Dream emotions: a comparison of home dream reports with laboratory early and late REM dream reports

PILLERIIN SIKKA[1,2] (iD), ANTTI REVONSUO[1,2], NILS SANDMAN[1,3], JARNO TUOMINEN[1] and KATJA VALLI[1,2]

[1]Centre for Cognitive Neuroscience, Department of Psychology and Speech-Language Pathology, University of Turku, Turku, Finland; [2]Department of Cognitive Neuroscience and Philosophy, School of Bioscience, University of Skövde, Skövde, Sweden; [3]The Genomics and Biomarkers Unit, National Institute for Health and Welfare, Helsinki, Finland

SUMMARY
The aim of this study was to compare the emotional content of dream reports collected at home upon morning awakenings with those collected in the laboratory upon early and late rapid eye movement (REM) sleep awakenings. Eighteen adults (11 women, seven men; mean age = 25.89 ± 4.85) wrote down their home dreams every morning immediately upon awakening during a 7-day period. Participants also spent two non-consecutive nights in the sleep laboratory where they were awoken 5 min into each continuous REM sleep stage, upon which they gave a verbal dream report. The content of a total of 151 home and 120 laboratory dream reports was analysed by two blind judges using the modified Differential Emotions Scale. It was found that: (1) home dream reports were more emotional than laboratory early REM dream reports, but not more emotional than laboratory late REM dream reports; (2) home dream reports contained a higher density of emotions than laboratory (early or late REM) dream reports; and (3) home dream reports were more negative than laboratory dream reports, but differences between home and early REM reports were larger than those between home and late REM reports. The results suggest that differences between home and laboratory dream reports in overall emotionality may be due to the time of night effect. Whether differences in the density of emotions and negative emotionality are due to sleep environment or due to different reporting procedures and time spent in a sleep stage, respectively, remains to be determined in future studies.

INTRODUCTION

A dream refers to subjective conscious experiences occurring during sleep. Emotions are an important aspect of dreams (Hobson *et al.*, 2000; Nir and Tononi, 2010). Studying the emotional content of dreams is not only theoretically relevant but also of clinical importance, due to the relationship between dream emotions and various sleep and psychiatric disorders (Levin and Nielsen, 2007; Nielsen and Levin, 2007; Schredl, 2011). However, research findings regarding the emotional content of dreams are inconsistent and often contradictory due, arguably, to unresolved methodological issues (Domhoff, 2005; Schredl, 2008).

One methodological discrepancy between studies lies in the experimental setting of the study; specifically, whether dream reports are collected at home or in the sleep laboratory. It has been debated whether and to what extent the (emotional) content of dream reports collected in the two settings is comparable (Domhoff, 2005; Schredl, 2008; Waterman *et al.*, 1993). However, only a few studies have compared the emotional content of dream reports obtained from the same individuals in the two settings (see Table 1 for a summary of the key characteristics and findings).

As evidenced in Table 1, when dream reports are obtained using constant sampling (morning awakenings in both settings) and reporting (either written or oral in both settings) conditions, no differences between laboratory and home dream reports are found, at least when rated by external judges (Foulkes, 1979, study 3; Weisz and Foulkes,

1970). However, when non-constant sampling [home morning awakenings versus laboratory serial rapid eye movement (REM) awakenings] and reporting (written home dream reports versus verbal laboratory dream reports) conditions are used, home dream reports contain more emotions, especially negative emotions (Foulkes, 1979, study 4; Okuma *et al.*, 1975; St-Onge *et al.*, 2005). These differences may arise because, at home, dream reports derive from either REM or non-REM (NREM) sleep, whereas in the laboratory they derive from REM sleep. However, it has been shown that the emotional content of dream reports obtained upon morning awakenings from REM and NREM sleep is similar (Cicogna *et al.*, 1998; McNamara *et al.*, 2007). Thus, the differences seem to occur mainly because dream reports derive from different times of night: home dream reports from late REM or NREM sleep dreams and laboratory dream reports from both early and late REM sleep dreams. Indeed, late REM sleep dream reports, compared to early REM sleep dream reports, have been found to have greater emotionality or emotional intensity (Sikka *et al.*, 2014; Wamsley *et al.*, 2007; cf. Fosse *et al.*, 2001). However, no studies have compared home dream reports collected from morning awakenings directly with laboratory dream reports collected separately from early and late REM sleep periods. Therefore, the aim of this study was to compare the emotional content of dream reports collected at home upon morning awakenings with those collected in the laboratory upon early and late REM sleep awakenings.

METHODS

Participants and procedure

Data were collected as part of a larger study. A detailed description of the participant selection criteria and procedure can be found in Sikka *et al.* (2014). Briefly, of the 159 volunteers, 53 fulfilled participation criteria (healthy, right-handed, native Finnish speakers, good sleep quality) and were asked to keep a home dream diary. Of the 22 participants who filled in the diary, 21 were invited and 19 agreed to sleep in the sleep laboratory. However, the home dream diary of one participant was filled in inadequately. Hence, 18 participants (11 women, seven men) with an average age of 25.89 years [standard deviation (SD) = 4.85; range = 19–39] provided adequate home and laboratory dream reports. Participants gave written informed consent and received a compensation of 100 euros upon completing the study. The study received approval from the Ethical Board of the University of Turku, Finland.

Home dream report collection

Participants were instructed to keep a home dream diary during a 7-day period (based on instructions from earlier studies, e.g. Revonsuo and Salmivalli, 1995). They were asked to write down their dreams systematically every morning immediately upon awakening, and to report them accurately, truthfully and in as much detail as possible, without adding things they did not remember, or that would make the dream report sound more logical. Instructions did not specifically emphasize reporting emotions. Participants were instructed to fill in the dream diary even if they did not remember dreams on awakening, or felt they had had a dream but could not recall any content. Sleep stages were not monitored at home, thus the proportion of dream reports originating from REM or NREM sleep is unknown.

Laboratory dream report collection

Participants spent two non-consecutive nights in the sleep laboratory. To avoid REM sleep deprivation, there was approximately a week between the two nights. Sleep was monitored using polysomnography (PSG), including electroencephalography (EEG; 24 electrodes Fp1/2, AF3/4, AF7/8, F7/8, F3/4, Fz, T7/8, C3/4, Cz, P7/8, P3/4, Pz, O1/2, Oz positioned according to the standard 10/10 system), vertical and horizontal electro-oculography (EOG; four electrodes) and electromyography (EMG; two chin electrodes). All electrodes (except bipolar EOG and EMG electrodes) were referenced to the right mastoid. The EEG signal was amplified (SynAmps Model 5083) and recorded using NeuroScan equipment and software. Sleep stages were scored manually (Iber *et al.*, 2007).

Participants were awoken using a signal tone after the REM sleep stage had lasted continuously for 5 min, and was in a phasic phase. Upon awakening they reported their dream to a microphone embedded in the room: starting with the last image they remembered, and then the whole dream in as much detail as possible. After this, participants filled in two self-rating scales, one measuring emotions [Finnish version of the modified Differential Emotions Scale (fmDES); Fredrickson, 2013] and the other measuring presence (Lempiäinen, 2012, unpublished Master's thesis). Participants were also asked to report if they recalled no dreams or felt as if they had had a dream but could not recall the content. Additionally, in the evening (before falling asleep) and in the morning (after having reported and rated the last dream), 8 min of waking state resting EEG was recorded, and participants rated their current waking state emotions using the fmDES. Data regarding waking state EEG and its relationship to self-rated emotions as well as dream presence will be reported elsewhere.

Early and late REM was specified as in Casagrande *et al.* (1996) and Sikka *et al.* (2014): the first two REM periods were defined as early REM and from the third period onwards as late REM.

Content analysis of dream reports

Home and laboratory dream reports were combined, randomized and anonymized. They were analysed following the

Table 1 Summary of studies comparing the emotional content of home and laboratory dreams

		Sampling procedure		Reporting procedure	
Study	Sample	*Home*	*Laboratory*	*Home*	*Laboratory*
Weisz and Foulkes (1970)	12 young males (19–28 years)	Morning awakenings (2 non-consecutive nights)	Morning awakenings (2 non-consecutive nights)	Verbal	Verbal
Okuma et al. (1975)	Five male psychiatrists (25–47 years)	1. Morning awakenings (2 weeks; during 1967–1968) 2. REM awakenings using the 'Dream Detector' (during 1972–1973)	Serial REM awakenings (during 1967–1968)	1. Written 2. Verbal	Verbal
Foulkes, (1979, study 3)	14 children (8 girls, 6 boys; 10–11 years)	Morning awakenings (3 consecutive nights)	Morning awakenings (3 consecutive nights)	Written	Written
Foulkes (1979, study 4)	18 children (7 girls, 11 boys; 12–13 years)	Morning awakenings (six consecutive mornings)	Serial REM awakenings (two non-consecutive nights)	Written	1. Verbal 2. Written (morning reports of recalled dreams)
St-Onge et al. (2005)	28 younger (20–33 years) versus 30 older (60–77 years) women	Morning awakenings (seven consecutive days)	Serial REM awakenings (one night)	Written	Verbal

*Includes also other variables not measuring emotions. NS: no significant differences; REM: rapid eye movement.

criteria, procedure, and measures described in detail elsewhere (Sikka et al., 2014). Briefly, two blind judges worked independently and first identified all emotions that the dream self either expressed explicitly or that could be inferred unambiguously from the behaviour of the dream self. Then, the judges classified these emotions using the fmDES. This scale consists of 20 emotion categories or items (with three words describing each category): 10 for positive emotions (PE) and 10 for negative emotions (NE). An additional 'Other' category was used for emotions which were difficult to classify into any of the existing 20 categories. Altogether, 38 occurrences of emotion were classified to belong into this category: 34 items with ambiguous valence (i.e. surprised: 12

occurrences; confused: 22 occurrences), one item referring to sexual pleasure, one item to irony and two items that the judges found difficult to label. The judges rated only the occurrence and not the intensity of emotions.

Subsequent analyses were based on both expressed and inferred emotions because (1) inter-rater reliability for the classification of both types of emotions was strong ($\kappa = 0.78$–0.95) and did not differ significantly (see Supporting information, Appendix S1 for detailed description and analysis); (2) preliminary analyses indicated that the pattern of results reported below was basically the same when including only expressed or only inferred emotions or both. In the analyses, each emotion category was counted only once per dream

Emotion rating measure	Self-ratings (SR) or external ratings (ER)	Data analysis unit: whole dream (D) or every occurrence of emotion (E) within dream	Findings regarding the differences between home (H) and laboratory (L) dreams
Two dimensions from the factored scale of Hauri *et al.* (1967): 'Vivid Fantasy'* and 'Hedonic Tone'	ER	D	NS
Hall and Van de Castle (1966) content analysis system: all five emotion categories (anger; apprehension; happiness; sadness; confusion) evaluated as one 'emotional elements' category	ER	E	Dreams containing emotional elements: 1. H > L 2. H > L
Scoring System for Children's Dreams (Foulkes and Shepherd, 1970): eight categories for emotional states: afraid/anxious/worried; angry/mad/hostile; sad/unhappy/disappointed; happy/pleased; surprised/startled; excited in an unspecific way; confused/unsettled; any (all emotions in total); 1 rating scale for measuring overall hedonic tone (pleasant, neutral, unpleasant)	1. ER 2. SR	1. E + D 2. D	1. NS 2. Fear: H > L; pleasant hedonic tone: H > L
Scoring System for Children's Dreams (Foulkes and Shepherd, 1970)	ER	E + D	1. Emotions: H > L Afraid: H > L Angry: H > L Excited: H > L Unpleasant hedonic tone: H > L Length: H < L 2. Emotions: H > L
Eight emotions; four positive: happiness, contentment, quietness, cheerfulness; four negative: anger, sadness, uncertainty, anxiety	SR (upon morning awakening)	D	Incidence and intensity of emotions: H > L Incidence and intensity of negative emotions: H > L Most frequent emotions: H: anxiety (57.5%), uncertainty (56.7%), quietness (52.6%), contentment (51%). L: quietness (57%), happiness (46.3%), cheerfulness (46.3%)

report, so that the same emotion category referring to the same event would not be counted several times.

Length of dream reports

The length or word count of a dream report was a total count of all dream-related words, excluding repetitions, fillers, corrections, and waking commentary (Antrobus, 1983).

Statistical analyses

Statistical analyses were conducted using IBM SPSS Statistics (version 20). The Shapiro–Wilk test was used to test the normality distribution of the variables. For the comparisons of non-normally distributed variables, Wilcoxon's signed-rank test (Z-value), and for normally distributed variables, paired-samples t-test were used. All statistical tests were two-tailed and for non-parametric tests exact tests were conducted. Effect sizes were calculated using Pearson's correlation (r) and Cohen's d, respectively. Spearman's rank correlation coefficient (r_s) was used for correlation analyses.

RESULTS

For all subsequent analyses, aggregate scores of every variable across all dream reports were calculated for each

Table 2 Percentage of non-emotional and emotional dream reports, number of emotions per dream report and length of dream reports in the home and laboratory setting

| | Home | | | Laboratory | | | | | | | | |
| | All | | | All | | | Early REM | | | Late REM | | |
	Mean	Median	(SD)	Mean	Median	(SD)	Mean	Median	(SD)	Mean	Median	(SD)
Non-Emotional dreams %	54.58	57.19	(31.56)	70.69	76.36	(28.46)	82.22	100.00	(21.10)	62.20	62.50	(36.97)
Emotional dreams %	45.42	42.81	(31.56)	29.31	23.63	(28.46)	17.78	0.00	(21.10)	37.80	37.50	(36.97)
Positive dreams %	2.59	0.00	(5.32)	8.40	4.55	(10.52)	4.44	0.00	(11.73)	9.50	0.00	(14.16)
Negative dreams %	36.66	40.00	(26.73)	12.64	4.17	(18.23)	8.33	0.00	(18.09)	18.48	0.00	(29.44)
Balanced dreams %	3.10	0.00	(9.58)	3.21	0.00	(6.49)	1.67	0.00	(6.45)	3.29	0.00	(7.80)
Undetermined dreams* %	3.07	0.00	(6.02)	5.06	0.00	(7.97)	3.33	0.00	(12.91)	6.53	0.00	(9.83)
Emotions per dream[†]	0.77	0.69	(0.71)	0.47	0.24	(0.52)	0.31	0.00	(0.45)	0.53	0.38	(0.57)
Positive emotions	0.11	0.00	(0.18)	0.16	0.11	(0.18)	0.09	0.00	(0.17)	0.15	0.00	(0.23)
Negative emotions	0.59	0.48	(0.50)	0.21	0.06	(0.28)	0.17	0.00	(0.35)	0.25	0.08	(0.34)
Emotions/100 words per dream	0.80	0.79	(0.65)	0.24	0.25	(0.24)	0.20	0.00	(0.28)	0.29	0.25	(0.30)
Word count	99.63	82.33	(103.61)	128.86	102.19	(81.58)	91.41	80.00	(69.46)	142.91	114.00	(96.51)

*Dream reports containing emotions classified into the "Other" category (e.g., surprised, confused).
[†]Includes also emotions belonging to the "Other" category. SD: standard deviation.

individual. Preliminary analyses indicated no significant differences between men and women in any of the variables studied; hence, the results are reported for both genders combined.

Number of dream reports

A total of 151 (mean = 8.39; SD = 4.39; range = 3–17) home dream reports were collected during the 7-day period. In the laboratory, a total of 133 awakenings (mean = 7.39; SD = 3.29) were conducted and 122 dream reports (mean = 6.78; SD = 3.26; range = 2–12) collected (see Supporting information, Appendix S2). The two laboratory nights did not differ in any of the dependent variables (see Supporting information, Appendix S2). Therefore, data from the two nights were pooled in subsequent analyses. Due to technical problems with recordings, two laboratory dream reports could not be included in the analyses. Thus, the following analyses were based on 120 laboratory dream reports (mean = 6.67; SD = 3.16). From these, 38 (mean = 2.11; SD = 1.28) were early REM and 82 (mean = 4.56; SD = 2.45) late REM dream reports ($t_{(17)}$ = −4.50, $P < 0.001$, $d = -1.17$). Three participants did not report any early REM dreams. Although the mean number of home and laboratory dream reports did not differ significantly ($t_{(17)}$ = 1.41, $P = 0.178$, $d = 0.34$), there were significantly more home dream reports compared to laboratory early REM ($t_{(17)}$ = 5.84, $P < 0.001$, $d = 1.58$) and late REM dream reports ($t_{(17)}$ = 3.38, $P = 0.004$, $d = 0.83$).

Percentage of emotional dream reports

A dream report was considered emotional if at least one of the 21 emotion categories was detected at least once in the report. To account for the different number of home and laboratory early and late REM dream reports, the analyses were based on the mean (or median) percentage of emotional dream reports of all reports per participant.

On average, a significantly larger percentage of home dream reports (45.42%), compared to laboratory dream reports (29.31%), was rated as emotional ($t_{(17)}$ = 2.43, $P = 0.026$, $d = 0.58$) (see Table 2). However, only the difference between the percentage of emotional home and emotional early REM dream reports was significant (n = 15, $Z = -3.06$, $P < 0.001$, $r = -0.56$), whereas the difference between the percentage of emotional home and emotional late REM dream reports was not significant (n = 18, $Z = -1.08$, $P = 0.296$, $r = -0.18$) (see Fig. 1). The percentage of emotional late REM dream reports was significantly larger than the percentage of emotional early REM dream reports (n = 15, $Z = -2.55$, $P = 0.008$, $r = -0.47$).

Percentage of emotionally valenced dream reports

A dream report was considered (a) positive, when the number of PE exceeded that of NE; (b) negative, when the number of NE exceeded that of PE; (c) to have a balanced emotional tone, when the number of PE and NE was equal; and (d) to have undetermined valence, when a report contained only those emotions for which the emotional valence could not be determined ('Other' category). All analyses were based on the mean (or median) percentage of emotionally valenced dream reports.

There was a significantly larger percentage of negatively valenced dream reports at home compared to the laboratory (n = 18, $Z = -3.11$, $P < 0.001$, $r = -0.52$) (see Table 2 and Fig. 1). Interestingly, the percentage of negatively valenced home dream reports was significantly larger than that of
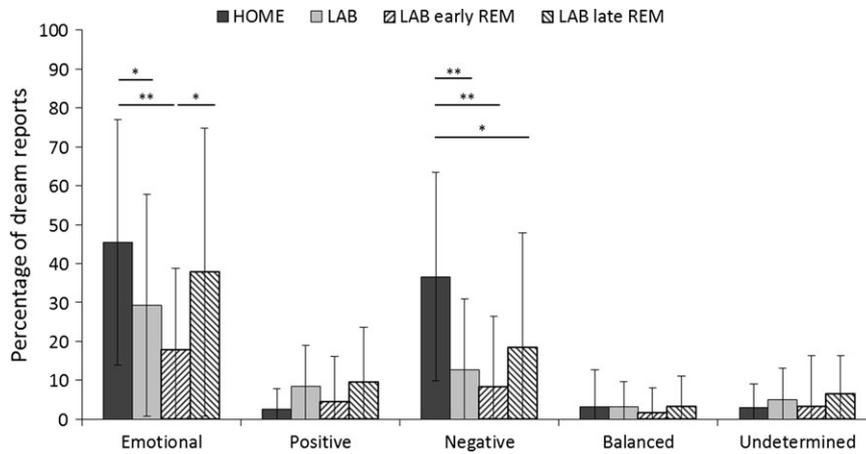
Figure 1. Mean percentage of emotional and emotionally valenced dream reports in the home and laboratory sleep environment. **$P < 0.01$; *$P < 0.05$.

negatively valenced laboratory early ($n = 15$, $Z = -3.06$, $P < 0.001$, $r = -0.56$) and late ($n = 18$, $Z = -2.32$, $P = 0.017$, $r = -0.39$) REM dream reports. The two settings did not differ in the percentage of dream reports with positive, balanced or undetermined valence ($Ps > 0.05$). Similarly, laboratory early and late REM dream reports did not differ with respect to emotional valence ($Ps > 0.05$).

When looking at the settings separately, at home the percentage of dream reports with negative valence was significantly larger than that with positive valence ($n = 18$, $Z = -3.18$, $P < 0.001$, $r = -0.53$). In contrast, in the laboratory the difference between the percentage of dream reports with negative and positive valence was not significant ($n = 18$, $Z = -0.83$, $P = 0.445$, $r = -0.14$).

Number of emotions per dream report

The overall number of emotions per dream report was calculated by summing up the occurrence of the 10 PE and

10 NE categories as well as those classified as belonging to the 'Other' category. Thus, the maximum number of both PE and NE was 10 and of all different emotion categories per dream was 21.

Regarding the number of all the different emotions per dream report, there were no significant differences between home and laboratory dream reports ($n = 18$, $Z = -1.76$, $P = 0.083$, $r = -0.29$), home and laboratory late REM dream reports ($n = 18$, $Z = -1.17$, $P = 0.258$, $r = -0.19$) or laboratory early and late REM dream reports ($n = 15$, $Z = -1.48$, $P = 0.152$, $r = -0.27$). However, home dream reports were rated to contain a significantly greater number of emotions than laboratory early REM dream reports ($n = 15$, $Z = -3.06$, $P < 0.001$, $r = -0.56$) (see Table 2 and Fig. 2). The length of dream reports could not explain this difference, because the length of home and early REM reports did not differ significantly (see Table 2) ($n = 15$, $Z = -0.17$, $P = 0.890$, $r = -0.03$) (see Supporting information, Appendix S3 for detailed results).
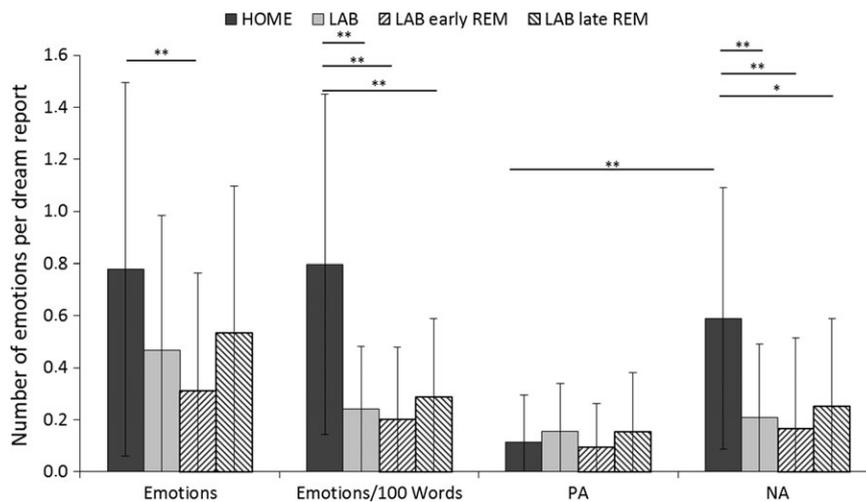

Figure 2. Mean number of (positive and negative) emotions per dream report in the home and laboratory sleep environment. **$P < 0.01$ *$P < 0.05$.

Table 3 Number of discrete emotions per emotional dream

	Emotion category and item	Home			Laboratory			Wilcoxon's signed-rank test (n = 10)		
		Mean	Median	(SD)	Mean	Median	(SD)	Z	P	r
NE1	Angry/irritated/annoyed	0.33	0.38	(0.25)	0.31	0.20	(0.32)	−0.18	0.914	−0.04
NE10	Stressed/nervous/overwhelmed	0.31	0.31	(0.17)	0.13	0.00	(0.20)	−1.84	0.070	−0.41
NE9	Scared/fearful/afraid	0.26	0.25	(0.18)	0.03	0.00	(0.10)	−2.02	0.047	−0.45
Other	Confused/surprised	0.11	0.00	(0.17)	0.32	0.33	(0.29)	−1.68	0.102	−0.38
NE4	Disgust/distaste/revulsion	0.09	0.00	(0.15)	0.02	0.00	(0.06)	−1.84	0.125	−0.41
NE3	Contemptuous/scornful/disdainful	0.08	0.00	(0.14)	0.02	0.00	(0.06)	−1.21	0.313	−0.27
NE5	Embarrassed/self-conscious/blushing	0.08	0.00	(0.11)	0.04	0.00	(0.12)	−0.37	0.875	−0.08
PE8	Love/closeness/trust	0.07	0.00	(0.16)	0.04	0.00	(0.08)	0.00	1.00	0.00
NE7	Hate/distrust/suspicion	0.05	0.00	(0.14)	0.04	0.00	(0.09)	0.00	1.00	0.00
PE1	Amused/fun-loving/giggly	0.04	0.00	(0.12)	0.09	0.00	(0.13)	−1.22	0.250	−0.27
PE6	Interested/alert/curious	0.04	0.00	(0.10)	0.00	0.00	(0.00)	−1.00	1.00	−0.22
PE2	Awe/wonder/amazement	0.03	0.00	(0.09)	0.02	0.00	(0.06)	0.00	1.00	0.00
NE2	Ashamed/humiliated/disgraced	0.03	0.00	(0.08)	0.00	0.00	(0.00)	−1.60	0.250	−0.36
NE8	Sad/downhearted/unhappy	0.03	0.00	(0.07)	0.06	0.00	(0.16)	−0.37	0.875	−0.08
PE7	Joyful/glad/happy	0.03	0.00	(0.06)	0.19	0.00	(0.30)	−1.37	0.219	−0.31
PE3	Grateful/appreciative/thankful	0.02	0.00	(0.09)	0.00	0.00	(0.00)	0.00	1.00	0.00
PE9	Proud/confident/self-assured	0.02	0.00	(0.05)	0.09	0.00	(0.09)	−1.21	0.313	−0.27
NE6	Guilty/repentant/blameworthy	0.01	0.00	(0.04)	0.00	0.00	(0.00)	−1.00	1.00	−0.22
PE10	Serene/content/peaceful	0.01	0.00	(0.02)	0.09	0.00	(0.16)	−1.60	0.250	−0.36
PE4	Hopeful/optimistic/encouraged	0.00	0.00	(0.00)	0.00	0.00	(0.00)	0.00	1.00	0.00
PE5	Inspired/uplifted/elevated	0.00	0.00	(0.00)	0.02	0.00	(0.08)	−1.00	1.00	−0.22

PE: positive emotion; NE: negative emotion; SD: standard deviation.

However, when analysing the density of emotions in a dream report—that is, the number of emotions per 100 words (by dividing the total number of emotions by the number of words in that dream report multiplied by 100)—a different pattern of results occurred. There were significantly more emotions per 100 words in home dream reports compared to laboratory dream reports overall ($n = 18$, $Z = -3.01$, $P = 0.001$, $r = -0.50$), early REM ($n = 15$, $Z = -2.90$, $P = 0.001$, $r = -0.53$) and late REM ($n = 18$, $Z = -3.07$, $P = 0.001$, $r = -0.51$) dream reports (see Fig. 2). The difference between early REM and late REM dream reports was not significant ($n = 15$, $Z = -1.78$, $P = 0.084$, $r = -0.33$).

Number of positive and negative emotions per dream report

Home dream reports contained a significantly greater number of NE compared to laboratory dream reports in general ($n = 18$, $Z = -3.11$, $P = 0.001$, $r = -0.52$) and compared to both early REM ($n = 15$, $Z = -3.06$, $P < 0.001$, $r = -0.56$) and late REM ($n = 18$, $Z = -2.54$, $P = 0.008$, $r = -0.42$) dream reports (see Table 2 and Fig. 2). There were no differences between the settings in the number of PE (Ps > 0.05). In home dream reports there were significantly more NE than PE ($n = 18$, $Z = -3.18$, $P < 0.001$, $r = -0.53$). In contrast, there were no differences in the number of PE and NE in laboratory dream reports (Ps > 0.05). The pattern of results was the same when

analysing the number of PE and NE per 100 words (see Supporting information, Appendix S4).

Exploratory analyses: discrete emotions

The occurrence of discrete emotions in a dream was calculated including only the 113 (74 home and 39 laboratory) emotional dream reports of 15 participants. The analysis was based on the 20 emotion categories of fmDES and the most frequently classified emotion items in the 'Other' category—confused and surprised (analysed together as a separate category).

The mean (and median) occurrence of each of the 21 emotion categories can be seen in Table 3. Dream reports collected in the two settings differed only with respect to one emotion category—home dream reports were rated to contain significantly more fear (category scared/fearful/afraid) than laboratory dream reports.

DISCUSSION

This study compared the emotional content of dream reports collected at home upon morning awakenings with those collected in the laboratory upon early and late REM sleep awakenings.

Regarding emotionality, both the percentage of emotional dream reports as well as the number of emotions per dream report showed that home dream reports were more emotional

than laboratory early REM dream reports, but not more emotional than laboratory late REM dream reports. This finding suggests that the difference in emotionality between home and laboratory dream reports obtained from serial REM awakenings (as in Foulkes, 1979, study 4; Okuma *et al.*, 1975; St-Onge *et al.*, 2005) is not due to environmental setting *per se*, but depends upon what time of night laboratory REM reports are collected.

Nevertheless, home dream reports were more densely packed with emotions than laboratory dream reports, irrespective of the time of night. This finding may also be explained by the different reporting procedures of home (written) and laboratory (verbal) dream reports, as it has been suggested that written reports have higher lexical density compared to verbal reports (Casagrande and Cortini, 2008). Whether the difference in emotion density reflects a true difference between home and laboratory dream reports or results from different reporting procedures remains to be determined in future studies.

Concerning valence, home dream reports were more negative than laboratory early or late REM dream reports. However, differences between home and laboratory early REM dream reports were larger (rs = 0.56) than those between home and late REM reports (rs = 0.39–42). Moreover, as demonstrated by *post-hoc* analyses, dream reports obtained in the laboratory upon awakenings from the latest REM period resembled home dream reports more closely (rs = 0.29–32; see Supporting information, Appendix S5). Furthermore, it cannot be ruled out that the lower negativity of laboratory late REM dream reports resulted from the relatively short time spent in a sleep stage (5 min into REM). Using home dream reports, it has been demonstrated that dreams tend to progress towards increased negativity (Merritt *et al.*, 1994). Also, the duration of late REM sleep periods and dream reports from these periods are longer than early REM sleep periods and dream reports, respectively (Casagrande *et al.*, 1996; Cipolli *et al.*, 2015; Stickgold *et al.*, 2001). Hence, awakenings after a longer time into REM might have led to increased negativity of laboratory, especially late REM, dream reports and to smaller differences between these and home dream reports. Thus, the question whether the greater negativity of home dream reports and dream emotions is due to differences in sleep environment or in the time spent in a sleep stage remains open, and stresses the need to carry out studies directly investigating this issue.

As for discrete emotions, such emotion categories as angry/irritated/annoyed, stressed/nervous/overwhelmed and confused/surprised were among the most frequently detected emotions in both home and laboratory dream reports. This is in line with several studies that have used external ratings of dream reports (e.g. Hall and Van de Castle, 1966; Schredl and Doll, 1998). The finding that home dream reports were rated to contain more fear (category scared/fearful/afraid) than laboratory dream reports corroborates the results of Foulkes (1979, study 4).

The results should be considered in light of the limitations that can be addressed in future research. First, as the study employed dream report collection procedures used in typical home and laboratory studies, the sampling of reports in the two settings differed. Whereas laboratory dream reports were obtained upon forced awakenings after a fixed time in each REM stage, home dream reports were obtained upon spontaneous morning awakenings after an unspecified time in REM or NREM stage. Therefore, future studies should control not only for the time of night (early versus late sleep period), but also for sleep stage (REM versus NREM), time spent in sleep stage (fixed versus unspecified) and method of awakenings (forced versus spontaneous) in both home and laboratory settings. Secondly, whereas home dream reports were written down, laboratory dream reports were reported verbally. As emotions may be represented differently in written versus verbal discourse, in future studies both home and laboratory reports should be reported using the same procedure (e.g. audio-recorded). Thirdly, because home dream reports were collected before laboratory sessions, the results may have been influenced by the systematic order effect. Thus, future studies should use a counterbalanced order for collecting home and laboratory reports. Fourthly, because participants did not rate emotions in their home dream reports, only external ratings (by judges) of dream emotions were compared. It has been demonstrated that with self-ratings, compared to external ratings, both home (Schredl and Doll, 1998; Sikka *et al.*, 2017) and laboratory (Sikka *et al.*, 2014) dreams are rated to be more emotional and more positive. As a result, with external ratings dream reports appear to be (relatively) more negative than with self-ratings. This might explain the preponderance of negative dreams and emotions in the current study, specifically in the home setting. To determine whether and to what extent differences in who rates dream emotions may affect differences found between the two settings, future studies should include both self- and external ratings of dream emotions. Lastly, it can be argued that by having filled in the emotion rating scale in the evening and after the first awakenings during the first laboratory night, participants may have understood the aim of the study and, as such, reported more emotions in subsequent reports. However, additional analyses showed that this is unlikely (see Supporting information, Appendix S6).

To conclude, this study contributes to the very limited body of research on the differences in the emotional content of dream reports collected in the home compared to the laboratory setting. It demonstrates that when conducting or interpreting studies, it is important to consider not only where (i.e. setting), but also when (i.e. time of night; sleep stage; time spent in sleep stage) and how (i.e. method of awakenings; reporting modality) dream reports are collected.

ACKNOWLEDGEMENTS

REFERENCES

Antrobus, J. REM and NREM sleep reports: comparison of word frequencies by cognitive classes. *Psychophysiology*, 1983, 20: 562–568.

Casagrande, M. and Cortini, P. Spoken and written dream communication: differences and methodological aspects. *Conscious. Cogn.*, 2008, 17: 145–158.

Casagrande, M., Violani, C., Lucidi, F., Buttinelli, E. and Bertini, M. Variations in sleep mentation as a function of time of night. *Int. J. Neurosci.*, 1996, 85: 19–30.

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

Cipolli, C., Guazzelli, M., Bellucci, C. *et al.* Time-of-night variations in the story-like organization of dream experience developed during rapid eye movement sleep. *J. Sleep Res.*, 2015, 24: 234–240.

Domhoff, G. W. The content of dreams: methodologic and theoretical implications. In: M. H. Kryger, T. Roth and W. C. Dement (Eds) *Principles and Practice of Sleep Medicine*. Elsevier, Philadelphia, 2005: 522–534.

Fosse, R., Stickgold, R. and Hobson, J. A. The mind in REM sleep: reports of emotional experience. *Sleep*, 2001, 24: 1–9.

Foulkes, D. Home and laboratory dreams: four empirical studies and a conceptual reevaluation. *Sleep*, 1979, 2: 233–251.

Foulkes, D. and Shepherd, J. A scoring system for children's dreams. *Psychophysiology*, 1970, 7: 335.

Fredrickson, B. L. Positive emotions broaden and build. In: G. Devine and E. A. Plant (Eds) *Advances in Experimental Social Psychology*. Academic Press, San Diego, CA, 2013: 1–53.

Hall, C. S. and Van de Castle, R. L. *The Content Analysis of Dreams*. Appleton-Century-Crofts, New York, 1966.

Hauri, P., Sawyer, J. and Rechtschaffen, A. Dimensions of dreaming: a factored scale for rating dream reports. *J. Abnorm. Psychol.*, 1967, 72: 16–22.

Hobson, J. A., Pace-Schott, E. F. and Stickgold, R. Dreaming and the brain: toward a cognitive neuroscience of conscious states. *Behav. Brain. Sci.*, 2000, 23: 793–842; discussion 904–1121.

Iber, C., Ancoli-Israel, S., Chesson, A. and Quan, S. F.; for the American Academy of Sleep Medicine. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications*. American Academy of Sleep Medicine, Westchester, IL, 2007.

Levin, R. and Nielsen, T. A. Disturbed dreaming, posttraumatic stress disorder, and affect distress: a review and neurocognitive model. *Psychol. Bull.*, 2007, 133: 482–528.

McNamara, P., McLaren, D. and Durso, K. Representation of the self in REM and NREM dreams. *Dreaming*, 2007, 17: 113–126.

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

Nielsen, T. and Levin, R. Nightmares: a new neurocognitive model. *Sleep Med. Rev.*, 2007, 11: 295–310.

Nir, Y. and Tononi, G. Dreaming and the brain: from phenomenology to neurophysiology. *Trends Cogn. Sci.*, 2010, 14: 88–100.

Okuma, T., Fukuma, E. and Kobayashi, K. 'Dream detector' and comparison of laboratory and home dreams collected by REMP-awakening technique. *Adv. Sleep Res.*, 1975, 2: 223–231.

Revonsuo, A. and Salmivalli, C. A content analysis of bizarre element in dreams. *Dreaming*, 1995, 5: 169–187.

Schredl, M. Laboratory references in dreams: methodological problem and/or evidence for the continuity hypothesis of dreaming? *Int. J. Dream Res.*, 2008, 1: 3–6.

Schredl, M. Dreams in patients with sleep disorders. In: M. H. Kryger, T. Roth and W. C. Dement (Eds) *Principles and Practice of Sleep Medicine*. W. B. Saunders, Philadelphia, 2011: 604–612.

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

Sikka, P., Valli, K., Virta, T. and Revonsuo, A. I know how you felt last night, or do I? Self- and external ratings of emotions in REM sleep dreams. *Conscious. Cogn.*, 2014, 25: 51–66.

Sikka, P., Feilhauer, D., Valli, K. and Revonsuo, A. How you measure is what you get: differences in self- and external ratings of emotional experiences in home dreams. *Am. J. Psychol.*, 2017, 130: 367–384.

Stickgold, R., Malia, A., Fosse, R., Propper, R. and Hobson, A. J. Brain-mind states: I. Longitudinal field study of sleep/wake factors influencing mentation report length. *Sleep*, 2001, 24: 171–179.

St-Onge, M., Lortie-Lussier, M., Mercier, P., Grenier, J. and De Koninck, J. Emotions in the diary and REM dreams of young and late adulthood women and their relation to life satisfaction. *Dreaming*, 2005, 15: 116–128.

Wamsley, E. J., Hirota, Y., Tucker, M. A., Smith, M. R. and Antrobus, J. S. Circadian and ultradian influences on dreaming: a dual rhythm model. *Brain Res. Bull.*, 2007, 71: 347–354.

Waterman, D., Elton, M. and Kenemans, L. J. Methodological issues affecting the collection of dreams. *J. Sleep Res.*, 1993, 2: 8–12.

Weisz, R. and Foulkes, D. Home and laboratory dreams collected under uniform sampling conditions. *Psychophysiology*, 1970, 6: 588–596.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article:

Appendix S1 Inter-rater reliability for identifying and classifying dream emotions

Appendix S2 Comparison of laboratory nights

Appendix S3 Length and number of emotions per dream report

Appendix S4 Density of positive and negative emotions per dream report

Appendix S5 Exploratory analyses: laboratory latest REM dream reports

Appendix S6 Possible influence of emotion ratings on reporting and rating subsequent dreams