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Dim nighttime illumination accelerates adjustment to timezone travel in an animal model

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Jetlag reflects a mismatch between local and circadian time following rapid timezone travel [1]. Appropriately timed bright light can shift human circadian rhythms but recovery is slow (e.g., 1–2 days per timezone). Most symptoms subside after resynchronization, but chronic jetlag may have enduring negative effects [2], including even accelerated mortality in mice [3]. Melatonin, prescription drugs, and/or exercise may help shift the clock but, like bright light, require complex schedules of application [1]. Thus, there is a need for more efficient and practical treatments for addressing jetlag. In contrast to bright daytime lighting, nighttime conditions have received scant attention. By incorporating more naturalistic nighttime lighting comparable in intensity to dim moonlight, we demonstrate that recovery after simulated jetlag is accelerated when nights are dimly lit rather than completely dark.

In the present studies of male Siberian and Syrian hamsters, the sole difference between experimental groups was whether nights were either completely dark or dimly lit (< 0.2 lux) by a low power, green-light-emitting diode (see Supplemental Data, available online with this issue). After recording wheel-running activity rhythms for one week, an eastward trip across four time zones (Figure S1). Activity rhythms after simulated travel in two hamster species, in both eastward and westward directions, after 4-hour and 8-hour shifts, and in young and aged animals. The present results demonstrate a latent circadian plasticity that emerges under conditions incorporating dimly lit nights. This contrasts with the conventional wisdom that the circadian clock is largely blind to light. Because resynchronization can be influenced by age, we investigated whether dim nighttime illumination would accelerate recovery from simulated jetlag in Siberian hamsters 82–100 weeks of age (Figure S1). Old Siberian hamsters took longer to resynchronize than younger animals, yet dimly lit nights still increased the rate of resynchronization (Figure 1B and Table S1). Notably, resynchronization for old animals with dimly lit nights was not different from that of young animals with dark nights even though these groups differed in age by more than a year (Figures 1B and S2).

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Figure 1. Dimly lit nights accelerate recovery from simulated timezone travel.

(A) Representative double-plotted actograms illustrating the simulated jetlag protocol and wheel-running rhythms of young Siberian hamsters provided dimly lit (left) or completely dark nights (right). White and shaded bars above each actogram illustrate the lighting conditions in place during the first week of the experiment, and the shading within each actogram depicts changes in the phase of relative darkness. (B) Days required for resynchronization (Mean ± SEM) after simulated journeys in the eastward and westward directions, calculated for individual animals using the number of days that elapsed before the midpoint of the active phase shifted from its baseline phase by an amount equal to the shift of the light:dark cycle. *p < 0.0001, *p < 0.05, #p < 0.1.

Syrian hamsters [6]. Nevertheless, this stimulus acts as an all-purpose facilitator of circadian re-entrainment in this and other paradigms [7].

By what mechanism does dim illumination alter circadian plasticity? Does it merely enhance wheel running and thereby potentiate non-photic feedback on the clock [8]? In young Siberian hamsters, dim nighttime illumination did increase baseline activity levels prior to simulated travel (Figure S1, p < 0.025). However, no difference in wheel-running levels was evident between older Siberian hamsters (Figure S1, p > 0.1) or Syrian hamsters (Figure S1, p > 0.2), showing robust effects of dim light during simulated jetlag [6]. Likewise, no baseline measure of entrainment consistently predicted an effect of dim light during jetlag (Figure S1). Does dim light potentiate the circadian response to bright light pulses? Phase resetting by 5-minute bright light pulses in Syrian hamsters is not differentially affected by nighttime lighting conditions [6]. Instead, the effect of dim light must derive from interactions with processes engaged during repeated or longer bright light exposure.

Neurobiological studies show that jetlag induces a transient dissociation among molecular and anatomical components in the circadian pacemaker [9,10]. Dim light may attenuate this desynchrony. Extension of the present findings may lead to a practical alternative to current jetlag treatments since this procedure may be relatively simple to implement and may be attractive to people unable to take advantage of pharmaceutical treatments (e.g., pilots and athletes).

Moreover, while other agents mainly facilitate resynchronization after eastward travel only, dim nighttime illumination accelerated recovery in both directions. Further research is required to assess whether these results generalize to diurnal mammals, such as humans. Clarification of the mechanism of dim light’s action in rodents through physiological, cellular and molecular analysis may yield novel targets for enhancing circadian plasticity and, in turn, therapeutic protocols to treat jetlag in humans.

Supplemental Data

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References

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