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Research

Influence of changes in luminous emittance before bedtime on sleep in companion dogs

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A B S T R A C T

Sleep is important for animals to stay healthy and recover from exhaustion. This study evaluated the effect of changes in luminous emittance before "lights-out" on sleeping behavior in dogs. Six healthy dogs (aged 15-51 months; 3 female and 3 male) were exposed individually to each of the 3 different luminous emittances: 600 lux as the control condition, 50 lux as the poorly lit condition, and 1600 lux as the brightly lit condition before "lights-out" (from 4 PM to 9 PM) for 2 days in succession, over a total 6-day period. For each exposure, we observed the dogs' behaviors from 4 PM to 7 AM the following day. The order of the 3 luminous intensities was random. Eye condition (open or closed), head position (contact or no contact with the floor or side of cage), posture (6 categories), and behavior (8 categories) were recorded every 15 seconds. Comparisons between the conditions on the number of events spent in each posture or behavior were assessed using a repeated-measures analysis of variance, with post hoc comparisons, and a $P < 0.05$ was used to assess significance. A paired t test was used to compare eye or head positions under each condition. During the period 4 PM-5:30 PM, there was no difference among the 3 conditions in terms of the number of events each posture or each behavior was shown. From 5 AM to 7 AM, after exposure to poorly lit conditions, the number of events involving lateral recumbency was significantly greater than that in the control (Tukey, $P < 0.05$). From 5 AM to 7 AM, after exposure to poorly lit or brightly lit conditions, the number of events involving eyes closed was significantly greater than that spent aroused (t test, $P < 0.05$), but otherwise there were no significant differences compared with the controls. These results suggest that changes in luminous intensity before night time might influence sleep quality in dogs.

Introduction

In domestic species, many behaviors differ from those seen in the wild because the animals are controlled by humans (Piccione et al., 2014). In particular, dogs living as pets with humans have to adjust to their owner's life rhythms and habitat. The activity of companion dogs is dependent on their housing environment, and it is influenced by human presence and care (Piccione et al., 2013). Among physiological behaviors, the pattern of sleeping and waking in dogs is also influenced by their living environment (Adams and Johnson, 1993). Sleep may not always provide normal rest for pet dogs. The human sleep cycle commonly consists of rapid eye movement (REM) and non–rapid eye movement (NREM) sleep, alternating on a cycle of 90 minutes (Speigel, 1981). When humans are falling asleep, NREM sleep appears first. After about 1 or 2 hours, the cycle moves to REM sleep; NREM sleep and REM sleep thus appear in turns. Several authors studied the sleep cycle in dogs and showed that REM is likely to occupy about 20% of the total sleep time in dogs, and the mean REM cycle lasts 30 minutes (e.g., Latash et al., 1977). In animal physiology and behavior, melatonin plays a physiological role in the timing of seasonal rhythms (Brown, 1994). Melatonin levels depend on illumination; strong illumination before bedtime has a strong negative influence on human sleep quality. Studies on humans showed that bright-light treatment has acute phase-shifting effects that can reset the human circadian rhythm (Czeisler et al., 1989). Honma and Honma (1988) found that bright-light around bedtime causes phase delay in the human sleep-wakefulness rhythm, and bright light around the time of

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rising causes phase advancement of the rhythm. In human circadian rhythms, it has also been suggested that the phase-shifting effect of light has a strongly nonlinear relationship with illuminance levels (Boivin et al., 1994). Studies of the effects of optimum illuminance and color temperature in bedrooms suggest that low–color temperature light creates a smooth lowering of central nervous system activity and that low–color temperature illumination can be used effectively in bedrooms or other such environments where it is desirable to facilitate a reduction in physiological activity (Noguchi and Sakaguchi, 1999). Despite these findings, there is no evidence of bright-light treatment effect on the sleeping pattern in dogs, and there is little information available on the relationship between the light levels at bedtime and dog circadian rhythms or behavior at night. The purpose of this study was to investigate the influence of different luminous emittances before lights-out on sleeping behavior in dogs.

Materials and methods

Animals

Six healthy dogs, 2 German Shepherds, 1 Labrador Retriever, 1 Golden Retriever, and 2 crossbreds (3 females and 3 males) participated in this study. The dogs varied in age (from 15 to 51 months) and in weight (from 13.2 to 36.4 kg). All dogs were allowed contact with the outside environment and with humans at any time. They were able to sleep alone without distress; hence, they were caged singly at night.

Experimental schedule

A room at Nihon University was used for the experiment. During the experimental period, each dog was accommodated in a wire cage to which was attached a water bottle. Four CCD cameras which set the four corners of the cage, were used to record dog behavior during the night. The size of the cage (large: 68 × 106 × 75 cm; medium: 60 × 90 × 71 cm; small: 55 × 74 × 65 cm) was selected such that each dog could comfortably achieve various postures, such as sternal recumbency, lateral recumbency, sitting, and standing.

First, all dogs were videotaped individually either 1 or 2 days before the start of the experiment when sleeping in their usual kennels; the lights-out time was 8 PM. After this, each dog was habituated to the experimental room under control lighting conditions (luminous emittance, 600 lux) for 6 contiguous days before the experiment because the experimental room differed from their usual kennels. During these observation days, rest time was defined as occurring when the dog was in sternal, lateral, or dorsal recumbency or curling up.

Because the average luminous emittance of the dogs' usual housing was 600 lux, this luminous emittance was defined as the control lighting condition. We used the following 3 lighting conditions before bedtime: 600 lux (FLR40S W/M-36; National, Osaka, Japan) as the control lighting condition, 1600 lux (FLR40SD/M-B, Hitachi, Tokyo, Japan; FLR40S W/M-36, National, Osaka, Japan) as the brightly lit condition, and 50 lux as the poorly lit condition. Luminous emittance in the room was measured with an illuminance meter (AHLT-102SD, Custom, Tokyo, Japan) every day. Overhead lighting (ceiling height 240 cm) was used for both environments (i.e., their usual kennels and the experimental room).

Each dog was exposed to the control conditions for 2 evenings after habituation. Both poorly lit and brightly lit conditions were randomly allocated to each dog for 2 evenings after the control-lit conditions.

Table 1
Condensed observational categories

Observational category	Description
Eye position	
Open	Dog keeps its eyes open
Closed	Dog closes its eyes
Head position	
Contact	Dog's head contacts floor or side of cage
Noncontact	Dog's head is not in contact with floor or side of cage
Posture	
Sternal recumbency	Dog lies down and its belly contacts floor
Lateral recumbency	Side of dog's body contacts floor during rest or sleep
Dorsal recumbency	Dog's back contacts floor during rest or sleep
Curling up	Side of dog's body contacts cage; dog curls up into a ball during rest or sleep
Sitting	Dog sits on floor of cage during rest or sleep
Standing	Dog stands on all 4 limbs when at rest
Behavior	
Vocalizing	Dog barks or growls
Yawning	Dog opens mouth widely and exhales
Panting	Dog pants with open mouth
Grooming	Dog grooms its body with its tongue
Scratching	Dog scratches its body
Stretching	Dog stretches its forelegs or hind legs
Drinking	Dog drinks water
Excretion	Dog urinates or defecates

Before the start of the experiment, each dog was given rest time in its own usual kennel from 3:30 PM. After about 20 minutes, the experimenter (a female in her 20s) took the dog outside for toileting. At 4 PM, the experimenter entered the experimentally lit room with the dog. The experimenter then removed the dog's collar, placed the dog in the cage, and sat on a chair with her back to the dog. At 5:30 PM, the experimenter took the dog for a walk for 30 minutes. After the exercise, the dog was given a short rest and then fed. Each dog spent 15 hours (4 PM-7 AM) in the experimental room each day for 6 contiguous days before the experiment began. The room was lit from 4 PM until 9 PM, at which time the experimenter left the room. The experimenter returned at 7 AM, turned the lights on, and took the dog for a walk.

Behavioral category

Four CCD cameras were used to record the dog's behavior during the experimental period. Eye position (open or closed), head position (contact or no contact with the floor), 6 categories of posture, and 8 categories of behavior were recorded every 15 seconds (Table 1) from 4 PM to 7 AM the following day. These recorded data were divided into 4 blocks (4 PM-5:30 PM; 9 PM-11 PM; 1 AM-3 AM; and 5 AM-7 AM) for data collection purposes.

Statistical analysis

The initial analysis used a repeated-measures analysis of variance to assess the effect of subject, lighting conditions, and repetition on the number of periods spent in each posture or behavior. Post hoc Tukey tests were used for pairwise comparison of the means of the number of periods when significant effects were found. A paired t test was used for the comparison of eye or head positions under each lighting condition.