The Mind in REM Sleep: Reports of Emotional Experience

Roar Fosse DSci,[1,2] Robert Stickgold PhD,[2] and J. Allan Hobson MD[2]

[1]Institute of Psychology, University in Oslo, Oslo; [2]Laboratory of Neurophysiology, Harvard Medical School, Boston

Study Objectives: No consensus has been reached on the characteristics of emotional experience during rapid eye movement sleep (REM). Thus, the relationship between the emotional brain activation and mental activity in REM remains unclear. Our objective is to characterize emotional experience in REM in order to facilitate understanding of brain-mind correlations in this state.

Design: We combined instrumental awakenings from REM with the subjects' own ratings of the occurrence and intensity of discrete emotion types for each line in their REM mentation reports.

Setting: The study was performed in the subjects' own homes over three consecutive nights using ambulatory polysomnography.

Participants: Nine normal healthy subjects, age 31—60 (mean=43.0).

Interventions: Awakenings 5-15 minutes into REM periods across the night.

Measurements and Results: Emotions were found in 74% of 88 mentation reports, with a balanced proportion of positive and negative emotions. Among the reports scored for emotions, 14% contained one emotion and 86% contained two or more different emotion types. Joy/elation was the most frequent emotion, found in 36% of the reports, followed by surprise (24%), anger (17%), anxiety/fear (11%), and sadness (10%). Anxiety/fear was significantly less intense than joy/elation, anger, and surprise. Except for surprise, no specific emotion type changed from the first to the second half of the night. Negative emotions and surprise but not positive emotions varied significantly across subjects.

Conclusions: The analysis of subject reports of emotions following instrumental awakenings demonstrate a balanced and widespread occurrence of both positive and negative emotions in REM sleep dreams. Emotions in REM are likely to be powerfully modulated by the neurobiological processes which differentiate REM from waking.

INTRODUCTION

EMOTIONS HAVE OFTEN BEEN ASSIGNED A CENTRAL ROLE NOT ONLY FOR OUR WAKING LIFE BUT ALSO FOR MENTAL ACTIVITY DURING SLEEP.[1-3] Recently, positron emission tomography (PET) studies have indicated that anterior limbic structures that undoubtedly are involved in emotion during waking,[4] are particularly active during REM,[5-9] the sleep stage in which hallucinatory mental activity reaches its peak. In sharp contrast to theoretical writings and neuroimaging findings, not much controlled empirical evidence exists regarding the emotional experience that accompanies mental activity in any sleep stage. The goal of this paper is to contribute new data on emotional experience during REM that can aid future attempts at integrating the psychology with the neurobiology of emotion in this sleep stage.

It has proven difficult to develop an agreement on the characteristics of emotion in REM. While some researchers view REM mentation as characteristically mundane, undramatic, and even devoid of strong emotional experience,[10,11] others consider REM mentation to be hyperemotional.[2,3,12] Moreover, some researchers have found negative emotions to outweigh positive ones,[3,11] while others have reported a balanced proportion[13] or even a preponderance of positive emotions (for a recent review see[14]).

This large variation in description is likely to reflect methodological differences between the studies. First, when external judges have scored the dream reports, emotions have been strongly underestimated compared to subjects' own ratings.[3] External raters tend to underestimate the occurrence of positive emotions in particular.[14] Second, when subjects are allowed some freedom of choice as to which dreams to report, such as in some spontaneous home recall studies, the resulting reports can constitute a strikingly biased subset, including the most emotional dreams, particularly those accompanied by anxiety and fear.[15] There is also some debate as to whether the typical laboratory environment biases emotions,[15-17] and factors such as the presleep state of mind, psychiatric symptoms, time of night, time in REM sleep, sex, and age may influence the characteristics of emotional experience.[3,14,18-25] Based upon these considerations, two fundamental requirements for studying the normative distribution of emotion in sleep appear to be to use instrumental awakenings and have the subjects themselves score each segment of their report for the presence of emotions.

We implemented these design elements to study emotions in the REM sleep of nine healthy persons sleeping in their homes and monitored by ambulatory polysomnography. Our aim was to determine the (report) prevalence and the intensity of emotions in normative REM sleep. Subjects were awakened by the experimenter 5 to 15 minutes into REM periods across the night. Upon awakening, the subjects wrote down any mentation recalled from the pre-awakening period. For each line in the report scheme, they noted the occurrence and intensity of any of the following emotions: anxiety/fear, anger, joy/elation, shame, sadness, surprise, and love/eroticism, in addition to any other emotions, identified in the "other" column of the report form.

METHODS

The details of the study from which the present data are drawn

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Address correspondence to: Roar Fosse, Laboratory of Neurophysiology, Department of Psychiatry, Harvard Medical School, Massachusetts Mental Health Center, 74 Fenwood Road, Boston, MA 02115; Tel: 617-626-9473; Fax: 617-734-7851; E-mail: roar.fosse@psykologi.uio.no

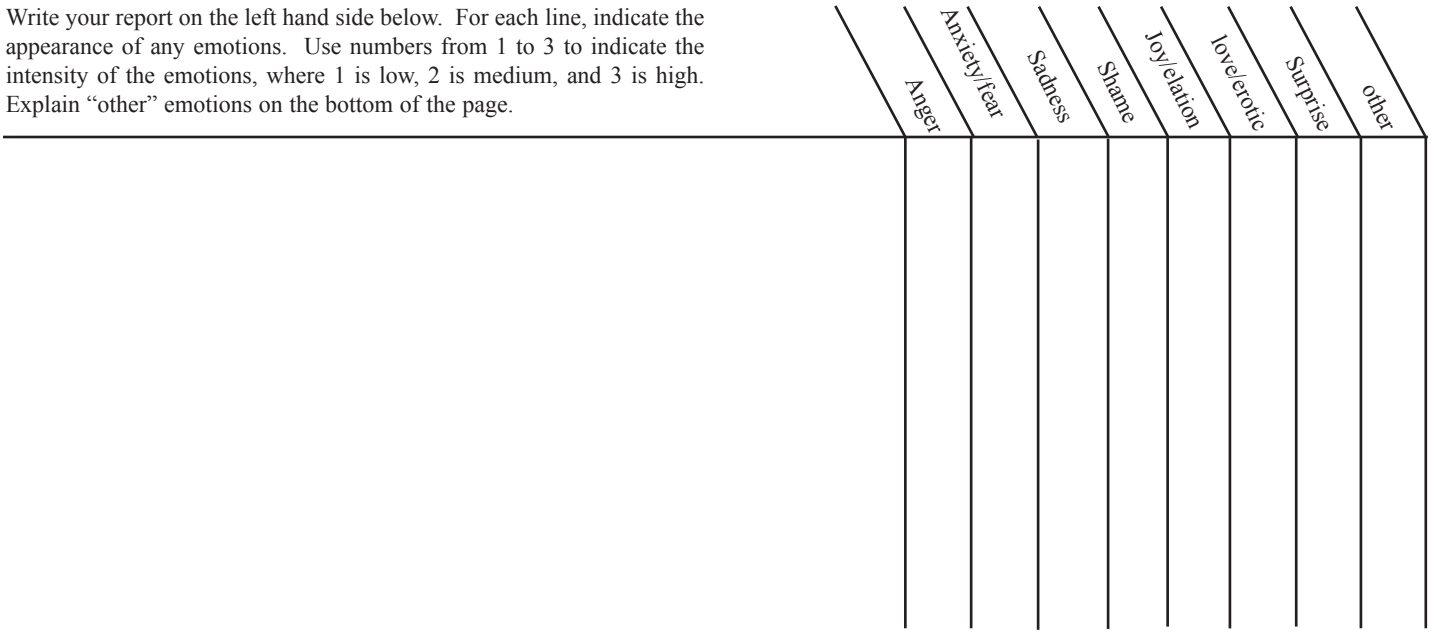

Figure 1—Emotion scoring sheet

have been described elsewhere.[26] In brief, nine healthy participants, seven women and two men, ages 31—60 years (mean 43.0, SD=8.7) were included in the study after providing informed consent. The subjects were either psychology students, physical or mental health care providers, or teachers and were all living in Oslo, Norway. No subjects were suffering from any neurological or psychiatric disorders or regularly used any medication.

Sleep stages were identified using Rechtschaffen and Kales'[27] criteria for sleep stage scoring. Six channels on an Oxford Medilog ambulatory system (9000) were used, two for EOG, two for EEG, and two for EMG. The signals from these channels were stored on cassette tape and simultaneously displayed on a portable Toshiba 3200 SXC personal computer. The participants slept in their own beds in their own home, with the experimenter situated in a room adjoining the bedroom.

Awakenings from sleep were based upon visual inspection of the polysomnographic readings and were performed through a two-way intercom system. All awakenings were performed from 5 to 15 minutes into REM throughout the night for three consecutive nights. Three to six awakenings were performed per night. From a total of 98 awakenings in the nine subjects, 88 reports (89%) included descriptions of prior mentation, and form the basis of this investigation. The mean time spent in REM sleep prior to these reports was 8.8 min (SD=1.6 min).

Scoring of Emotions

Eight columns along the right-hand side of the report form were used to indicate any experience of the following emotions or groups of emotions (derived from ref. [3]); anger, anxiety/fear, sadness, shame, joy/elation, love/eroticism, surprise, and "other" emotions (Fig. 1). For the "other" category, subjects described the type of emotion at the bottom of the form. The intensity of emotions was indicated by using the numbers 1 (low), 2 (medium), and 3 (high). No attempt was made to distinguish between emotions and moods; the subjects were instructed to register any experience of emotions, regardless of its duration, degree of relatedness to dream elements, its specificity vs. diffuse character, etc. Report forms and reports were written in Norwegian.

Statistical Analysis

In the initial analysis, we calculated average report scores for each measure and subject, and submitted these scores to paired t-tests. In cases where the mentation report was the natural unit of analysis or in order to control for type II errors, we supplemented these analyses with t-tests or ANOVAs using mentation report as the unit of analysis. All levels of significance refer to two-tailed confidence intervals. The analyses were performed in StatView for the Macintosh computer.

RESULTS

One hundred and fifty-seven instances of emotion were identified in 65 of the 88 REM reports (74%). Individual subjects reported emotion in from 60% to 100% of their reports, with a mean across subjects of 76% of reports. Forty-eight percent of the reports, or 65% of those containing emotions, contained two or more different emotions, and 16% (21% of reports with emotions) contained at least three different emotions. Examples of segments of reports with emotions are given in Table 1.

Below, we analyze the 157 instances of emotion with respect to 1) the prevalence of positive and negative emotions in general as well as of discrete emotion types, 2) emotion intensity, 3) inter-subject differences, and 4) the total sleep time prior to reporting.

Positive and Negative Emotion

In comparing positive (PE) and negative (NE) emotion, instances of joy/elation, love/erotic, and "other" positive emotions (e.g., "interest" and "motivation") were defined as PE, while anxiety/fear, anger, sadness, shame, and "other" negative

Table 1—Examples of emotions in REM

	REM dream element	Emotion type and intensity (1—3)
1	Our national anthem is played on the radio, but it has been changed! I am surprised and ask if it is really the case.	Surprise 3
2	I needed to find out something and needed a specific book. The yellow book in Christianity that the pupils were using before Christmas. I was struggling a lot to find it and felt in despair	Stress1, despair 1
3	I was talking with three girls from my study . . . A blond girl told me that she had obtained a very good grade on her thesis, a grade that was far beyond anything she had ever got before, a gigantic leap. Some people had been surprised and so was I.	Anxiety/fear 1, joy/elation 1, surprise 1
4	I was in two strange rooms. . . Cars were driving along in a steady tempo. . .They appeared as a stream, and the cars and people were falling down from the first to the second room. It appeared almost to be like play.	Joy/elation 2
5	I was in a shop—a souvenir shop—to buy stuff. . . Suddenly two persons were quarrelling and they both had guns.	Anxiety/fear 2
6	I imagined or read a poem. It was a very sad poem, written by a contemporary poet . . . I felt I had tears in my eyes. The poem was written down on the page of a newspaper, in the left hand corner. The poem itself was a dialogue that the poet had with another poet. These two persons had a bet going about who would die last.	Sadness 3

Table 2—Prevalence and intensity of discrete emotion types in REM

Emotion type	Prevalence (% of reports)	Intensity[2]
Anxiety/fear	11%	1.3
Anger	17%	2.1
Joy/elation	36%	1.8
Surprise	24%	2.1
Sadness	10%	1.9
Love/eroticism	7%	2.3
Shame	6%	1.8
Other categories1:		
Stress/despair	10%	
Frustration/irritation	4%	
Interest/motivation	4%	
Other positive emotions	6%	
Other negative emotions	6%	

[1]The "stress-despair" category included disappointment, indecisiveness, discomfort, and hopelessness, in addition to stress and despair. The "Other positive emotions" category included calmness, relief, pride, and sensibility. The "Other negative emotions" category included boredom and jealousy.
[2]Entries represent the average intensity score per report for each emotion, including only those reports that contained the respective emotion. Intensity scores: 1 = low, 2 = medium, and 3 = high.

emotions, including all instances in the stress-despair and frustration-irritation subcategories (see legend, Table 2) were categorized as NE's. Surprise was considered to be neutral and was not included in either category. When thus sorted, 52 (33%) of the 157 instances of emotion were positive, 69 (44%) were negative, and 36 (23%) were neutral. However, PE's were found in 49% of the reports and NE's in only 42%. This difference between incidence and report prevalence reflected the fact that when occurring in a report, NE's showed a higher average frequency than did PE's (1.73 vs. 1.25). The difference between the PE's and NE's was not significant either on an overall incidence basis (binomial test, assuming equal probability for PE and NE, n=121, p=.14), a per-report basis (paired sample t-test, T(87)=1.2, p=.23), or a per-subject basis (t(8)=1.5, p=.16).

We then calculated and compared the total level of positive (TPE) and negative (TNE) emotions in each report. TPE and TNE were calculated as the sum of the highest intensity score for each discrete positive and negative emotion, respectively, in the report. For example, a report with a score of 2 for joy/elation, 1 for anxiety/fear, and 3 for anger would be given a TPE of 2 and a TNE of 4. Again, the average TPE and TNE did not differ significantly either when tested on a per-subject basis using average report scores (paired sample t-test, T(1, 8)=1.3, p=.25) or on a per-report basis (paired sample t-test, T(1, 87)=.96, p=.34). Moreover, about half the subjects had higher TPE's than TNE's (n=5) and half had higher TNE's (n=4). Thus, positive and negative emotions occurred in a balanced fashion in this data set.

Table 3—Subject percentages for emotions

	Joy/elation	Surprise	Anger	Anxiety/fear	Positive emotion	Negative emotion
Subject 1: n=12[1]	42%[2]	42%	8%	8%	42%	33%
Subject 2: n=13	31%	8%	31%	0	46%	69%
Subject 3: n=15	27%	13%	7%	20%	53%	33%
Subject 4: n= 7	58%	0	0	0	86%	14%
Subject 5: n=13	46%	23%	8%	8%	46%	31%
Subject 6: n=10	30%	20%	30%	20%	50%	70%
Subject 7: n= 8	38%	75%	13%	0	38%	13%
Subject 8: n= 5	40%	20%	60%	20%	60%	80%
Subject 9: n= 5	20%	20%	20%	40%	20%	40%
Average subject percentages	**37%**	**25%**	**20%**	**13%**	**49%**	**43%**

[1]Number of reports with remembered content for each subject.
[2]Percentage of reports for the subject containing the respective emotion or emotion category.

Prevalence of Discrete Emotions

As can be seen in Table 2, joy/elation was the most prevalent discrete emotion, found in 36% of the reports. The second most prevalent emotion type was surprise (24% of reports), followed by anger (17%), anxiety/fear (11%), and sadness (10%). In 27 reports (31%) the "other" category was used, together reflecting 16 additional emotions (see Table 2). None of these "other" emotions was found in more than three reports.

Most subjects reported at least one incidence of each of the four most prevalent emotions, joy/elation, surprise, anger, and anxiety/fear (Table 3). The difference in the occurrence of these emotion types could thus be tested using the average report prevalence for each subject in paired sample t-tests. These tests confirmed that joy/elation occurred significantly more often than anxiety/fear ($T(8)=3.2$, $p=.013$), and showed a strong trend towards increased prevalence compared to anger ($T(8)=2.1$, $p = .066$). When the tests were carried out on a per-report basis in order to control for a type II statistical error, surprise was also found to be more prevalent than anxiety/fear (independent sample t-test, $T(87)=2.5$, $p=.016$).

When grouping all instances of frustration and irritation into the anger category and all instances from the stress-despair subcategory (see Table 2) into the anxiety/fear category, joy/elation (average subject prevalence of 37%) was still more prevalent than the extended anxiety/fear category (18%, $T(1, 8)=2.6$, $p=.034$), with a similar tendency when compared to the extended anger category (21%, $T(1, 8)=1.9$, $p=.093$). When these analyses were repeated on a per report basis, joy/elation (report prevalence of 36%) scored significantly higher than both of the extended categories (anger extended, 18%; anxiety/fear extended, 17%, paired sample t-test, $T(1, 87)=2.9$, $p=.007$ for both comparisons).

Intensity of Emotions

The emotional intensity of a report was defined as the highest intensity score given to any emotion in the report. While 26% of the reports had no emotions (intensity score of zero), 18% had an intensity score of 1 (low), 28% a score of 2 (medium), and 28% of 3 (high). Thus, about half the reports were given an emotional intensity score of medium or higher.

We next compared the intensity of the four most frequent emotions; joy/elation, surprise, anger, and anxiety/fear. For each report, if an emotion was scored more than once, the highest intensity score for that emotion was used. Since some of these four emotions occurred with relatively low frequencies, differences in intensity level were tested on a per-report basis. However, it is noteworthy that even when tested on a per-subject basis in a paired t-test, anxiety/fear was found to be less intense than both joy/elation ($T(5)=3.2$, $p=.025$) and anger ($T(4)=3.7$, $p=.022$).

On a per-report basis, significant overall differences were found in the intensity levels of joy/elation, surprise, anger, and anxiety/fear (one way ANOVA, $F(3, 74)=5.6$, $p=.0016$; Table 2). Post-hoc Fisher PLSD tests showed anxiety/fear to be less intense than each of the other emotions (joy/elation, $p=.045$; surprise, $p=.0004$; anger, $p=.0022$). The average intensity score for anxiety/fear (1.3 per report) was one standard deviation below the mean of the average intensity scores for joy/elation, anger, and surprise (2.1, SD=0.7) combined. Thus, anxiety/fear appeared to be not only less frequent than these other emotions, but also less intense when it occurred. Finally, joy/elation was found to be less intense than surprise ($p=.018$) and tended to be less intense than anger ($p=.079$), which contrasted with the primacy of joy/elation with respect to prevalence.

Inter-subject Differences

We tested whether the total scores for positive emotions (TPE), negative emotions (TNE), and surprise were stable across subjects or whether significant inter-subject differences existed.

Significant inter-subject differences were found for TNE (one way ANOVA, $F(8, 79)=2.1$, $p=.042$; Fig. 2) and surprise ($F(8, 79)=4.8$, $p < .0001$). In contrast, no comparable variation was found for TPE ($F(8, 79)=0.6$, $p=.76$), in line with the finding that at least 20% of the reports for each subject contained joy/elation (see Table 1). But it is noteworthy that TPE's differed nine-fold between the subjects with highest and lowest scores (Fig. 2). These findings indicate that positive emotions are typical of most subjects, but that both negative emotions and surprise are more typical of some but less so for other subjects.

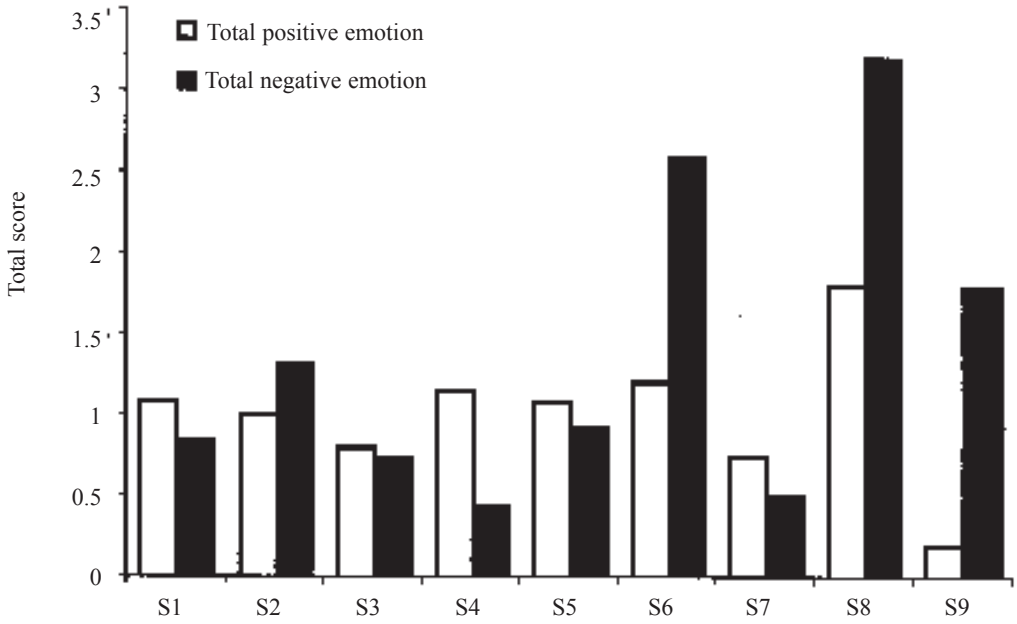

Figure 2—Entries are mean report scores for each subject, calculated on basis of the sum of the highest intensity score for each positive and negative emotion, respectively, in each report.

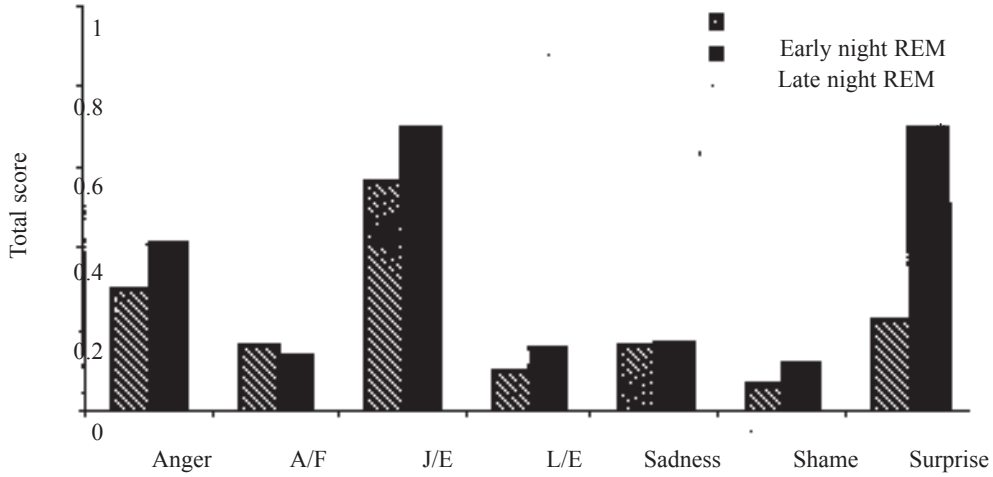

Figure 3—Abbreviations: A/F – anxiety/fear; J/E – joy/elation; L/E – love/eroticism. Entries are average report scores (0—3 per report for each emotion). The tests of changes from early to late night REM were performed on the subject averages. *p=.006.

Emotion and Sleep Time Since Sleep Onset

Since other features of mental activity have been found to increase within REM across successive NREM-REM cycles of the night,[26,28,29] an increase was also predicted for emotion. The relation to time spent in sleep was analyzed for each of the seven probed emotions and for TPE and TNE. For each discrete emotion, the maximum intensity score in each report was used. Analyses were based on average report scores per subject and were calculated for the first half of the night (less than four hours after sleep onset) and the second half of the night (more than four hours). This yielded 30 reports from early night REM and 58 from late-night REM, with all subjects having entries in both conditions. The time spent in REM before awakening averaged 8.3 min and 9.1 min for the for the early and late night conditions, respectively.

For surprise, a significant increase was found from the first to the second half of the night (13% vs. 29% of reports; paired sample t-test, $t(8)=3.71$, $p=.006$). In contrast to surprise, no significant change across the night was found in either direction for any of the other emotions ($p>.25$; Fig. 3). This was even true when the analysis were repeated on a per-report basis ($p>.3$).

In addition, no significant change was found across the night

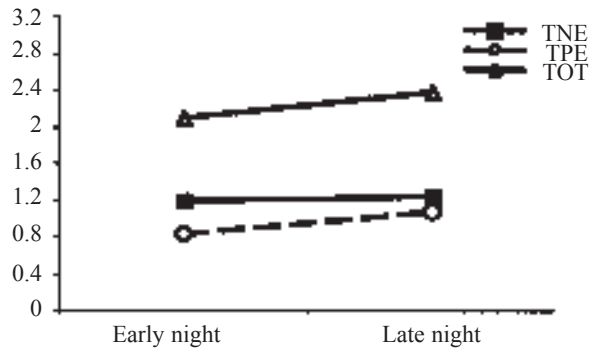

Figure 4—Abbreviations: TNE, total negative emotions; TPE, total positive emotions; Tot, total emotions except surprise. Entries in the figure are the mean of the average report scores per subject.

for either TPE (paired sample t-test, t(1, 8)=1.5, p=.18) or TNE (T(1, 8)=.78, p=.46). When combining TNE and TPE scores and all scores for neutral emotions (except surprise) to obtain the total emotion score for each report, we again found no change across the night (T(1, 8)=.23, p=.83; Fig. 4). This pattern persisted even when the analyses were carried out on a per report basis to control for a type II error (unpaired t-tests, TPE: t(86)=.89, p=.38); TNE: (T(86)=.097, p=.92; total emotion score: (T(86)=.51, p=.61). Thus, only surprise showed an overall change from early to late night REM.

DISCUSSION

The Characteristics of Emotion in REM: Comparison with Previous Studies

The overall prevalence of emotions found here is consistent with that reported in the few previous studies that combined instrumental awakenings with first-person ratings. In the only such previous study where the occurrence of discrete emotion types was reported, emotion was found in 72.5% of 500 REM reports from 44 subjects,[13] which is nearly identical to the 74% in the present study. These prevalence rates exceed the 50% to 66% reported in instrumental awakening studies where discrete emotion types were not probed, but that instead merely probed for the presence or absence of emotion.[18,23,30-32] This difference in prevalence rates is likely to reflect the difference in strength of the emotion probes.

The highest prevalence rate reported for emotion in dreams is the 95% presented by Merritt et al.[3] This study was based on a class exercise where students obtained 10 dream reports from spontaneous awakenings in their home over three weeks, each dream required to count at least 50 words, and where the subjects had been instructed to score these reports for emotions. As argued below, this type of spontaneous home recall design is likely to sample selectively the most dramatic and emotionally intense dreams, neglecting or missing reports of less salient emotions.[15] In addition, since the underlying sleep stage was not identified, many of the reports in this study could have resulted from states other than REM where emotions might tend to be different, such as a dissociated or mixed sleep-wake state. Most importantly, the findings of Merritt et al. almost certainly represent an overestimation of emotion in normative REM.

The present findings give no indication that REM mentation is dominated by negative emotion, in particular not by anxiety and fear. Consistent with previous studies that combined first person ratings with instrumental awakenings from REM, there was no dominance of negative over positive emotions, but instead a relatively balanced proportion.[13,18,23] Furthermore, we found joy/elation to be the most frequent emotion, occurring significantly more often than either anger or anxiety/fear, the two most frequent negative emotions. This ranking is consistent with the findings from Strauch and Meier's extensive laboratory study,[13] although these researchers found a lower prevalence rate for each of our probed emotions, including joy/elation (12.0% versus our 36%), anger (8.9% vs. 17%), anxiety/fear (8.5% vs. 11%), and surprise (3.9% vs. 24%). These differences in report prevalence may reflect the stronger probe of emotion used in the present study. While we had subjects rate each line of their written mentation reports for the occurrence and intensity of a given set of emotions, Strauch and Meier merely asked their subjects to characterize the overall emotional tone of their mental activity.

One likely reason for the dominance of negative emotions, in particular anxiety and fear, over positive emotions reported from spontaneous home recall studies[3,11] is a biased selection of mental activity. Foulkes[15] has demonstrated the importance of applying a strict sampling protocol when studying emotions in sleep. In one study, Foulkes[15] compared spontaneously reported home dreams to those elicited after controlled laboratory awakenings from REM and found that the spontaneous dreams constituted an extremely biased subset of the most dramatic and emotionally unpleasant dreams (see also ref. [10]). Prior to this, Foulkes had demonstrated that there were no similar differences between home and laboratory dreams when the same protocol was used.[33] He went on to demonstrate a recall bias within the laboratory setting when the reporting was delayed: Having first obtained reports from successive REM periods across the night, the subjects were asked in the morning to report all dreams they could remember from that night. This gave a selective recall of the most dramatic and emotionally intense dreams, in particular those containing anxiety. These findings parallel the well-known fact for waking cognition that vividness and emotionality are strong determinants of subsequent recall (e.g., [34]). Thus, when one departs from a strict sampling protocol of REM mentation, the resulting mentation reports become increasingly biased towards including the most emotional and otherwise salient dreams.

Although methodological factors can account for the varied prevalence rates of REM emotions across different studies, it should be cautioned that the current results may reflect features specific for the group of subjects that were studied. Methodologically valid studies of people from different cultures and from different subgroups within the same culture (e.g., young university undergraduates versus healthy middle aged people) are crucial to determine not only the normative character of REM emotion but also the mechanisms underlying the emotions.

Future studies on the influence on emotion of factors other than those targeted here should rely upon instrumental awakenings from REM and the subjects' own rating of each segment of their mental activity for emotion. From a neurocognitive point of

view, one factor that is of particular interest is the amount of time spent in REM before awakening. Since cognitive measures such as mentation report length[20,35] and dream intensity[36] and a physiological measure such as ponto-geniculate-occipital spikes in cats[37] vary with time spent in REM, it is possible that emotion may vary as well.

Variation in Emotion across the Night and between Subjects

The stability in positive and negative emotions across the night is surprising, since most other mentation features, such as mentation report length, visual vividness, and bizarreness all increase markedly in REM as the night progresses.[20,26,28,29,31] Instead, the stable rates of positive and negative emotion parallels the relatively constant low level of internal deliberation (directed thinking) seen in REM across the night.[29] In contrast, the increase seen in surprise across the night is similar to the increases seen in most aspects of the reports. Specifically, the increase in surprise in the present data set was paralleled by an increase in bizarreness,[26] and bizarreness and emotion have been reported to covary in dreams.[3] These findings could mean that different subsets of emotions are differentially related to and variously dependent on aspects of the hallucinated scenario on the one hand, and the dreamer's ability to think and reflect, on the other, possibly in combination with the intensity of the REM period itself, which presumably also contributes to controlling the variability of these other cognitive features.

The finding that the level of both negative emotions and surprise varied significantly across the nine subjects cannot be explained by our data. Of relevance is the observation that a negative pre-sleep state of mind can influence emotions in REM sleep at least early in the night. In a group of subjects with depression, Cartwright et al.[18] found that mental activity in early (but not late) night REM periods was more negatively toned than in controls. Similarly, in normal healthy subjects, disturbing films have been reported to influence emotional experience in the first REM periods of the night.[19] Although our data did not permit selective tests of inter-subject differences for early and late night REM periods, these findings suggest that a different pre-sleep state of mind could have been one factor that contributed to the variation between the subjects in negative emotions.

But many other factors, including differing perceptions of emotions, personality type, and constitution need to be considered. Systematic studies of individual differences are needed to resolve this issue. Utilizing new techniques, it is now possible to conduct large scale field studies of emotion in REM and other states of the brain/mind.[20, 38]

Integrating the Psychology and Neurobiology of Emotion in REM

Considered together with findings from cognitive neuroscience and neurobiology, the heterogeneity and variation across subjects in emotional experience in REM indicate that the production of emotion in this state is complex, mediated by subcortical and cortical brain regions as well as neuromodulatory systems controlled by the brainstem.

The neuromodulatory systems that are most strongly altered in REM are all known to play a central role in emotions such as anxiety and fear in waking. While both serotonin and norepinephrine have anxiety promoting properties,[39,40] recent findings suggest that acetylcholine has an anxiolytic effect.[41-43] The strong aminergic withdrawal and the enhanced cholinergic activity in REM[17] should thus act to constrain anxiety and fear, which fits well with our psychological data.

Since the amygdala has been found to be associated with anxiety and fear in waking,[44,45] its marked engagement in REM,[5-9,46-49] could be speculated to specifically facilitate these emotions. However, recent findings from waking studies indicate that the amygdala neither gives rise to anxiety and fear selectively nor directly supports the experience of emotions in general.[50-52] Whalen[51] has argued that although the amygdala clearly tends to respond to stimuli that predict threat, a more general role is to modulate the organism's overall state of vigilance, and, in the face of ambiguous stimuli, to potentiate higher order cortical structures for subsequent information processing.

Maquet[46,53] has pointed out that the frontal and temporal cortical regions activated in REM are those that receive afferents from the amygdala while those not being activated do not receive such input. The activated regions include Broadman areas 24 and 32 in the anterior cingulate, caudal orbitofrontal regions, medial prefrontal area 10, the insula, and the entorhinal and parahippocampal cortices.[5-9] Taken together, these regions are usually held to comprise central components of the highest order control system for emotion.[54-56] Thus the brain seems to be predisposed during REM sleep towards complex emotional functioning.

How these and other components combine to produce the phenomenon of REM dream emotions, or even of waking emotions, is not yet clear. But it is, in our opinion, abundantly clear that the shifts in brain activity seen in REM would powerfully modulate emotion.

Summary and Conclusions

Our results are generally in line with findings from the few previous studies that combined instrumental REM awakenings with first person ratings of emotions. In contrast, the data from studies where third person ratings and spontaneous (and intermittent) reporting have been used, are not representative for normative emotional experience in any specific sleep stage. We hypothesize that the fundamental characteristics of emotion during REM are as follows: 1) emotional experience occurs in most —although not all—epochs of REM mentation, as recalled upon awakening; 2) most instances of recalled REM mentation with emotion contain at least two discretely different emotions; 3) negative and positive emotions occur in a balanced fashion, but with considerable inter-subject variability; 4) joy/elation is the most typical emotion, followed by surprise, anger, and anxiety/fear; 5) emotion types show a substantial variation in level of intensity, with reports of anxiety/fear having particularly low intensity; 6) except for surprise, the overall occurrence of emotions shows no marked change across the night, and 7) both the general neurobiological characteristics of the REM state and complex cortical functioning within this biological frame contribute to the characteristics of emotional experience.

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