Mouse actogram responses

This is an explanation of the circadian rhythm phenomena that can be observed in circadian rhythm studies and with the mouse actogram activity. See the “Exploration Guide” for instructions on how to use the activity.

12:12 light-dark

When an animal's activity pattern matches the external light schedule, it is described as "entrained" to that schedule. In a schedule with 12 hours of light-on and 12 hours of lights-off, we can see that the mouse is active almost exclusively during the dark. It also begins activity at approximately the same time every day. The correlate in humans may be waking up to an alarm clock set for the same time every day.

Constant darkness

In constant darkness, the mouse is no longer bound by external cues, and its internal clock modulates the timing of daily activity. This internal circadian clock is a bit different in every animal, but generally the length of the subjective day in constant darkness is a bit *under* 24 hours. There is a consistent shift in activity onset that is called “free-running.” Mice in constant darkness begin daily activity a bit earlier every day.

The correlate in humans would be to start waking up "naturally" after being used to waking up to an alarm clock every day. In humans, without external cues that tie us to the environmental schedule, our subjective day-length is a bit *over* 24 hours. For a few days, we may continue to get up at the same time, but over time we may wake up a bit later every morning.

Constant light

Experiment prompt: Entrain your mouse to a 12:12 light-dark cycle and then introduce your mouse to days with 24 hours of light.

In constant light, the mouse is no longer bound by external cues, and its internal clock modulates the timing of daily activity. This internal circadian clock is a bit different in every animal, but generally the length of the "subjective day" in constant light is a bit *over* 24 hours. There is a shift in activity onset that you can measure in the actograms. Mice in constant light begin daily activity a bit later every day. However, light is a stress stimulus for mice (in nature, they would be hiding in burrows during the day). So in addition to a daily sift in circadian rhythms there is a general decrease in activity.

Skeleton Photoperiod

In nature, nocturnal animals are active at night and burrow or hide during the day. Normally, they are not exposed to light during the day but rather for shorter periods at dawn and dust (a "crepuscular" light schedule). Animals in skeleton photoperiods are kept in constant darkness with sort periods of lights-on in the morning or at the evening.

Phase Response
Experiment prompt: First, your mouse is kept in constant dark. Then a pulse of light is introduced for one day and afterward the mouse is kept in constant dark again.

This type of experiment is used to measure how an animal re-sets their internal rhythm in response to an external stimulus (like light exposure). A phase response results from a surprise in the timing of an external light stimulus compared to what the internal clock leads the animal to expect. For example, the lights may go on when the mouse is active (when it expects darkness). When there is an inconsistency between the internal clock and the external cues, the mouse will reset its internal clock to be in sync with the environment. The extent of the phase response depends on species and stimulus.

An analogy in humans might be an alarm clock instead of a light pulse. For example, imagine you are in the habit of waking up to your alarm every morning at 6 am. But if this morning your alarm clock sounded at 8 am, then tomorrow you might feel like sleeping in again. (A phase delay: activity onset is adjusted to later in the day).

On the other hand, if your alarm went off at 4am this morning, you may try to adjust the next morning to get up earlier. (A phase advance, with activity onset earlier in the day.) This is a backward analogy, because the alarm clock for humans is a getup-and-get-going stimulus, while the light for mice is a hide-and-go-sleep stimulus. However, both the light and the alarm are external cues that help organisms re-set their internal circadian clocks to be in sync with the external environment.

1. Light during the subjective day:
<u>Experiment prompt</u>: Introduce the pulse during the mouse's subjective daylight period (when the mouse expects light and is sleeping).

A light stimulus when the mouse is inactive (the subjective day) is not unexpected. There will be very little, or no, resetting of the internal clock in response to this and therefore no phase response. The cue is that that the internal clock is appropriately "set" or "in sync" with the external environment.

2. A phase advance shifts the onset of activity earlier:
<u>Experiment prompt</u>: Introduce the pulse at the *beginning* of the mouse's subjective 'night' (when the mouse expects darkness and is active).

If the light is turned on for 1 hour in the first half of the subjective dark period (when the mouse is active), the animal tries to adjust its clock accordingly. It will begin activity later than usual the next day, resulting in a phase delay.

3. A phase delay shifts the onset of activity to a later position in the circadian cycle:
Experiment prompt: Introduce the pulse at the *end* of the mouse's subjective night (when the mouse expects darkness and is active).

If the light is turned on for 1 hour in the second half of the subjective dark period (when the mouse is active), the animal tries to adjust its clock accordingly and will begin activity earlier than usual the next day-a phase advance.