial prefrontal cortex (part of the orbitofrontal cortex); the anterior insula; and more.
30. *times when you are stressed*: For more on cortisol, see [heam.info/cortisol-1](#).
31. *of everyone else around us*: If we had also measured Erika's endocrine and immune responses, we would have found them elevated. For example, body-budgeting circuitry instructs the autonomic nervous system to regulate your immune response to avoid joint inflammation as you move. See Koopman et al. 2011.
32. *and other objects and scenes*: The stimuli are from the International Affective Pic-

- ture System (Lang et al. 1993). *blood vessels dilate*: See [heam.info/galvanic-1](#). *controlling these inner-body movements*: Weierich et al. 2010; Moriguchi et al. 2011. See also [heam.info/fMRI](#).
33. *anything else relevant to you*: My lab has demonstrated this in collaboration with the cognitive scientist Larry Barsalou and Christy Wilson-Mendenhall (Larry's former Ph.D. student, who completed a postdoctoral fellowship in my lab). We asked test subjects to imagine some scenarios we provided while we observed their brain activity using fMRI scanning (Wilson-Mendenhall et al. 2011). See [heam.info/scenarios](#). *simulation strongly drives their feelings*: Killingsworth and Gilbert 2010.
 34. *leading to tangible benefits*: Palumbo et al., in press. Synchrony can also incur costs if one person is stressed; see Waters et al. 2014; Pratt et al. 2015. *less bothered by pain*: Scientists have seen this in experiments using electric shocks (Coan et al. 2006; Younger et al. 2010). For reviews, see Eisenberger 2012; Eisenberger and Cole 2012. *than if you are alone*: Schnall et al. 2008. *supportive person in your life*: John-Henderson, Stellar, et al. 2015. See chapter 10 and [heam.info/children-2](#) for additional discussion. *helping to regulate your budget*: Sbarra and Hazan 2008; Hofer 1984, 2006.
 35. *that you experience every day*: This is what some people call "mood."
 36. *simpler feeling with two features*: Scholars and scientists have confused affect and emotion for centuries. See [heam.info/affect-1](#). In the science of emotion, the term "affect" is sometimes used to mean anything emotional. In this book, we limit the term to a specific meaning: a change in your internal environment that you experience as feelings of valence and arousal. This modern conception of affect was developed by Wilhelm Wundt; see [heam.info/wundt-1](#). *which scientists call valence*: Barrett and Bliss-Moreau 2009a; Russell 2003. The word "valence" has other meanings in science; see [heam.info/valence-1](#).
 37. *basic features of human experience*: Eastern and Western philosophy describe valence and arousal as basic to human experience; see [heam.info/affect-2](#). *with fully formed emotions*: Infants experience affect, even as there is no consistent evidence that they experience emotions (Mesman et al. 2012); see [heam.info/affect-3](#).
 38. *from birth until death*: Barrett and Bliss-Moreau 2009a; Quattrocki and Friston 2014. See [heam.info/affect-4](#).
 39. *the great mysteries of science*: The structure of the cortex provides some hints to the mystery of affect; see [heam.info/cortex-2](#). *to regulate your body budget*: People believe interoception is "for" feeling because feelings are important to people, and scientists, as people, create causal hypotheses to explain what is important to them. See [heam.info/teleology](#). *if so, how desperately*: Unpleasant affect might be the brain's signal for an unbalanced body budget; see [heam.info/budget-1](#).
 40. *to search for explanations*: For example, arousal is a cue to learn (i.e., process prediction error; Johansen and Fields 2004; Fields and Margolis 2015; McNally et al. 2011). With learning comes better prediction and categorization, and therefore a specific action plan. *are collectively your affective niche*: A similar concept is "ecological niche," which is all the aspects of a creature's physical environment that are relevant to its survival.
 41. *from the origin representing intensity*: A circumplex represents relationships through the geometry of a circle (Barrett and Russell 1999); see [heam.info/circumplex](#).
 42. *"unpleasant, low arousal"*: Hundreds of studies over the past thirty years have demonstrated that feelings can be characterized as points within this affective circumplex (Russell and Barrett 1999; Barrett and Bliss-Moreau 2009a). Some people feel changes

- of valence and arousal together, whereas for others the two properties are independent (Kuppens et al. 2013). *cultures like China and Japan*: Tsai 2007; Zhang et al. 2013.
43. *that your judgment was correct*: Philosophers call this “world-focused” affect; see [heam.info/affect-8](#). *a 2011 study of judges*: Danziger et al. 2011. In laboratory experiments, when test subjects use strong affect to make harsh sentencing decisions, we see increased activity in a visceromotor region of the interoceptive network (Buckholz et al. 2008).
 44. *based on gut feelings*: Huntsinger et al. 2014. People use affect as information about whatever is in one’s focus of attention; see [heam.info/realism-3](#). *explicitly asked about the weather*: Schwarz and Clore 1983. *negatively when it is rainy*: Interview candidates receive lower ratings on rainy days; see Redelmeier and Baxter 2009; [heam.info/realism-4](#). *maybe it’s just lunchtime*: People have invented the concept “hangry” to cover this experience. *anything to do with you*: Even simple actions like taking a drink become moments of affective realism (Winkielman et al. 2005). See [heam.info/realism-5](#).
 45. *see the person’s face differently*: Anderson et al. 2012. Affect takes as its object whatever is in mind at the time; see [heam.info/realism-1](#).
 46. *“bring it on themselves”*: Affective realism lets us sidestep responsibility; see [heam.info/realism-2](#).
 47. *when they are performing well*: Shenhav et al. 2013; Inzlicht et al. 2015.
 48. *camera to be a gun*: Reuters journalist Namir Noor-Eldeen, driver Saeed Chmagh, and several others were killed; see [heam.info/gunner-1](#).
 49. *as a weapon*: Fachner et al. 2015, 27–30.
 50. *in preparation to run*: Your arteries contain special cells called baroreceptors; see [heam.info/budget-2](#). *predict those sensations as well*: See [heam.info/interoception-8](#).
 51. *your interoceptive predictions are not*: Barrett and Simmons 2015. *the predicted need is over*: See [heam.info/cortex-1](#).
 52. *sluggish to correct their predictions*: Sometimes your body-budgeting regions can act quickly to change their predictions, like when your life is on the line. If you’re driving on the highway and another driver cuts you off, those body-budgeting regions let you correct your trajectory plenty fast.
 53. *simulations in your interoceptive network*: Barrett and Simmons 2015. My lab has evidence that affect is largely prediction; see [heam.info/affect-5](#).
 54. *ideas are not just speculation*: Is it possible to peer into a person’s brain and see exactly how interoceptive predictions are transformed into affect during brain imaging? The answer, I’m afraid, is not yet. But a meta-analysis conducted by members of my lab examining over four hundred brain-imaging studies found that body-budgeting regions in the interoceptive network, which issue interoceptive predictions, consistently increase in activity when people report strong changes in their affective feelings (Lindquist et al. 2015). *from treatment-resistant depression*: Holtzheimer et al. 2012; Lujan et al. 2013. *in the patient’s interoceptive network*: Specifically, the bundles of axons that connect body-budgeting regions within the interoceptive network; see [heam.info/mayberg-1](#). *in synchrony with the stimulation*: Choi et al. 2015. *new treatments for mental illness*: The neurons stimulated by Mayberg are not specific for affect, however; see [heam.info/affect-6](#).
 55. *destroyed by a rare illness*: Feinstein et al. 2010. See [heam.info/HSE](#). *difficulty with smell and taste*: These last items are no surprise because limbic tissue regulates these

- bodily functions. *producing the same outcome*: Since Roger has working autonomic nervous, endocrine, and immune systems, and much of the subcortical circuitry involved in interoception is still intact (like regions of his brainstem and hypothalamus), he still has sensory inputs coming to his interoceptive cortex from the body, which can be used to compute prediction error. See heam.info/roger. *based primarily on uncorrected predictions*: These patients still have interoceptive perceptions; see heam.info/PAF.
56. *predictors in your entire brain*: van den Heuvel and Sporns 2011, 2013. *are wired to listen*: Chanes and Barrett 2016. According to the noted neuroanatomist Helen Barbas, body-budgeting regions (also called “limbic” regions) are the most powerful feedback system in the brain, based on the pattern of their connections to other cortical regions. Another name for “feedback” is “prediction.” See Barbas and Rempel-Clower 1997, and heam.info/cortex-1.
57. *through affect-colored glasses*: Seo et al. 2010. Neuroeconomics seeks to understand how the brain estimates the value of different choices to allow decision-making. Value and affect are related concepts. See heam.info/neuroeconomics.
58. *for wisdom*: Damasio 1994. *the fabric of every decision*: Certainly other philosophers, such as David Hume, have held that view; see heam.info/affect-7.
59. *continued to guide economic practice*: Notably, the last century of seesawing among crisis, increased regulation, complaints, decreased regulation, followed by another crisis. See also heam.info/econ-1.
60. *up to the Great Recession*: Madrick 2014. *people are rational decision makers*: Krugman 2014. Another condition is that people are assumed to have all the price and product information they need, a situation that rarely occurs in practice; Marshall Sonenshine, professor of finance and economics at Columbia University, personal communication, May 10–July 31, 2013. *lurking beneath the surface*: Other economic disasters may have been precipitated by the anatomy of the human cortex. See heam.info/crises.
61. *uniquely human cortex*: The “neocortex” is not really new to the mammalian brain; see heam.info/triune-1. *successful misconceptions in human biology*: MacLean and Kral 1973. See heam.info/triune-2. *in his bestseller Emotional Intelligence*: Goleman 2006. He continues to rely on a version of the triune brain in his newer books. *brain evolution knows*: Evolutionary biologist Georg Striedter, editor of the scholarly journal *Brain, Behavior and Evolution* and author of *Principles of Brain Evolution* (2005), writes, “Many ‘classic’ notions about how vertebrate brains evolved (e.g., by adding neocortex to an ancestral ‘smell-brain’) continue to hold sway among many non-specialists, even though they have long been disproved” (2006, 2). “*present in all vertebrates*”: See more quotes from Finlay at heam.info/finlay-1. *keep themselves efficient and nimble*: Striedter 2006; Finlay and Uchiyama 2015. For more on brain evolution, see heam.info/evolution-1.

5. Concepts, Goals, and Words

1. *to perceive bands of color*: This process is called “categorical perception”; see heam.info/rainbow-1.
2. *sound into syllables and words*: In an unfamiliar spoken language, you might not even discern word boundaries; see heam.info/speech-1.

3. *context within the same speaker*: Many thanks to Larry Barsalou for this description; Barsalou 1992, chapter 9. *when presented in isolation*: Pollack and Pickett 1964. *to communicate with others*: Foulke and Sticht 1969; Liberman et al. 1967.
4. *like complex objects and scenes*: Grill-Spector and Weiner 2014.
5. *incapable of learning*: Jorge Luis Borges's story "Funes the Memorious" dramatizes this condition; see heam.info/funes.
6. *really out there*: William James used the phrase "blooming, buzzing confusion" to describe the world as a newborn infant would perceive it.
7. *means to be human*: There is an animated and important debate about whether a few concepts are inborn, such as number and cause. This debate is not central to our discussion here, because it doesn't change the theory of constructed emotion nor any interpretations of experiments. I do flag the debate where relevant, however.
8. *events by categorizing using concepts*: The philosopher Immanuel Kant wrote that we perceive the world in terms of concepts; see heam.info/kant-2.
9. *describing necessary and sufficient features*: Smith and Medin 1981; Murphy 2002.
10. *from antiquity until the 1970s*: Murphy 2002. *an ostrich a representative bird*: Philosopher Ludwig Wittgenstein also pointed out that most concepts cannot be defined by necessary and sufficient features and instead preferred to use family resemblances (Wittgenstein 1953; also see Murphy 2002; Lakoff 1990). *view of concepts finally collapsed*: Murphy 2002.
11. *known as the prototype*: Rosch 1978; Mervis and Rosch 1981; Posner and Keele 1968. *majority of the category's features*: Also known as family resemblance; see heam.info/prototype-1.
12. *of a given emotion category*: J. A. Russell, for example, has a prototype view of emotion concepts (Russell 1991b); see heam.info/russell-1.
13. *rarely found in real life*: In my research, I call this state of affairs "the emotion paradox" (Barrett 2006b); see heam.info/paradox-1.
14. *need them, on the spot*: Your brain is engaged in conceptual combination, discussed later in this chapter and at heam.info/combination-1. *that best fits the situation*: Your brain is using something like pattern classification; see heam.info/pattern-2.
15. *finding similarities in the variations*: Posner and Keele 1968. *constructed in the same manner*: Some scientists still believe that each emotion concept is a fixed prototype in the brain, however; see heam.info/prototype-2.
16. *with four wheels nailed on*: Barsalou 1985; Voorspoels et al. 2011; but see Kim and Murphy 2011. For a discussion, see Murphy 2002.
17. *in a particular situation*: Your brain combines bits and pieces of past experience to create a concept that is the best fit to the sensory cues of the current situation; this allows you to achieve your goal in this situation. Barsalou (1985) demonstrated that concepts are constructed dynamically and flexibly; see heam.info/goals-1.
18. *your goal in the moment*: These ideas are similar, although not identical, to those found in Edelman 1987; see heam.info/edelman-1.
19. *a process called statistical learning*: Xu and Kushnir 2013; Tenenbaum et al. 2011. See more on statistical learning at heam.info/stats-1.
20. *I won't enter that debate*: This is the nativism/empiricism debate; see heam.info/concepts-1.
21. *interest in listening to speech*: Vouloumanos and Waxman 2014. *and even in utero*: Moon et al. 2013. *a few minutes of exposure*: See Maye et al. 2002, in Kuhl 2007.

- Whether the patterning of certain sound concepts (phonemes) is learned from experience or triggered by experience (i.e., is innate) is a matter of great debate. For an excellent treatment of the nativist view, see Berent 2013. For a discussion of the empiricist view, how concepts can be learned from similarity, see Goldstone 1994. See also heam.info/concepts-5. *heard spoken by live humans*: The neural connections that are not used are likely pruned away. For more on the world's tuning of language, see Kuhl and Rivera-Gaxiola 2008.
22. *association between color and sound*: Gweon et al. 2010.
 23. *color was in the majority*: Denison and Xu 2010. Infants are sensitive to probabilities as young as six months old (Denison et al. 2013), and can use probabilities to make predictions and decisions (Denison and Xu 2014).
 24. *environment but anticipate them*: Freddolino and Tavaoie 2012. of the people around them: Keil and Newman 2010; Gelman 2009. The information that resides in the minds of others is the similarities created by their conceptual systems.
 25. *in the world does too*: Repacholi and Gopnik 1997. *interesting, colorful Slinky toys*: Ma and Xu 2011.
 26. *randomly versus with intent*: Details on this experiment are at heam.info/ball-1. *will occur several minutes later*: Southgate and Csibra 2009; Vouloumanos et al. 2012. Infants as young as eight months old can infer goals (Hamlin et al. 2009; Nielsen 2009; Brandone and Wellman 2009).
 27. *and strong eye contact*: Vouloumanos and Waxman 2014; Vouloumanos et al. 2012; Keil and Newman 2010; Lloyd-Fox et al. 2015; Golinkoff et al. 2015.
 28. *regularity that speeds concept learning*: Sloutsky and Fisher 2012. *infant to form a concept*: Waxman and Gelman 2010; Waxman and Markow 1995.
 29. *the effect never materialized*: Other sounds don't work either; see heam.info/sounds-1.
 30. *"equivalence that is mental"*: Waxman and Gelman 2010.
 31. *"wug" or "dak"*: Xu et al. 2005. *to represent things as equivalent*: See heam.info/goals-2. *physical similarity without a word*: Yin and Csibra 2015. See experimental results at heam.info/goals-3.
 32. *and so are experientially blind*: Turati 2004. See also heam.info/faces-1.
 33. *understanding of facial expressions*: E.g., Denham 1998; Izard 1994; Leppänen and Nelson 2009.
 34. *has put in your path*: Clore and Ortony 2008; Ceulemans et al. 2012; Roseman 2011.
 35. *in all its sensory detail*: Schyns et al. 1998.
 36. *to construct perceptions of anger*: This may be when children begin to learn that emotions cause actions; see heam.info/knowledge-1.
 37. *or wishing to appear powerful*: For more on goals related to anger, see also heam.info/anger-1.
 38. *until around age three*: The psychologists James A. Russell and Sherri C. Widen have a long program of research on children's emotion concepts; for a review, see Widen, in press; also see heam.info/russell-2. *to four months of age*: For the details on infant affect concepts, see heam.info/infants-1.
 39. *and "hoot" faces*: Parr et al. 2007. *concepts for the face categories*: Fugate et al. 2010.
 40. *"give me a hug"*: Harris et al., in press.
 41. *suffocation, and constriction*: Panayiotou 2004.
 42. *no equivalent in English*: Pavlenko 2014. *ones from your primary language*: Pavlenko 2009. See also heam.info/language-1. *situation, known as zlit'sia*: Ibid., chapter 6.

43. *the English concept for guilt*: Victor Danilchenko, a Ukrainian immigrant and computer scientist who worked with my husband, tells me that native Russian speakers in the United States sometimes use English idioms while speaking in Russian. A favorite example is “to run out of sugar,” literally translated as bursting forth at a run from a pile of sugar.
44. *special power called conceptual combination*: Wu and Barsalou 2009. See also [heam.info/combination-1](#).
45. *those that describe the situation*: This is another point where the theory of constructed emotion diverges from the classical view, which would say that a person is “feeling several emotions at the same time,” as if those emotions were objectively distinguishable, rather than constructing a completely new emotional experience.
46. *potent capability of the brain*: See [heam.info/combination-1](#).
47. *to six objects in mind*: Feigenson and Halberda 2008.
48. *10 percent of the world’s population*: Salminen et al. 1999. The word “alexithymia” comes from the roots “a” (lack), “lexis” (word), and “thymos” (mood). See Lindquist and Barrett 2008 for a review, and [heam.info/alexithymia-1](#). *to experience them as emotional*: Lane et al. 1997; Lane and Garfield 2005. *emotion in others as well*: Lane et al. 2000. See [heam.info/alexithymia-1](#). *have a restricted emotion vocabulary*: Lecours et al. 2009; Meganck et al. 2009. See [heam.info/alexithymia-1](#). *have difficulty remembering emotion words*: Luminet et al. 2004.
49. *touches, and interoceptive sensations*: Frost et al. 2015.
50. *forgetting your best friend’s birthday*: See [heam.info/shepard-1](#).
51. *to use as predictions*: Using Bayesian rules of probability (Perfors et al. 2011). See also [heam.info/bayes-1](#).
52. *architect of the whole experience*: Nonetheless, people actively construct the temporal order of events; see [heam.info/causality-1](#).

6. How the Brain Makes Emotions

1. *predictions of “Anger” simultaneously*: A common goal for “Anger” in Western cultures is to defend oneself from threat or harm (Clore and Ortony 2008; Ceulemans et al. 2012).
2. *the promotion in your place*: See [heam.info/anger-1](#).
3. *is exquisitely bright but diffuse*: Gopnik 2009. See also [heam.info/gopnik-1](#). *other things in the dark*: Posner et al. 1980.
4. *predictions that span the senses*: Different senses play “supporting roles” for one another; see [heam.info/multi-2](#).
5. *regardless of the sensory differences*: Many papers use faces as the textbook example for explaining concept formation, because the visual system has been well-studied and so is better understood than most other sensory systems, and because humans are experts at seeing faces in sensory inputs. For a well-written, accessible example using faces, see Hawkins and Blakeslee 2004; see also [heam.info/muller-1](#).
6. *identical, groupings of neurons*: See more on these distributed response patterns of neurons at [heam.info/concepts-2](#).
7. *of neurons on each occasion*: As you’ve read many times now, neurons are multipurpose; this is true even when it comes to concepts. Neurons alter their firing rate to participate in many different assemblies, so that a single neuron contributes to numerous

- instances of the same concept, as well as different concepts. Multipurpose does not mean all-purpose, of course. Different instances of the same concept need not share the same neurons, and instances of different concepts need not be located in different groupings of neurons; different instances must be separable, not separate. See Grill-Spector and Weiner 2014, and [heam.info/multi-1](#).
8. *in any concrete way*: See [heam.info/multi-1](#).
 9. *“a prediction” of happiness*: Also, when your brain “learns an instance of a concept,” that is equivalent to saying your brain receives and processes sensory input, that is, prediction error, making the new instance more similar to some previous instances and less similar to others.
 10. *sensory input before it arrives*: Chanes and Barrett 2016. If things “settle” and “predict” too quickly, then the prediction will not seem calibrated to context. This is probably a hallmark of psychopathology.
 11. *such as the Korean word jeong*: Lin 2013.
 12. *future, such as imagination*: Also called prospection (e.g., Schacter et al. 2012; Buckner 2012; Mesulam 2002). *experiences of the present moment*: Clark 2013; Friston 2010; Bar 2009; Bruner 1990; Barsalou 2009. See chapter 4, figure 4-3. As I explained in chapter 5, it is metabolically inefficient to compute perceptions and plan actions from scratch in every moment of your life. We have evolved an efficient nervous system that saves costs by minimizing redundancy (which is wasteful, metabolically speaking). The brain exploits the fact that certain patterns of sensations and events tend to recur with some regularity. It learns (i.e., changes neural firing rates, and eventually grows new neurons or connections) only what is novel and relevant to the body budget; this is why the brain predicts (i.e., reconstructs, infers, or guesses) those regularities, where possible, rather than squandering resources to detect them again and again. See [heam.info/present-1](#). *“the remembered present”*: Edelman 1990.
 13. *are more probabilistic than that*: Since thousands of predictions are launched, many could be active at the same time, but the one that fits the incoming input best will become your experience and either confirm or correct your action. This is possibly one reason why a feeling of anger in the exact same situation might feel slightly different than it does on another occasion. The other predictions in the population might be different. Exact identity might require more precision — at the level of every single neuron — than the brain is capable of achieving (because of noise and context).
 14. *known as your control network*: Scientists have identified three overlapping, intrinsic networks for this purpose (e.g., Power et al. 2011); see [heam.info/control-4](#).
 15. *number? — in each moment*: There are other selection mechanisms in the brain; see [heam.info/selection-1](#).
 16. *shape your perception and action*: I briefly discuss Edelman’s Theory of Neural Darwinism at [heam.info/edelman-1](#).
 17. *perception, and launch an action*: In psychology, we have many names for describing this “tinkering,” such as keeping a goal in mind, focusing attention, weeding out distractions, selecting the best action, and so on, and we refer to them as different processes, such as working memory, selective attention, and so on. See [heam.info/control-5](#).
 18. *I scream or not?*: See [heam.info/selection-1](#).
 19. *but refrain from punching him*: Gross and Barrett 2011; Ochsner and Gross 2005. See [heam.info/regulation-1](#).

20. *the interoceptive and control networks*: This efficient structure is a small world architecture with rich club hubs; see [heam.info/hubs-1](#).
21. *be a prerequisite for consciousness*: Chanes and Barrett 2016. See also [heam.info/meg-1](#). *all associated with hub damage*: Particularly the anterior insula and anterior cingulate cortex (Menon 2011; Crossley et al. 2014).
22. *go beyond the information given*: Cognitive psychologist Jerome S. Bruner coined the term “acts of meaning” (Bruner 1990). See also [heam.info/bruner-1](#).

7. Emotions as Social Reality

1. *can make those changes meaningful*: Some people believe that these vibrations are the essence of the sound because a sound cannot be heard without them. But this explanation misses the point. Vibrations are not sufficient for a sound to occur. Sounds do not have simple, single causes; see [heam.info/sound-1](#).
2. *made meaningful by a brain*: All three cone types must work together to perceive a single category of color, like red; see [heam.info/cones-1](#).
3. *learn from conversations and books*: Shepard and Cooper 1992. See [heam.info/shepard-1](#). *up the continuous spectrum differently*: Roberson et al. 2005. See [heam.info/color-1](#).
4. *perceiver-independent categories*: Philosophers call them “ontologically objective”; see [heam.info/perceiver-1](#).
5. *your two-year-old child*: Even biologists’ criteria for flowers and weeds are subjective; see [heam.info/flower-1](#). *by the external world*: Einstein and Infeld 1938, 33. Or see Max Planck’s more cynical take from *The Universe in the Light of Modern Physics* (1931, 58–59): “We have no right to assume that any physical laws exist, or if they have existed up to now, that they will continue to exist in a similar manner in the future.”
6. *you sample the sensory world*: Susskind et al. 2008.
7. *be discarded for scientific endeavors*: The sixteenth-century philosopher Francis Bacon, for instance, warned about using common-sense language in science, reifying the referent of the word that doesn’t warrant it. So did William James. Many scientists and philosophers since then have warned about the evils of “folk psychology.” Common-sense concepts or words might not be the best flashlights to illuminate the search for underlying mechanisms. *I took this latter view*: Barrett 2006a.
8. *classic example of social reality*: Searle 1995. Ernst Cassirer anticipated the idea of social reality; see [heam.info/reality-3](#).
9. *the core of social reality*: A concept is a population of instances that might be physically different but are treated as similar for some purpose; in social reality, that purpose is the set of functions that people impose that transcend the physical nature of the instances themselves (i.e., people treat the instances as mentally similar, despite the instances’ physical differences).
10. *knowledge is called* collective intentionality: See more on collective intentionality at [heam.info/collective-1](#).
11. *categorization as a cooperative act*: I created my lab through cooperative categorization. I gathered all the people working with me, gave us a name (so we identified ourselves as a group with a common goal), and poof: instant lab. T-shirts and mousepads with the lab logo didn’t hurt either.
12. *of communication and social influence*: Tomasello 2014.

13. *the two concepts are named*: For more on how concept learning can occur without a word, see heam.info/concepts-3.
14. *the functions of an emotion*: The linguist George Lakoff calls emotion an essentially contested concept, because people in American culture agree that emotions exist, but they don't necessarily agree on the definition, and scientists are unable to settle the matter. It seems to me that contested concepts are casualties in a battle over social reality: whose concepts are going to win and define what exists?
15. *man acts as he does*: Tomasello 2014.
16. *the norms of our culture*: The emoter and the perceiver are not categorizing the same psychological moment; see heam.info/concepts-4.
17. *asking in the first place*: This is an example of a "category error." According to the philosopher Gilbert Ryle, a category error is an ontological error where things belonging to one category are mistaken for belonging to another. Here, social reality is mistaken for physical reality.
18. *comrades-in-arms*: Bourke 2000; Jamison 2005; Lawrence (1922) 2015. *needed for their military duties*: The psychologist Maya Tamir would refer to this as an example of instrumental emotion regulation. People construct unpleasant emotions because they are useful in a given context (Tamir 2009).
19. *and to create civilizations*: Boyd et al. 2011.
20. *on the African savanna*: Even universality does not necessarily imply innateness — think Coca-Cola. *a matter of cultural evolution*: Case in point: the Hadza of Tanzania, who have lived continuously on the African savanna for at least 150,000 years since the Pleistocene Epoch, do not recognize posed facial configurations of fear, based on my lab's visit in 2016. For excellent treatments of the relation between culture and evolution, see Laland and Brown 2011; Richerson and Boyd 2008; and Jablonka et al. 2014. See also heam.info/culture-1.
21. *people of the Kalahari Desert*: See more about the !Kung people, as well as languages that seem to lack a distinct word for "fear," at heam.info/kung-1.
22. *driving force behind human culture*: Social reality is embedded in the definition of culture. Zoologists Kevin N. Laland and Gillian R. Brown call culture "a cohesive set of mental representations, a collections of ideas, beliefs, and values that are transmitted among individuals and acquired through social learning" (Laland and Brown 2011, 9). The geneticist Eva Jablonka's definition adds behaviors and products (Jablonka et al. 2014). *be more fit to reproduce*: Boyd et al. 2011. This paper argues that biology and culture are not battling for control of human behavior (just as cognition and emotion are not waging a battle). This war is all in our minds — it is a social reality created by minds that are as much a consequence of culture as of genes. Robert Boyd and his colleagues write, "Culture is as much a part of human biology as our particular pelvis" (2011, 10924). The capacity to create emotion concepts, share them with others, and use them to construct social reality is a function of our biological makeup.
23. *word for rainbow, радуга*: To produce the word радуга with a non-Russian keyboard, visit translate.google.com and translate the word "rainbow" to Russian, then copy and paste.
24. *green are to an American*: Other cultural examples include the Himba, who categorize some shades of Western "green" and "blue" as a single color, and the Berinmo of Papua New Guinea, who have only five color categories.
25. *that don't exist in English*: Good summaries can be found in Russell 1991a; Mesquita

- and Frijda 1992; and Pavlenko 2014. *calling it "Forelsket"*: So Bad So Good 2012. *certain feeling of close friendship*: Verosupertramp85 2012. *"Tocka" is a spiritual anguish*: Ibid. *a strong, spiritual longing*: Wikipedia, s.v. "Saudade," last modified April 1, 2016, <http://en.wikipedia.org/wiki/Saudade>. *called "Pena Ajena"*: So Bad So Good 2012.
26. *something that is unbearably adorable*: Garber 2013; So Bad So Good 2012.
 27. *before the event takes place*: "Better Than English" 2016.
 28. *looking worse after a haircut*: Pimsleur 2014.
 29. *depending on context*: Lutz 1980; Russell 1991b. *"the desire for revenge"*: Kundera 1994. *required to be grateful anyway*: So Bad So Good 2012.
 30. *no concept of "Anger"*: Briggs 1970. *no concept of "Sadness"*: Levy 1975; Levy 2014.
 31. *individual, in the body*: Nummenmaa et al. 2014. Various scholars throughout history have also located emotion in the body; see heam.info/body-3. *require two or more people*: Pavlenko 2014. *Westerners lump together as emotional*: Ibid.
 32. *"to basic psychological realities"*: Wierzbicka 1986, 584. *invention of the seventeenth century*: Danziger 1997.
 33. *spatial relations, and causality*: Mapping words to conceptual representations is neither simple nor universal; see heam.info/concepts-13. *language to language is astonishing*: Malt and Wolff 2010, 7.
 34. *had never smiled so much*: Victor Danilchenko, my husband's colleague, tells me that in his native Ukraine, habitual smiling is not the norm, and the term "American smile" means a fake and insincere smile. *prefer high arousal, pleasant states*: Tsai 2007.
 35. *shame, and respect*: De Leersnyder et al. 2011.
 36. *report more physical illness*: Consedine et al. 2014.

8. A New View of Human Nature

1. *lower salaries in the future*: The human brain develops until late adolescence, but the most sensitive time begins during the first trimester and continues throughout the first several years of life, particularly for brain regions important for body-budgeting, control, and learning (Hill et al. 2010). These brain regions are thinner (fewer connections between neurons, or even fewer neurons) in infants and young children raised in poverty. Importantly, their brains do not start off smaller but grow more slowly over the first three years of life (Hanson et al. 2013); the growth occurs particularly in the connections between neurons (Kostović and Judaš 2015), so reduced connectivity will limit conceptual development and speed of processing, which is strongly related to IQ. Social reality thus becomes physical reality; see heam.info/children-1.
2. *as in control or not*: The experience of being in control is often a function of affect and belief and is largely unrelated to the actual amount of control you have (Job et al. 2013; Inzlicht et al. 2015; Job et al. 2015; Barrett et al. 2004). See heam.info/control-7.
3. *for five months after training*: Halperin et al. 2013. The method of recategorization in these studies was called "reappraisal," which is defined as changing the meaning of a situation.
4. *and only partly predictable world*: Sporns 2011.
5. *from an early animal ancestor*: Darwin (1872) 2005.
6. *to refer to both possibilities*: Philosophers debate over the definition of essences; see heam.info/essences-1.
7. *subcortical regions of your brain*: See also Panksepp 1998; Pinker 2002, 220; Tracy and

- Randles 2011. *is a set of genes*: Pinker 1997. Each emotion supposedly issues from a specialized “organ of computation” designed to solve a specific problem for your hominin ancestors on the African savanna, so your genes have a better chance of replicating themselves into the next generation. Much has been written on the idea of mental organs and evolution; see [heam.info/organs-1](#). *a metaphorical “program”*: Cosmides and Tooby 2000; Ekman and Cordaro 2011. Pinker does not go in for emotion programs as essences and takes a more nuanced approach. In *How the Mind Works*, he writes, “The problem with the emotions is not that they are untamed forces or vestiges of our animal past; it is that they were designed to propagate copies of the genes that built them rather than to promote happiness, wisdom, or moral values” (1997, 370). So, even though we are supposed to walk around with stone-age minds created by stone-age brains, emotions are not “burned so deeply into the brain that organisms are condemned to feel as their remote ancestors did” (371). *and events in the world*: Scientists debate which emotions should be considered basic; see [heam.info/basic-1](#). *whether to trigger an emotion*: E.g., Frijda 1988; Roseman 1991.
8. *biology into a modern science*: Darwin (1859) 2003. “*paralyzing grip of essentialism*”: Mayr 1982, 87. See also [heam.info/darwin-2](#).
 9. *with their own essences*: The types were strictly ordered and catalogued by how they looked to the naked eye, an arrangement known as a typology; see [heam.info/typology](#). *rich, dense, lustrous gold*: American Kennel Club 2016.
 10. “*survival of the fittest*”: The scholar Herbert Spencer coined this term in 1864 after reading Darwin’s *Origin*. *no essence at their core*: A species is a goal-based concept, where the goal is successful reproduction. There are different properties or mechanisms that can be used to anchor this concept; see Mayr 2007, chapter 10. Using the species concept to classify individuals as belonging to the same reproductive community makes those individuals a conceptual category. *to Darwin’s theory of evolution*: *Origin* actually contained five conceptual innovations; see [heam.info/origin-1](#).
 11. *greatest achievement by writing* Expression: What was the reason for Darwin’s hypocrisy? See [heam.info/darwin-3](#).
 12. *parts together to make sounds*: Darwin (1872) 2005, 188. *imbalance could cause frizzy hair*: This is a great example of the representativeness error; see [heam.info/frizzy](#).
 13. “*fear of a bear*”: James 1894, 206.
 14. *other popular books on emotion*: Damasio 1994. *like little bits of wisdom*: Damasio and Carvalho 2013. Damasio has further outlined his somatic marker hypothesis in his three bestselling books. See also [heam.info/damasio-1](#). *are transformed into conscious feelings*: Damasio and Carvalho 2013.
 15. *logically impossible to prove false*: Hope can be dangerous in science; see [heam.info/essentialism-1](#).
 16. *the psychological origin of essentialism*: The developmental psychologist Fei Xu, whom we met in chapter 5, refers to words as “essence placeholders” (Xu 2002). “*shall be the name*”: James (1890) 2007, 195. *reflect firm boundaries in nature*: Philosophers use the term “natural kinds” to describe categories with essences. These categories have firm boundaries in nature. For example, if you assume that an emotion category is a natural kind, then its fingerprint is the set of necessary and sufficient features that describe all instances; it defines the kind of emotion by analogy. The emotion’s underlying cause defines the category by homology (Barrett 2006a).
 17. *original red “blicket”*: Gopnik and Sobel 2000. *extend concepts by ignoring variation*:

- Early in life, infants have many concepts and therefore perform induction. E.g., Bergelson and Swingle 2012; Parise and Csibra 2012.
18. *compressing them into efficient summaries*: For more detail, see heam.info/finlay-2.
 19. *“of his lowly origin”*: Darwin (1871) 2004, 689. *pinnacle of the animal kingdom*: Aristotle, Darwin, and others weigh in at heam.info/beast-1.
 20. *the world completely outside you*: Different branches of the classical view frame this boundary differently; see heam.info/boundary-1.
 21. *“a common progenitor”*: Darwin (1872) 2005, 11.
 22. *a dozen times in Expression*: Ibid., 19 (twice), 25, 27 (twice), 30 (twice), 32, 39, 44 (three times), 46, 187 (twice). *his broader arguments about evolution*: A claim that infuriated many of his contemporaries; see heam.info/darwin-4.
 23. *wrote extensively on Darwin’s ideas*: Floyd Allport is not often discussed in modern psychology, but his brother, Gordon Allport, is a towering figure in social psychology who wrote important scientific works on personality and prejudice, and who trained some of the most influential psychologists of the twentieth century. *“which the latter develops”*: Allport 1924, 215.
 24. *“rest and . . . TV”*: Gardner 1975.
 25. *evidence that he was wrong*: Finger 2001. *a perfectly healthy Broca’s area*: This matches other evidence available at the time; see heam.info/broca-1. *a healthy dose of essentialism*: Lorch 2008. See also heam.info/broca-2. *essentialist views of the mind*: The full story of Broca’s area is at heam.info/broca-3.
 26. *was sculpted by evolution*: See more on *The Descent of Man* at heam.info/darwin-5. *our “lowly origin”*: Darwin (1871) 2004, 89, 689.
 27. *that regulate mankind’s animalistic emotions*: The term “limbic” originated in the murky world of seventeenth-century anatomy; see heam.info/limbic-1. *rationality as our crowning glory*: Darwin’s ideas came from Plato and Aristotle; see heam.info/darwin-6.
 28. *alone consider it a system*: Criticisms of the limbic system concept are at heam.info/limbic-2.
 29. *charioteer wrangling two winged horses*: Plato called his model the tripartite soul; see heam.info/plato-1. *human constructions dependent on concepts*: Both views are in practice today (Dreyfus and Thompson 2007).
 30. *world through judgment and inference*: Sabra 1989, cited in Hohwy 2013, 5. *imagination, and intelligence*: See more on these Christian theologians at heam.info/medi eval-1. *“functions of the latter”*: James (1890) 2007, 28. *an essentialist sort of evolution*: See heam.info/war-1.
 31. *as blobs in the brain*: “I describe mental life by the metaphor of two agents, called System 1 and System 2, which respectively produce fast and slow thinking. I speak of the features of intuitive and deliberate thought as if there were traits and dispositions of two characters in your mind. In the picture that emerges from recent research, the intuitive System 1 is more influential than your experience tells you, and it is the secret author of many of the choices and judgments you make” (Kahneman 2011, 13). Like most ideas in psychology, System 1 and System 2 are metaphors or concepts of social reality that people use, in agreement, to refer to phenomena, not to processes or brain systems. System 1 refers to times when predictions are less corrected by prediction error. System 2 refers to times when predictions are more corrected by prediction error.
 32. *a construction theory of memory*: Schacter 1996.

33. *shaped this way and that*: Pinker 2002. *to the environment we are*: E.g., Charney 2012; see heam.info/genes-1.
34. *“are learned or innate”*: Pinker 2002, 40–41. *devil is in the details*: See heam.info/evolution-3.
35. *the “four F’s”*: These behaviors were mentioned as a group in 1958 by psychologist Karl H. Pribram, though he referred to the fourth “F” as “sex” (Pribram 1958).
36. *to function like a computer*: Neisser 2014; Fodor 1983; Chomsky 1980; Pinker 1997.
37. *emotion research was allegedly dead*: Duffy 1934, 1941. *colleagues had never heard of*: A short list of papers is at heam.info/chorus-1. *and speculating about constructionist ideas*: Gendron and Barrett 2009.
38. *“to reject science itself”*: Kuhn 1966, 79. *how emotions are made*: Details on the face-reading initiatives of Microsoft, Apple, and the rest are at heam.info/faces-3.
39. *They are following an ideology*: Lewontin 1991.
40. *change who you become tomorrow*: We’re not talking about radical transformations here but small, incremental changes.

9. Mastering Your Emotions

1. *if you try hard enough*: A popular theory of emotion regulation used in self-help books comes from psychologist James J. Gross. For a recent example, see Gross 2015. See also heam.info/gross-1.
2. *refined sugar and bad fats*: Kiecolt-Glaser 2010. *regularly sleep-deprived*: National Sleep Foundation 2011. *depression and other mental illnesses*: Cassoff et al. 2012; Banks and Dinges 2007; Harvey et al. 2011; Goldstein and Walker 2014. *toxic for your body budget*: Some evidence that people have unrealistic goals, from Rottenberg 2014: In 2006, over 25% of high school students said that earning a lot of money was extremely important to them, up from 16% in 1976 (Bachman et al. 2006); 31% said they had a goal to be famous one day (Halpern 2008); and the number of people having aesthetic procedures rose 20% in just 2015 alone and 500% between 1997 and 2007 (American Society for Aesthetic Plastic Surgery 2016). *time disrupts your sleeping patterns*: Chang, Aeschbach, et al. 2015. See heam.info/sleep-1.
3. *some form of distress*: TedMed 2015. A recent study by the Mayo Clinic confirmed this high number, reporting that 26% of Americans are taking prescription opioids or antidepressants (Nauert 2013). And between 80% and 90% surveyed believe that people take drugs to relieve stress (American Psychological Association 2012). There was a 200% increase in the use of opioids stronger than morphine over a ten-year period (from 2002 to 2012), and a majority of people taking prescription opioids (80%) are taking a morphine equivalent or something stronger; this was almost 7% of the adult population of the United States in 2012 (Center for Disease Control and Prevention 2015).
4. *work out vigorously and regularly*: Numerous studies show that exercise benefits health in many different ways (Gleeson et al. 2011; Denham et al. 2016; Erickson et al. 2011), particularly jogging, at least if you are a rat (Nokia et al. 2016). *and get plenty of sleep*: Goldstein and Walker 2014.
5. *way of your interoceptive network*: Olausson et al. 2010; McGlone et al. 2014. *might otherwise experience as unpleasant*: E.g., Tejero-Fernández et al. 2015.
6. *the slow-paced breathing*: Deep, slow breathing helps perk up your parasympathetic nervous system, which in turn has a calming effect. It’s an easy way to control the

- activation of your body-budgeting regions voluntarily. Quick, short breaths have the opposite effect. *harmful inflammation in your body*: Kiecolt-Glaser et al. 2014; Kiecolt-Glaser et al. 2010. *depression, and other illnesses*: Pinto et al. 2012; Ford 2002; Josefsson et al. 2014.
7. *psychiatric patients recover more quickly*: Park and Mattson 2009; Beukeboom et al. 2012. Also the toxic effects of uncontrollable noise, lack of green spaces, inconsistent temperature, crowding, lack of fresh vegetables, and other ills of poverty are well known, as we will discuss in chapter 10.
 8. *also beneficial to the budget*: Crying, when it slows your breathing, will tweak your parasympathetic nervous system, which helps calm you; see heam.info/crying-1.
 9. *you reap the benefits*: Dunn et al. 2011. See also Dunn and Norton 2013.
 10. *Knitting works, apparently*: Clave-Brule et al. 2009.
 11. *“as purely cognitive abilities”*: Goleman 1998, 34. *then you’re emotionally intelligent*: E.g., in Bourassa-Perron 2011.
 12. *low to high emotional granularity*: For a review, see Barrett and Bliss-Moreau 2009a.
 13. *fewer days hospitalized for illness*: Quoidbach et al. 2014, Study 2, with ten thousand test subjects.
 14. *your experiences in new ways*: See heam.info/emotions-1.
 15. *study about fear of spiders*: Kircanski et al. 2012. “Emotion labeling” or “affect labeling,” as it is called, is associated with reduced activity in the interoceptive network’s body-budgeting regions and greater activity in a control network region (Lieberman et al. 2007; Lieberman et al. 2005).
 16. *flexible when regulating their emotions*: Barrett et al. 2001. This paper showed for the first time that intense negative affect, if categorized as emotional experience, is linked to improved emotion regulation. For a review, see Kashdan et al. 2015. Also see heam.info/negative-1. *to drink excessively when stressed*: They consumed about 40% less alcohol than their lower-granularity peers (Kashdan et al. 2010). *someone who has hurt them*: Twenty to fifty percent less likely (Pond et al. 2012). *correct action in social situations*: Kimhy et al. 2014.
 17. *major depressive disorder*: Demiralp et al. 2012. *social anxiety disorder*: Kashdan and Farmer 2014. *eating disorders*: Selby et al. 2013. *autism spectrum disorders*: Erbas et al. 2013. *borderline personality disorder*: Suvak et al. 2011; Dixon-Gordon et al. 2014. *more anxiety and depressed feelings*: Mennin et al. 2005, Study 1; Erbas et al. 2014, Studies 2 and 3. *distinguishing positive from negative emotions*: Kimhy et al. 2014.
 18. *new moments to cultivate positivity*: E.g., Emmons and McCullough 2003; Froh et al. 2008.
 19. *anger before a big game*: Ford and Tamir 2012.
 20. *and their movements and sounds*: Gottman et al. 1996; Katz et al. 2012. *well-developed conceptual system for emotion*: E.g., Taumoepeau and Ruffman 2006, 2008. For review, see Harris et al., in press.
 21. *themselves for building emotion concepts*: Ensor and Hughes 2008.
 22. *poised for greater academic success*: For a review, see Merz et al. 2015. *social behavior and academic performance*: Brackett et al. 2012. See also heam.info/yale-1. *better instructional support for students*: Hagelskamp et al. 2013.
 23. *better vocabulary and reading comprehension*: Hart and Risley 1995. The details of these studies are at heam.info/words-1. *lag in the social world*: Fernald et al. 2013. *improves the children’s school performance*: Merz et al. 2015; Weisleder and Fernald 2013; Leffel and Suskind 2013; Rowe and Goldin-Meadow 2009; Hirsh-Pasek et al. 2015.

24. *resources to deal with it*: Hart and Risley 2003.
25. *impacts the child's nervous system*: Infants also learn to perceive affect in a voice earlier than in faces; see heam.info/affect-10.
26. *a walk in a park*: Reynolds 2015; Bratman et al. 2015.
27. *10 percent of users avoid relapse*: Spiegel 2012. See also Wood and R nger 2016.
28. *rather than for the nutrients*: Mysels and Sullivan 2010.
29. *tangible benefits to your life*: This topic is known as stress reappraisal (Jamieson, Mendes, et al. 2013). *that the body is coping*: Jamieson et al. 2010; Jamieson et al. 2012; Jamieson, Nock, et al. 2013. *generally make people feel crappy*: Crum et al. 2013. *so they perform better*: John-Henderson, Rheinschmidt, et al. 2015. *course grade through effective recategorization*: Jamieson et al. 2016. *struggle to make ends meet*: Only 27% of students in remedial math ever earn a bachelor's degree; for details see heam.info/math-1.
30. *the health benefits of continuing*: Cabanac and Leblanc 1983; Ekkekakis et al. 2013; Williams et al. 2012. Also thanks to Ian Kleckner for the Marines example.
31. *intensity of the pain does*: Sullivan et al. 2005. *and crave them less*: Garland et al. 2014. *symptoms with long-term use*: Chen 2014.
32. *the essence of you*: For more on Western psychology's take on the self, see heam.info/self-1.
33. *would call prolonged unpleasant affect*: Buddhism refers to self-affirming possessions, compliments, etc., as "mental poisons." Not only do they cause you to suffer (e.g., feeling like an imposter), but also you feel the urge to harm anything that might invalidate you or threaten to unmask your fictional self. For an example of a fictional self, see heam.info/self-2. *It is an enduring affliction*: It's also a good idea to give up the fiction that people remain the same; see heam.info/self-3.
34. *It depends on other people*: I am not saying that your "Self" is a mere reflection of how others see you or treat you. That is symbolic interactionism, proposed by the philosopher George Herbert Mead and sociologist C. H. Cooley. Still, do you ever find yourself acting and feeling very differently when you are in a new context where no one knows who you are (like when traveling on an airplane)? *be a self by yourself*: This is a signature phrase of social psychologist Hazel Markus. *Wilson out of a volleyball*: The volleyball had the name "Wilson" stamped on it because it was made by the Wilson Sporting Goods Company.
35. *"Stinging Insects," and "Fear"*: The self is a concept, but not in the way that social psychologists mean it; see heam.info/self-4.
36. *that we have multiple selves*: After the pioneering research of psychologist Hazel Markus; see heam.info/markus-1. *goal shifts based on context*: Could it be that the population of instances which are "your self" are held together by a word — perhaps your name? See heam.info/self-5.
37. *relation to the same body*: Lebrecht et al. 2012. *of your sense of self*: Other scientists and philosophers have had similar intuitions (Damasio 1999; Craig 2015).
38. *lose your sense of self*: Prebble et al. 2012.
39. *"Wealth" become unnecessary*: Deconstructing the self means putting aside mental poisons to reveal the true nature of experience, i.e., the dharmas in the traditional Abhidharma Buddhist account.
40. *an antacid tablet in water*: Heartbreak from being dumped is a little trickier, because forming an attachment with someone means that you two are co-regulating each oth-

er's body budgets, so separation and loss actually involve some recalibration of your body budget to account for this.

41. *between these regions are stronger*: Tang et al. 2015; Creswell et al., in press. For a summary of the brain-related influences on three types of meditation practice, see heam.info/meditation-1. *[not all] have been well-controlled*: How meditation helps one deconstruct the self and be mindful is an open question; see heam.info/meditation-2.
42. *something vastly greater than yourself*: Keltner and Haidt 2003. Awe in atheists is similar to faith in those who are believers (Caldwell-Harris et al. 2011).
43. *song comforting while falling asleep*: Only male crickets chirp, and they have different songs for different purposes, but mostly they are singing to attract females. So engage in a little mental inference and think of these sounds as rapturous love songs of nature.
44. *(nobody has proved cause and effect)*: Stellar et al. 2015.
45. *a moment of affective realism*: Rimmele et al. 2011.
46. *predict and categorize in synchrony*: Gendron and Barrett, in press; Stolk et al. 2016.
47. *other's chests rising and falling*: For indirect supporting evidence, see Giuliano et al. 2015. *to prepare them for hypnosis*: Some scientists refer to this phenomenon as affective synchrony or affective contagion.
48. *bees, ants, and cockroaches*: Broly and Deneubourg 2015.
49. *to be a good sender*: Zaki et al. 2008.

10. Emotion and Illness

1. *25–40 percent get sick*: Cohen and Williamson 1991.
2. *from a noseful of germs*: Cohen et al. 2003.
3. *inflammation flares up*: Yeager et al. 2011. See more on inflammation at heam.info/inflammation-1.
4. *to feel seriously like crap*: In a laboratory, when test subjects are injected with the typhoid vaccine, which causes a temporary increase in their proinflammatory cytokines, this was associated with increased activity in the interoceptive network, along with reports of feeling fatigued and very unpleasant (Eisenberger et al. 2010; Harrison, Brydon, Walker, Gray, Steptoe, and Critchley 2009; Harrison, Brydon, Walker, Gray, Steptoe, Dolan, et al. 2009). *cytokines that make inflammation worse*: Mathis and Shoelson 2011. *even get sick more often*: Yang et al. 2016; Cohen et al. 1997; Holt-Lunstad et al. 2010.
5. *the body into the brain*: Proinflammatory cytokines cross the blood-brain barrier (Dantzer et al. 2000; Wilson et al. 2002; Miller et al. 2013). *cells that secrete these cytokines*: Louveau et al. 2015. *particularly within your interoceptive network*: Soskin et al. 2012; Ganzel et al. 2010; McEwen and Gianaros 2011; McEwen et al. 2015. See heam.info/inflammation-2. *pay attention and remember things*: Karlsson et al. 2010. *lowering performance on IQ tests*: There is a vicious cycle: lower IQ, often associated with childhood adversity and poverty, predicts higher levels of inflammation in midlife (Calvin et al. 2011). See also Metti et al. 2015.
6. *flush with cortisol and cytokines*: See more on the relationship between cytokines and cortisol levels at heam.info/cortisol-2. *and chronic inflammation sets in*: Dantzer et al. 2014; Miller et al. 2013. This situation actually sensitizes you to interoceptive and nociceptive input (Walker et al. 2014).

7. *really, truly in trouble*: Dowlati et al. 2010; Slavich and Cole 2013; Slavich and Irwin 2014; Seruga et al. 2008.
8. *acts like fertilizer for disease*: Irwin and Cole 2011; Slavich and Cole 2013. See more on stress, genes, and cytokines at heam.info/cytokines-1. See also heam.info/glia1-1. *Death from cancer comes sooner*: Stress-related increases in β -adrenergic sympathetic nervous system (SNS) activity encourage proinflammatory gene expression and discourage anti-viral immune gene expression as cells replicate (Irwin and Cole 2011). These transcriptional effects have been observed in breast tissue, lymph nodes, and the brain (Williams et al. 2009; Sloan et al. 2007; Drnevich et al. 2012). In this way, an acute physiological state can influence cellular makeup for days, weeks, months, or even years (Slavich and Cole 2013), enhancing vulnerability to cancer. Stress-related SNS activity also directly influences the micro-environment of tumor cells, enhancing metastasis, augmenting tumor cell potency, and increasing mortality (Antoni et al. 2006; Cole and Sood 2012).
9. *distinguished it from all others*: Zachar and Kendler 2007; Zachar 2014.
10. *all associated with hub damage*: Menon 2011; Crossley et al. 2014; Goodkind et al. 2015.
11. *poverty, abuse, or loneliness*: For a discussion of childhood adversity and earlier mortality in adulthood, see Danese and McEwen 2012. For loneliness-related death, see Perissinotto et al. 2012. For the link between poverty and brain development, see Hanson et al. 2013, and for the link between childhood poverty and premature adult mortality (independent of family history, ethnicity, cigarette smoking, and other risk factors), see Hertzman and Boyce 2010. Also see Adler et al. 1994.
12. *stress and emotion are independent*: For a rare counterexample, see Lazarus 1998.
13. *circuitry that regulates the budget*: Ganzel et al. 2010; McEwen and Gianaros 2011; McEwen et al. 2015.
14. *accurately regulate your body budget*: E.g., Danese and McEwen 2012; Sheridan and McLaughlin 2014; Schilling et al. 2008; Ansell et al. 2012; Hart and Rubia 2012; Teicher and Samson 2016; Felitti et al. 1998. For more on how childhood adversity wires the brain, see heam.info/adversity-1. *trajectory toward chronic disease*: Miller and Chen 2010. *childhood abuse or neglect*: Teicher et al. 2002; Teicher et al. 2003; Teicher et al. 2006; Teicher and Samson 2016. *the target of a bully*: Teicher et al. 2002; Teicher et al. 2003; Teicher et al. 2006. *psychiatric and physical diseases*: Copeland et al. 2014. *cancer, and other diseases*: Repetti et al. 2002. For more on the bad effects of stress, see heam.info/stress-3.
15. *during recovery from prostate cancer*: Hoyt et al. 2013. *or after a stressful event*: Master et al. 2009. *affect that they didn't label*: Hoyt et al. 2013. *for cancer-related symptoms*: Stanton et al. 2000; Stanton et al. 2002. *that lead to poor health*: Labeling reduced sympathetic nervous system reactivity to negative images for up to a week (Tabibnia et al. 2008).
16. *brain predicts damage is imminent*: International Association for the Study of Pain 2012. The IASP now defines pain as an emotional experience and writes that "pain is always subjective. Each individual learns the application of the word through experiences related to injury in early life." Translation: pain is a population of perceptions that vary, one from the next, and the concept needed to construct these perceptions is learned early in life. Sounds like the theory of constructed emotion, doesn't it?
17. *sensations and made them meaningful*: For an example of body-budgeting regions processing nociceptive prediction errors, see Roy et al. 2014.

18. *process nociception change their activity*: E.g., Wiech et al. 2010. For a review, see Tracey 2010; Wager and Atlas 2015. *treatment like a sugar pill*: Büchel et al. 2014; Tracey 2010; Wager and Atlas 2015. *and other opiate drugs*: Opioids are not the only neurotransmitters responsible for the placebo effect. Also involved is cholecystokinin (CCK), which acts on endogenous cannabinoid receptors in your brain, the same as marijuana. CCK tunes up nociception, whereas opioids tune it down (Wager and Atlas 2015). “*your internal medicine cabinet*”: Benedetti et al. 2006; Benedetti 2014; Tracey 2010; Wager and Atlas 2015. See also heam.info/opioids-1. Many people believe that dopamine is the neurochemical that is linked to positivity and reward; for more on that, see heam.info/dopamine-1.
19. *interoceptive and control networks*: For another example of how these same brain networks configure to make meaning of nociceptive input during the construction of pain experiences, see Woo et al. 2015. For more on similarities between the construction of pain and emotion, see heam.info/pain-1. *is a form of interoception*: The prominent neuroanatomist A. D. (Bud) Craig, who knows more about this circuitry than just about anyone else, argues that nociception is a form of interoception (Craig 2015). See heam.info/craig-1.
20. *you’d report feeling more pain*: E.g., Wiech and Tracey 2009; Roy et al. 2009; Bushnell et al. 2013; Ellingsen et al. 2013. *like a volume control*: For a partial outline of some of the circuitry, see Wager and Atlas 2015. *status reports to your brain*: See more on nociceptive pathways at heam.info/pain-2. *you could develop a stomachache*: E.g., Traub et al. 2014.
21. *and chronic back pain*: Chronic pain can be neuropathic, inflammatory, or idiopathic; see heam.info/pain-3. *\$635 billion each year*: American Academy of Pain Medicine 2012. *more than half the time*: Apkarian et al. 2013 estimates that 50 million Americans are either partially or totally disabled by pain. *today’s great medical mysteries*: One part of the mystery: opioid drugs taken to relieve pain actually have a hand in transforming acute pain into chronic pain; see Lee et al. 2011 for a comprehensive review of opioid-induced hyperalgesia. See also heam.info/opioids-2.
22. *with its roots in inflammation*: Borsook 2012; Scholz and Woolf 2007; Tsuda et al. 2013. The International Association for the Study of Pain defines chronic pain (which they call “neuropathic pain”) as “pain caused by a lesion or disease of the somatosensory system” (IASP 2012). Aberrant predictions count as “a disease.”
23. *keeps issuing predictions about it*: van der Laan et al. 2011. See more on phantom limb syndrome at heam.info/phantom-1.
24. *likely to develop persistent pain*: Beggs et al. 2012. *heightened pain in later childhood*: Hermann et al. 2006; Walker et al. 2009. *routinely not anesthetized*: Wikipedia, s.v. “Pain in Babies,” last modified February 23, 2016, http://en.wikipedia.org/wiki/Pain_in_babies. *linked to bad nociceptive predictions*: National Institute of Neurological Disorders and Stroke 2013; Maihöfner et al. 2005; Birklein 2005.
25. *scans will look somewhat different*: In chapter 1, we discussed the use of pattern classification to diagnose instances of different emotion categories (e.g., distinguishing instances of anger from fear). Each classifier is not a brain state for the emotion; the pattern that successfully diagnoses instances of an emotion is an abstract statistical representation that need not exist in any instance of the category. The same holds true for emotion and pain. My colleague Tor D. Wager has published a pattern classifier that successfully distinguishes between nociceptive pain and emotion (Wager et al. 2013; Chang, Gianaros, et al. 2015), and together we have published pattern

- classifiers for anger, sadness, fear, disgust, and happiness (Wager et al. 2015). These classifiers are not neural essences for pain and emotion but are statistical summaries of highly variable instances of each category. *they look somewhat different too*: Wilson-Mendenhall et al. 2011.
26. *make sense of bodily sensations*: See [heam.info/pain-8](#). *or threat to your tissue*: See [heam.info/pain-5](#). *misleading data from your body*: Chronic pain spits in the face of the classical view of human nature; see [heam.info/pain-6](#).
 27. *“no longer be borne”*: Styron 2010.
 28. *a disease of the mind*: For a comparison of which diseases are “neurological” versus “psychiatric,” Neuroskeptic (2011) tallied the number of scholarly papers, by topic, published in the journals *Neurology* versus the *American Journal of Psychiatry* from 1990 to 2011. See also [heam.info/neurology-1](#). *your genes make you vulnerable*: Certain genes make you more or less sensitive to the environment (Ellis and Boyce 2008). For an informative lecture, see Akil 2015. See also [heam.info/depression-1](#).
 29. *not effective for everyone either*: Olfson and Marcus 2009; Kirsch 2010. See also [heam.info/depression-5](#). *and then recur throughout life*: Curry et al. 2011. *war, or accidents*: Mathers et al. 2008.
 30. *is not just one thing*: This is true because most human phenomena and characteristics are caused by degenerate gene combinations that are so variable that a detailed genetic explanation (involving the exact genes and mechanisms by which they influence one another) for any of them is unlikely, even when they have high heritability quotients, meaning that much of the observed variation in that characteristic is due to genetic variability (Turkheimer et al. 2014).
 31. *sensory information from your body*: Your muscles contain energy sensors, for example, that send feedback about energy usage back to your brain (Craig 2015). *or other symptoms of depression*: Barrett and Simmons 2015. *heart disease, and cancer*: Your metabolism controls your immune system to some extent; fat cells emit proinflammatory cytokines (Mathis and Shoelson 2011), which means that obesity makes chronic inflammation worse. See, e.g., Spyridaki et al. 2014.
 32. *scale that shuts you down*: Kaiser et al. 2015. When we look at the brains of people suffering from depression, we see activity and connectivity changes that are consistent with this hypothesis; see [heam.info/depression-2](#).
 33. *the parts of a machine*: In depression, dysregulation is widespread; see [heam.info/depression-3](#). *built from toxic past experiences*: Ganzel et al. 2010; Dannlowski et al. 2012. Once a glucocorticoid gene becomes overexpressed at a young age (in rats), the brain pathways become set, creating a lifelong vulnerability to mood disorders and more lability, even if the gene turns off in adulthood (Wei et al. 2012). Toxic past experiences also lead to prolonged inflammation in childhood that increases the risk of depression and other illnesses later in life (Khandaker et al. 2014). *environment and every little problem*: Sometimes called “neuroticism” or “affective reactivity”; also see [heam.info/depression-1](#). *post-traumatic stress disorder*: Risk is greatest with high levels of the ovarian hormone progesterone. This might help explain why the proportion of women suffering from mood disorders is so much higher than the proportion of men (Lokuge et al. 2011; Soni et al. 2013); e.g., Bryant et al. 2011. See also [heam.info/women-1](#).
 34. *your interoceptive network is restored*: Namely, the subgenual anterior cingulate cortex decreases in activity, and its connectivity with the rest of the interoceptive network increases, as does connectivity to the thalamus, which brings prediction error signals

- (Riva-Posse et al. 2014; Seminowicz et al. 2004; Mayberg 2009; Goldapple et al. 2004; Nobler et al. 2001). For a meta-analytic review, see Fu et al. 2013. *for whom no treatments work*: McGrath et al. 2014.
35. *critical to anxiety as well*: On the connectivity of the interoceptive and control networks during anxiety, see McMEnamin et al. 2014. On the similarity between anxiety and chronic pain, see Zhuo 2016, and Hunter and McEwen 2013. And for evidence consistent with the idea that anxiety enhances pain via prediction, see Ploghaus et al. 2001. *error across these two networks*: Paulus and Stein 2010. *stress, and depression*: E.g., Menon 2011; Crossley et al. 2014. Even fear and anxiety were once thought to be caused by separate circuits (Tovote et al. 2015). Also see heam.info/anxiety-1.
 36. *is failing to regulate it*: Compare Suvak and Barrett 2011, and Etkin and Wager 2007. See also heam.info/anxiety-2.
 37. *That's classic anxiety*: Anxiety followed by depression might be worse than depression followed by anxiety, because in the latter, a person might be starting to process prediction error again.
 38. *sit in the control network*: van den Heuvel and Sporns 2013. *to learn effectively from experience*: Browning et al. 2015. *imprecisely or not at all*: A brain awash in prediction error is not always anxious; consider the infant's lantern of attention (chapter 6) or times when novelty and uncertainty are pleasant (e.g., meeting a new lover); see, e.g., Wilson et al. 2013. See heam.info/anxiety-3. *your brain ignores them*: Damasio and Carvalho 2013; Paulus and Stein 2010. *error that you can't resolve*: Specifically, from using prediction error as a "teaching signal" (McNally et al. 2011; Fields and Margolis 2015). *know their disease is permanent*: Six months after a serious operation (a colostomy), those who had a chance of having their colostomies reversed were less satisfied with life than those with permanent disability (Smith et al. 2009). Hope can be a cruel mistress.
 39. *also with chronic fatigue syndrome*: To be clear, I am not saying that depression and chronic pain are the same phenomenon. I am saying that they have a set of common causes. There is a longstanding debate whether certain chronic pain syndromes are independent of depression, as opposed to being expressions of depression. In the past, this debate has been framed as a version of "it's all in your head," where spontaneously experienced pain in the absence of tissue damage is assumed to be a sign of mental illness. This line of argument assumes that depression is merely a mental illness, but this historical distinction is not meaningful in the light of modern neuroscience. Both depression and chronic pain can be considered neurodegenerative brain diseases that have metabolic and inflammatory roots. The fact that some prescription drugs are successful at reducing some instances of depression but not of chronic pain (or vice versa) does not mean the two are distinct biological categories, because depression has degenerate causes. Not everyone suffering from depression (i.e., the variable members of that category) is treated successfully with the same medication (i.e., variation is the norm). The same logic probably works for any category of chronic pain.
 40. *are highly variable and malleable*: Barrett 2013.
 41. *symptoms sounds just like autism*: The diagnostic symptoms of autism are consistent with my description; see heam.info/autism-1.
 42. *have multiple, complex causes*: Jeste and Geschwind 2014. See also heam.info/autism-2.
 43. "An Inside View of Autism": Grandin 1991. "why she was not a cat": Grandin 2009. "and all is well": Higashida 2013.

44. *is a failure of prediction*: Van de Cruys et al. 2014; Quattrocki and Friston 2014; Sinha et al. 2014. *the trajectory of brain development*: For a discussion, see heam.info/autism-3.
45. *sound of a laugh track*: There is now ample evidence that children and adolescents learn both physical and relational aggression from the media (Anderson et al. 2003). Situation comedies, both those designed for children and those for general audiences, contain some aggression in over 90% of programs sampled, compared with 71% of reality programs (Martins and Wilson 2011). In the fifty television shows that are most popular with children ages two to eleven years old, episodes contained, on average, fourteen different incidents of relational aggression per hour, or one every four or five minutes (Martins and Wilson 2012a). Young teenagers find relational and physical aggression funny (as opposed to upsetting) when it's performed by a likeable character in teenage ("tween") sitcoms; in addition, teens report that they are more likely to imitate the aggression themselves (Martins et al., in press). In younger school-aged children (K-5), girls are more likely to model relational aggression at school after having watched it on television (Martins and Wilson 2012b). Most concerning of all, these shows usually depict victims as experiencing no pain, particularly in the reality shows (Martins and Wilson 2011). Television shows influence not only how children and adolescents act but also their expectations of others. For example, after watching television clips with one character harming another in a physically or relationally aggressive way, children are more likely to predict that others have hostile intent (Martins 2013).
46. *midst of an opiate crisis*: Kolodny et al. 2015.
47. *when they are not hungry*: Mena et al. 2013. *act as a mild analgesic*: Mysels and Sullivan 2010. *might not be far off*: Avena et al. 2008.
48. *common underlying factors instead*: These observations led the U.S. National Institute of Mental Health (NIMH) to completely revamp its scientific approach in ways that are reminiscent of the theory of constructed emotion. Instead of considering each named illness as having a distinct essence, scientists now treat each one as a category full of variety and search for common, underlying causes (NIMH 2015).

11. Emotion and the Law

1. *is lowered into the ground*: Unless you are Dan Wegner, social psychologist and my good friend, who died in 2013 after bravely suffering amyotrophic lateral sclerosis (ALS). At Dan's memorial service, per his request, the speakers sauntered in wearing plastic Groucho Marx glasses with fake noses.
2. *responsible for your actions*: You are legally responsible for a criminal action but not necessarily for a civil action or negligent action like professional negligence, where the law requires a duty to another person, dereliction of that duty, proximate or legal cause, and compensable harm, for example. *an individual with free will*: One exception might be "fighting words," the idea that certain words spoken by another person are so offensive that you may be justified in harming the speaker.
3. *if you intended that harm*: The law distinguishes action, intent, and motivation; see heam.info/harm-1.
4. *the time of the crime*: *People v. Patterson*, 39 N.Y.2d 288 (1976).
5. *of destruction in its path*: Kahan and Nussbaum 1996; Percy et al. 2010. For wonderful metaphors, see Lakoff 1990. *person's responsibility for his actions*: Some legal scholars

acknowledge that emotions might not be a departure from rationality but rather a form of it; see [heam.info/rational-1](#).

6. *sadness, and fear*: Kreibig 2010; Siegel et al., under review.
7. *wishing ill upon their oppressor*: Kuppens et al. 2007.
8. *deliberately into a frothing anger*: Kim et al. 2015. Knowing just when to get angry is a key aspect of emotional intelligence (Ford and Tamir 2012). See also [heam.info/anger-2](#). “*You have to go*”: Zavadski 2015; Sanchez and Foster 2015.
9. *times are not necessarily emotional*: Barrett et al. 2004. See also [heam.info/control-1](#).
10. *distinct systems in the brain*: Cisek and Kalaska 2010.
11. *due to the direct wiring*: Actually, it just seems as if there is one motor action. Many slightly different motor actions can be executed to perform the same behavior, as motor actions are degenerate. For a helpful summary, see Anderson 2014, Interlude 5. Also see Franklin and Wolpert 2011.
12. *decision-making*: Swanson 2012, following George Howard Parker (1919) and the neuroscientist and Nobel laureate Santiago Ramon y Cajal (1909–1911). See also [heam.info/association-1](#).
13. *just that — an experience*: Your control network is always actively engaged whether you’re aware or not; see [heam.info/control-2](#).
14. *of your thoughts and actions*: The feeling of control is defined as awareness (you are able to report or reflect on your attempts at control), agency (you experience yourself as in control, as the agent), effort (you experience processing as effortful), and control (you are aware that automatic processes are occurring and are motivated to counteract them); see [heam.info/control-3](#).
15. *the experience of having control*: I suspect the brain creates the experience of control like any other experience: you have a concept for “Agency,” and you apply it as a prediction to a bunch of sensations. For a similar view, see Graziano 2013.
16. *are more stoic and analytical*: More on stereotypes of emotionality in men and women is at [heam.info/stereo-1](#). “*that I considered important*”: Albright 2003. See also [heam.info/albright-1](#).
17. *there are no sex differences*: Barrett et al. 1998. *hardwired for stoicism or rationality*: Neuroscience evidence suggests that the “male brain” and “female brain” are myths; see [heam.info/stereo-2](#).
18. *experiences of emotion while watching*: Kring and Gordon 1998; Dunsmore et al. 2009. Actually, women just move their facial muscles more in general, so they are not really more “expressive” (Kelly et al. 2006). Also, in studies that measure facial EMG, there are as many studies that find sex differences as those that don’t (Barrett and Bliss-Moreau 2009b).
19. *the sex of the defendant*: Kahan and Nussbaum 1996.
20. *are supposed to be aggressors*: Tiedens 2001. *they’re supposed to be afraid*: This belief exists even though all mammals attack during threat; see [heam.info/attack-1](#). *and perhaps even their jobs*: Brescoll and Uhlmann 2008; Tiedens 2001. *be really competent and powerful*: Hillary Clinton is another example; see [heam.info/clinton-1](#).
21. *who kill their intimate partners*: Percy et al. 2010; Miller 2010.
22. *passive, and helpless*: Morrison 2006; Moore 1994. See also “Developments in the Law” 1993, citing court opinions that portray battered women as “helpless, passive or psychologically disturbed” (1592).
23. *of second-degree murder*: Moore 1994. *manslaughter, a lesser charge*: African American women are in a catch-22; see [heam.info/defense-1](#).

24. *the rapist a heavier sentence*: Schuster and Proven 2010, in Banes, forthcoming. *just having a bad day*: Barrett and Bliss-Moreau 2009b.
25. *relief and happiness go unmentioned*: Abrams and Keren 2009. *people of the same sex*: Calhoun 1999.
26. *in and out of court*: For example, laws related to the “war on crime” put in place by Richard Nixon created a culture of fear against certain ethnic groups in the United States (Simon 2007). *the target of inconsistent rulings*: Abrams and Keren 2009, 2032.
27. *and her crime was possible*: Feresin 2011.
28. *findings in their defense strategy*: For a review, see Edersheim et al. 2012.
29. *neurons in the human brain*: Graziano 2016.
30. *to pain to math skills*: As shown by a meta-analysis of almost six thousand brain-imaging experiments; see heam.info/meta-1. *and impulsivity in some instances*: This is called the “reverse inference problem”; see heam.info/rev-1.
31. *aggression, let alone murder*: For more on brain region size and free will, see heam.info/size-1. *and cause severe personality changes*: Burns and Swerdlow 2003; Mobbs et al. 2007.
32. *automatically releases someone from responsibility*: The same argument could serve as a reason to keep Albertani locked up; see heam.info/albertani-1.
33. *“he has no regrets”*: McKelvey 2015. *“he is devoid of”*: Stevenson 2015.
34. *sex, or ethnicity*: Haney 2005, 189–209; Lynch and Haney 2011. See also heam.info/empathy-1. So much for the idea of being judged by a jury of your peers (which is enshrined in the Magna Carta and the U.S. Bill of Rights).
35. *the “Chechen wolf”*: Wikipedia, s.v. “Chechen Wolf” last modified March 18, 2015, http://en.wikipedia.org/wiki/Chechen_wolf.
36. *painful to shame your family*: Nisbett and Cohen 1996.
37. *leading to his death sentence*: Imagine if a defendant in a murder case smiled through the proceedings; see heam.info/trial-1.
38. *as evidence from the trial*: Keefe 2015. See also Gertner 2015.
39. *decision between imprisonment and death*: In fact, the jury’s perception of whether or not a defendant is remorseful largely determines whether it recommends the death penalty (Lynch and Haney 2011).
40. *of the parole board resign*: Some reports say six members resigned; see heam.info/tsarnaev-1.
41. *to have a fair trial*: *Riggins v. Nevada*, 504 U.S. 127, 142 (1992) (Kennedy, J., concurring). Presumably, defendants are deprived of a fair trial by those things that interfere with a jury’s perceiving remorse.
42. *cascade of predictions (chapter 6)*: It’s so ubiquitous in Western culture that scholars keep rediscovering it and calling it by different names, such as “mind perception,” “person-perception,” and “mentalizing.” For an entertaining and insightful treatment on this issue, see Wegner and Gray 2016.
43. *mental inferences, that is, guesses*: Gilbert 1998.
44. *conservative subjects inferred violent intentions*: Kahan et al. 2012.
45. *to recommend more severe punishments*: Nadler and Rose 2002; Salerno and Bottoms 2009, both in Banes, forthcoming. See also Banes and Blumenthal 2012. *a jury-swaying masterpiece*: *Kelly v. California*, 555 US 1020 (2008).
46. *stuck while he was traveling*: Goodnough 2009.
47. *justification for Florida’s law*: Montgomery 2012.

48. *but they were not neuroscientists*: For the full statement of the Second Amendment, see [heam.info/second.gun.will.make.them.safer](#): Kohut 2015, in Blow 2015.
49. *literal readout of the world*: Loftus and Palmer 1974; Kassin et al. 2001.
50. *place in Australia in 1975*: Massachusetts General Hospital Center for Law, Brain, and Behavior 2013.
51. *convicted based on eyewitness testimony*: Innocence Project 2015; Arkowitz and Lilienfeld 2010.
52. *go wrong in eyewitness testimony*: New Jersey Courts 2012; *State v. Lawson*, 291 P.3d 673, 352 Or. 724 (2012); *Commonwealth v. Gomes*, 470 Mass. 352, 22 N.E.3d 897 (2015). *that they did not commit*: Schacter and Loftus 2013; Deffenbacher et al. 2004.
53. *“most especially their emotions”*: Scalia and Garner 2008.
54. *“or Easter bunnies”*: *United States v. Ballard*, 322 U.S. 78, 93–94 (1944) (Jackson, J., dissenting). *instead of to hunger (chapter 4)*: Danziger et al. 2011. *more likeable or sympathetic people*: Wistrich et al. 2015.
55. *is more likely to lose*: Black et al. 2011. *affective connotations in the judges’ words*: Ironically, the late Justice Antonin Scalia was known for his emotional style of discourse; see [heam.info/scalia-1](#).
56. *half of the United States*: Wikipedia, s.v. “David Souter,” last modified March 30, 2016, http://en.wikipedia.org/wiki/David_Souter. *under the fiction of equanimity*: The sociologist Arlie Hochschild calls it “emotional labor” (Hochschild 1983).
57. *sentencing portion of criminal cases*: In 1972, the Supreme Court decreed that “any decision to impose the death sentence be, and appear to be, based on reason rather than caprice or emotion” (*Furman v. Georgia*, 408 U.S. 238, 311 [1972], [Stewart, J., concurring], as cited in Pillsbury 1989, 655n2). Since then, the Supreme Court has worked hard to remove emotional considerations from sentencing. Presumably, they assume that if a judge follows the rules, without the aid of emotion, then the outcome will be fair. Of course, the brain’s wiring reveals that no judgment is ever free of body-budgeting considerations, and therefore a judge can implement the rules with affective realism (chapter 4) without ever knowing it. Ironically, judges know they need affect to do their job. Here is a quote from one judge: “Now, there’s two things that can happen to you. Either you’re going to remain a decent person and become terribly upset by it all because your emotions — because your feelings are being pricked by all of this constantly or you’re going to become — you’re going to grow a skin on you as thick as a rhino, in which case I believe you’re going to become an inadequate judicial officer because once you lose the human — the feeling for humanity you can’t really — I don’t believe you can do the job” (Anleu and Mack 2005, 612). See [heam.info/judges-1](#). *“more to be nurtured than feared”*: Brennan 1988, as cited in Wistrich et al. 2015. Brennan foreshadowed Antonio Damasio. Science is on Justice Brennan’s side here: no one is immune to affective realism (chapter 4).
58. *Aurora, Colorado, in 2012*: Wikipedia, s.v. “2012 Aurora Shooting,” last modified April 21, 2016, http://en.wikipedia.org/wiki/2012_Aurora_shooting. *construct an experience of anger*: We might say that anger is appropriate, and even useful, because it is a form of social reality that shows the judge to be committed to preserving moral order in a society that promotes respect for others. See Berns 1979, in Pillsbury 1989, 689n112; also see Ortony et al. 1990. *victim of some sort himself*: Pillsbury 1989. There is a longstanding controversy over the role of empathy and emotions in judicial practice. Interested readers should see [heam.info/empathy-2](#). *ignorance of the defendant’s*

- perspective*: Anger as ignorance comes from contemplative philosophies such as Buddhism. *punishing the offender during sentencing*: Pillsbury 1989. It is difficult for a judge to see himself as similar to a defendant, which might be why judges are more likely to hand out maximum sentences (ibid., 705n155). *of emotion in the courtroom*: See heam.info/empathy-3. For an example of how enhanced emotional granularity improves moral decision-making, see Cameron et al. 2013.
59. *a host of other illnesses*: Copeland et al. 2013.
 60. *early adversity have shorter telomeres*: Kiecolt-Glaser et al. 2011.
 61. *disease of prediction gone wrong*: Borsook 2012.
 62. “*cruel and unusual punishment*”: Convention (III) relative to the Treatment of Prisoners of War. Geneva, August 12, 1949. Prisoners of war “are entitled in all circumstances to respect for their persons and their honour” (article 14) and “must at all times be protected . . . against insults and public curiosity” (article 13). U.S. Constitution, Eighth Amendment.
 63. *telomeres and potentially their lifespan*: Guarneri-White 2014. *verbal aggression and physical threats*: Wikipedia, s.v. “Suicide of Phoebe Prince,” last modified January 30, 2016, https://en.wikipedia.org/wiki/Suicide_of_Phoebe_Prince. *playground in a legal context*: Matters surrounding bullying are made more complicated by the fact that our culture models bullying as normative; see heam.info/bully-1.
 64. *reported involvement with electronic bullying*: During a two-month period in 2005, using a nationally representative sample of over seven thousand children from grades six to ten (Wang et al. 2009).
 65. *contaminating its warehouse with feces*: Monyak 2015. “*distress and mental anguish*”: The lawyer arguing the case asked the jury to send corporate America a message; see heam.info/atlanta-1. *consequently so does compensation*: Note that the large majority of civil cases reach a settlement out of court; see heam.info/harm-2.
 66. *which is far more variable*: How do you quantify suffering in dollars? See heam.info/harm-3.
 67. *withdrawal from an addictive drug*: Fisher et al. 2010.
 68. *a defendant than others will*: Zaki et al. 2008. *this synchrony and cultivate empathy*: Schumann et al. 2014.
 69. *deep dividing lines in nature*: Even biological sex is not a natural kind; for informative discussions, see Dreger 1998, and Dreger et al. 2005. See also Dreger 2015.
 70. (*self-reports are not necessarily valid*): One useful approach during voir dire can be adapted from the research of U.S. attorney Dan Kahan; see heam.info/kahan-1.
 71. *guilt was true or false*: I am not implying that objective evidence is error-free, nor that it is completely free of human judgment. *consistency produces a just outcome*: Judges and lawyers must have realized that consistency does not always deliver justice, meaning that there will be some false positives (innocent people who are convicted). Thinking about the implication — that some sacrifices must be made for the good of the system — is worrisome, even alarming. Who said *The Hunger Games* was complete fiction?
 72. *to hand out maximum sentences*: Pillsbury 1989, 705n155.
 73. *influences you were pickled in*: This wonderful phrase comes from my friend and colleague Judith Edersheim, codirector of the Center for Law, Brain, and Behavior at Massachusetts General Hospital. *an unarmed African American civilian*: Fachner et al. 2015, 27–30. *the symbols of your culture*: As another example: a Confederate battle flag, which symbolizes racism to many people, flying atop a statehouse building and even appearing as part of a couple of state flags; see heam.info/flag-1.

12. Is a Growling Dog Angry?

1. *scientific discoveries in animal emotion*: A quick search of *Time*, *Pacific Standard*, *Newsweek*, *Atlantic Monthly*, *Boston Globe*, *Chicago Tribune*, *USA Today*, *Los Angeles Times*, and the *New York Times* turned up twenty-six articles between 2009–2014 reporting that animals have emotions. *dogs get jealous*: Harris and Prouvost 2014. *rats experience regret*: Steiner and Redish 2014. *crayfish feel anxiety*: Fossat et al. 2014. *flies fear the incoming flyswatter*: Gibson et al. 2015. *“they’re largely the same”*: Safina 2015, 34.
2. *but not for emotion*: LeDoux 2014.
3. *same basic nervous system plan*: Swanson 2012; Donoghue and Purnell 2005.
4. *about 25 million years ago*: Goodman 1999. All of these species have evolved since then to suit their habitats, so our modern forms hardly count for an evolutionary comparison. But scientists do their best to take that into consideration when interpreting the experimental results. *that the human network does*: Touroutoglou et al. 2016. More generally, macaque and human brains are very similar to one another (Barbas 2015), with a few notable changes, mostly at the front of the brain (Hill et al. 2010); see also heam.info/macaque-1.
5. *watching negative behaviors like cowering*: Bliss-Moreau et al. 2013. See also heam.info/macaque-2.
6. *are paired with electric shock*: Malik and Hodge 2014.
7. *can feel pleasure or pain*: Bentham believed in utilitarianism; see heam.info/bentham-1.
8. *more things matter to us*: Globalization is just a massive expansion of your affective niche; see heam.info/niche-1.
9. *“baby talk” tone of voice*: Amso and Scerif 2015. The infant and her caregiver are sharing attention; see heam.info/sharing-1.
10. *what is in her mind*: Okamoto-Barth and Tomonaga 2006; see also heam.info/gaze-1.
11. *large as a macaque brain*: Passingham 2009. *to learn purely mental concepts*: Most of the evolutionary changes have occurred in the cortical areas that have many neurons for processing prediction errors; see heam.info/evolution-2.
12. *animals learn concepts by smell*: Animals have concepts (Lea 2010). Primary olfactory cortex has a limbic structure that is closely connected to visceromotor limbic regions. For a review, see Chanes and Barrett 2016. *sight or sound as well*: While mammals are more dominated by olfactory concepts, birds are more visually dominated. Mammals and birds split from a common ancestor about 200 million years ago. *goats by vocal bleats*: Lea 2010.
13. *reward them with food or drink*: Mareschal et al. 2010. See also heam.info/animals-1. *regardless of font*: Vauclair and Fagot 1996. *animal images from food images*: Fabre-Thorpe 2010. *differ only by color*: Yoshikubo 1985; Marmi et al. 2004. For more examples, see Fabre-Thorpe 2010. *van Gogh, and Salvador Dalí*: Four macaques were trained to classify parts of paintings from these three painters and a fourth, Jean-Léon Gérôme. These parts contained no faces or full objects that could be memorized; monkeys were required to attend to the style of painting (Altschul et al. 2015).
14. *more of this critical wiring*: Goodman 1999. See also heam.info/evolution-2.
15. *making a mental inference*: Vallacher and Wegner 1987; Gilbert 1998. *thinking, desiring, or feeling*: Martin and Santos 2014.

16. *mental similarities amid perceptual differences*: For example, Tomasello 2014; Hare and Woods 2013. *just an action; it's a goal*: According to Michael Tomasello (2014, 27–29), great apes create concepts that go beyond mere perceptual similarities, and they represent information about the situation (e.g., whether food is present or not). Most likely, they also create concepts in a generative way, meaning they can use bits and pieces of prior experience to create a novel prediction, up to a point (ibid., 28). A discussion of the concept “To Climb” can be found in ibid., 29. *have a shared mental goal*: The default mode networks in human and chimp brains are similar in the brain regions that are connected to one another but not in the microscopic wiring; see heam.info/chimp-1. *way that human infants do*: Scientists actively debate the brain mechanisms for human language; see heam.info/language-2.
17. *“wanting to have some”*: Tomasello 2014, 105. See also heam.info/animals-2. *in order to request rewards*: Famous attempts to teach language to apes are described at heam.info/animals-3.
18. *use symbols on their own*: That is, just by exposing chimps to symbol-based language, without explicit rewards (e.g., Matsuzawa 2010; Hillix and Rumbaugh 2004). *the symbol to unfamiliar tools*: Tanaka 2011. Chimps seem to be able to recognize that different-looking objects can achieve the same function, as long as that function involves some sort of direct motor action. For example, chimps may understand that a stick can be used to obtain food in multiple ways: retrieving termites from the ground, opening a can of food, or shaking fruit from a tree. They might even understand that a ladder is a “Tool” to shake fruit from a tree. But would they understand that completely dissimilar objects, when employed with very dissimilar actions, are both “Tools,” like a rock for cracking nuts and a ladder for reaching fruit in a tree? Would they understand that the same rock is also a “Tool” when used for non-food-related purposes, like weighting down light objects to keep them from blowing away in the wind? If a chimp uses a stick to threaten a subordinate, or if the chimp requests food from a human, would it understand that the stick and the human are “Tools” as well?
19. *waiting at the other end*: Herb Terrace, personal communication, June 6, 2015. *alone are not worth learning*: If an event or object does not perturb an animal's body budget, and is not relevant to energy regulation, then there is less need to invest the resources to build a concept for it. Research by the cognitive psychologist Patricia K. Kuhl suggests that language learning requires a brain's body-budgeting regions to be engaged, for example; see Kuhl 2014.
20. *cooperative than common chimps*: Chimps and bonobos last shared a common ancestor about 1 million years ago (Becquet et al. 2007; Hey 2010). *the meaning of concrete words*: A comparison of chimps and bonobos is at heam.info/chimp-2.
21. *the results of the experiments*: Tetsuro Matsuzawa, personal communication, June 12, 2015. See also heam.info/chimp-3.
22. *equally well under these conditions*: Murai et al. 2005.
23. *a flying leopard*: Tomasello 2014, 29. *from different points of view*: Ibid. This requires a type of simulation (Mesulam 2002) that a chimp brain does not seem wired to do. *the heads of other creatures*: Infant chimps stop following their mother's gaze during the first year of life (Matsuzawa 2010). Adult chimps can follow gaze under some circumstances; see heam.info/chimp-4.
24. *exchangeable for goods in general*: Sousa and Matsuzawa 2006. Chimps are capable of constructing and using tools in complex ways. See also heam.info/chimp-5.

25. *had picked up the practice*: Trivedi 2004. For discussion, see Jablonka et al. 2014.
26. *unique in the animal kingdom*: Other scientists have similar views; see heam.info/reality-2.
27. *“letting the infant nurse”*: Morell 2013, 222–223.
28. *motivation to interact with humans*: For more on Belyaev’s story, see Hare and Woods 2013.
29. *can regulate ours in turn*: Learn more about the experiments showing human-dog body-budget regulation at heam.info/dogs-1.
30. *and vice versa*: Quaranta et al. 2007.
31. *heart rate and other factors*: Siniscalchi et al. 2013. For commentary, see heam.info/sides-1. *faces and voices of humans*: Turcsán et al. 2015.
32. *if trained to do so*: Range et al. 2008.
33. *the smells of other humans*: Settle et al. 1994.
34. *gestures and following human gaze*: Hare and Woods 2013, 50–51. *our mind in our eyes*: For a thoughtful discussion, see Bradshaw 2014, 200. *get information about the world*: Hare and Woods 2013, 50.
35. *more sophisticated than playing fetch*: Kaminski et al. 2009; Hare and Woods 2013, 129. *(affect) in the acoustic signal*: Owren and Rendall 2001. *food, and her crate*: Rossi and Ades 2008.
36. *clever study investigated this question*: Horowitz 2009.
37. *anus of the toy dog*: Harris and Prouvost 2014. *in only one condition*: An owner’s subtle movements can have a large effect on an animal’s behavior (due to statistical learning); see heam.info/animals-4.
38. *in distress, for example*: The act lifts a burden on their body budgets (e.g., Bartal et al. 2011). For more, see heam.info/burden-1. *infant who is in distress*: Dunfield and Kuhlmeier 2013; see heam.info/burden-2.
39. *with a bunch of strangers*: For an enlightening discussion of why wolves are not aggressive creatures by nature, read Bradshaw 2014. See also heam.info/wolves-1.
40. *experience some kind of grief*: Morell 2013, 148; Bekoff and Goodall 2008, 66. *operates similarly to drug withdrawal*: Vernon et al. 2016. *love is a drug*: Fisher et al. 2010.
41. *why isn’t it “anger learning”*: A similar point was made by Jerome Kagan (Kagan 2007).
42. *the “triune brain”*: “Fear learning” studies, which assume a triune brain, have also been performed on humans, in support of the classical view (e.g., LaBar et al. 1998).
43. *this circuitry in elegant detail*: E.g., the neuroscientist Joseph LeDoux’s groundbreaking research illustrates how synapses change within key sites of the amygdala, allowing neutral sensory inputs, like sounds, to automatically elicit an inborn defense response, like freezing (LeDoux 2015).
44. *automatically and effortlessly*: For an accessible introduction, see Wegner and Gray 2016. Mental inference is so ubiquitous in Western culture that scholars keep discovering it again and again and calling it by different names; see heam.info/inference-1.
45. *meaningful by making an inference*: This began with the first psychology experiment, which was conducted by Wilhelm Wundt in the late 1800s; see heam.info/wundt-2.
46. *into an industry of fear*: This confusion became institutionalized in psychology during behaviorism; see heam.info/behaviorism-1.
47. *rats run away*: E.g., Belau and McGaugh 2003; see heam.info/rats-1. *in which case they attack*: Reynolds and Berridge 2008. See heam.info/rats-2. *goes down instead of up*: Iwata and LeDoux 1988. *not all of these varied behaviors require the amygdala*: Fear learning does not necessarily involve the amygdala. Aggression toward a preda-

- tor (called “defensive treading” or “burying”) does not depend on the amygdala (De Boer and Koolhaas 2003; Kopchia et al. 1992). The amygdala is involved when the threat is maximally ambiguous and learning is required (i.e., when prediction error must be processed [Li and McNally 2014]). Even if amygdala neurons are routinely involved in learning, they may not be necessary for learning to occur. For example, infant monkeys who have their amygdalae removed about two weeks after birth are able to learn about aversive things; a body-budgeting region (the anterior cingulate cortex) had expanded in these monkeys during brain development, and this region also supports aversive learning (Bliss-Moreau and Amaral, under review). *of the mental inference fallacy*: Gross and Canteras 2012; Silva et al. 2013. See also [heam.info/inference-2](#). *specific to freezing or fear*: Tovote et al. 2015; see [heam.info/inference-3](#).
48. *be the circuitry for distress*: Blumberg et al. 2000. According to the neuroscientist Jaak Panksepp (Panksepp 1998), “distress/panic” calls are made by infant rats and occur following social isolation. For example, in a recent paper, he writes, “Distinct emotional powers that engender crying, allow young animals to signal their desperate need for care, especially when lost or isolated from caretakers by experimenters. These separation calls alert caretakers to seek out, retrieve, and attend to the needs of the offspring” (Panksepp 2011, 1799). *done by their absent mothers*: Blumberg and Sokoloff 2001. For a discussion, see Barrett, Lindquist, Bliss-Moreau, et al. 2007.
 49. *evidence and revised his position*: His recent theoretical papers clearly distinguish an instance of the emotion “Fear” from freezing behavior (LeDoux 2015).
 50. *the rodent is feeling empathy*: Burkett et al. 2016; Panksepp and Panksepp 2013. Don’t get me wrong — rodents are social animals that regulate each other’s body budgets, which means they can feel distress and perceive it in others of their species. Social insects regulate each other’s body budgets with chemicals. Mammals also do it with touch and perhaps with sound. Humans use all these means, plus words. But the question remains, do all these animals feel empathy? Or do only humans have the goal-based concept necessary to impose additional functions to transform body-budget regulation into empathy?
 51. *question is similar to yourself*: Mitchell et al. 1997. For other reasons, see Epley et al. 2007; Wegner and Gray 2016. *babies on her own flesh*: Kupfer et al. 2006. *of people chasing one another*: The similarities to humans can be simple; see [heam.info/inference-4](#).
 52. *itself—it’s completely normal*: I’ve avoided the term “anthropomorphism”; see [heam.info/anthro-1](#).
 53. *diminished versions of ourselves*: The classical view encourages this conceit, fueled by the “triune brain” myth of a simple brain evolving into something more complex; see [heam.info/evolution-4](#). *not to build mental similarities*: Matsuzawa 2010.
 54. *“crying for their mothers”*: See more on Panksepp’s circuits at [heam.info/panksepp-1](#). *exist in any animal brain*: Barrett, Lindquist, Bliss-Moreau, et al. 2007. *are not dedicated to emotion*: Survival circuits are not one-to-one with emotion concepts; see [heam.info/survival-1](#).

13. From Brain to Mind: The New Frontier

1. *distinctions between thinking and feeling*: Some cultures have a single word best translated as “thought-feeling” (e.g., Danziger 1997, chapter 1; William Reddy, personal communication, September 16, 2007; Wikan 1990); also see [heam.info/balinese-1](#).

2. *are structured completely alike*: Van Essen and Dierker 2007; Finn et al. 2015; Hathaway 2015.
3. *neurons in certain brain regions*: Opendak and Gould 2015; Ernst and Friséen 2015. *also occurs with experience*: See [heam.info/plasticity-1](#).
4. *neurotransmitters make this possible*: Bargmann 2012. Neurotransmitters change how efficiently your neurons communicate and more; see [heam.info/neuro-1](#). *information flows along different paths*: Sporns 2011, 272. *greater than the sum of the parts*: For a review, see Park and Friston 2013; e.g., networks reconfigure as cognitive demands increase (Kitzbichler et al. 2011). For more, see [heam.info/wiring-2](#).
5. *or even vision or hearing*: A single brain cell can be multipurpose, as we discussed in chapters 1 and 2, contributing to multiple psychological states; see [heam.info/neurons-2](#).
6. *and other scholarly disciplines*: Bullmore and Sporns 2012. The brain is a complex, adaptive system, meaning that it constantly reconfigures the connectivity strength of its neurons to anticipate changes in the environment (which includes the body and outside world). Complex systems produce emergence, i.e., products of the system as a whole that cannot be reduced to the components of the system alone; they are “more than the sum of their parts” (Simon 1962). Complexity means that variation is the norm in patterns of brain activity; see [heam.info/complexity-1](#).
7. *that it can support consciousness*: Tononi and Edelman 1998; Edelman and Tononi 2000. *its single function by itself*: A brain full of uniquely purposed neurons would also have low complexity, as would a fully synchronized brain, because in both cases, the majority of neurons do not share information (they all act differently in the former case and identically in the latter case).
8. *get to the same end*: Whitacre and Bender 2010, figure 10; see also [heam.info/whitacre-1](#). *genes to the next generation*: Edelman and Gally 2001. Degeneracy accompanies natural selection. It makes the brain more resilient to injury, which is why natural selection favors a brain built with degeneracy. The variation that degeneracy provides is a prerequisite for natural selection in the first place; see [heam.info/degeneracy-4](#).
9. *favors a complex brain*: The evolutionary success of a brain depends on its ability to model the ever-changing environment in a metabolically efficient way (Edelman and Gally 2001; Whitacre and Bender 2010). Evolution must select for individuals with a combination of genes that produce this kind of brain (and that genetic combination is, itself, degenerate and complex). The more important a system is to the survival of a species, the more degeneracy and complexity will exist in the genes that support that system. Therefore, degeneracy and complexity are prerequisites for and an inescapable product of natural selection. I am not claiming that natural selection favors ever-increasing complexity; natural selection does favor complex adaptive systems.
10. *and other properties of consciousness*: And perhaps a few other concepts as well; see [heam.info/properties-1](#). *practices to address that dilemma*: See [heam.info/world-1](#).
11. *perhaps a Jackson Pollock*: The brain doesn’t construct a representation of an object like a bee or a car and then evaluate its significance for the self. The significance for your body budget is built into the construction in the first place, via interoceptive predictions. Note that this is at odds with a version of the classical view called causal appraisal theories of emotion, which assume that first you perceive an object and then you evaluate it for its self-relevance, novelty, etc.
12. *out for several thousand years*: Many other worldviews exist; see [heam.info/world-1](#).

13. *has exactly the same function*: Pinker 2002, 40. *the next generation of humans*: Durham 1991; Jablonka et al. 2014; Richerson and Boyd 2008.
14. *mindful enough to cultivate doubt*: Firestein 2012.
15. *for parent-infant bonding*: See heam.info/synchrony-1.
16. *in the world just fine*: The activist Caroline Casey didn't know she was blind until age seventeen, when she proposed to learn to drive (Casey 2010).
17. *more aliases than Sherlock Holmes*: The default mode and salience networks go by many names (Barrett and Satpute 2013); see heam.info/dmn-5.
18. *prefrontal cortex (PFC)*: Neurons in the upper layers of cortex are born last during the prenatal period and continue to mature and develop their connectivity after birth, during infancy and childhood (Kostović and Judaš 2015). Poverty is similarly toxic for other aspects of brain development (Noble et al. 2015). *(prediction error) and control*: Barrett and Simmons 2015; Finlay and Uchiyama 2015. *leads back to poverty*: See heam.info/children-1.
19. *accurate than we might think*: Jussim, Cain, et al. 2009; Jussim, Crawford, et al. 2009. *when compared to census figures*: Pinker 2002, 204. *muddled assumptions about human nature*: Jussim 2012; Pinker 2002.
20. *"next generation of tools"*: Firestein 2012, 21.
21. *new government and social order*: Even the concept of a "Revolution" is social reality; see heam.info/revolution-1.

Appendix A

1. *2004 as a charity event*: "Fright Night" 2012.
2. *changing its rate of firing*: Marder 2012. The transmission is made more or less efficient by glial cells (Ji et al. 2013; Salter and Beggs 2014); see heam.info/glia-2.
3. *wired into circuits and networks*: The transition between the cortex and subcortical regions is called allocortex, and it ranges from having barely visible columns to three layers (Zilles et al. 2015).
4. *organized as clumps of neurons*: The word "cortical" means "in the cortex," hence "subcortical" is "below the cortex."
5. *important for coordinating physical movements*: The cerebellum's main role is to anticipate how the body's movements in time and space will influence the predictions and pattern completion going on in the cortex (Pisotta and Molinari 2014; Shadmehr et al. 2010).
6. *that replenish those resources*: There are three branches of the autonomic nervous system. The sympathetic nervous system, sometimes called the "fight or flight" system, tells the body to spend its energy resources. It sends information to the sweat glands in your skin, to the smooth muscles that surround your blood vessels, to your internal body organs, to the muscles that dilate your pupils, to the parts of the body that generate your immune cells, and so on. The parasympathetic nervous system, also known as the "rest and digest" system, tells the body to replenish its energy resources. It tells your pupillary muscles to contract, your body to secrete saliva and insulin, and other functions related to digesting food, in part by communicating with the third branch, called the enteric nervous system. See heam.info/nervous-1.

Appendix D

1. *(hearing, etc.) operate by prediction*: For a summary, see Chanes and Barrett 2016; details are at heam.info/prediction-12. *structured to function this way*: Barrett and Simmons 2015.
2. *cascade within the visual system*: Grill-Spector and Weiner 2014; Gilbert and Li 2013. *across the structure of cortex*: Barbas and Rempel-Clower 1997; Barbas 2015. *multisensory summaries in chapter 6*: Many neurons pass information to fewer, more densely connected neurons, meaning compression and dimension reduction must happen (Finlay and Uchiyama 2015).
3. *some of the same neurons*: A recent discovery is that conceptually similar visual instances are stored closer to one another in cortical space; for an example in visual cortex, see Grill-Spector and Weiner 2014.
4. *subjects were lying at rest*: Ironically, because scientists assumed that the brain was “off” when not stimulated by the external world, they missed evidence of this network several times. For more on how the default mode network was discovered, see Buckner 2012. *stimulated by an experimental procedure*: Obviously, intrinsic brain activity is not important only when the brain is not being probed explicitly in an experiment. Those who originally named the network probably did not appreciate the importance of this network (or intrinsic activity) to everyday thoughts, feelings, and perceptions when they named the network. *networks have since been discovered*: Yeo et al. 2011; Barrett and Satpute 2013. *name fit this network nicely*: The default mode network goes by many names; see heam.info/dmn-1.
5. *default mode network, as predicted*: Binder showed that conceptual processing occurs even when people are not explicitly asked about concepts (Binder et al. 1999). For more details on this experiment, see heam.info/binder-2. *similar brain-imaging experiments*: Binder et al. 2009.
6. *in the default mode network*: Spunt et al. 2010.
7. *way it is right now*: E.g., Barrett 2009; Bar 2007. For a review, see Buckner 2012.
8. *a key role in categorization*: Barrett 2012; Lindquist and Barrett 2012. For a similar but not identical point of view, see Edelman 1990, and Binder and Desai 2011.
9. *to construct instances of concepts*: The cognitive neuroscientist Eleanor A. Maguire comes close to this idea (Hassabis and Maguire 2009); see heam.info/maguire-1.
10. *“lantern” of attention*: Gao, Alcauter, et al. 2014.
11. *category to any brain region*: Lindquist et al. 2012. *the interoceptive and control networks*: Kober et al. 2008.
12. *clearly for happiness and sadness*: Wager et al. 2015. Further details are in chapter 1 and at heam.info/patterns-1. *exactly like its associated summary*: Clark-Polner, Johnson, et al., in press; Clark-Polner, Wager, et al., in press.
13. *changes in the interoceptive network*: Wilson-Mendenhall et al. 2013. Even more striking, when volunteers imagined physical danger, a relatively greater increase in neural activity was observed in a network that tracks and locates physical objects in space, but when they imagined social scenarios, the increase occurred in a network that helps infer the thoughts and feelings of others (Wilson-Mendenhall et al. 2011).
14. *is exactly what we observed*: Wilson-Mendenhall et al. 2015. See also Oosterwijk et al. 2015. For other brain-imaging studies that support the theory of constructed emotion, see heam.info/TCE-1.

15. *reported more intense emotional experiences*: Raz et al. 2016. More details are at [heam.info/movies-1](#).
16. *similar case for emotion perception*: See research by the cognitive neuroscientist Robert Spunt and colleagues (e.g., Spunt and Lieberman 2012). See also Peelen et al. 2010, and Skerry and Saxe 2015, discussed in more detail in [heam.info/dmn-3](#).
17. *represented by the entire brain*: Some scientists try to find a compromise between these two views of concepts (that they involve sensory and motor representations versus that they are “abstract,” meaning they are stored without reference to sensory and motor details); see [heam.info/dmn-4](#). *movements have increased their firing*: Chao and Martin 2000. See Barsalou 2008b for a review. *the name of the object (“hammer”)*: Tucker and Ellis 2004. *gripping motion with your hand*: Klatzky et al. 1989; Tucker and Ellis 2001.
18. *represented throughout the entire brain*: For a review, see Barsalou 2009.
19. *of neurons for each goal*: Further details on this misconception are at [heam.info/concepts-20](#). *see nothing of the kind*: For a discussion of evidence, see Lebois et al. 2015.
20. *can be different each time*: Within a concept, there can be several different goals, none of which is core; see [heam.info/concepts-21](#).
21. *dark, empty bucket*: Years later, I finally forgave myself for this embarrassing error after reading Brian Greene’s 2007 book *The Fabric of the Cosmos*, whose second chapter is titled “The Universe and the Bucket: Is Space a Human Abstraction or a Physical Entity?” (Greene 2007). “*eye of the beholder*”: Ibid., 47.
22. “*memories*” stored in your brain: Schacter 1996.