Learning and Memory (Cognitive core course) - Todd M. Gureckis - Midterm Exam

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Long Answer Questions (choose 4 of the 9 to answer). Note: the target length for the responses is 1-1.5 pages.

Question 1. In our first class lecture, we discussed the challenge of coming up with a satisfactory definition of learning. If you were hired to write an introductory textbook on the topic, how would you go about defining learning behavior? Explain the suitability of your definition by discussing how it excludes non-learning behaviors (getting drunk) but includes things that are more clearly agreed to be examples of learning. Your response should reference the issue raised by the Phattanasri, et al. (2007) paper (i.e., that non-plastic systems can exhibit forms of adaptive learning). Do you believe the system studied by Phattanasari, et al. is "learning" and would it count in your definition of learning?

Question 2. Lashley (1950) conducted a series of experiment attempting to isolate the "engram" or the pathway between stimulus and response. Despite many attempts, he was forced to conclude that "learning is just not possible." Why do you think that Lashley failed to isolate the "engram"? What parts of his experiments appear consistent with our contemporary understanding of the neural organization of learning and memory and which appear to diverge? Use the specifics of Lashley's methods, the brain regions he investigated, the other readings we have considered so far in class, and what we have learned so far about the neural systems supporting learning to inform your response.

Question 3. The work of Tolman has loomed large in a number of our lectures and readings. In particular, we have discussed two related aspect of his theoretical work. First, he advocated the idea of "latent learning." Second, was his idea of "cognitive maps." Both of these ideas offer a perspective on behavior that sharply diverges from traditional Behaviorist theories of S-R learning. Summarize the major contributions to the field of learning by Tolman. In particular, in your response be sure to define what both "latent learning" and "cognitive maps" are. Explain how such views of behavior diverge from those of Thorndike, Pavlov, and Skinner. Cite specific evidence that supports the "cognitive map" idea (as distinct from simple S-R learning). Your response should draw from both behavioral findings, neuroscientific results, lesion studies, and modern computational theories.

Question 4. Discuss the four principals of perceptual learning laid out by Goldstone (1998). In each case, give examples of empirical phenomena that are consistent with each mechanism. We discussed perceptual learning in our lecture on "non-associative" learning. However, some mechanisms of perceptual learning are in fact "associative". In your discussion of each example, highlight the degree to which you think the phenomena can meaningfully be described as "non-associative."

Question 5. The Rescorla-Wagner Model

a. Philosophical ideas about associative learning going back to Aristotle focused on concepts like continguity and contingency. In 2 paragraphs (max) explain how each of these concepts are in turn insufficient to explain learning in the Pavlovian paradigm, and how the Resorla-Wagner model defines the primary "driver" of learning.

b. Explain why the reward predictions learned by the Rescorla-Wagner model will converge to the same values regardless of the learning rate (i.e., the learning curve will have the same asympotote). What is the effect of the learning rate on the learning curve?

c. Explain why the "learning rate" (eta) in R-W can also be thought of as a "forgetting rate"

d. How does R-W explain blocking?

e. Imagine an experiment where animals were conditioned with three types of trials (randomly interleaved):

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CS1 → US
CS2 → US
CS1+CS2 → no US
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After conditioning, animals show a CR to each stimulus presented separately, but not to the simultaneous presentation of both CS1+CS2. Can the Rescorla-Wagner theory explain this pattern? If no, why not? Also, if your answer is no, how might you extend the Rescorla-Wagner model to account for this pattern?

Question 6: The temporal-difference learning model explains a number of phenomena not addressed by the Rescorla-Wagner theory. Describe the motivation for the temporal-difference equation from both the empirical and computational perspective. In other words, what behavioral data does the temporal difference learning equation account for that Rescorla-Wagner does not? Computationally, what is the goal of TD (as distinct from RW)? What, ultimately, are the crucial differences between TD and RW? In your answer explain how the specific firing pattern of dopamine neurons conforms to the predictions of the TD model. Finally, what are the limitations of the TD model, what does it likely get wrong? Be sure to explain why the TD model predicts a spike in neural firing on the presentation of the CS after extensive training.

Question 7: As noted extensively in lecture, the Rescorla-Wagner theory essentially assumes that learning results in changes in US effectiveness. Alternative theories (such as Pearce-Hall model) assume that learning results in changes in CS effectiveness. Explain what this distinction means. Furthermore, explain the limitations of Rescorla-Wagner that motivate this alternative conception of learning. Finally, explain how alternative theories (such as Pearce-Hall) address these limitation in the R-W theory. In your response, discuss modern theories of CS modulation including the ideas described in the Dayan, Kakade, & Montague (2000) paper.

Question 8: A number of modern theories of classical and instrumental condition have adopted a “latent” cause approach. What does the “latent cause” approach offer that is missing from more traditional models such as T-D? What do these approaches get wrong? Discuss the relationship of latent cause models and Tolman’s idea of a “cognitive map”. Describe three empirical studies and how they support the specific latent cause models we considered (in particular either the Courville, et al. paper or the Gershman, et al. paper).

Question 9: A central theme in all of our readings this semester has been that learning is not a unitary processes but is supported by multiple brain systems. Review the empirical support for this idea using two examples taken from our readings. In other words, choose two learning phenomena and argue why they supports a “multiple learning systems” view of the brain. Where appropriate use both neural data (e.g., lesion studies, imaging results) as well as behavioral findings to make the point that different forms of learning are indeed dissociable.