Problem for understanding entrainment.

The following is to help you study. We are not collecting your answers, and thus you will not receive a grade. We discourage you from looking at the answers (attached) until you have really tried to work through the problem.

Scenario: Your hamster cage is kept in a dark closet without any light. Your pet began running in his wheel at 10:30 a.m. on Saturday, 10:00 a.m. on Sunday, 9:30 on Monday, and 8:30 on Wednesday. You forgot to observe it on Tuesday. The hamster runs continuously for 10 h each day.

1. Sketch a double plotted actogram for your hamster.

2. What is happening to the circadian clock of your hamster? Calculate τ.

3. What time will correspond to CT12 on Friday? to CT15?

4. Now suppose that you turn on the lights for a short period on Friday at CT15. Using the phase response curve illustrated in Fig. 3.5B (in your book), describe what will happen to the rhythm over the next several days.

5. If you want to entrain your hamster to the normal 24 h day, how do you need to change the rhythm on a daily basis?

6. What time on the PRC gives you this needed change?

7. If the hamster is given a light pulse at the same time each day (i.e., T = 24 h), describe in words how the light pulse and activity onset will eventually line up.

8. Does it matter what time you choose to do the daily light pulse?

9. What is the term for how these two rhythms are phased?

10. What is α?

NOTE: For simplicity, we're not dealing with the issue of whether activity is going to align with the beginning or end of the brief light pulse. This can be left for another time.

Answers:

1. We're leaving the solution of this to you. Figure 3.2 can serve as an example, although it plots months of data instead of the 5 days in this problem.

2. The clock is free-running. $\tau = 23.5$ h

3. CT12 is defined (for a nocturnal hamster) as the time of activity onset. This will be at 7:30 on Friday. CT15 is 3 circadian hours after CT12. Each circadian h = τ/ 24 h. Thus CT 15 = CT12 (7.5) + 3 x (23.5/24) = 10.4375 o'clock. In minutes, that 10:26 a.m.

4. A brief light pulse at CT15 causes about a 3.5 h delay (you may read a slightly different value off of the graph). Thus, activity onset will continue to free-run, but on the day after the light pulse, activity onset will occur 3.5 h later than expected. With no light, we would have expected it to start at 7:00 on Saturday. Because you gave the light pulse, activity onset will occur 3.5 h later, at 10:30 a.m. On the next day, the free-run resumes so activity starts at 10:00 a.m. on Sunday, and so on.

5. To make up the difference between the free-running rhythm (τ) and the 24 h day (T), you need a daily phase *delay* of 30 minutes (0.5 h). $\Delta\varphi = \tau - T$ (23.5 – 24.0 = -0.5 h)

6. From Fig. 3.5B, you get a 0.5 h delay at about CT11 (again, you might read a slightly different value from the graph).

7. The hamster needs a 30 minute delay each day, which it gets from a light pulse falling at CT11. CT12 is defined as activity onset. Without the pulse, that would occur one circadian hour after CT11. But because of the pulse, there is a 30 min delay plus one circadian hour so activity will ~90 min after the light pulse. (it is ~ rather than exact because I didn't correct for the circadian hour).

8. For entrainment to occur, it doesn't matter what time you choose to give the pulse. Eventually, the hamster will entrain as described in 7. It may get to its final steady state more or less quickly depending on the time you choose for the daily pulse, but ultimately it will establish the same relationship between the pulse and activity.

9. The phase angle of entrainment. $\Psi = \phi - \varphi$. So, if the light pulse occurs at 11 am, activity onset will be at 12:30 p.m. (see above). Thus, Ψ = 11.0 – 12.5 = - 1.5 h.

10. α is the duration of the active phase, given as 10 h in this example.