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REM sleep deprivation fails to increase aggression in female rats

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The effect of REM sleep deprivation (RSD) on intraspecies aggressiveness in female Sprague-Dawley rats was investigated. Female rats were divided into 10 trial groups. Among individual groups, rats were randomly assigned to an RSD, a dry control, or a wet control condition. Each triad was given a 20-min pretreatment dominance test, and the animals were then placed into their respective conditions for 4 days. Posttreatment dominance tests were given on Day 5 immediately following treatment, Day 10, and Day 15. Contrary to the findings of some previous studies, the difference in this form of aggression between RSD and control animals was not significant. When viewed in the context of the existing studies, the present data suggest that RSD does not have a general activating effect on aggression, and that in the specific instances where positive results for intraspecies aggression have been reported, these may be the consequence of complex interactions of RSD with other variables.

As a partial explanation of the effects of REM sleep deprivation (RSD) on behavior, Vogel (1975) argued that REM sleep is a period during which accumulated drive energy is dissipated. Thus, he suggested that RSD prevents the dissipation of drive and, as a result, serves to augment the level of generalized drive. In support of this position, he noted that RSD seemed to increase an array of drive-motivated behaviors, such as aggression, eating, and sexual activity. However, the evidence of this hypothesis is sparse, and with respect to aggression, it is ambiguous.

In one of the first experiments that is relevant to this issue, Morden, Conner, Mitchell, Dement, and Levine (1968) found that RSD increased shock-induced fighting in male rats, and they concluded that RSD increases aggression. However, the use of shock-induced fighting as a measure of aggression has been questioned. For example, Blanchard, Fukunaga, Blanchard, and Kelly (1977) and Miczek (1979) have suggested that shock-induced fighting is a defensive behavior pattern that is unrelated to true aggression. Sloan (1972) investigated the effects of RSD on intraspecies aggression in male Charles River albino rats. Although Sloan reported that RSD increased aggression in these animals, both the design of his study and his results warrant a critical examination. To explain, he noted that during the course of treatment, the weights of his RSD animals declined and were substantially lower than those of his controls. This inequality in weight suggests the possibility that the differences in aggressive behavior that he observed might have been potentiated by factors other than RSD, such as differential food deprivation and/or stress. Furthermore, during most of the aggression-test periods, aggressive behaviors were observed and scored by only one person, and throughout all of these tests for aggression, the raters were aware of the animals' treatment conditions. Therefore, because experimenter bias may have been a source of confounding, the results of Sloan's study are difficult to interpret.

As a more precise test of Vogel's theory, recent investigations have been concerned with nonspecific aggression, competition for food, interspecies aggression, and intraspecies aggression. To summarize these findings briefly, Kuroda, Gonzales, Gomez, Reyes, and Hicks (1982) found that RSD increased nonspecific aggression in young Sprague-Dawley rats. Young male and female rats previously trained to traverse a runway for a food reward encountered a cotton barrier that had been placed in the middle of the runway. Latency to push through this barrier was used as the dependent variable in measuring nonspecific aggression. Kuroda et al.'s results indicated that the RSD animals had lower mean latency times than did controls. In an earlier and related experiment, Hicks et al. (1981) found that RSD increased aggressiveness in a food-competition paradigm (aggressiveness was measured by the ability of one animal to push another down a runway for a food reward). They demonstrated that RSD animals were more likely to win in this food-competition paradigm than nondeprived controls, and they concluded that their data provide support for the theory that RSD increases drive-related behaviors. Finally, after measuring the effects of RSD on interspecies aggression of rats by recording the frequency and latency of attacks on mice by male Sprague-Dawley rats, Hicks, Moore, Hayes, Phillips, and Hawkins (1979) concluded that RSD substantially increased interspecies aggression in a dose-related fashion.

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More recent studies on the relationship between RSD and intraspecies aggression have yielded conflicting results, and implicitly, these data raise the issue that effects of RSD on intraspecies aggression may be species-specific and/or sex-linked. Moore, McRainey, and Hicks (1981) measured the effects of RSD on intraspecies dominance behaviors in female spiny mice. After reporting a sharp increase in the dominance of RSD animals, they concluded that the effects of RSD on aggression might, in part, be a function of the form of aggression measured, the species, and the sex of the animals used as subjects. Subsequent studies of intraspecies aggression have supported the validity of this speculation. For example, Kuroda (1984), using the intruder paradigm, failed to find an increase in intraspecies aggression in male rats. Consistent with Kuroda's observations, Peder, Elomaa, and Johansson (1986) reported that RSD failed to increase intraspecies aggression in male and female Wistar rats following exposure to reductions in the dimension of their enclosure (i.e., a paradigm designed to increase irritable intraspecies fighting). The failure by both Kuroda and Peder et al. to find an increase in intraspecies aggression in their male RSD rats calls into question Vogel's general hypothesis that RSD activates drive-related behaviors. In addition, these data, together with those of Moore et al., suggest that the effects of RSD on intraspecies aggression may be species-specific and/or sex-linked.

As a partial test of these possibilities, the present study was designed to measure the effects of RSD on the intraspecies aggression of female rats. We used the procedures that Moore et al. (1981) followed in their study of female spiny mice. Thus, we hypothesized that if RSD affects the intraspecies aggression of female animals, regardless of species, we should observe an increase in aggressive behavior in our RSD animals.

METHOD

Subjects

Thirty female Sprague-Dawley rats (mean body weight at the beginning of the experiment = 184.4 g) were matched by weight and then divided into 1 of 10 triad groups in which they would remain throughout the experiment. The 3 animals within each triad group were randomly assigned to one of the three treatment groups: RSD, a wet control (WC), or a dry control (DC) condition. Therefore, a total of 20 animals served as non-sleep-deprived controls, whereas 10 animals were deprived of REM sleep.

REM Sleep Deprivation

RSD was achieved using the water-tank procedure, which is described in detail by Hicks and Moore (1979). During the 4-day treatment period, all of the animals were housed in 18.9-liter buckets that were modified so that food and water were available ad lib from a feeder on the side of the cage. The top of each bucket was covered with wire mesh and the water bottle was positioned so that the spout was within easy reach of the animal. During the treatment period, each animal in the RSD condition spent its time in the bucket on a 6.5-cm platform that was surrounded by water (19° C) to within 1 cm of the platform. The animals in the WC group were treated identically, with the exception that these animals spent the entire treatment period on a 16.5-cm platform that was surrounded by water. These larger platforms were large enough to prevent the animals from falling into the water at the onset of REM sleep. Thus, this group served as a non-RSD control for exposure to the wet environment. The DC group spent the entire treatment period housed in a dry RSD apparatus with a 16.5-cm platform in place, and therefore served as a non-RSD control for exposure to the novel RSD apparatus.

Aggression

Aggressive posturing has been viewed in the literature as consisting of two components, a nonfighting dominance component and a true aggressive fighting behavior (Blanchard & Blanchard, 1977; Kuroda, 1984; Powell & Buchanon, 1978). Since, as Powell and Buchanon (1978) have noted, female rats are more likely to engage in dominant nonfighting postures than in true aggressive fighting behavior, we measured four nonfighting dominance behaviors and three true aggressive fighting postures for these animals. The four dominance behaviors measured were allogrooming/autogrooming, crawling over/under, sniffing, and upright posture. As Kuroda (1984) reported, these dominance behaviors are highly intercorrelated, and they were thus summed to provide a single dominance score for each animal on a given test. The true aggressive fighting postures measured were attack/fighting, chase, and on-top full aggressive posture. Powell and Buchanon found that these behaviors were highly intercorrelated; therefore, they were summed for each animal for each test to provide a single score for true aggression. During pilot work, we found that biting could not be accurately seen on our videotapes and, as a consequence, we did not include this behavior on our scoring of true aggression.

Procedure

After the animals were received from the supplier, they were put through a 10-day adaptation period. During this period, the animals were housed individually in a dry RSD apparatus with a large platform in place. Each animal was handled for a 7-min period and placed into the open-field apparatus for a 3-min period on each day of the 10-day adaptation period. Just prior to the treatment period, the animals were weighed and divided into triads that were matched on weight; the 3 animals within each triad group were randomly assigned to the three treatment conditions. Upon completion of the 10-day adaptation period, and before treatment (Day 1), individual triads were randomly placed into an 81.3×81.3×38 cm open-field apparatus for a 20-min pretreatment assessment of dominance and true aggression. During each 20-min test, the triads were videotaped. Later, an experienced scorer, blind to the animal's treatment condition, viewed each tape and recorded the frequency of dominance and three true aggressive behaviors. The open-field container was cleaned following each test so that odor cues were eliminated.

RESULTS AND DISCUSSION

First, as a rough check on the relative stressfulness of the treatment conditions, a one-way analysis of variance (ANOVA) was computed to test pre-posttreatment differences in weight for the three treatment groups. The result of this analysis was not significant [$F(2,28) = 1.5$].

The means and standard deviations computed for the total dominance and true aggressive behaviors for each treatment group for each aggression test are listed in Table 1.

Using the data summarized in Table 1, separate 3 (treatments) × 4 (tests) mixed ANOVAs with repeated measures over the second factor were computed for the total dominance and total true-aggression scores. The results of these analyses for total true aggression demonstrated that neither the main effects for treatments and tests, nor the treatment × tests interaction, were significant [$F(2,27) = 0.32$, $F(3,81) = 1.88$, and $F(6,81) = 0.83$, respectively]. As a result of the ANOVA computed to analyze the total dominance scores, a significant main effect for tests [$F(3,81) = 5.41$, $p = .002$] and for the treat-

Table 1
Mean (and Standard Deviation) Total True Aggression and Total Dominance Scores for Each Group for Each Test

	Total True Aggression								Total Dominance							
	Pretreatment Test		Immediate Posttreatment Test		5-Day Posttreatment Test		10-Day Posttreatment Test		Pretreatment Test		Immediate Posttreatment Test		5-Day Posttreatment Test		10-Day Posttreatment Test	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
RSD	39	29	28	23	31	13	39	33	151	31	118	35	151	34	151	23
WC	47	53	38	27	37	31	28	20	144	25	119	33	149	26	156	28
DC	40	29	37	25	28	22	17	12	144	30	139	22	139	29	122	22

Note—RSD = REM sleep deprived, WC = wet control, DC = dry control.

ment × tests interaction [$F(6,81) = 2.99, p = .01$] were found, whereas the main effect for treatments was not significant [$F(2,27) = 0.30$]. Inspection of Table 1 clearly shows that the significant treatments × tests interaction cannot be attributed to increased dominance in the RSD animals following loss of REM sleep. In fact, both dominance and true aggression was diminished in these animals during the immediate posttreatment test and returned to baseline levels only after a 10-day period of recovery. Put differently, these data fail to support the hypothesis that RSD increases intraspecies aggression in female rats.

Our data are consistent with the results reported by both Kuroda (1984) and Peder et al. (1986), who also failed to find increases in intraspecies aggression in male rats subjected to RSD. As noted above, Sloan (1972) found that RSD increased intraspecies aggression in male rats. Collectively, the present data, together with those of Kuroda and Peder et al., reinforce our view that Sloan's results may have been the consequence of confounding that he introduced in feeding, housing, and/or recording his animals' responses during the RSD treatment period. Thus, it seems that RSD may not have a general effect on aggression, but, as Moore et al. (1981) noted, such effects, when they are observed, may be dependent on sex, species, and/or the type of aggression being measured.

As an alternative to the general motivational hypothesis of RSD, Hicks et al. (1979) suggested that RSD lowers the activation threshold for certain behaviors. It is therefore possible that behaviors not measured in the present study may have precluded the expression of true aggression and dominance in the animals. To explain, it is well established that RSD increases exploration in both male and female rats (e.g., see Hicks & Moore, 1979; Hicks, Thomsen, Pettey, & Okuda, 1976), and an increase in exploration in the RSD animals could conceivably have reduced interactive behaviors such as the expression of aggression and dominance in these animals during the immediate posttreatment test in the open-field apparatus. That is, it is possible that the observed decreases in both aggression and dominance in the RSD animals could have been due to increases in a behavior not measured in this study (i.e., exploration). This raises the interesting speculation that RSD may influence a variety of behaviors in a hierarchical way. However, we know of no research that has tested for this possibility.

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