8/28/08: Chapter 1, Talented and Gifted Animals

1. Dehaene raises four “riddles” on pp. 3 and 4. Not having read the book, what would you expect that the answers to these questions might be? (Beyond Dehaene’s comment that all reflect the structure of the brain, which is true but not very informative.)

2. Are you surprised that animals such as rats and pigeons can do simple numerical operations? Why might evolution have prepared these animals to be able to process numbers in relatively precise ways?

3. What are the implications of the Clever Hans story for interpreting difficult to understand modern claims, such as those regarding ESP (extra sensory perception), seers such as Jean Dixon, and 1- and 2-year-olds’ learning to read and do math from being presented flashcards?

4. Why was it important that the rats did not know during training in the Church and Meck experiment that they would later be tested on the number of objects? What conclusion does this allow us to draw that we could not have drawn if they did know (from past experience) that their knowledge of the number of objects would be tested?

5. Why might animals code approximations of numbers rather than exact numbers? Why might the amount of variation of rats’ number of bar presses be greater for larger numbers than for smaller ones (p. 19)?

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6. Does the experiment described on pp. 25-26 convince you that the animals are adding the number of objects? What other possible interpretations would need to be ruled out before you would accept this conclusion?

7. What are the distance and magnitude effects? Why do you think they’re so widespread among animals?

8. What are neural net models? Why are they frequently used to model thought processes?

9. Does Dehaene’s neural model (pp. 31-34) imply that animals have neurons dedicated to detecting, for example, the numbers 45 and 50? If not, how do animals make this discrimination, which Dehaene earlier indicated that they can make?

10. Dehaene describes the chimpanzee Ai as having learned to add pairs of the first 9 numbers with 95% accuracy (p. 36) and indicates that analyses of the chimp’s response times suggest that he uses serial counting for all except the first few the numbers. What
are the implications of animals being able to learn to do simple numerical activities but taking a great amount of time and training to do so?

11. Describe each stage of the Boysen experiment with Sheba. At what point, if any, would you say that Sheba demonstrated an understanding of numbers?

12. What were the implications of Sheba understanding immediately that the symbol for representing 2+2 would be 4, as opposed to her requiring training before she showed similar understanding?

13. Did Abel and Baker understand as much about numbers as Sheba? What, if anything, did the experiments with Sheba show that she understood that Abel and Baker didn’t understand?

9/04/08: Chapter 2, Babies Who Count

14. Why do you think children fail number conservation tasks, when they have other types of understanding about numbers? Why do they fail class inclusion tasks (six tulips, two roses, more tulips or flowers)? How can we reconcile infants’ and toddlers’ competence in some aspects of numerical understanding with much older children’s lack of competence in other aspects?

15. Can you think of explanations for Mehler and Bever’s findings other than that they were judging on the basis of the number of candies?

16. After reading Dehaene’s summary on pages 46 and 47, does it surprise you to learn that 5-year-olds make a similar mistake when a single row of objects is spread out and the experimenter asks if the number is the same or different than before? Is the finding consistent with Dehaene’s account?

17. Why would infants attend to three objects when they hear three sounds? Do they have good reason to do so?

18. Should the long looking time in Wynn’s experiments and other habituation paradigm studies be viewed as indicative of surprise? Can you think of other reasons why babies might look for a long time at certain displays even if they were not surprised?

19. Studies conducted after Dehaene wrote this book indicated that his prediction in the first full paragraph on p. 57 was correct. Does this imply that we should take his interpretation of the findings more seriously than we otherwise would?

20. Do you find the interpretation in the last paragraph on p. 59 of why babies attend to number but not identity to be convincing? Why or why not?

21. Dehaene bases many of his interpretations in evolutionary theory. Would it do babies much good for survival to recognize the number of objects in very small sets if they did not know which of two sets was more numerous?
9/09/08: Chapter 3, The Adult Number Line

22. Do Dehaene’s examples (p. 65) support his claim that “most if not all civilizations stop using this system beyond the number 3?” Does the exact point at which the initial system is abandoned matter?

23. Can you think of reasons why there might be a discontinuity between numbers 3 and 5 in our ability to subitize?

24. Does it surprise you that human number abilities resemble those of rats and pigeons in many ways (p. 72)? Can you generate a hypothesis regarding how humans and animals are similar in number processing and how they differ?

25. Why do currencies in all countries have more coins and bills corresponding to small values than large ones? Might this be related to the reasons why people and other animals seem to have a logarithmic ruler for representing quantity?

26. What does it mean to say, “understanding numbers occurs as a reflex” (p. 78)?

27. Why do numbers seem to be represented spatially? Is it just because we’ve all seen number lines in school (or do we have number lines because people tend to represent numbers spatially)?

28. What is the SNARC effect? In what way does it provide evidence for spatial representations of numbers?

29. “If we did not already possess some internal non-verbal representation of the quantity ‘eight,’ we would probably be unable to attribute a meaning to the digit 8” (p. 87). Do you agree with this statement? Do we also have a non-verbal representation of the quantity “53”? How about 553? If not, are these quantities meaningless?

9/11/08: Chapter 4, The Language of Numbers

30. Most languages have systematic, hierarchical terms for representing numbers; for example, to represent “426”, we concatenate a number of hundreds, a number of 10’s, and a number of 1’s. Not all languages do so, however (p. 93). What do you think determines whether a language does or does not adopt a hierarchical system for representing numbers?

31. Why did base 10 become the most common system in widely dispersed societies? Why not base 2, 5, or 20?

32. Why was the invention of 0 so important?

33. Why is it advantageous to have number symbols that are visually unrelated to the numbers that they represent?
34. If the East Asian system of representing numbers is more efficient (p. 104), as it seems to be, why don’t we in the U. S. just adopt an English equivalent?

35. How much good would the principle of contrast do the hypothetical baby Charlie in learning the meaning of 3 (p. 107)? Can you think of other hypotheses that a baby might develop other than that 3 refers to the number of puppies?

36. Is Dehaene right (and Bruno wrong) about a mile or three never sounding right (p. 110)?

37. Do you find it surprising that the numbers 1-3 appear so much more often than other numbers? Why might this occur?

38. Dehaene claims that the number 12 is of elevated frequency in diverse societies and languages (pp. 111 and 114). Why should this be the case? Do you think it is true in all languages?

9/16/08: Chapter 5, Small Heads for Big Calculations

39. Does Dehaene’s claim that counting is somewhat innate, as well as somewhat learned, surprise you? What evidence does he cite to support his claim, and how compelling do you find the evidence?

40. Why do young children like to count objects, if they do not know the purpose of the counting (p. 121)?

41. Dehaene’s argument at the bottom of p. 121 could be taken to mean that children would be more likely to learn the meaning of counting when counting very small sets (ones of 3 or less) than larger sets? What is the logic of his argument, and do you find it compelling?

42. What role do fingers serve in children’s learning of arithmetic?

43. Dehaene claims on p. 125 that “There was only one way out of this conundrum.” Is he right; can you think of alternatives?

44. Do some of you use strategies other than retrieval on problems such as 6X9 and 7X8? What strategies do you use?

45. Is the comparison to multiplication of the arbitrary facts on p. 127 a persuasive one? What is the difference between learning multiple facts and learning the logical statements on p. 127?

46. When you read the example on p. 129, did you do what Dehaene said you would? What does his example tell us about arithmetic?

47. Toward the bottom of p. 131, Dehaene provides an example, and writes, “suggesting that in parallel to calculating the exact result, our brain also computes a coarse estimate of its size.” What general lesson does this example, together with his general emphasis on the verbal nature of arithmetic, have for understanding the working of the brain?
48. Why don’t textbooks typically spell out the long subtraction algorithm (p. 133)? Would arithmetic learning be enhanced if they did so?

49. Does the frequency of subtraction bugs indicate that, “the child’s brain registers and executes most calculation algorithms without caring much about their meaning?” (p. 133)?

50. Dehaene argues that relying more on calculators, rather than practice with arithmetic facts, would lead to better understanding of mathematical concepts. Do you agree?

9/18/08: Chapter 6, Geniuses and Prodigies

51. Dehaene emphasizes similarities between mathematical geniuses and idiot savants who are good at calendar calculation and related feats. Do you see the unusual abilities of the two groups as being related? What kind of data would be crucial for deciding whether they are in fact related?

52. As Dehaene notes on p. 155, claims were made in the 19th Century that the brains of women were smaller than those of men, and that women were therefore less intelligent. Subsequent research has shown that the brains of women are indeed smaller on average than those of men, but that there are no differences in average intelligence between men and women. Why, then, might women's brains typically be smaller?

53. As Dehaene notes on p. 157, the larger sizes of certain brain areas relevant to musical performance in musicians is as likely due to their experience playing their instrument as to any innate difference in their brains. How might it be possible to determine if there are innate differences in the brains of musicians independent of their musical experience?

54. The gender differences in mathematical test scores that Dehaene describes on pp. 158-160 have changed somewhat in the years since the studies that he describes were done. Which phenomena that he describes would you guess have changed (and why), and which would you expect to have stayed the same?

55. Within the testosterone explanation of sex differences in mathematical giftedness that Dehaene advances on p. 161, why might the number of men at the superior level of math achievement be higher than the number of women, even if average math achievement is the same for men and women?

56. The experiments regarding expert memorizers of numbers that Dehaene describes on p. 163 (conducted with Carnegie Mellon students) took advantage of certain ways that the students spontaneously remembered the numbers. Can you anticipate what some of them might be? (Hint: One of the memory experts was a runner.)

57. Great mental calculators almost always calculate from left to right. Why do you think they do this?
58. It is plausible that children learn that there are some numbers, such as 12, that can be divided into equal size groups, and others, such as 13, that cannot (p. 169)? But how does anyone learn this (except from instruction) for large and uncommon numbers such as 389?

59. In his conclusion, Dehaene says that biology probably plays a part in great mathematical achievement, but then says that they “do not weigh much compared to the powers of learning, fueled by a passion for numbers.” Is it purely a matter of a supportive environment whether a person develops a passion for numbers? Might biology play a role there too?

9/23/08: Chapter 7, Loosing Number Sense

60. What is the idea of “double dissociation”? Why is it a particularly valued type of evidence in the study of brain-damaged patients? What kinds of hypotheses does it allow us to rule out?

61. How well do you think that Dehaene’s summary of Mr. N’s deficit as involving exact knowledge fit the observations of Mr. N that he describes?

62. What is the logic of split-brain studies; what have they told us about processing of numbers in each hemisphere?

63. Does the description of patient J. S. on pp. 184-185 shake your confidence in any of Dehaene’s conclusions earlier in the section on split-brain patients?

64. Do people need to understand math to answer problems such as 4 minus 3? Does Dehaene’s description indicate why Mr. M could add but not subtract?

65. Why might the inferior parietal lobe be specialized for mathematical processing, in particular for “the number sense”? What principles of brain organization are implicit in Dehaene’s arguments for the view that the inferior parietal lobe is the prime location of the number sense?

66. If Mr. M doesn’t have a sense of magnitude, how can he estimate “the duration of Columbus’ trip to the New World or the distance from Marseilles to Paris” (p. 193)?

67. Does the specificity of processing pathways for reading and understanding different types of material surprise you (pp. 195-196)? What are the implications of such extreme specificity of content knowledge for the future of cognitive neuroscience?

68. Some authorities have argued that the prefrontal cortex is particularly crucial in making human beings human. Do Dehaene’s descriptions of prefrontal functioning in math support or contradict this view? How so?

69. What is cortical plasticity? Why is it so important for learning mathematics and other “unnatural” activities?
9/25/08: Chapter 8, The Computing Brain

70. What are the advantages of brain imaging technologies over studying the thinking of brain damaged patients? Do we gain any valuable information from studying brain damaged patients that we do not gain from neuro-imaging studies?

71. How does PET work? Why is blood flow in the brain relevant to cognitive activity?

72. Why does Lennox’s experiment seem prescient from a modern perspective?

73. What was Dehaene’s objection to the Roland and Friberg experiment? How does his interpretation differ from theirs? Could some future scientist have the same objection to Dehaene’s interpretation of the Roland and Friberg findings?

74. Why did Dehaene anticipate inferior parietal activation on the magnitude comparison task but not on the multiplication task (p. 220)? What are the implications of the reverse actually being the case?

75. Why is it important to present a specific event within event-related potential research, rather than just watching the brain functioning (p. 223)?

76. What is the main limitation of PET technology? What is the main problem with EEG technology? What properties would an ideal imaging technology possess?

77. What does single cell recording add to the information that can be gained from PET and other imaging technologies?