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Sleep, work, and the effects of shift work in drug detector dogs *Canis familiaris*

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Abstract

Sleep–wake cycles of six drug detector dogs were video recorded, and the effects on them of shift work assessed. Observations were also recorded of interactions between dogs and their handlers during rest and work. Non-working dogs recorded immediately after work or at the same time of day or night when not scheduled for work, slept for 43 ± 16% (SD) of the 8-h recording sessions. They had 3.8 ± 1.2 sleep sessions per h, each of which lasted 7.2 ± 2.3 min. Active sleep occurred during 6.4% ± 4.8% of the total recorded time; there were 0.6 ± 0.4 active sleep sessions per h, each lasting on average 5.9 ± 3.8 min. The rhythms, duration and nature of active sleep were closely comparable with rapid eye movement (REM) sleep patterns recorded electrophysiologically by other workers; active and REM sleep in dogs are most probably identical. Patterns of sleep–wake cycles were not altered when handler–dog teams worked different day and night shifts. The ability of dogs to cope with changing shifts may be due to their natural brief and frequent sleep–wake cycles which may allow them sufficient and easy adjustment to changing routines. Two dogs examined after extended periods of not working showed a first-day-back-at-work effect in which active sleep on the following night was diminished, and less total time was spent asleep.

Keywords: Dog; Circadian rhythm, Sleep; Activity pattern; Olfaction

1. Introduction

Urban dogs serve not only as companions for people, but also contribute to society through their work in numerous situations such as law enforcement and search and rescue operations. In these latter capacities they may be required to operate alongside humans or sometimes independently both day and night. This

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project investigates the sleep–wake cycles of such dogs and their ability to cope with shift work.

People who regularly work night shifts often complain of difficulty in getting to sleep and staying asleep (Akerstedt and Gillberg, 1981). Also, people who undertake irregular shift work experience altered sleep characteristics, a disruption of circadian rhythms, and may suffer from stress and a reduction of vigilance whilst working (Pternitis, 1981; Wegmann et al., 1981). Dogs may also experience disrupted sleep patterns after changes in their routine; for example, when a dog was placed in new surroundings it was observed to have no active sleep on the first night although it displayed active sleep during the next two nights (Adams and Johnson, 1993).

Domestic dogs in urban habitats in Perth, W.A., have about three sleep sessions per hour at night. On average their 21 min sleep–wake cycle consisted of 16 min asleep, with quiet sleep followed by active sleep, then spontaneous arousal and 5 min awake (Adams and Johnson, 1993).

The drug detector dogs of the Australian Customs Service routinely operate in airports, and in shipping and postal services. Additionally they may be required at short notice for special operations in conjunction with the police force. Each dog has a specific handler and the two almost always work as a 'team'; only in rare instances will a handler work with a colleague's dog. The sleep patterns of these dogs were chosen for study because the animals are regularly engaged in both highly demanding activities and potentially disruptive shift work where their well-being is likely to be important for their effectiveness.

2. Animals, materials and methods

2.1. Animals

Six drug detector dogs (*Canis familiaris*) of the Western Australian branch of the Australian Customs Service were studied. Five dogs were entire males: Sabre a 7-year-old German Shepherd, Luke a 6-year-old German Short-haired Pointer, Stubby a 5-year-old Rhodesian Ridgeback cross-breed, Jaffa a 4-year-old Labrador, and Rex a 10-year-old Labrador Retriever. Otis was a neutered, 2.5-year-old male Retriever cross-breed. The dogs were individually housed in kennels with attached activity runs, and had periodic access to a communal exercise area and a training assault course.

2.2. Drug detector dog training

There is a misconception held by some people that drug detector dogs are worked by rewarding them with narcotics. To correct this misconception and provide an insight into the handler–dog bond, a brief outline of their training follows. During initial training dogs retrieve a stick or ball and are rewarded with a game of tug-of-war and praise. The thrown stick is then replaced by a Tug-Of-War

Towelling Incentive Toy (TOWTIT). Subsequently, the dogs are encouraged to seek the TOWTIT in open cardboard boxes, and are rewarded with tug-of-war and praise. The scents of various drugs (or synthetic substitutes) are then introduced into the absorbent material of the TOWTITs which are placed in closed boxes, so the dog has to search by detecting for those specific scents. Dogs which graduate from the training program are able to locate trace amounts of drugs within almost sealed containers. During operations when the dog detects a drug odour it becomes aroused and the handler immediately places the TOWTIT in front of the dog and rewards it with a game. Handlers carry their dog's TOWTIT in a pocket on the outside of their trousers so it can be used at short notice.

2.3. *Working shifts and kennel routine*

Dog–handler teams can be required to work shifts of 7–8 h beginning at 06:00 h, 13:00 h, 18:30 h or at other times on call. Dogs which are not working are left in their kennels and allowed out for about 5 min of exercise at approximately 06:00 h, 10:30 h, 13:00 h, and then between 17:00 and 20:00 h during which they are also fed.

2.4. *Observation schedule*

Over 6 months, one of us (G.J.A.) made overt day and night observations of the six dogs while they were off duty, both on their own and while they interacted with their handlers. During each observation session (listed in Table 2), after the handlers and observer left the dogs, activities of the six dogs were recorded by remote audio and video-recording for 8-h sessions. Recordings were made for 29 sessions totalling 232 h of observations. A red globe was used to illuminate the dog's customary sleeping site and another globe illuminated its activity run. The dogs were filmed using a low light, video-camera (Sony, CCD-AU 230 sensitive to 5 lux) mounted on a tripod 2 m above the subject at its customary sleeping site, and set to record on a video recorder (National Panasonic, Japan, NV 788A). A second video-camera (National Panasonic, WVP200N) with a wide angle lens was used to record the activity of the subject in its activity run. Both systems recorded continuously for 8 h. The dogs were allowed to sniff and become familiar with the equipment whilst it was being set up and all dogs habituated to its presence and showed no indication of altered behaviour.

To document working activity, three dogs and their handlers were monitored during operational duties, with a hand-held video-camera (Sony, CCD-AU 230).

2.5. *Data handling of video records*

The behaviour observed during each minute of the 8-h records was put into one of six categories which were plotted against time:

(0) 'away', where the dog was out of range of both cameras. As no data were obtained at these times, these activities were excluded from calculations;

(1) 'active sleep', where the dog was lying with its head down and its neck muscles relaxed but showing rapid eye movement or spasmodic movements of its legs, paws, ears, tail, tongue or muzzle. Vocalisation by whining, yelping and muffled barking sometimes accompanied this pattern. During active sleep the dog was usually lying on its side. It finished this activity by spontaneously awakening either by raising its head and looking about, or by straightening all four legs which was usually accompanied by an audible sigh;
(2) 'quiet sleep', where the dog was lying still, other than for breathing, with its eyes closed;
(3) 'alert', where the dog had its eyes open and neck muscles tensed whilst lying (and in some cases with ears raised and nose scenting the air), or was sitting, standing, scratching, biting or licking itself but remained within one body length of its sleeping site;
(4) 'active', where the dog was pacing, running, chewing, playing, digging, eating, drinking, urinating or defecating;
(5) 'barking', where the awake dog emitted a loud vocalisation (including howling and baying but not whining).

After initial observations of two dogs (Luke and Otis), a null hypothesis was proposed that a change of work shift would have no effect on the sleeping and waking behaviour of the dogs. The dog handlers proposed that any effect on the sleep–wake cycles of the dogs would most likely be seen as a difference in behaviour between that occurring directly after the busy morning shift and that at the same time on the dogs' rest days. The handlers suggested that the dogs would have more episodes of active sleep (rapid eye movement, REM) after the excitement of work when they believed the dogs would dream about their activities.

The dog's sleep–wake cycles were described by percentages, means and standard deviations; t-tests were used to analyse for any significant differences between the values of sleep–wake cycles recorded after work and at the same times after no work.

3. Results

The mean values of characteristics of the sleep–wake patterns for all dogs during the 8-h recording sessions are listed in Table 1.

3.1. Activity patterns

Activity patterns were used to represent the dogs' varied activities (Monk, 1982; Adams and Johnson, 1993). Fig. 1(a) is a record of the night-time activities of Otis in his kennel and illustrates the full range of behaviours. It shows Otis at 02:03 h being 'active' when returned to his kennel after having worked. From 02:10 h he alternated between being 'active' and 'alert'. At 02:20 h he was in 'quiet sleep', and then went into 'active sleep' at 02:30 h for 2 min, then spontaneously awoke to become 'alert'. At 05:55 h Otis was in 'quiet sleep' and woke to

Table 1
Sleep-wake patterns of drug detector dogs during 8 h recording. Values are means ± standard deviations for values after work, or at the same time of day after not working. Active sleep was not recorded in all sessions

Time in camera (%)	Time asleep (%)	Sleep sessions per 8 h	Sleep sessions per h	Sleep length, mean (min)
92	43 ± 16	27 ± 9	3.8 ± 1.2	7.2 ± 2.3
	Time in active sleep (%)	Active sleep sessions per 8 h	Active sleep sessions per h	Active sleep length, mean (min)
	6.4 ± 4.8	4.5 ± 3.3	0.6 ± 0.4	5.9 ± 3.8

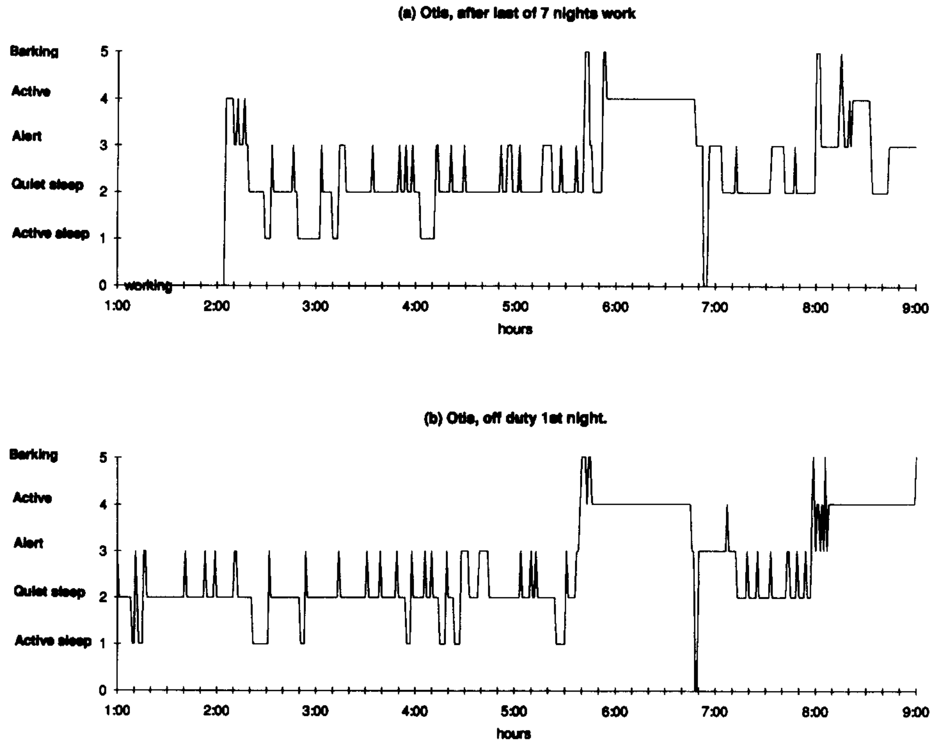


Fig. 1. Activities of Otis plotted against time over 8 h on two nights showing no apparent difference between night-time sleep-wake cycles (a) after the last of seven nights work and (b) on the following night at the same time.

bark. He was then 'active' until 06:55 h when he was briefly out of sight from both cameras.

3.2. Night shift effects on sleep–wake activities

Overall there was no significant difference in the sleep–wake patterns for the dogs after they had been working, compared with corresponding times after not working. The percentage time asleep, number and length of bouts of sleep, and number and length of active sleep sessions, were in all cases not significantly different under the two conditions (*t*-test). Fig. 1 (a) shows the night-time sleep–wake activity of Otis after work, and Fig. 1 (b) shows the very similar pattern of behaviour at the same time after not working. Figs. 2 (a) and 2 (b) illustrate that Otis also had similar day-time sleep–wake cycles (a) after work and (b) after no work. Contrary to initial expectations, whenever the handlers were around Otis always became active regardless of whether he had been working or not. Even after 7 nights of work in succession his handler reported that Otis had no loss of his detecting ability.

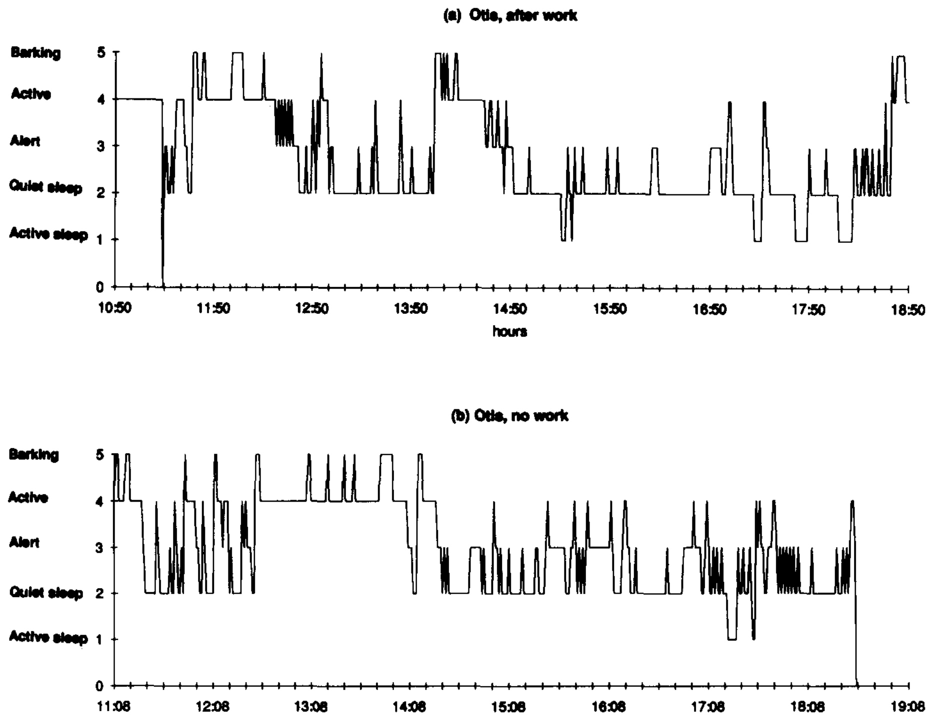
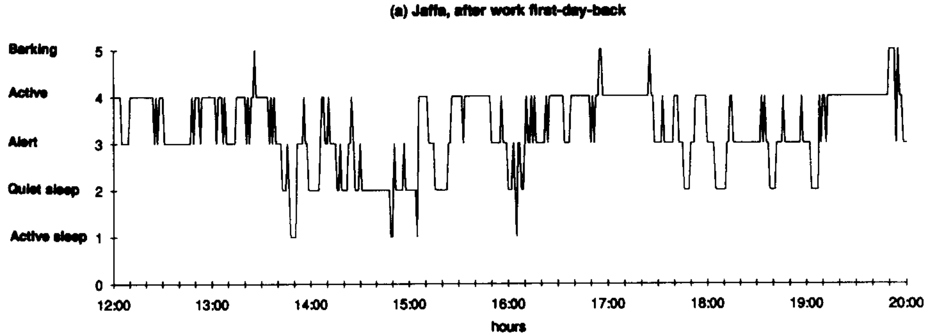


Fig. 2. Activities of Otis showing no apparent difference between the day-time sleep-wake cycles (a) after working and (b) at a similar time after not working.

3.3. Effect of return to work on sleep–wake cycles

Figs. 3(a) and 3(b) illustrate a phenomenon very similar to that occurring in humans called the 'first-night effect' (Agnew et al., 1966; Mendels and Hawkins, 1967). After the first day back at work, REM is diminished, there are more awakenings, and less time is spent asleep. Although the sampling regime was not initially planned to find this phenomenon, it was seen, first in the dog Sabre. The schedule was then changed to enhance detection of the phenomenon, and it was also seen in Jaffa. The work schedule and film sampling regime for the six dogs (Table 2) reveals that only Sabre and Jaffa had the opportunity to exhibit this first-day-back phenomena whilst being filmed. Both had an extended period of rest, followed by their first day back at work, immediately after which they were videotaped.

After Jaffa worked his first-day-back (Fig. 3(a)) he spent 19% of the time asleep, with mean sleep length sessions of 5.2 min, compared with the comparable times after no work of 48% of the time asleep and 8.8 min sleep length sessions. Recordings 3 days later showed a return to original sleep–wake patterns after work of 44% of the time asleep and 8.3 min mean sleep length sessions. Sabre had 3 weeks of no work and after his first-day-back he spent 18% of the



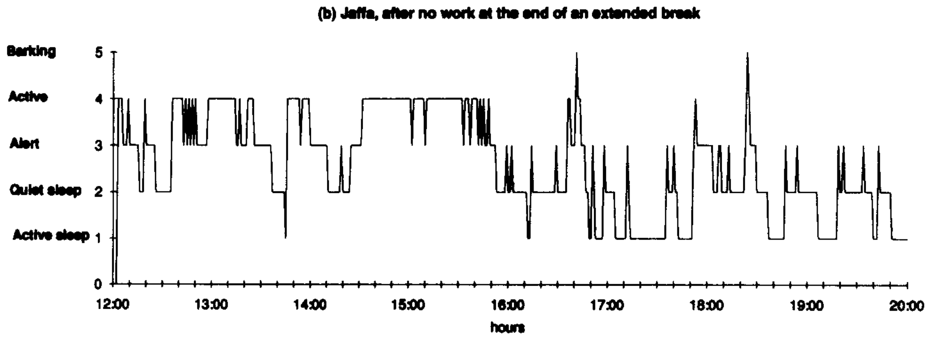


Fig. 3. Activities of Jaffa (a) showing the sleep-wake pattern after the first-day-back at work with less active sleep and more time awake than in (b) after an extended break.

Table 2
The working and filming schedule for the drug detector dogs. Each row represents 1 day. First-day-back effects occurred after an extended break at the days marked with an asterisk (see text)

Luke	Otis	Rex	Stubby	Sabre	Jaffa
Work	Work	Work	Work	Off//for 3 weeks	Off
WORK	Work	Work	Work	Off//	OFF
WORK	WORK	WORK	WORK	Off	OFF
WORK	WORK	WORK	WORK	OFF	WORK*
OFF	WORK	Work	Work	WORK*	Off
OFF	WORK	Work	Work	Work	Off
Off	Work	OFF	Work	Work/off	WORK
Work	WORK	OFF	OFF	3-weeks	Work
	OFF	Work	OFF	Off	
	OFF		Off	Off	
	OFF			WORK	
	OFF			OFF	
	Work				
	Work				

Key: (WORK, OFF) = filmed.

time asleep, with mean sleep length sessions of 3.9 min, compared with the same time at the end of the last day of his extended break with 32% of the time asleep and 6.8 min mean sleep length sessions. Recordings 3 weeks later on Sabre also showed a return to original sleep–wake patterns of 30% asleep and 6.8 min mean sleep length sessions. Fig. 3(b) although based on only two dogs indicates a pattern where, during extended breaks, dogs may have elongated periods of active sleep.

3.4. Interaction of handlers and their dogs

The close interaction between the handlers and their dogs is described in detail below because of its possible relevance to the effect on dogs returning to work described above. Drug detector dogs are given almost no opportunity to interact with each other. This is deliberate, and is said by the handlers to be so their dog will assume the status of pack leader; in fact, it is more likely each dog is effectively in a pack of two, with the dog subordinate to its handler. Drug detector dogs are dependent on their handlers for food, and for release from the solitary confinement of their kennels. When the dogs are worked they receive acknowledgment and frequent praise from their handlers. Working could affect a dogs' sleep–wake behaviour, yet the animals are always expected to be in a state of readiness should they be needed.

The dogs spend much of their time at the front of their activity runs while off duty, in a position to see the handlers when they walk outside their office. When a handler appears the dogs vigorously bark and jump at the fences. Often, the handlers will call loudly for the dogs to be quiet and a period of relative calm follows, with the dogs standing, sitting, or lying sternally recumbent facing the handlers. During the kennel cleaning and exercise times around 06:00 h all dogs are in a high state of arousal. As the handlers approach the dogs, the barking intensifies and most of them spin in circles. If the handler passes by, the dog resumes its spinning and barking. When a handler touches the dog's gate the dog immediately stops and is usually allowed to run into the grassed exercise area. A dog in the exercise area usually bounds around the perimeter for one or two laps and then urinates at the gate leading to the dog vans. The dog will usually defecate, sniff at and urinate on the other regular urination sites, and wait at the gate to the dog vans. If the dog is not required for work, a handler has to call determinedly to get the dog back to its kennel. At each exercise time the procedure is repeated. When a dog is allowed into the back of the double-caged dog van it becomes very aroused and often has a penile erection. Some dogs pace around in the limited space of the van and one dog (Jaffa) manages to spin in circles. When the dog Otis, who regularly works night shift, is returned to his kennel at about 02:00 h the other dogs rarely bark and then only briefly as if they realise there is little chance they will be called to work.

The 'passive' detector dog, Otis, is used principally to check arriving passengers at airports. After completing his dog-oriented activities in the compound, he is taken by van to the airport. Before work Otis's handler removes the choker chain and replaces it with a body harness and long leash, whereupon the dog becomes alert and wags his tail vigorously. Whilst guiding him towards the passenger area the handler allows Otis to freely scent the air and ground. At times Otis darts off, presumably in pursuit of an interesting scent. Otis walks rapidly past the queue of disembarked passengers sniffing them and their hand luggage. When Otis detects drug odour he passively sits next to the person and wags his tail. His handler immediately gives Otis the TOWTIT and a tug-of-war takes place in an area away from the queuing passengers. After a few minutes Otis is ready to work again and continues the search.

The other dogs, which are 'active' drug detectors, are taken to the airport after carrying out their dog-oriented activities at their compound. These dogs become very excited, with some individuals barking and spinning even within the confines of the van. Like Otis, the active drug detector dogs are also allowed to carry out almost ritual dog-oriented activities immediately before working, then they too adopt an alert body posture when fitted with their working harnesses. When a luggage train stops at the airport terminal, a dog and handler walk briskly around it and the handler directs his dog to search each container for scents as it is opened. When a dog detects drug odour it tries to bite at the source or generally becomes agitated. When this containerised luggage is placed on the conveyor belt the dog is allowed to run over the cases until it identifies the source of the drug odour. At this point the dog is given a TOWTIT as a reward before it can bite the luggage, and a game of tug-of-war takes place.

4. Discussion

4.1. Sleep–wake cycles of drug detector dogs

The drug detector dogs had a mean of 3.8 sleep sessions per h which was similar to the mean of 3.0 sleep sessions per h recorded at night in a previous experiment on 24 urban dogs (Adams and Johnson, 1993). The shorter, mean sleep session length of 7 min for the drug detector dogs may have arisen partly because the recordings were made both night and day, compared with the longer 12 min mean sleep length, recorded only at night for the institution housed dogs. However, it is also possible that the drug detector dogs had acquired a habit of having shorter sleep sessions in response to being called on to work at short notice.

4.2. Pattern similarities between REM and 'active' sleep

These experiments revealed similar timing patterns in 'active' and REM sleep. The two categories of sleep are not known to be identical, although during REM sleep dogs commonly exhibit spasmodic twitching of their limbs, paws and muzzles together with muffled vocalisations, which defines Active sleep in this experiment. Copley et al. (1976) and Lucas et al. (1976) made electrophysiological observations in laboratories on five dogs over 48 h and six dogs over 24 h, respectively. The laboratory dogs were awake for a similar time, $67.8 \pm 0.9\%$ SEM (Copley et al., 1976) and 65% (Lucas et al., 1976) of the observation period, as the $57 \pm 16\%$ awake (or 43% asleep) recorded in these drug detector dogs (Table 1). The laboratory dogs also spent a similar time in NREM (non-rapid eye movement) sleep, $23.1 \pm 0.7\%$ SEM (Copley et al., 1976) and 23% (Lucas et al., 1976), compared with the 36.6% for these drug detector dogs. REM sleep was reported to last $8.8 \pm 0.6\%$ by Copley et al. (1976) and 12% by Lucas et al. (1976), compared with 6.4% of the time in active sleep for these drug detector dogs. The dogs monitored by Lucas et al. (1976) had a mean REM sleep length of 6 min which is similar to the active sleep time of the drug detector dogs of 5.9 ± 3.8 min. The dogs of Lucas et al. (1976) may have spent slightly more time awake due to the fact that they were in a group of 17, rather than a group of six as for the drug detector dogs. Adams and Johnson (1993, 1994) have shown that larger groups of dogs wake and bark more frequently.

The method used here of recording 'active' sleep on video has produced very similar results to recordings of REM sleep by electro-physiological means. Video recordings of active sleep can therefore probably be used instead of electrophysiological recordings, thereby avoiding the obvious technical difficulties monitoring REM sleep. Ideally simultaneous recordings of REM and active sleep should be examined to check that the states are indeed identical.

4.3. Coping with the demands of shift work

The first-day-back phenomenon after an extended break was the only effect noted in the dogs when they changed from one routine to another and this disruption to their sleep–wake cycles disappeared the next day. As it was only possible to record the effect in the schedule of two of the six dogs, it is possible that the first-day-back effect was a chance occurrence confined to these conditions. However the effect on sleep pattern was quite dramatic (Fig. 3) and warrants further study. Apart from this effect, the dogs seemed to have coped with the demands of working shifts at least in terms of sleep requirements. Even working night shifts whilst other dogs worked during daytime appeared to have no effect on the sleep–wake patterns of Otis. There was no evidence that he was suffering any ill effects such as suppression of active sleep with subsequent rebound the next night (extra REM/active sleep; Adams and Johnson, 1993). This successful adaptation may be similar to that of people experienced at coping with working night shifts who take regular naps before and during work in addition to their regular day-time sleep (Gillberg, 1985). The drug detector dogs may likewise be able to cope with the demands of shift work by having sufficient sleep in their naturally occurring, short duration and frequent sleep–wake cycles, which can fit easily into the shift routines imposed.

5. Conclusion

Regardless of whether drug detector dogs carried out their intensive work during the day or night they always appeared rested and eager to work. This ability to cope with the rigours of shift work was attributed to the dogs' ability to derive sufficient sleep from their naturally occurring, short duration, and frequent sleep–wake cycles which easily fitted into the shift routines imposed. However dogs (two tested) did experience longer periods of active sleep during peaceful extended periods of no work and also a first-day-back effect after having an extended break from work, with disrupted sleep–wake cycles perhaps due to the associated excitement.

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