Situational factors affecting sleep paralysis and associated hallucinations: position and timing effects

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SUMMARY Sleep paralysis (SP) entails a period of paralysis upon waking or falling asleep and is often accompanied by terrifying hallucinations. Two situational conditions for sleep paralysis, body position (supine, prone, and left or right lateral decubitus) and timing (beginning, middle, or end of sleep), were investigated in two studies involving 6730 subjects, including 4699 SP experients. A greater number of individuals reported SP in the supine position than all other positions combined. The supine position was also 3–4 times more common during SP than when normally falling asleep. The supine position during SP was reported to be more prevalent at the middle and end of sleep than at the beginning suggesting that the SP episodes at the later times might arise from brief microarousals during REM, possibly induced by apnea. Reported frequency of SP was also greater among those consistently reporting episodes at the beginning and middle of sleep than among those reporting episodes when waking up at the end of sleep. The effects of position and timing of SP on the nature of hallucinations that accompany SP were also examined. Modest effects were found for SP timing, but not body position, and the reported intensity of hallucinations and fear during SP. Thus, body position and timing of SP episodes appear to affect both the incidence and, to a lesser extent, the quality of the SP experience.

KEYWORDS hallucinations, hypnagogic, hypnopompic, sleep paralysis, supine, vigilance

INTRODUCTION

Sleep paralysis (SP) is a transient, conscious state of involuntary immobility occurring when falling asleep or upon wakening (Hishikawa 1976; Hishikawa & Shimizu 1995). It has been associated with sleep-onset rapid eye movement periods (SOREMP), or mixed or incipient rapid eye movement (REM) and waking electroencephalogram (EEG) in laboratory studies (Takeuchi *et al.* 1992, 2001). Estimates of prevalence of 6–40% of people reporting at least one lifetime experience of SP are common in recent studies, with many people reporting multiple episodes over extended periods (Cheyne *et al.* 1999a; Fukuda *et al.* 1998; Ohayon *et al.* 1999; Spanos *et al.* 1995).

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It is widely believed that lying in the supine position is a proximate cause of SP. Jones (1931) and Hufford (1982) cite numerous traditional sources for this belief. More recently, empirical studies have investigated body position during SP. Spanos *et al.* (1995) found that 70% of their subjects reported being in the supine position during SP. No information was provided on the normal sleeping position, however. Fukuda *et al.* (1998) found that 58% of Canadian and 84% of Japanese students reported being in the supine position during SP. In contrast, only 4% of Canadian and 41% of Japanese students reported being in the supine position during regular sleep. Fukuda *et al.* (1998) suggest that the supine posture might permit the greatest relaxation and hence potentiate SP. Unfortunately, the table (Fukuda *et al.* 1998: Table 6) in which regular sleeping positions are reported combines SP and non-SP subjects so it is not possible to determine whether these two groups differ in their normal sleeping positions. It is possible that individuals who regularly assume the supine position when falling asleep expose themselves to a greater risk of SP. The high incidence reported for the supine position in Japanese samples for both regular sleep and SP episodes is consistent with this hypothesis, although there are alternative cultural explanations for the high rate of reported SP in Japanese samples (Fukuda *et al.* 1987; Fukuda *et al.* 2000). To enable a test of this hypothesis in the present investigation, sleep position when normally falling asleep was assessed for those who experienced SP and those who have not.

The supine position and REM appear also to have a significant effect on the incidence and duration of obstructive sleep apnea (OSA) though the positional dependency appears to be specific to non-rapid eye movement (NREM) (Berger *et al.* 1997; Cartwright 1984; Cartwright *et al.* 1991; George *et al.* 1988; Pevernagie and Shepard 1992). Obstructive sleep apnea, in turn, has been reported to be associated with SP (Ohayon *et al.* 1996). The supine position is associated with obstruction of the airways by the collapsed soft tissue of the upper airways in both apneic and non-apneic individuals (Hiyama *et al.* 2000; Penzel *et al.* 2001). There is, in addition, greater compressive force on the lungs from the heart in the supine position (Albert and Hubermayr 2000). All of these factors can potentially contribute to an increase in microarousals during sleep in the supine position, which might then lead to SP episodes.

Hypnagogic and hypnopompic hallucinations frequently accompany SP (Hishikawa 1976). Recent research has provided evidence that these hallucinoid experiences fall into three major categories (Cheyne *et al.* 1999b; Cheyne 2001). Intruder experiences involve a numinous sense of a threatening presence followed or accompanied by visual, auditory and tactile hallucinations. Incubus experiences include breathing difficulties, choking or smothering, bodily pressure, typically on the chest, and pain. The SP-subjects sometimes interpret these sensations as an assault by the intruder. The Intruder and Incubus factors are moderately positively correlated with one another and with intense fear. The qualitative features of the two types of experiences are coherently interpretable as experiences of immanent threat and assault. A third factor comprises a variety of spatial, temporal and orientational (STO) experiences of the body and include feelings of floating, flying, falling, out-of-body experiences, and autoscopic hallucinations. This factor is somewhat less strongly associated with the first two factors though all three are positively correlated. The STO is not, however, significantly associated with fear but rather with blissful and erotic feelings, which are, nonetheless rare when compared to fear and may be accompanied or followed by fear as well. Regular dreams have variable affective content or sometimes none at all with fear being reported in approximately one-third of dreams (Merritt *et al.* 1994; Schredl and Doll 1998; Strauch & Meier 1996), whereas SP hallucinations are very strongly (78–98% of cases report fear during SP) associated with fear (Cheyne 2001). Based on the foregoing considerations, it has been proposed that SP with Intruder and Incubus hallucinations and high levels of fear implicates an amygdalar threat activated vigilance system (TAVS) (Cheyne 2001). In the light of the TAVS hypothesis, it is interesting to note that SP also bears some resemblance to the tonic immobility (TI) emergency response to predation (Gallup and Maser 1977; Ratner 1967). Indeed, TI has been suggested as a potential model for SP (Gallup and Rager 1996; Marks 1987). Tonic immobility is a state of profound but temporary paralysis found in many animals as a response to handling, inversion and restraint (often in the supine position). These considerations lead to the prediction that more intense Intruder and Incubus hallucinations as well as greater fear will characterize SP episodes experienced in the supine position.

There are also grounds to suspect that restraint is more stressful in the supine than in the prone position. Rats have been found to have a more elevated adrenocortical stress response to supine that prone restraint (Natelson *et al.* 1989). Immobilized mental patients appear to find restraint in the supine position less tolerable than in the prone position (Aschen 1995). Human infants may also prefer the prone to the supine position. Infants have been reported to be more than twice as likely to roll over from the supine to the prone position as from the prone to the supine in the course of the night (Togari *et al.* 2000). Thus, the aversive character of restraint or immobility in the supine position, possibly related to the link to TI, may be a factor in the potentiation of SP.

The timing of SP has been somewhat less studied than position and with less consistent results. SP has been reported to be more (Spanos *et al.* 1995) as well as less common when falling asleep than when waking (Buzzi and Cirignotta 2000; Ohayon *et al.* 1999). Interestingly, TI has been found to exhibit a circadian rhythm in a variety of species (Hennig and Dunlap 1977; Hill *et al.* 1994; Stahlbaum *et al.* 1986; Ternes 1977), in which induction sensitivity and duration vary according to time of day. Patterning varies somewhat according to species characteristics (e.g. diurnal vs. nocturnal) but generally animals appear to be more susceptible to TI induction under conditions of twilight or darkness. This might be related to the fact that diurnal primates are reluctant to flee at night and hence are more inclined to rely on crypsis when selecting a sleeping site. Among diurnal primate species nocturnal predation is a significant factor in sleeping site selection (Anderson 1998). In addition to being inconspicuous, sites selected are negatively correlated with accessibility to predators (Hamilton 1982). Nonetheless, despite these precautions and although primates are subject to both diurnal and nocturnal predation, at least some predators are more successful at night than during the day (Cowlishaw 1994). Thus, vigilance and fear thresholds would likely be reduced at night in diurnal primate species. In a study of the effects of shift work on the incidence of SP, episodes were reported only during the night even though the care was taken to indicate to subjects that SP could occur at any time of day (Folkard *et al.* 1983). Reported incidence in that study peaked at 4:00 am. The TAVS hypothesis for SP, therefore, also leads to the prediction that SP will be more frequent for diurnal primate species at initial sleep onset and during sleep, typically associated with fading light and darkness than at sleep offset when typically waking at dawn, especially in the supine position. The TAVS hypothesis, therefore, also predicts timing differences in the incidence of SP and in the intensity of Intruder and Incubus hallucinations as well as fear.

It is also possible, however, that the intensity of SP hallucinations will show the same circadian and ultradian effects as REM dreams. REM (and perhaps NREM) dreams later in the sleep period, especially in the late morning hours, are sometimes reported to be more vivid and bizarre than those early in the sleep period (Antrobus *et al*. 1995; Kondo *et al*. 1989). Antrobus (1991), for example, has argued that REM/NREM fluctuations and cycles may jointly effect overall production of dream imagery. The hypothesis of additive effects of REM and diurnal activation leads to the prediction that all SP hallucinations will be more intense when waking up and in the midst of the sleep than when falling asleep.

In Study 1, positions during SP and during normal sleep onset are compared for individuals reporting SP. In addition, sleeping positions during normal sleep onset of those reporting SP is compared with individuals not reporting SP episodes. In Study 2, we further examine the positional hypotheses as well as hypotheses about timing of SP, the relation between timing of SP and positional effects, and of the effects of position and timing on the intensity of hallucinations accompanying SP.

METHOD

Study 1

As part of a mass testing of psychology undergraduates, 1446 students (795 females and 651 males) with a mean age of 19.87 (SD = 2.54) were screened for SP experiences over six terms from 1997 to 1999. There were 415 students (276 females and 139 males) classified as SP subjects when they endorsed the following statement: 'Sometimes when just falling asleep or just waking up I have experienced an inability to move for a brief period.' Further questions concerned hypnagogic and hypnopompic experiences not addressed here. Students were also asked to indicate which position they were in during SP by choosing among the following options: varies from time to time, on my back, face down, and on side. In a separate section of mass testing all students were asked to indicate their position when normally falling asleep by choosing among the same set of options.

Study 2

The Waterloo Unusual Sleep Experiences Scale includes items assessing frequency of SP on a four-point scale (never, once, two to five times, and more than five times) as well as intensity or vividness of a variety of hallucinations accompanying SP. Intensity of each hallucination type is rated on a 7-point scale, ranging from a vague impression to a vivid and lifelike experience. After each question a text box is provided for respondents to elaborate or comment on the question. Intensity measures for each of the major hallucination types (Intruder, Incubus, and STO) were created by taking the mean of their constituent hallucination subtypes. These subtypes were: for the Intruder factor: sensed presence, auditory, visual, and tactile hallucinations, as well as hallucinations that the bedding is moving or being pulled; for the Incubus factor: breathing constriction, smothering or choking feelings, pressure on the chest, or other body part, and pain; and for the STO factor: floating, flying, and falling sensations, out-of-body experiences, and autoscopy, as well as illusions of movement, such as sitting up, getting out of bed, and walking around the room. Respondents were also asked to indicate which position they were in during SP and when normally going to sleep as in Study 1 with the following modification; 'on side' option was expanded to 'on left side' and 'on right side.' These same options were provided for the questions 'In what position do you normally lie when you are falling asleep?' Finally, respondents were asked to indicate if they had experienced SP at the beginning (i.e. when falling asleep), middle (i.e. during sleep), or the end of sleep (i.e. upon awakening). The responses were not mutually exclusive (i.e. respondents were asked to indicate any of the times that applied to their experience).

An HTML version of the scale was placed on the World Wide Web linked to a web page on SP. The scale can be found by potential respondents either through a variety of search engines and related links to other sleep pages. The data reported here were collected over a period of 14 months in 2000 and 2001. During that time 5284 respondents (3491 females 1793 males) with a mean age of 29.47 (SD = 10.22) submitted complete forms.

Studies 1 and 2 received ethics clearance from the Office of Human Research at the University of Waterloo.

RESULTS

Given the considerable statistical power resulting from the large sample sizes α was set at $P < 0.001$ for all analyses reported.

Study 1

The supine position was reported to be the most common position during SP (see Table 1). Percentages, rather than frequencies, of subjects reporting each position for each context (i.e. SP or normally falling asleep) are presented in Table 1 to facilitate comparisons among rows. The supine position was more than four times more commonly reported during SP than during normal sleep onset. To test the hypothesis that SP positions were different from position typically taken at the beginning of sleep, the frequencies for each position at sleep onset were used to predict the frequencies for the corresponding SP positions. That is, the frequencies for positions taken when falling asleep were used as expected frequencies for a chi-square goodness-of-fit test under the null hypothesis that no positional differences exist between the two contexts. This test yielded a highly significant chi-square (see Analysis A: Table 1). The standardized residuals (*z*-scores) for each cell reflect the degree of deviation for a given SP position cell from the predicted values. Adjusted residuals were used to control for the large discrepancies in some of the marginal frequencies of the arrays. The cell for the supine position during SP generated a very large positive residual indicating that the supine SP frequency was much higher than predicted by the model based on the regular sleep onset position. In contrast, frequencies for different positions when falling asleep did not differ significantly for the SP group and the non-SP group. A chi-square test was not significant and all residuals were less than one (see Analysis B: Table 1). It is evident that the pattern of data for the sleep onset positions of the two groups are highly similar and both are markedly different from the SP pattern. There were no sex differences in sleeping positions reported and the pattern of results reported for the entire sample was replicated for men and women separately.

The hypothesis that the supine position is more common during SP than during normal sleep onset was strongly corroborated in Study 1. There was no evidence, however, that individuals who report episodes of SP were more likely to lie in the supine position during regular sleep onset than those who report never experiencing SP.

Study 2

Timing

Selections of times for SP episodes were not mutually exclusive and almost half of the respondents (47%) reported that SP occurred at more than one time period. Therefore, four timing groups were formed, three groups reporting consistent timing of SP episodes (beginning, middle, and end of sleep) and a mixed group reporting different combinations of times (see rightmost column of Table 2 for group frequencies). A chi-square analysis comparing the sizes of the three consistent groups was not significant.

Body position and timing

As in Study 1, frequencies of positions taken during regular sleep onset were used to predict position during SP at different times using a chi-square goodness-of-fit test. Separate tests were conducted for each of the consistent times (beginning, middle, and end) and for the mixed group as well. That is, for each timing group, the frequencies for each of the positions taken during regular sleep onset were used to predict positions during SP. The frequencies for the various positions were significantly different under the two conditions for all timing groups (see results of chi-square analyses for each timing group in Table 2). Row percentages rather than frequencies are presented in Table 2 to facilitate comparisons between rows as well as between tables. The standardized residuals revealed that the supine position was reported to be significantly and markedly more frequent during SP than predicted by positions at regular sleep onset for all timing groups. The residuals for the supine position are, however, significantly and substantially greater for the middle and end than for the beginning of sleep. All other positions were significantly less common during SP than during normal sleep onset, with the exception of the variable group. The variable position frequencies were equivalent for sleep onset and SP except for the mixed group in which the variable position was somewhat greater during SP than during regular sleep onset. As in Study 1, no sex differences were found in sleeping positions and the pattern of results reported for the entire sample was replicated for men and women separately.

Position when falling asleep and during sleep paralysis

A cross-tabulation of position during normal sleep and SP episodes revealed a moderate relation between the two positions, χ^2 (16, $n = 3723$) = 1098.58, $P < 0.001$, Cramer's $\varphi = 0.23$. A second comparison was made eliminating the variable position and mixed timing groups to assess the association among those reporting consistent positions for both contexts. This comparison revealed a slightly stronger association, χ^2 (9, $n = 2881$) = 843.59, $P < 0.001$, Cramer's $\varphi = 0.31$. Thus, in spite of the strong effect of supine position, respondents did tend to be more somewhat likely to report experiencing SP in their normal sleeping position than in other positions. These findings were replicated for females and males separately.

Given that the comparison context for SP position is position at the beginning of sleep, it is possible that the association between positions in the two contexts depends upon the timing of the SP episodes. In particular, it was

Table 1 Percentages of subjects reporting different positions when falling asleep and during SP (Study 1)

Group	*Position*	*Variable*	*Supine*	*Prone*	*Side*	*n*
Sleep paralysis[1]	When falling asleep	44.09	13.69	13.98	27.95	415
	During SP	17.11	58.07	7.95	16.87	
No sleep paralysis	When falling asleep	38.99	13.00	15.03	32.98	1031
Analysis A: SP position vs. regular position when falling asleep	χ^2 (3, $n = 415$) = 674.96, $P < 0.001$					
SP subjects only	Residuals[1]	−8.28	24.03	−3.28	−4.27	
Analysis B: SP subjects vs. non-SP subjects	χ^2 (3, $n = 1446$) = 4.17, $P < 0.19$					
Regular position when falling asleep	Residuals[1]	−0.74	−0.25	0.25	0.82	

[1]Standardized residuals reflect discrepancy of cell frequency for SP position from value predicted by position when falling asleep and were generated by the associated χ^2 analysis.

Table 2 Percentages of subjects reporting different positions when falling asleep and during SP at different time periods: beginning, middle, and end of sleep or mixed

					Side		
SP timing	*Position*	*Variable*	*Supine*	*Prone*	*Left*	*Right*	*n*
Beginning	When falling asleep	26.51	18.68	13.67	17.75	23.38	
	During SP	27.77	51.67	6.89	6.47	7.20	958
	Residuals[1]	0.75	23.62	−5.68	−8.28	−10.36	
	χ^2 (4, $n = 958$) = 766.54, $P < 0.001$						
Middle	When falling asleep	24.21	14.98	16.27	18.95	25.60	
	During SP	20.23	60.35	7.21	5.35	6.86	860
	Residuals[1]	−1.02	34.99	−7.65	−8.97	−11.95	
	χ^2 (4, $n = 860$) = 1552.57, $P < 0.001$						
End	When falling asleep	24.21	14.98	16.27	18.95	25.60	
	During SP	22.62	57.64	6.55	6.65	6.55	1008
	Residuals[1]	−1.02	34.99	−7.65	−8.97	−11.95	
	χ^2 (4, $n = 1008$) = 1507.50, $P < 0.001$						
Mixed	Falling asleep	28.56	15.66	15.34	17.82	22.62	
	During SP	36.09	49.02	5.00	4.64	5.25	2458
	Residuals[1]	6.98	41.79	−13.08	−15.48	−18.11	
	χ^2 (4, $n = 2458$) = 2533.98, $P < 0.001$						

[1]Standardized residuals reflect discrepancies of cell frequencies for SP position from values predicted by position when falling asleep and are based on χ^2-analyses at each time period.

expected that position during SP at the beginning of sleep would be more similar to that taken when normally falling asleep than SP positions at other times. Therefore, separate analyses were conducted on the association of the two position contexts, among those reporting consistent timing of SP episodes, for each timing period: beginning, middle or end of sleep period. As expected, the association between the two positions (during SP and when normally falling asleep) was stronger at sleep onset, χ^2 (9, $n = 534$) = 389.99, $P < 0.001$, Cramer's $\varphi = 0.42$, than in the middle of sleep period, χ^2 (9, $n = 540$) = 123.51, $P < 0.001$, Cramer's $\varphi = 0.28$, or at the end of the sleep period, χ^2 (9, $n = 604$) = 95.80, $P < 0.001$, Cramer's $\varphi = 0.23$. To test the significance of these differences and to determine the effect on the degree of consistency of the supine position at the two times, a three-way log-linear analysis was employed. Under the hypothesis that timing had no effect on the association between the two positions, a model was constructed using only the interaction of SP position and regular position to predict frequencies for each combination of positions. The test of this model yielded a significant likelihood-ratio χ^2 (32, $n = 2826$) = 70.17, $P < 0.001$. Adjusted standardized residuals revealed that the association of the supine position for SP and regular sleep onset position was higher than expected under the model of no timing effect, $z = 3.47$, when SP was consistently reported at the beginning of the sleep period, and higher than at the middle or end of sleep ($z = –2.57$ and $z = –0.89$, respectively). That is, there was a greater degree of correspondence between regular position when falling asleep and SP position when SP was reported to have occurred at the beginning than at the middle or end of the sleep period. All of these analyses generated similar results for males and females separately.

Position, timing and frequency of SP episodes

To assess the relations between frequency of SP, on the one hand, and position and timing, on the other, a 5 (position: variable, supine, prone, right and left side) × 4 (timing: beginning, middle, end, and mixed, i.e. combinations of different times) by 2 (sex) analysis of variance (ANOVA) was conducted with SP frequency as the dependent variable. Significant main effects were followed up with Bonferroni-corrected contrasts. For positional effects the contrasts of theoretical interest were among the groups reporting consistent positions. The supine group was predicted to report higher frequencies of SP than other position groups. For the timing variable the contrasts of theoretical interest were among the groups reporting consistent times. Groups reporting SP at the beginning and middle of SP were predicted to report higher SP frequencies than those reporting SP at the end of sleep.

There was significant effect of SP position, F (4, 5244) = 35.44, $P < 0.001$. Bonferroni-corrected contrasts revealed only that the variable position group reported more frequent SP episodes than all other groups. There was also a timing effect, F (3, 5244) = 46.77, $P < 0.001$. Bonferroni-corrected contrasts revealed that reported SP frequency was significantly greater for the beginning group than for the middle and end groups and greater for the mixed group than all other groups (Table 3). No other effects were significant.

Position, timing and intensity of hallucinations during SP

The relation between position and intensity of hallucinations was assessed by a series of 5 (position) × 4 (timing) × 2 (sex) analysis of covariance (ANCOVA) for each major hallucination

Table 3 Means and (SDs) for frequency of SP, intensity[1] of Intruder, Incubus, and STO hallucinations, and intensity ratings of fear at different SP times (Beginning, Middle, and End of Sleep and Mixed times group)

Timing	*SP Frequency*	*Intruder*	*Incubus*	*STO*	*Fear*	*n*
Beginning	2.90b (0.82)	2.93a (0.95)	2.48a (0.98)	2.11a (1.00)	6.02a (1.10)	958
Middle	2.60c (0.87)	2.88a (0.97)	2.49a (0.99)	1.81b (0.89)	6.02a (1.17)	860
End	2.69c (0.88)	2.58b (0.99)	2.30b (0.97)	1.80b (0.86)	5.85b (1.11)	1008
Mixed	3.08a (0.67)	3.10a (0.94)	2.59a (0.99)	2.20a (1.00)	6.13a (0.89)	2458

[1]Intensity means and SDs are adjusted residuals (*z*-score + corresponding raw intensity means) controlling for frequency of SP.
Any two means not sharing a common subscript in the same column are significantly different from one another ($P < 0.001$).

categories. Intensity scores for each of the Intruder, Incubus, and STO factors were entered as dependent variables. There were significant correlations between frequency of SP episodes and intensity of Intruder, Incubus, and STO hallucinations, *r*s (5284) = 0.27, 0.29, 0.28, respectively; therefore, the frequency of SP episodes was entered as a covariate. In cases of significant position or timing effects Bonferroni-corrected comparisons were made using the residuals of the intensity scores controlling for frequency. The Bonferroni-corrected contrasts were made on residualized intensity scores controlling for frequency of SP. The intensity means presented in Table 3 were created by adding the corresponding raw intensity means to the residuals to recalibrate the intensity scale. The theoretical contrasts of interest were the same as for the frequency of SP.

The covariate was significant in all analyses. For the Intruder hallucinations, there was a significant timing effect, F (3, 5244) = 15.22, $P < 0.001$. Follow-up Bonferroni-corrected tests revealed that the group experiencing SP at the end of sleep reported fewer Intruder hallucinations than all other groups (Table 3). No other effects involving Intruder hallucinations were significant. There was a significant timing effect for Incubus intensity, F (3, 5244) = 5.30, $P < 0.001$. The mean for the end of sleep group was smaller than for all other groups (Table 3). There was also a significant sex effect, F (2, 5244) = 13.87, $P < 0.001$. Females reported higher Incubus intensities than males ($M_{\text{residual}} = 2.57$, SD = 1.01 vs. $M_{\text{residual}} = 2.39$, SD = 0.96). For the STO hallucinations, the timing effect only was significant, F (3, 5244) = 7.25, $P < 0.001$. Follow-up Bonferroni-tests revealed that frequencies were significantly greater for the beginning and mixed group than for the middle or end groups (Table 3).

Position, timing, and intensity of affective reactions during SP

The relation between position and type of affective experience was assessed by 5 (position) × 4 (timing) × 2 (sex) ANCOVAS for frequency of fear, bliss, and erotic feelings as dependent variables. Although the frequency of hallucinations was only slightly but significantly correlated with frequency of fear, r (5284) = 0.07, bliss, r (5284) = 0.10, and erotic feelings, r (5284) = 0.11, it was nonetheless used as a covariate. Bonferroni-corrected contrasts using scores residualized and recalibrated as for hallucinations types were used to follow up significant effects and the theoretical contrasts of interest were the same as for the previous variables. The covariate was significant in all cases. For intensity of fear there were significant effects of timing, $F(3, 5244) = 7.25$, $P < 0.001$, and sex, $F(2, 5244) = 37.28$, $P < 0.001$. Bonferroni-corrected contrasts revealed that fear was significantly less intense at the end of sleep than at the beginning or middle of sleep. Females reported greater fear intensities than males ($M_{\text{residual}} = 6.09$, SD = 0.94 vs. $M_{\text{residual}} = 5.85$, SD = 1.08). There were no significant effects for bliss or erotic feelings.

DISCUSSION

The traditional belief that lying in the supine position is associated with SP was clearly corroborated in both studies. Although only a small minority of subjects in both samples (13–19%) reported normally falling asleep in the supine position, it was the most common position during SP being reported by over 50% of cases in both studies. If one considers only individuals reporting a consistent position for each context this increases to 75% for SP episodes at the middle or end of the sleep period. It was not found to be the case, however, that SP subjects are more likely to be in the supine position when normally falling asleep than non-SP subjects. Moreover, the proportions of subjects reporting normally falling asleep in different positions is consistent with those reported for lab studies. When the variable category is eliminated the proportions of 0.22, 0.21, 0.25 and 0.32 found in the present study for supine, prone, left and right side, respectively, are very close to the proportions reported for laboratory observations by Lorrain and De Koninck (1998, fig. 1). These were estimated for all groups for stages 1 and 2 (being closest to sleep onset) from the figure provided: 0.23, 0.14, 0.29 and 0.34. Lorrain and De Koninck did not find sleeping position to be associated with sleep stage and found no evidence to suggest that the supine position is more generally related to REM sleep.

It is perhaps worth asking how so many people find themselves in the supine position so frequently during SP when they do not normally attempt to sleep in that position. In general, body motility is relatively high prior to entry into REM states (De Koninck and Gagnon 1983; Hobson *et al.* 1978). One possibility is that SP often occurs when susceptible individuals inadvertently turn to the supine position as they fall asleep or, perhaps even more likely, when they change position during sleep stage transition during the night, particularly to and from REM. This latter hypothesis is consistent with the finding that the supine positions were more frequent among those consistently reporting SP at the middle or end of sleep than those reporting SP at the beginning. The same hypothesis received further corroboration in the finding that the association between position when falling asleep and SP positions, especially for the supine position, was significantly stronger for those reporting SP at the beginning than for those reporting SP at the middle or end of sleep. Thus, for those experiencing SP in the supine position to avoid episodes of SP it is, therefore, insufficient to avoid falling asleep in the supine position. Active steps to prevent turning over to the supine position during sleep would seem to be required. Perhaps the 'tennis-ball technique', sometimes recommended for obstructive sleep apnea (e.g. Berger *et al.* 1997), might prove beneficial for chronic SP subjects, at least for those who regularly experience SP in the supine position.

There were no effects of SP position on frequency of SP or intensity of hallucinations or fear. Thus, the predictions based on the Fukuda *et al.* (1998) relaxation or the TAVS hypotheses were not borne out by the position effect. The frequency of SP and the intensity of all hallucination types as well as of fear were, however, greater at the beginning of sleep than at the end of sleep. Moreover, the frequency of SP and intensity of Intruder and Incubus hallucinations as well as fear, but not STO hallucinations, were greater at the middle than at the end of sleep. The TAVS model predicted all these effects, with the exception of the greater intensity of STO hallucinations at the beginning than at the end. That is, feelings of vulnerability to threat, as might plausibly be indexed by intensity of Intruder and Incubus hallucinations and fear, were argued to be greater at the beginning and middle of sleep periods than at the end. It should be acknowledged, however, that all significant effects involving intensity of hallucinations and fear were weak and the results for STO suggest the possibility of some alternative, or additional, mechanisms. The temporal patterning of SP found in the present study appears to be quite different from that reported for conventional dreams (Antrobus 1991; Cicogna *et al.* 1998). In addition, the simultaneous environmental awareness, the presence of dream-like hallucinations, and especially the high levels of fear are difficult to explain with general cortical activation and high threshold (GCAT) models (Antrobus 1986, 1990, 1991). It is possible, however, that the processes biasing the intensity to be greater early in the sleep period were partially counteracted by the diurnal patterning of conventional dreams, which are reported to be more vivid later in the sleep period.

The finding that SP is commonly experienced during the night or in the morning might appear to be inconsistent with the laboratory observation of SP as a sleep onset phenomenon (Bassetti and Aldrich 1996; Hishikawa 1976; Takeuchi *et al.* 1992, 2001). Of course, if one wakens during the night, or in the morning, from a REM dream, it is possible to then enter SOREMP (Miyasita *et al.* 1989; Sasaki *et al.* 2000; Takeuchi *et al.* 2001), especially given the rather commodious definition of a SOREMP as occurring up to 25 min after sleep onset. Sleep paralysis episodes do seem to many respondents, however, to develop out of a dream. In a preliminary analysis of an ongoing study of concurrent individual SP episodes we found 24% of episodes to be preceded by a conventional dream. This percentage increased to 36% when SP occurred in the supine position in the middle of sleep. It is possible that, among susceptible individuals, REM sleep in the supine position can create a higher likelihood of apnea and microarousals leading to SP episodes.

A related, and not incompatible, hypothesis, is that SP is less a disorder of REM, *per se*, than of transitions in states of consciousness independent of and, hence, sometimes in the midst of, REM. It has been argued that narcolepsy involves malfunctioning state boundary control mechanisms (Broughton and Mullington 1994) leading to a dampening of circadian and ultradian rhythms with increased daytime sleepiness and nighttime arousals (Broughton *et al.* 1998). Similarly, Nishino *et al.* (2000) argue that narcolepsy involves 'a dysfunction in the maintenance of and transition between vigilance states' and that there is little support for 'the current notion that narcolepsy is a disorder of REM sleep generation' (p. 445). In particular, these authors provide evidence that, in narcoleptic dogs compared with control animals, all states studied (wake, drowsy, as well as light and deep sleep) were fragmented (high frequencies and short durations), except REM. SP may also involve a similar disruption of nocturnal sleep–wake periodicity and a failure of inhibition of REM during such transitions. These considerations provide a reasonable framework to explain the effects of timing found in the present study. On this view, SP subjects have more fragmented sleep than non-SP subjects. Indeed, Ohayon *et al.* (1999) reported that SP subjects (rated as 'severe', that is, episodes at least once a week) were more likely than non-SP subjects, to report more early morning awakenings and more disrupted sleep as well as daytime sleepiness and daytime napping.

A substantial number of people reported SP episodes to occur in more than one position. Moreover, people reporting SP in different positions and at different times also reported high frequencies of SP. The mixed timing group also reported comparatively high intensity ratings for all hallucinations types as well as for fear. It is possible that the people who experience SP in different positions and at different times simply have lower thresholds for SP.

Females also reported significantly more intense Incubus experiences and higher levels of fear than did men. Recall that the Incubus hallucinations accompanied by fear are often interpreted as assault by human or demonic intruders. SP experiences in traditional cultures are sometimes thought to be a kind of demonic rape by supernatural beings (Adler 1994). Although erotic feelings are not strongly associated with Incubus hallucinations or fear all three experiences do sometimes co-occur. When this happens the combined experience can be experienced as rape. In the present survey 37 women and five men spontaneously mentioned the term 'rape' when attempting to describe their experiences. Aside from these few sex differences all other effects held equally for females and males.

In summary, the effect of the supine position on SP was strongly corroborated in the present study and several novel effects of timing of SP during the sleep period were found. Moreover, the effects of timing on the incidence and quality SP episodes as well as on the effects of position during SP implicate several potential causal factors; including vigilance and fear mechanisms, apnea, microarousals, and circadian and ultradian sleep–wake rhythms.

REFERENCES

Adler, S. R. Ethnomedical pathogenesis and Hmong immigrants' sudden nocturnal deaths. *Cult. Med. Psychiatry*, 1994, 18: 23–59.

Albert, R. K. and Hubermayr, R. D. The prone position eliminates compression of the lungs by the heart. *Am. J. Respir. Care Med.*, 2000, 161: 1660–1665.

Anderson, J. R. Sleep, sleeping sites, and sleep-related activities: awakening to their significance. *Am. J. Primatol.*, 1998, 46: 63–75.

Antrobus, J. Dreaming: cortical activation and perceptual thresholds. *J. Mind Behav.*, 1986, 7: 193–211.

Antrobus, J. The neurocognition of sleep mentation: rapid eye movements, visual imagery and sleep mentation. In: R. R. Boozin, J. F. Kihlstrom and D. L. Schachter (Eds) *Sleep and Cognition*. American Psychological Association, Washington, DC, 1990: 3–24.

Antrobus, J. Dreaming: cognitive processes during cortical activation and high afferent thresholds. *Psychol. Rev.*, 1991, 98: 96–121.

Antrobus, J., Kondo, T. and Reinsel, R. Dreaming in the late morning: summation of REM and diurnal cortical activation. *Conscious Cogn.*, 1995, 4: 275–299.

Aschen, S. R. Restraints: Does position make a difference? *Issues Ment. Health Nurs.*, 1995, 16: 87–92.

Bassetti, C. and Aldrich, M. S. Narcolepsy. *Neurol. Clin.*, 1996, 14: 545–571.

Berger, M., Oksenberg, A., Silverberg, D. S., Arons, E., Radwan, H. and Iaina, A. Avoiding the supine position during sleep lowers 24 h blood pressure in obstructive sleep apnea (OSA) patients. *J. Hum. Hypertens.*, 1997, 11: 657–664.

Broughton, R. and Mullington, J. Chronobiological aspects of narcolepsy. *Sleep,* 1994, 17: S35–S44.

Broughton, R., Krupa, S., Boucher, B., Rivers, M. and Mullington, J. Impaired circadian waking arousal in narcolepsy-cataplexy. *Sleep Res. Online,* 1998, 1: 159–165.

Buzzi, G. and Cirignotta, F. Isolated sleep paralysis: a web survey. *Sleep Res. Online*, 2000, 3: 61–66.

Cartwright, R. D. Effect of sleep position on sleep apnea severity. *Sleep*, 1984, 7: 110–114.

Cartwright, R. D., Diaz, F. and Lloyd, S. The effects of sleep posture and sleep stage on apnea frequency. *Sleep*, 1991, 14: 351–353.

Cheyne, J. A. The ominous numinous: sensed presence and other hallucinations. *J. Conscious Stud.*, 2001, 8: 133–150.

Cheyne, J. A., Newby-Clark, I. R. and Rueffer, S. D. Sleep paralysis and associated hypnagogic and hypnopompic experiences. *J. Sleep Res.*, 1999a, 8: 313–317.

Cheyne, J. A., Rueffer, S. D. and Newby-Clark, I. R. Hypnagogic and hypnopompic hallucinations during sleep paralysis: neurological and cultural construction of the night-mare. *Conscious Cogn.*, 1999b, 8: 319–337.

Cicogna, P., Natale, V., Occhionero, M. and Bosinelli, A. A comparison of mental activity during sleep onset and morning awakening. *Sleep*, 1998, 21: 462–470.

Cowlishaw, G. Vulnerability to predation in baboon populations. *Behav.*, 1994, 131: 293–304.

De Koninck, J. and Gagnon, P. Sleep positions in young adults and their relationship to the subjective quality of sleep. *Sleep*, 1983, 6: 52–56.

Folkard, S., Condon, R. and Herbert, M. Night shift paralysis. *Experientia*, 40: 510–512.

Fukuda, K., Miyasita, A., Inugami, M. and Ishihara, K. High prevalence of isolated sleep paralysis. *Sleep*, 1987, 10: 279–286.

Fukuda, K., Ogilvie, R. D., Chilcott, L., Vendittelli, A.-M. and Takeuchi, T. The prevalence of sleep paralysis among Canadian and Japanese college students. *Dreaming*, 1998, 8: 59–66.

Fukuda, K., Ogilvie, R. D. and Takeuchi, T. Recognition of sleep paralysis among normal adults in Canada and in Japan. *Psychiatry Clin. Neurosci.*, 2000, 54: 292–293.

Gallup, G. G. *Jr* and Maser, J. D. Catatonia:tonic immobility: evolutionary underpinnings of human catalepsy and catatonia. In: J. D. Maser and M. E. P. Seligman (Eds) *Psychopathology: Experimental Models*. W.H. Freeman, San Francisco, CA, 1977: 334–357.

Gallup, G. G. Jr and Rager, D. R. Tonic immobility as a model of extreme stress of behavioral inhibition: issues of methodology and measurement. In: P. R. Sanberg, K. P. Ossenkopp and M. Kavaliers (Eds) *Motor Activity and Movement Disorders: Research Issues and Applications*. Humana Press, Totowa, NJ, 1996: 57–80.

George, C. F., Millar, T. W. and Kryger, M. H. Sleep apnea and body position during sleep. *Sleep*, 1988, 11: 90–99.

Hamilton, W. J. Baboon sleeping site preferences and relationships to primate grouping patterns. *Am. J. Primatol.*, 1982, 3: 41–53.

Hennig, C. W. and Dunlap, W. P. Circadian rhythms of tonic immobility in the rat: evidence of an endogenous mechanism. *Anim. Learn. Behav.*, 1977, 5: 253–258.

Hill, W. T., Fleming, T. M. and Shrier, E. M. Tonic immobility and high-intensity calls in a precocial chick as a function of age, diet, and time of day. *Dev. Psychobiol.*, 1994, 27: 331–342.

Hishikawa, Y. Sleep paralysis. In: C. Guilleminault, W. C. Dement and P. Passouant (Eds) *Advances in Sleep Research*, Vol. 3. Spectrum, New York, 1976: 97–124.

Hishikawa, Y. and Shimizu, T. Physiology of REM sleep, cataplexy and sleep paralysis. In: S. Fahn, M. Hallett, H. O. Lüders and C. D. Marsden (Eds) *Advances in Neurology*, Vol. 67. Lippencott-Raven, Philadelphia, 1995: 245–271.

Hiyama, S., Ono, T., Ishiwata, Y. and Kuroda, T. Supine cephalometric study on sleep-related changes in normal subjects. *Sleep*, 2000, 23: 783–790.

Hobson, J. A., Spagna, T. and Malenka, R. Ethology of sleep with time-lapse photography: postural immobility and sleep cycle phase in man. *Science*, 1978, 201: 1251–1253.

Hufford, D. J. *The Terror that Comes in the Night*. University of Pennsylvania Press, Philadelphia, 1982.

Jones, E. M. (1931) *On the Nightmare*. Hogarth Press, London (originally published in 1911).

Kondo, T., Antrobus, J. and Fein, G. Later REM activation and sleep mentation. *Sleep Res.*, 1989, 18: 147.

Lorrain, D. and De Koninck, J. Sleep position and sleep stages: evidence of their independence. *Sleep*, 1998, 21: 335–340.

Marks, I. M. *Fears, Phobias and Rituals: Panic, Anxiety, and their Disorders*. Oxford University Press, London, 1987.

Merritt, J. M., Stickgold, R., Pace-Schott, E., Williams, J. and Hobson, J. A. Emotion profiles in dreams of men and women. *Conscious Cogn.*, 1994, 3: 46–60.

Miyasita, A., Fukuda, K. and Inugami, M. Effects of sleep interruption on REM–MREM cycle in nocturnal human sleep. *Electroencephalogr. Clin. Neurophysiol.*, 1989, 73: 107–116.

Natelson, B. H., Ottenweller, J. E., Cook, J. A. and Pitman, D. L. Effect of stressor intensity on habituation of the adrenocortical stress system. *Physiol. Behav.*, 1989, 43: 41–46.

Nishino, S., Riehl, J., Hong, J., Kwan, M., Reid, M. and Mignot, E. Is narcolepsy a REM sleep disorder? Analysis of sleep abnormalities in narcoleptic Dobermans. *Neurosci. Res.*, 2000, 38: 437–446.

Ohayon, M. M., Priest, R. G., Caulet, M. and Guilleminault, C. Hypnagogic and hypnopompic hallucinations: pathological phenomena? *Br. J. Psychiatry*, 1996, 169: 459–467.

Ohayon, M. M., Zulley, Guilleminault, C. and Smirne, S. Prevalence and pathological associations of sleep paralysis in the general population. *Neurol.*, 1999, 52: 1194–1200.

Penzel, T., Möller, M., Becker, H. F., Knaack, L. and Peter, J.-H. Effect of sleep position and sleep stage on the collapsibility of the upper airways in patients with sleep apnea. *Sleep*, 2001, 24: 90–95.

Pevernagie, D. A. and Shepard, J. W. Relations between sleep stage, posture and effective nasal CPAP levels in OSA. *Sleep*, 1992, 15: 162–167.

Ratner, S. C. Comparative aspects of hypnosis. In: J. E. Gordon (Ed) *Handbook of Clinical and Experimental Hypnosis*. The Macmillan Company, New York, 1967: 550–587.

Sasaki, Y., Fukuda, K., Takeuchi, T., Inugami, M. and Miyasita, A. Sleep onset REM period appearance rate is affected by REM propensity in circadian rhythm in normal nocturnal sleep. *Clin. Neurophysiol.*, 2000, 111: 428–433.

Schredl, M. and Doll, E. Emotions in diary dreams. *Conscious Cogn.*, 1998, 7: 634–646.

Spanos, N. P., McNulty, S. A., DuBreuil, S. C., Pires, M. and Burgess, M. F. The frequency and correlates of sleep paralysis in a University sample. *J. Res. Pers.*, 1995, 29: 285–305.

Stahlbaum, C. C., Rovee-Collier, C., Fagen, J. W. and Collier, G. Twilight activity and antipredator behaviour of young fowl housed in artificial or natural light. *Physiol. Behav.*, 1986, 36: 751–758.

Strauch, I. and Meier, B. *In Search of Dreams: Results of Experimental Dream Research*. State University of New York Press, Albany, NY, 1996.

Takeuchi, T., Miyasita, A., Sasaki, Y., Inugami, M. and Fukuda, K. Isolated sleep paralysis elicited by sleep interruptions. *Sleep*, 1992, 15: 217–225.

Takeuchi, T., Fukuda, K., Sasaki, Y., Inugami, M. and Murphy, T. I. Factors related to the occurrence of isolated sleep paralysis elicited during a multi-phasic sleep–wake schedule. *Sleep*, 2001, 25: 89–96.

Ternes, J. W. Circadian susceptibility to animal hypnosis. *Psychol. Rec.*, 1977, 1: 15–19.

Togari, H., Kato, I., Saito, N. and Yamaguchi, N. The healthy human infant tends to sleep in the prone rather than the supine position. *Early Hum. Dev.*, 2000, 59: 151–158.