# SOURCE NOTES & GLOSSARY
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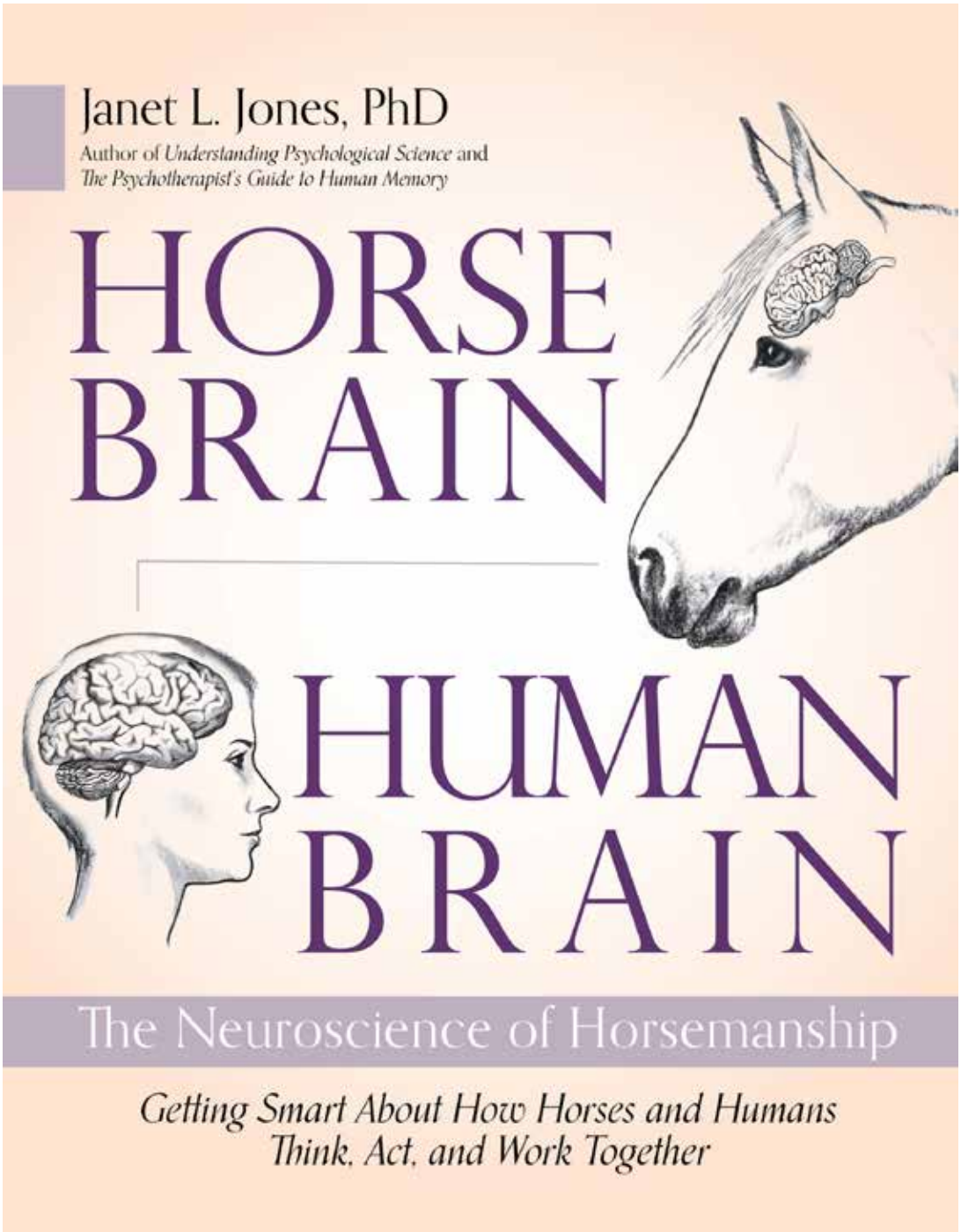


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# Source Notes

**P. ix | "The Brain—is wider..."**—There are several versions of this poem, but I have chosen to reprint the original exactly as Dickinson wrote it. Emily Dickinson, The Complete Poems of Emily Dickinson, ed. Thomas H. Johnson (Boston: Little, Brown and Company, 1960), 312.

## CHAPTER 1

**P. 3 | Earliest evidence of horses being ridden and milked**—https://www.sciencedaily.com/releases/2009/03/090305141627.htm

**P. 3 | American Horse Council Foundation statistics, 2017**—They report 7.2 million horses in the United States, not counting ponies or minis. https://www.horsecouncil.org/about-us/ahc-programs/ahc-foundation/

**P. 3 | 27 million Americans ride**—https://www.sportsbusinessdaily.com/Journal/Issues/2017/01/09/Marketing-and-Sponsorship/Equestrian.aspx

**P. 4 | 4150 breeds**—Domestic Animal Diversity Information System, a database of the United Nations' Food and Agriculture Organization. https://www/fao.org/dad-is/en

**P. 9 | Highest puissance wall jumped is 8' 1"**—https://en.wikipedia.org/wiki/Puissance

**P. 11 | Xenophon**—Xenophon, *The Art of Horsemanship* (New York: Dover Publications, 350 BC/2006 AD).

**P. 12 | Scottsdale population**—10,026 in 1960 census, 3.8 square miles. https://scottsdalehistory.org/page-18189

**P. 15 | "Simplicity is…"**—usually attributed to Leonardo da Vinci, but the exact source is uncertain. https://quoteinvestigator.com/2015/04/02/simple/

**P. 15 | "Where in this wide world…"**—is the first stanza of a poem by Ronald Duncan, *The Horse* (London: Souvenir Press Ltd, 1990). © (Copyright of) the Ronald Duncan Estate.

## CHAPTER 2

**P. 18 | Human brain maturation to age 25**—J. N. Giedd, "Structural Magnetic Resonance Imaging of the Adolescent Brain," *Annals of the New York Academy of Sciences,* 1021 (2004): 77–85.

**P. 18 | Equine physical maturity takes five to seven years**—Isabella Edwards, "When are Horses Mature?," *Equine Wellness,* April 17, 2014.

**P. 18 | New neurons born throughout adulthood**—Aurèlie Ernst and Jonas Frisèn, "Adult Neurogenesis in Humans—Common and Unique Traits in Mammals," PLOS Biology, 13 (2015): doi 10.1371/journal.pbio.1002045

**P. 18 | Effects of the Ice Age 35 million years ago**—https://www.science20.com/news_releases/why_did_ice_antarctica_suddenly_appear_35_million_years_ago_co2_says_study

**P. 19 | Splint bones were outer toes**—https://www.inverse.com/article/40590-horse-toe-feet evolution-metacarpal-equus-mesohippus; and https://ker.com/equinews/horse-splints/

**P. 19 | Natural history of the horse**—Wendy Williams, *The Horse* (New York:

Scientific American/Farrar, Straus and Giroux, 2015). This bestselling book describes the horse's natural history in entertaining detail. It contains photographs of equine fossils and explains how archeologists date them.

**P. 20 | Equine axon length**—The longest equine axon is the recurrent laryngeal nerve which runs from the brainstem to the larynx, a few inches away. For interesting evolutionary reasons, it takes an indirect route from the brainstem all the way to the horse's heart, then loops back up to the larynx. Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 73; and Janet L. Jones, "Cory's Second Wind," *EQUUS* 470, (November 2016): 32-42.

**P. 20 | Equine axon speed**—Zoe Davies, *Equine Science* (Hoboken, NJ: John Wiley & Sons, 2018).

**P. 20 | Glucose consumption**—Human brain comprises 2% of body weight https://faculty.washington.edu/chudler/ffacts.html. Horse brain weighs 1 ½ to 2 pounds http://www.ebhrc.com/article2.html. Calculating the horse's average weight at 1000 pounds, the ratio of brain to body weight is .002. Horse uses 25% of body's glucose - American Association of Equine Practitioners, *Equine Veterinary Education,* (October 2017). Available online: https://aaep.org/site-search?search=glucose+brain.

**P. 21 | Human pathway from vision to action**—A second pathway in human brains reduces prefrontal analysis under certain circumstances, but it is still not as fast as the equine route. Joseph LeDoux, *The Emotional Brain* (New York: Simon and Schuster, 1996).

**P. 22 | Brain link between human navigation and smell**—Louisa Dahmani, Raihaan M. Patel, Yiling Yang, M. Mallar Chakravarty, Lesley K. Fellows, and Veronique D. Bohbot, "An Intrinsic Association Between Olfactory Identification and Spatial Memory in Humans," *Nature Communications* 9, (October 16, 2018): 4162.

**P. 24 | Hard wired social interaction**—Lauren Wingfield, "Glimpses Into Brain Uncover Neurological Basis for Processing Social Information," *Neuroscience News* (November 5, 2018).

**P. 26 | 6000 years of domestication**—Wendy Williams, *The Horse* (New York: Scientific American/Farrar, Straus and Giroux, 2015).

**P. 26 | Przewalski horse**—Wendy Williams, *The Horse* (New York: Scientific American/Farrar, Straus and Giroux, 2015).

**P. 26 | Przewalski horse descended from domesticated horses**—Elizabeth Pennisi, "Ancient DNA upends the horse family tree," *Science* (February 22, 2018). Available online: https://www.sciencemag.org/news/2018/02/ancient-dna-upends-horse-family-tree

**P. 27 | Brain texture like soft tofu**—Katrina Firlik, *Another Day in the Frontal Lobe* (New York: Random House, 2006).

**P. 27, 28 | Weight and dimensions of the equine brain**—Bruno Cozzi, Michele Povinelli, Cristina Ballarin, and Alberto Granato, "The Brain of the Horse: Weight and Cephalization Quotients," *Brain Behavior and Evolution* 83, no. 1 (December 2013): 9-16.

**P. 27 | Volume of the equine brain**—Bruno Cozzi, DMV, PhD, 2019, e-mail messages to author, September 17-18.

**P. 28 | Number of neurons in human brain**—Suzana Herculano-Houzel, *The Human Advantage: A New Understanding of How Our Brain Became Remarkable* (Cambridge, MA: The MIT Press, 2017).



Horse Brain Human Brain text 7.indd 268 5/6/20 9:17 AM

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**P. 28 | Number of neurons in equine brain**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 28 | Each pyramidal neuron allows up to 10,000 connections**—John Morrison, Professor of Neurology at University of California, Davis. https://www.brainfacts.org/thinking-sensing-and-behaving/learning-and-memory/2019/the-short-answer-what-is-a-synapse-072519

## CHAPTER 3

**P. 32 | Blindsight in animals**—Jason Holt, *Blindsight and the Nature of Consciousness* (Peterborough, Ontario: Broadview Press, 2003).

**P. 32 | Edelman quote**—"If our view of memory is correct, in higher organisms every act of perception is, to some degree, an act of creation, and every act of memory is, to some degree, an act of imagination." Gerald M. Edelman and Guilio Tononi, *A Universe of Consciousness: How Matter Becomes Imagination* (New York: Basic Books, 2000), 101.

**P. 33 | Equine eye size**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 33 | Normal equine acuity**—Zoe Davies, *Equine Science* (Hoboken, NJ: John Wiley & Sons, 2018).

**P. 33 | Near- and far-sighted horses**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 34 | Horse vs. human view of a jump**—See photograph credited to Alison Harman in Paul McGreevy, *Equine Behavior 2e* (Sydney: Saunders Elsevier, 2012), 41.

**P. 34 | Variations in acuity with age and breed**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 36 | Equine eyes can move independently**—www.horsewyse.com.au/howhorsessee.html

**P. 36 | 340 degree range of view**—*Merck Veterinary Manual*. Available online: https://www.merckvetmanual.com/horse-owners/eye-disorders-of-horses/eye-structure-and-function-in-horses

**P. 42 | 55 types of retinal cells**—Richard H. Masland, "The Fundamental Plan of the Retina," *Nature Neuroscience* 4 (2001): 877-886.

**P. 42 | 210 million rods and cones**—Margaret W. Matlin and Hugh J. Foley, *Sensation and Perception 4e* (Needham Heights, MA: Allyn and Bacon, 1997).

**P. 42 | Half second to perceive a sight**—David Eagleman, *The Brain: The Story of You* (New York: Pantheon Books, 2015).

**P. 45 | "Decapitating" with the blind spot**—Vilayanur S. Ramachandran, *Phantoms in the Brain* (New York: William Morrow and Company, Inc., 1998), 91.

## CHAPTER 4

**P. 49 | Pupillary adaptation time and sensitivity**—Zoe Davies, *Equine Science* (Hoboken, NJ: Wiley Blackwell, 2018).

**P. 50 | Humans see 66% less light at age 60**—Atul Gawande, *Being Mortal* (New York: Metropolitan Books, 2014).

**P. 51 | Depth perception**—This section focuses on binocular disparity, but human and equine vision systems use monocular cues for depth perception as well. For example, motion parallax is important to both species.



Horse Brain Human Brain text 7.indd 269 5/6/20 9:17 AM

**P. 51 | Human depth perception of ⅛ inch at 16 ½ feet**—O.J. Braddick, Binocular Vision. In H.B. Barlow and J.D. Mollon (Eds.), *The Senses* (Cambridge: Cambridge University Press, 1982).

**P. 51 | Equine depth perception of 9 inches at 16 ½ feet**—calculated from information provided in B. Timney and K. Keil, "Local and Global Stereopsis in the Horse," *Vision Research* 39, (1999): 1861-1867.

**P. 53 | Half the area visible to two human eyes is visible to two horse eyes**—Francis Burton, *Ultimate Horse Care* (Lydney, UK: Ringpress Books, 1999). Leblanc specifies that the equine binocular field is about 60 degrees compared to a human binocular field of 120 degrees. Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 54 | Human visual system uses almost ⅓ of brain**—David Eagleman, *The Brain: The Story of You* (New York: Pantheon Books, 2015).

**P. 56 | Red jacket against green grass**—Wendy Williams, *The Horse* (New York: Scientific American/Farrar, Straus and Giroux, 2015).

**P. 56 | Steeplechase colors**—Bianca Britton, "New Research on Horse Eyesight Could Improve Racecourse Safety," *CNN News* (October 23, 2018). Available online: https://edition.cnn.com/2018/10/23/sport/racecourse-safety-horse-vision-spt-intl/index.html

**P. 56 | 201 racehorses died in 2018**—Marcus Armytage, "Horse Deaths at Racecourses Reach Highest Level for Six Years," *The Telegraph* (January 28, 2019). Available online: https://www.telegraph.co.uk/racing/2019/01/28/horse-deaths-racecourses-reach-highest-level-six-years/

**P. 57 | Video contrasting horse and human views**—I have been unable to verify the origin of this video but believe it was created and posted by the French Riding School, Le Haras de la Cense, 2016. Available online: https://www.agdaily.com/video/simulation-shows-horse-eye-view/.

## CHAPTER 5

**P. 60 | Loudness and pitch thresholds for horses and cattle**—Rickye S. Heffner and Henry E. Heffner, "Hearing in Large Mammals: Horses (*Equus caballus*) and Cattle (*Bos taurus*)," *Behavioral Neuroscience* 97 (1983): 299-309. The landmark study of equine auditory thresholds, this research is well designed. However, it only includes results from three very young horses. To generalize from a small number of immature individuals to the 60 million horses worldwide is a matter of concern.

**P. 60 | Pitch thresholds for dogs**—Henry E. Heffner, "Hearing in Large and Small Dogs: Absolute Thresholds and Size of the Tympanic Membrane," *Behavioral Neuroscience* 97 (1983): 310-318.

**P. 60 | Pitch thresholds for cats**—Rickye S. Heffner and Henry E. Heffner, "Hearing Range of the Domestic Cat," *Hearing Research* 19, no. 1 (1985): 85-88.

**P. 60 | Pitch range on piano**—http://hyperphysics.phy-astr.gsu.edu/hbase/Music/pianof.html

**P. 61 | Male horses pay more attention to sound**—Rickye S. Heffner, "Your Horse's Hearing," *Practical Horseman* (August 2000). Available online: https://practicalhorsemanmag.com/health-archive/eqhearing933-11344

**P. 61 | Hearing loss by age 17-22 in horses**—Elaine Pascoe, "All Ears: Horse Hearing Problems," *Practical Horseman* (November 2014).



Horse Brain Human Brain text 7.indd 270 5/6/20 9:17 AM

https://practicalhorsemanmag.com/health-archive/ears-horse-hearing-problems-25832

**P. 63 | "High" and "canter"**—Susan McBane, *Horse Senses* (London: Manson Publishing Ltd, 2012), 84-5, 90.

**P. 64 | Quotes from victims of amusia**—Oliver Sacks, *Musicophilia: Tales of Music and the Brain* (NY: Knopf, 2007) 105, 113.

**P. 64 | Brainwaves synchronize over music**—Jens Madsen, Elizabeth Hellmuth Margulis, Rhimmon Simchy-Gross, and Lucas C. Parra, "Music Synchronizes Brainwaves Across Listeners with Strong Effects of Repetition, Familiarity, and Training," *Nature: Scientific Reports* 9 (March 5, 2019), Article 3576.

**P. 65 | Music calms horses and improves performance**—Anna Stachurska, Iwona Janczarek, Isabela Wilk, and Witold Kedzierski, "Does Music Influence Emotional State in Race Horses?" *Journal of Equine Veterinary Science* 35, no. 8 (August 2015): 650-656.

**P. 65 | 16 muscles per ear**—Several freelance writers state that horses have 10 muscles per ear. Burton and Leblanc, both respected experts in equine sensory perception, state there are 16 muscles per ear. Francis Burton, *Ultimate Horse Care* (Lydney, UK: Ringpress Books, 1999); and Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 66 | Sound localization in horses**—Rickye S. Heffner and Henry E. Heffner, "Localization of Tones by Horses: Use of Binaural Cues and the Role of the Superior Olivary Complex," *Behavioral Neuroscience* 100 (1986): 93-103. Also Brian Timney and Todd Macuda, "Vision and Hearing in Horses," *Journal of the American Veterinary Medical Association* 218, no. 10 (May 15, 2001): 1567-1574.

**P. 69, 70 | Whinny analysis**—Several related studies are described in Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 308-319.

**P. 70 | Equine identification of human voices**—L. Proops and K. McComb, "Cross-modal Individual Recognition in Domestic Horses (*Equus caballus*)," *Proceedings of the National Academy of Sciences of the USA* 106 (2012): 947-51.

## CHAPTER 6

**P. 73 | Bending light in 1666**—Isaac Newton, "Optics," (1704), in *Great Books of the Western World*, ed. R.M. Hutchins (Chicago: Encyclopedia Britannica, Inc., 1952).

**P. 73 | Predicting the scent of a molecule's structure**—Andreas Keller, et al., "Predicting Human Olfactory Perception from Chemical Features of Odor Molecules," *Science* 355, no. 6327 (February 24, 2017): 820-826.

**P. 73, 74 | Information gleaned from sniffing**—Susan McBane, *Horse Senses* (London: Manson Publishing, 2012) and Michel-Antoine Leblanc, *The Mind of the Horse*, trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 74 | Casting for scent**—Stephen Budiansky, *The Nature of Horses* (New York: Free Press, 1997), 170.

**P. 75 | Masking scents to change behavior**—Karen Briggs, "Equine Sense of Smell," *The Horse* (December 11, 2013). Available online: https://thehorse.com/13971/equine-sense-of-smell/

**P. 76 | Sniffing humans and clothing**—Susan McBane, *Horse Senses* (London: Manson Publishing, 2012).

**P. 77 | Effects of smelling predators**—Michel-Antoine Leblanc, *The Mind of the*



Horse Brain Human Brain text 7.indd 271 5/6/20 9:17 AM

*Horse*, trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013).

**P. 77 | Vomeronasal organ for pheromones**—Peter A. Brennan, "Pheromones and Mammalian Behavior," in *The Neurobiology of Olfaction*, ed. A. Menini. Boca Raton, FL: CRC Press/Taylor & Francis, 2010. Available online: https://www.ncbi.nlm.nih.gov/books/NBK55973/

**P. 78 | Diseases dogs can sniff out**—Maureen Maurer, Michael McCulloch, Angel M. Willey, Wendi Hirsch, and Danielle Dewey, "Detection of Bacteriuria by Canine Olfaction," *Open Forum Infectious Diseases* 3, no. 2 (March 9, 2016) Available online: https://doi.org/10.1093/ofid/ofw051. Also, https://massivesci.com/articles/dogs-smell-diseases-diagnose-cancer-diabetes/ and https://www.mnn.com/family/pets/stories/6-medical-conditions-that-dogs-can-sniff

**P. 78 | Comparison of canine to equine olfaction**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 337-341.

**P. 78 | Humans' 6 million olfactory receptor cells**—Estimates vary. Leblanc estimates there are 10 million olfactory receptors in the human system, based on a 1982 study. But a newer and more reliable source estimates 6 million – Michael W. Levine, *Fundamentals of Sensation and Perception 3e* (Oxford: Oxford University Press, 2006), 465.

**P. 78 | Bloodhounds have 300 million olfactory receptor cells**—Stanley Coren, *How Dogs Think* (New York: Free Press, 2004), 55.

**P. 80 | 80% of taste is from smell; dimensions of equine tongue**—Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 354.

**P. 81 | Variety in pasture grass**—Susan McBane, *Horse Senses* (London: Manson Publishing, 2012).

## CHAPTER 7

**P. 83 | Patch**—Eliza McGraw, "A One-eyed Horse named Patch has a Chance of Winning the Kentucky Derby," *The Washington Post Animalia*, May 3, 2017. Available online: https://www.washingtonpost.com/news/animalia/wp/2017/05/03/a-one-eyed-horse-named-patch-has-a-chance-of-winning-the-kentucky-derby/?noredirect=on&utm_term=.177417e41d34

**P. 83 | Gunner**—Colonel's Smoking Gun https://www.usef.org/media/press-releases/2570_the-reining-horse-gunner-becomes-million-dollar-sire

**P. 83 | Addy**—Adventure de Kannan was "the only horse to win the Speed Derby, the Eventing Grand Prix, the All England Grand Prix, the Queen Elizabeth II Cup and the British Jumping Derby." These events are among the most difficult show jumping challenges in the world. http://www.hickstead.co.uk/news/2017/the-one-eyed-wonder-horse-adventure-de-kannan-to-be-retired-at-this-year-s-al-shira-aa-hickstead-derby-meeting/ https://www.independent.ie/irish-news/news/wonder-horse-astonishing-success-of-showjumping-champ-with-just-one-eye-30495783.html

**P. 84 | Splashed-white deafness**—Ed Kane, "Hearing Loss in Veterinary Equine Patients," *Veterinary News DVM360*, March 19, 2015.

**P. 84 | Tough Sunday**—earnings as of March 2020. https://www.google.com/search?q=Tough+Sunday+earnings&rlz=1C1AVFC_enUS886US886&oq=Tough+Sunday+earnings&aqs=chrome..69i57.11598j0j7&sourceid=chrome&ie=UTF-8-



Horse Brain Human Brain text 7.indd 272 5/6/20 9:17 AM

**P. 85 | Karen Law**—http://www.ejbevents.co.uk/press/karen-law-britains-first-blind-show-jumper/

**P. 85 | Kristen Knouse**—https://apnews.com/1b308a6abc7ff2667fc8d25eec1ccf68

**P. 85 | Blind people have better hearing**—Elizabeth Huber, Kelly Chang, Ivan Alvarex, Aaron Hundle, Holly Bridge, and Ione Fine, "Early Blindness Shapes Cortical Representations of Auditory Frequency within Auditory Cortex," *The Journal of Neuroscience* (April 22, 2019): 2896-2918.

**P. 87 | Hidden stress during trailering**—Hajime Ohmura, Seiji Hobo, Atsushi Hiraga, and James H. Jones, "Changes in Heart Rate and Heart Rate Variability during Transportation of Horses by Road and Air," *American Journal of Veterinary Research* 73, no. 4 (April 2012): 515-521.

**P. 87 | Hidden stress during clipping**—Kelly Yarnell, Carol Hall, and E. Billett, "An Assessment of the Aversive Nature of an Animal Management Procedure (Clipping) using Behavioral and Physiological Measures," *Physiology and Behavior* 118 (June, 2013): 32-39.

**P. 89 | Stabilized retinal images disappear**—Margaret W. Matlin and Hugh J. Foley, *Sensation and Perception 4e* (Boston: Allyn and Bacon, 1997), 96-97.

## CHAPTER 8

**P. 98 | "The horse moved like a dancer…"**—Quote from Mark Helprin, *Winter's Tale* (New York: Mariner Books, 1983).

**P. 99 | Ian Waterman lost proprioception**—Jonathan Cole, *Pride and a Daily Marathon* (London: MIT Press, 1991). Video clips of Mr. Waterman are available on youtube.

**P. 99 | Spindles detect differences in muscle length of .002%**—Richard C. Fitzpatrick, Douglas K. Rogers, and Dierdre I. McCloskey, "Stable Human Standing with Lower-Limb Muscle Afferents Providing the Only Sensory Input," *Journal of Physiology* 480 (October 15, 1994): 395-403.

**P. 100 | Proprioception corrects errors in less than half the time vision does**—Jennifer A. Stone, Nina B. Partin, Joseph S. Lueken, Kent E. Timm, and Edward J. Ryan, "Upper Extremity Proprioceptive Training," *Journal of Athletic Training* 29 (1994): 15.

**P. 100 | Muscle spindle illusions**—Guy M. Goodwin, Dierdre I. McCloskey, and P. B. Matthews, "Proprioceptive Illusions Induced by Muscle Vibration: Contribution by Muscle Spindles to Perception?" *Science* 175, no. 4028 (March 24, 1972): 1382-1384.

**P. 101 | Joint angle receptor sensitivity in hip and toe**—Grigore C. Burdea and Philippe Coiffet, *Virtual Reality Technology, Volume 1* (Hoboken, NJ: Wiley, 2003), 95.

**P. 101 | Dorsal columns of the spine carry proprioceptive data**—Dale Purves, George J. Augustine, and David Fitzpatrick et al., "The Major Afferent Pathway for Mechanosensory Information: The Dorsal Column-Medial Lemniscus System," *Neuroscience 2e* (Sunderland, MA: Sinauer Associates, 2001).

**P. 102 | Stork toe raise**—*Women's Health*, November 2014, p. 64.

**P. 107 | The man who lost his leg**—Oliver Sacks, *A Leg To Stand On* (New York: Touchstone, 1984), 54-60.

**P. 107 | Human sensorimotor cortex**—E. Bruce Goldstein, *Sensation & Perception 7e* (Belmont, CA: Thomson Wadsworth, 2007).

**P. 107 | Mapping of equine motor cortex**—Jonathan M. Levine, Gwendolyn J. Levine, Anton G. Hoffman, and Gerald



Horse Brain Human Brain text 7.indd 273 5/6/20 9:17 AM

Bratton, "Comparative Anatomy of the Horse, Ox, and Dog: The Brain and Associated Vessels," *Compendium Equine* (April 2008): 153-164. Magnetic Resonance Imaging (MRI), Computer Tomography (CT) scans, and transcranial magnetic stimulation can now be used on the equine brain. Although such images are rarely precise enough to map networks representing specific body parts, they do help us explore general areas.

**P. 109 | Sheep and horse brains are similar—**Yvette Nout-Lomas, DVM, PhD, 2020, e-mail messages to author, January 16.

**P. 109 | Locating somatosensory cortex in sheep—** Mortimer Gierthmuehlen, et al., "Mapping of Sheep Sensory Cortex with a Novel Microelectrocorticography Grid," *The Journal of Comparative Neurology* 522 (2014): 3590-3608.

**P. 109 | Equine Parkinsonism from toxic weeds—** Thomas Gore, Paula Gore, and James M. Giffin, *Horse Owner's Veterinary Handbook 3e* (Hoboken, NJ: Wiley, 2008), 432-433.

## CHAPTER 9

**P. 112 | Weight of a housefly—**https://animaldiversity.org/accounts/Musca_domestica/

**P. 112 | Weight of dandelion seeds—**http://www.agroatlas.ru/en/content/weeds/Taraxacum_officinale/

**P. 112 | Horse's ability to sense a fly—**Statistics are calculated from information in Michel-Antoine Leblanc, *The Mind of the Horse*, trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013); Carol A. Saslow, "Understanding the Perceptual World of Horses," *Applied Animal Behaviour Science* 78 (2002): 209-224; the online source www.agroatlas.ru; www.biokids.umich.edu; "How Sensitive is Human Touch?" Available online: www.isciencetimes.com; Michael S. Fleming and Wenqin Luo, "The Anatomy, Function, and Development of Mammalian A-beta Low-Threshold Mechanoreceptors," *Frontiers in Biology* 8, no. 4 (2013): 408-420; and Stanley Coren, Lawrence M. Ward, and James T. Enns, *Sensation and Perception 6e* (New York: Wiley, 2004).

**P. 112 | Sensitivity in noticing the nod of a head—** Statistics are calculated from information in Michel-Antoine Leblanc, *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 31; and Joseph S. Lappin, Duje Tadin, Jeffrey B. Nyquist, and Anne L. Corn, "Spatial and Temporal Limits of Motion Perception Across Variations in Speed, Eccentricity, and Low Vision," *Journal of Vision* 9, no. 1 (2009): 1-14.

**P. 112 | Equine discrimination for head movement—**Clever Hans was able to detect a head movement of .20 millimeters – Michel-Antoine Leblanc *The Mind of the Horse,* trans. Giselle Weiss (Cambridge, MA: Harvard University Press, 2013), 31.

**P. 112 | Human discrimination for head movement—**Joseph S. Lappin, Duje Tadin, Jeffrey B. Nyquist, and Anne L. Corn, "Spatial and Temporal Limits of Motion Perception Across Variations in Speed, Eccentricity, and Low Vision." *Journal of Vision* 9, No. 1 (2009): 1-14.

**P. 112 | Equine pressure detection—**Lea Lansade, Gaelle Pichard, and Mathilde Leconte, "Sensory Sensitivities: Components of a horse's temperament dimension," *Applied Animal Behavior Science* 114, No. 3-4 (2008): 534-553.

**P. 112 | Weight of an "average" grain of sand—**https://www.quora.com/How-many-atoms-are-there-in-a-grain-of-sand

**P. 112 | Human pressure detection—** Jack Loomis, "An Investigation of Tactile Hyperacuity," *Sensory Processes* 3 (1979):



Horse Brain Human Brain text 7.indd 274 5/6/20 9:17 AM

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Horse Brain Human Brain text 7.indd 278 5/6/20 9:17 AM

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Horse Brain Human Brain text 7.indd 282 5/6/20 9:17 AM

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Horse Brain Human Brain text 7.indd 283 5/6/20 9:17 AM

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## CHAPTER 20

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Horse Brain Human Brain text 7.indd 284 5/6/20 9:17 AM

# Glossary

**Accommodation** Bending of the eye's lens to focus on near objects.

**Acetylcholine** Abundant brain chemical in the horse, important for muscle activation and memory.

**Activation** Electrical and chemical process that ignites a neuron to send a message.

**Acuity** Ability to see fine detail.

**Adductors** Human inner thigh muscles.

**Adrenaline** A natural chemical that increases blood flow in the fight or flight response, also called epinephrine.

**Agency** Origin of a cause.

**Agnosia** Inability to perceive related sights or sounds wholistically.

**Aids** Cues to the horse delivered by the rider's body, especially hands, seat, legs, back, and weight distribution.

**Amusia** Inability to perceive related tones as music.

**Amygdala** Area of brain that processes emotion.

**Angle receptors** Cells that tell the brain how much and in which direction a joint is bent.

**Anterior cingulate** Area near the center of the brain that regulates heart rate and blood pressure along with some emotional and cognitive processes.

**Artificial selection** Selection of male and female individuals to enhance traits in a species.

**Auditory cortex** Area of the brain's surface where hearing is processed.

**Axon** The part of a brain cell that transmits an electrical impulse from one neuron to another.

**Balint's syndrome** Rare disorder in which people can focus on only one object at a time.

**Banamine** A bitter-tasting equine pain medicine.

**Barrel (of a horse)** The round body of the horse between shoulders and hips.

**Basal ganglia** A set of neural structures deep in the brain important for motor control and learning.

**Blindsight** Knowledge of an object's location despite inability to see it.

**Capriole** Dressage maneuver in which a horse leaps upward, kicking both hind legs to the rear.

**Categorical perception** Human brain bias in which items with individual variation are grouped together automatically.

**Cerebellum** Portion of the brain that is important for coordinated movement and learning.

**Cerebrospinal fluid** Nutrient liquid contained in the spine and certain passages of the brain.

**Chestnuts** Hard scaly deposits on a horse's inner legs.

**Ciliary muscle** Muscle that pulls the eye's lens into shape when focusing.

**Classical conditioning** Associating a new stimulus, like a bell, with an established behavior.

**Cognitive psychology** Study of the normal human mind.

**Cognitive science** Interdisciplinary study of the human mind and brain.

**Comparative psychology** Study of the human mind and brain in comparison to animal minds and brains.

**Cones** Cells in the eye that encode color.

**Cortex** Surface of the human and equine brains, containing cells that mediate perception, memory, language, and thought.

**Cortical blindness** Blindness at the level of the brain; the eyes still function normally.

**Corticosterone** Stress hormone in rodents, birds, and reptiles.

**Cortisol** Stress hormone in horses and humans.

**Counter-canter** An exercise in which horses canter on the outside lead with an outside bend.

**Counter-condition** To substitute a related behavior for an undesired behavior.

**Crest** The top of a horse's neck, where the mane grows.

**Cribbing** A vice in which horses hold the edge of an object and inhale sharply.

**Cross-modal perception** Perceiving through multiple organs, like seeing and hearing simultaneously.

**Cue sensitivity** A horse's heightened response to aids.

**Dark adaptation** Process of pupil contraction in which the eye adapts from bright to dark surroundings.

**Decibels (dB)** Measurement of loudness.

**Dendrites** Small branches on neurons that receive information from other neurons.

**Displacement** The horse's natural habit of yielding away from pressure.

**Domestication** Breeding for traits that allow easier training, like calmness.

**Dopamine** Reward chemical made by the brain.

**Downward transition** A change from a faster gait to a slower gait.

**Draft** Breeds built for strength and power, such as Clydesdales and Percherons.

**Emotion** An observable state of mind that drives optional behaviors.

**Epinephrine** A natural chemical that increases blood flow in the fight or flight response, also called adrenaline.

**Equus caballus** The species name for modern horses.

**Ergots** Hard callouses under the fetlocks.

**Ethology** Study of animal behavior.

**Executive function** The human brain's ability to plan, reason, and strategize.

**Extinction** Process of undoing a learned association.

**Fast-twitch muscles** Muscle fibers that produce speed and sudden power.

**Feeling** An internal subjective mental state that cannot be observed.

**FEI** Fèdèration Equestre Internationale, which governs international horse shows.

**Fetlock** The primary equine joint between knee (carpus) and hoof, sometimes called the ankle.

**Flehmen** The lifting of the equine upper lip to trap air inside the vomeronasal organ.

**Frontal cortex** Portion of the surface of the human brain, located behind the forehead and back to the crown.

**Frontal lobe** Portion of the human brain behind the forehead and back to the crown, responsible for speech, movement, personality, executive function, and more.

**Fronto-temporal dementia** A form of dementia in which the frontal and temporal lobes shrink, impairing reason while memory and language remain intact until late stages.



Horse Brain Human Brain text 7.indd 286 5/6/20 9:17 AM

**Generalization** Applying learned behaviors across different contexts.

**Glial cells** Brain cells that clean up after neurons.

**Glucose** Sugar used for brain fuel.

**Golgi organs** Cells that tell the brain how much tension is applied to a muscle.

**Groundwork** Unmounted horse training.

**Gustation** The sense of taste.

**Half-halt** Rider's maneuver that slows a horse or changes to a slower gait.

**Half-seat** A position used by hunter riders, in which the seat is lifted slightly off the saddle.

**Half-pass** Diagonal movement with the horse's head flexed slightly to the inside and his body straight.

**Hard wiring** Permanent pathways of the brain.

**Hertz (Hz)** Measurement of frequency in sound waves.

**Hippocampus** Area of the brain reponsible for consolidating new memories.

**Horsemanship** Philosophical spirit of placing the horse's needs first, based on detailed equine knowledge.

**Hotblood** A nervous excitable breed, like a Thoroughbred or Arabian.

**Inattentional blindness** Human failure to notice obvious stimuli when attention is focused elsewhere.

**Incentive** A lure offered prior to desired behavior.

**Indiscriminate rewards** Rewards given in association with no particular behavior.

**Instinct** A specific inborn behavior.

**Instrumental conditioning** Teaching by consequence of reward, negative reinforcement, or punishment; also called operant conditioning.

**Iris** Colored portion of the eye.

**Jig** A prancing trot that occurs when nervous horses won't walk.

**Join-up** A horse's movement toward and following of a handler.

**Leg-yield** Horse moves away from the rider's leg, on a diagonal line, with his head straight or slightly flexed to the outside.

**Lens** Portion of the eye that bends light to focus an image.

**Levade** Dressage maneuver in which a horse stands on bent hind legs.

**Light adaptation** Process of pupil dilation in which the eye adapts from dark to bright surroundings.

**Lobes** Sections of human cortex including frontal, parietal, temporal, and occipital areas.

**Longe line** A 25- to 30-foot line on which a horse circles a handler at various gaits.

**Long-term potentiation** Heightened potential for activation in neurons.

**Loudness** Perceived differences in volume.

**Mammalian** Related to all mammals.

**Mirror neurons** Brain cells that prepare motor neurons for action; they activate even when we only watch someone else take an action.

**Motion detector cells** Visual cells that pick up movement and send the information to the brain.

**Motor cortex** A strip of brain tissue that contains neurons designed to initiate the movement of specific body parts.

**Multipolar neuron** A standard brain cell that transmits and receives impulses.

**Multi-tasking** The illusory effort to increase productivity by doing several tasks at once.



Horse Brain Human Brain text 7.indd 287 5/6/20 9:17 AM

**Muscle spindles** Muscle cells that tell the brain how fast and how much a muscle is extending its length.

**Natural selection** Survival and reproduction of individuals who are best adapted to the environment.

**Negative reinforcement** Teaching by release of pressure.

**Neural fatigue** The natural time limit of a neuron's ability to remain activated.

**Neural network** A group of neurons connected to each other, representing a particular ability or concept.

**Neural tuning** Process of limiting the specific stimulation to which a neuron responds.

**Neuron** The basic brain cell of mental function; there are also other types of brain cells.

**Nicotine** A chemical made by the brain that increases vigilance.

**Norepinephrine** A natural chemical that prepares the body for action, increasing the fight or flight response; also called noradrenaline.

**Occipital lobe** Area of the human brain responsible for vision.

**Olfaction** Sense of smell.

**Olfactory bulbs** Area of the brain that collects information from receptor cells about scents.

**Operant conditioning** Teaching by consequence of reward, negative reinforcement, or punishment; also called instrumental conditioning.

**Optic disk** Eye area where rods and cones cannot transmit information.

**Optic nerve** Nerve that carries information from eye to brain.

**Oxer** A jump in which at least two poles are spread apart in width.

**Pacing** A vice in which horses move rapidly back and forth in a line.

**Parietal lobe** An area of the brain located between the crown and back of the head.

**Patho-calm** My term for a human attitude of near-pathological calmness that frantic or nervous horses sometimes require.

**Pheromones** Natural chemicals that trigger animal behaviors.

**Piaffe** A dressage maneuver in which the horse trots in place.

**Pitch** Perceived differences in auditory frequency, for example between bass and soprano notes.

**Poll** Location between a horse's ears.

**Pop-out** Automatic processing of certain stimulus attributes like color and tilt.

**Power moment** My term for common activities during which reward is especially effective.

**Predator** An animal designed to kill, having front-facing eyes for depth perception during a chase.

**Prefrontal cortex** The portion of the brain's surface that is located behind the forehead and above the eyes.

**Prey** An animal designed to escape predators, with side-facing eyes for range of view and motion detection.

**Proprioception** The ability to sense one's own body position and movement.

**Pruning** The killing of unused brain cells.

**Punishment** An unpleasant consequence following undesired behavior, to be distinguished from abuse.

**Pupil** Portion of the eye that dilates and contracts to adjust the amount of light.

**Receptor cells** Cells in sensory organs that are designed to receive incoming stimulation, like rods and cones.

**Reflex** An automatic response at the level of the spinal cord that is not controlled by the brain.



Horse Brain Human Brain text 7.indd 288 5/6/20 9:17 AM

**Reticular activating system** An area of the brain responsible for wakefulness.

**Reward** A pleasant experience given after performance of a desired behavior.

**Rods** Cells in the eye that encode motion.

**Sclera** The white portion of the eye.

**Search asymmetry** A human brain bias in which we notice presence more easily than absence.

**Self-carriage** The horse's ability to maintain position, speed, balance, or gait without a rider's aids.

**Somatosensory cortex** Area of the brain that receives information from the body about skin touch, pressure, movement, and temperature.

**Sound localization** The ability to determine where a sound is coming from.

**Splashed-white** A hereditary form of equine deafness.

**Splint bones** Small vestigial bones in the horse's lower legs.

**Sprezzatura** The ability to make the difficult seem simple.

**Stereoacuity** The brain's ability to compute depth with views from two eyes.

**Stimulus** An external item or event that stimulates the brain.

**Supplementary motor area** An area of the human cortex that processes obscene language.

**Swing phase** Brief moment between lifting a hoof and setting it down again.

**Tapetum** Shiny fibers of the horse's eye that reflect light in dim surroundings.

**Taste buds** Receptor cells in the tongue that pick up information about taste.

**Tempi changes** A dressage move in which the horse completes flying changes every one or two strides on a straight line.

**Temporal lobe** An area of the brain just above each ear, helpful in processing sound, music, and memory.

**Testing** A natural means of equine learning, to be encouraged.

**Thalamus** A neural structure that coordinates incoming data from all the senses.

**Transduce** To transform an external sensory stimulus (like light) into electrical impulses the brain can understand.

**Two-point position** A riding exercise for balance and strength, in which body weight is balanced on the balls of the feet.

**USEF** The United States Equestrian Federation, which governs American horse shows.

**Vasopressin** A hormone that controls blood pressure and kidney function, often elevated during stress.

**Vertical jump** A jump with height but no width.

**Visual capture** The human brain's bias toward prioritizing vision.

**Visual cortex** Area of the brain's surface where visual data are processed.

**Vomeronasal organ** The horse's second "nose," capturing odors for extra processing.

**Von Economo neuron** A large type of neuron that is specialized for promoting attention.

**Warmblood** Breeds initiated by crossing drafts and hotbloods.

**Weaving** A vice in which horses shift their weight side to side repetitively.

**Withers** The bony area at the base of the top of the horse's neck.



Horse Brain Human Brain text 7.indd 289 5/6/20 9:17 AM