

Title: The effect of time of night on wake-dream continuity

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Running head: Time of night effects on continuity

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Abstract

Research has demonstrated a number of time of night and stage of sleep differences in dream content, such as that dreams from later in the night are longer, more emotional, and more bizarre. It was hypothesised that time of night may therefore demonstrate differences in the continuity of waking life into dreams. Participants (N=16) were systematically awoken four times a night for two nights and rated their dreams for wake-dream continuity on a number of dimensions. It was found that time of night affects wake-dream continuity overall, particularly showing an increase of bizarreness over time; that there were more references to waking-life media in the early than late night; that there were more references to waking-life activities and objects in the late than early night; and that the ways in which different types of wake-dream continuity correlate (such as continuity with present, past, and future waking life) change from the early to the late night. No stage of sleep effects were able to be demonstrated. The results support the hypothesis that time of night affects wake-dream continuity.

1 Introduction

'Continuity' in dream research refers to the ways in which aspects of waking life (such as experiences, thoughts, and emotions) are carried over into dreams, and vice versa. A factor that may influence wake-dream incorporation is the time of night from whence the dream came (Schredl, 2002), and, if found, these time of night differences on wake-dream continuity may reflect altering memory consolidation and/or integration processes across the night (Payne, 2010). The purpose of the present study was to investigate time of night effects on continuity.

Stage of sleep differences in dream content have been demonstrated empirically in many studies. Rapid-eye-movement (REM) sleep, the stage of sleep associated with brain wave activity similar to wakefulness (high frequency, low amplitude) (Nir & Tononi, 2010), which dominates the second half of the sleep cycle (McNamara et al., 2010), has been shown to contain dreams that have more aggressive than friendly interactions (McNamara et al., 2005), and are longer, more vivid, more bizarre, and more emotional than NREM dreams (Hobson et al., 2000). Additionally, one paper has found that they are associated with 'recent residues' (waking-life episodes within a year of the dream), as opposed to 'day residues' (from the day immediately prior to the dream) (Battaglia et al., 1987), and Blagrove et al. (2011) demonstrated that the dream-lag effect, that is the trend for experiences from 5-7 days ago to be incorporated into dreams (over and above events from 2-4 days ago) was evident in REM but not NREM dreams. These latter findings might demonstrate time of night effects also, whereby the dream-lag effect reflects the activation of recent residues

rather than day- or remote-residues within late night dreams. More research is needed to confirm these findings.

Although non-REM (NREM) sleep dreams are less common than REM sleep dreams (Hobson et al., 2000), they have been shown to occur even in the absence of prior REM sleep (Suzuki et al., 2004), illustrating that they exist independently of REM sleep. NREM sleep comprises three stages of sleep all with different characteristics, which include slower brain waves and sleep spindles (Maquet, 2010; Nir & Tononi, 2010). NREM sleep dreams have more friendly than aggressive interactions (McNamara et al., 2005), and are shorter, more thought-like, and more related to current concerns than REM dreams (Hobson et al., 2000). Sleep onset dreams (Stage 1 NREM) are mostly associated with day residues as opposed to recent residues (Battaglia et al., 1987).

Some REM/NREM dream content differences disappear when word length is controlled, but it has been argued convincingly that to control for word length is to control for the very feature of the dream that is being measured, since word length is likely to be an effect of dream features (such as bizarreness), not a cause of them (Hobson et al., 2000), and is probably a marker of overall cortical activation (Wamsley et al., 2007). Furthermore, some dream features remain significantly different between REM and NREM sleep even when word length *is* controlled (Hobson et al., 2000), so searching for differences is valid whichever stance is taken on word count.

However, the REM/NREM dichotomy is somewhat obscured by time of night effects, because NREM dreaming becomes much like REM dreaming later in the night (Payne, 2010), and 10-30% of these later NREM dreams are indistinguishable from

REM dreams (Nir & Tononi, 2010). For example, hallucinatory thoughts are more frequent in REM dreams across the night, but directed thought is only more frequent in NREM dreams in the first five hours of the night (Fosse et al., 2004); and while only REM dreams become more emotionally intense, bright, and clear later in the night, both REM and NREM dreams become more bizarre, dreamlike, and longer (Wamsley et al., 2007). Late-night REM dreams have also been found to contain more remote waking-life episodes than early-night REM dreams in one study (Verdone, 1965), although this was not replicated in a later study (see Domhoff, 2003), and so this finding requires further investigation. Nevertheless, sampling dreams from systematic time periods across the night has been shown to be comparable to sampling dreams from specific stages of sleep (Noreika, Valli Lahtela, & Revonsuo, 2009).

Whilst there have been some investigations of the memory sources of dreams sampled across the night, indicating differences in types of memories present in different stages of sleep (Baylor & Cavallero, 2001), it remains unclear as to how this can be conceived of in terms of continuity. Continuity between waking life and dreams may exist that cannot be highlighted by identification of memory sources, since continuity extends beyond the mere incorporation of episodic memories (Fosse et al., 2003; Malinowski & Horton, 2014). Similarly, elements such as bizarreness and/or discontinuity may change over the night, which may provide insights into continuity. Our study presents the first attempt to map continuity as a construct onto time of night, rather than identifying the memory sources of dream content. Based on the evidence cited above, it was hypothesized that early-night dreams would contain more day residues and late-night dreams more recent residues; that early-night dreams would be more continuous, perhaps particularly in relation to waking-life

concerns and thoughts, than late-night dreams; and that late-night dreams would be more emotional, bizarre, and discontinuous than early-night dreams.

1.2 Method

1.2.1 Participants

Participants were recruited via a participation credit scheme at Leeds Metropolitan University, in which undergraduate psychology students participate for course credits; and via opportunity sample. 16 participants (11 female, 5 male; 7 Leeds Metropolitan University undergraduates, 9 acquaintances of the researchers) were recruited, with an age range of 19 to 54 years of age ($M = 27$, $SD = 9.00$). 51 dreams were collected (per participant: $M = 3.19$, $SD = 2.01$) over two nights. Participants were recruited on the basis of their having good general health, being over 18 years of age, and not currently suffering nor historically having suffered from any sleep disorders or health problems that may affect sleep (e.g. depression), or any health problems that might worsen as a result of being awoken several times during the course of two nights' sleep (e.g. insomnia).

1.2.2 Design

Dreams were collected from participants awoken at certain intervals after they had retired to bed: in early-night sleep (between 0.5 and 2.0 hours); in early-mid-night

sleep (between 2.5 and 4.0 hours); in mid-late-night sleep (between 4.5 and 6.0 hours); and in late-night sleep (between 6.5 and 8.0). Participants also slept attached to a home-based sleep-monitoring device called REMview, to track their stages of sleep. REMview is identical in essence to the Nightcap, which has been demonstrated to be able to detect REM and NREM (Stages 1, 2, or 3) (Aijilore et al., 1995), using an eyelid sensor to measure eye movements and a head sensor to measure body movements. However, due to equipment problems, stages of sleep were not always recorded accurately, and so the focus of the results here is the time of night differences. (For more details on this methodology, consult Malinowski, 2012). Upon awakening, participants were requested to verbalise their dream or whatever was “going through their mind” (to elicit all mentation, not just participants’ idea of what a dream is, based on Foulkes, 1999), and these were audio-recorded. Following the night’s awakenings, participants listened to their dreams and completed a series of questions about them, as below.

1.2.3 Self-report questions

Participants completed one form per dream recorded, each morning of the study. They reported all waking-life concerns, activities, emotions, people, objects, media, and thoughts that appeared in the dream. Examples of each were given. They were also asked to record when they had last experienced (“Experiences”) and when they had last thought (“Cognitions”) about the waking-life element they had recorded. These time referents were subsequently split into three categories: Day Residue, Recent Residue (within a year), and Remote Residue (over a year), after Battaglia et

al. (1987). Finally, participants answered 12 questions, some pertaining to wake-dream continuity (such as “How related is the dream to your present (within the last month) waking life?”), and others to the general qualities of the dream (such as “How emotionally intense was your dream?”), answerable on a scale of 0 to 9. After the second night participants could also answer feedback questions (such as “Did you understand everything that you were asked? If no, what didn’t you understand?”).

1.2.4 Procedure

Participants met with one of the researchers on their first study day, who illustrated how to use the equipment by running through the standardised instructions. Participants were instructed not to drink any alcohol or caffeine or consume anything else that might interfere with sleep in the evening. In the evening, participants retired to bed as per their usual routine and fitted the equipment themselves. During the night, participants were awoken from the four time of night periods (see Section 1.2.2) and audio-recorded their dream. In the morning, participants removed the equipment, listened to their recorded dreams, and filled in the forms corresponding to each dream. Following the second night, participants met up with the researcher again to return the equipment and were debriefed.

The study abided by British Psychological Society ethical guidelines, and received local approval from an institutional ethical review panel.

1.2.5 Analyses

Four sets of analyses were performed on the data to assess the effect of time of night differences on:

1. The 12 dream variables (continuity with present, recent past, distant past, and future waking life; general continuity; similarity to waking life; metaphorical relation with waking life; emotional continuity; bizarreness; emotional and stressfulness intensity; and importance).
2. The frequency of the different waking-life elements (worries/concerns, activities, emotions, characters, objects, media, and thoughts)
3. The frequency of the three time referents (day / recent / remote residues)
4. The magnitude of correlations between the 12 dream variables.

Please see Appendix for the dream questions form participants filled in for each dream, illustrating the wording of the 12 dream variables and the scoring method used by participants.

1.3 Results

51 dreams were collected. The minimum word count was one word, the maximum 574 ($M = 102.55$, $SD = 136.86$). Dream forms were used in the analysis regardless of dream word length, provided the form was completed in its entirety. Of the 51 dreams, 49 dreams were suitable; two fell outside of the specified time categories. These 49 were split into the time of night categories and the word counts for these

are as follows: 7 Early ($M = 97.50$, $SD = 81.51$), 12 Early-Mid ($M = 61.17$, $SD = 54.16$), 16 Mid-Late ($M = 69.31$, $SD = 109.57$), and 14 Late ($M = 164.23$, $SD = 162.91$). There were no differences in word count between these four time point categories, $F(3,41) = 1.84$, $p > .05$.

Four one-way MANOVAs were performed. In all four, time of night (four levels: Early, Early-Mid, Mid-Late, and Late night sleep) was the independent variable. In the first analysis, the participant self-ratings for the 12 dream variables were the dependent variables. In the second analysis, frequency of occurrence of the seven waking-life elements was the dependent variable. In the third analysis, the frequency of occurrence of the three time referents for 'experiences' was the dependent variable. In the fourth analysis, the frequency of occurrence of the three time referents for 'cognitions' was the dependent variable. For all three analyses, each dream was treated as a case.

The dependent variables were all non-normally distributed according to the Shapiro-Wilk test of normality. Three different transformations were attempted on all variables (log, square root, and reciprocal), but none of the sets of transformed data displayed normal distributions. However, Field (2009) has noted that all four test statistics available in MANOVA are relatively robust to violations of multivariate normality and thus it remained a suitable analysis. Box's test of the assumption of the equality of covariance matrices was met for all analyses.

1.3.1 The effect of time of night on the 12 dream content variables

Table 1 displays the means and standard deviations for the 12 variables.

Table 1 – Means (SDs) of the 12 dream content variables

	Early	Early-Mid	Mid-Late	Late
Present Continuity	7.86 (0.90)	6.30 (2.95)	6.14 (3.37)	6.14 (2.57)
Recent Continuity	6.57 (2.15)	6.60 (2.32)	6.00 (3.10)	5.36 (2.56)
Distant Continuity	3.29 (3.35)	1.90 (3.10)	2.63 (2.97)	2.36 (3.08)
Future Continuity	3.71 (3.59)	5.70 (2.50)	5.75 (2.13)	6.64 (2.13)
General Continuity	7.57 (0.98)	6.40 (2.31)	6.25 (2.11)	6.21 (1.71)
Similarity	6.43 (2.07)	3.70 (2.91)	5.50 (3.27)	5.21 (2.52)
Metaphorical Continuity	3.14 (3.48)	5.20 (2.74)	4.56 (3.39)	5.42 (2.59)
Emotional Continuity	5.57 (3.40)	5.70 (3.50)	5.88 (2.73)	5.21 (2.94)
Bizarreness	2.43 (2.64)	5.70 (2.71)	3.75 (3.26)	5.71 (2.20)
Emotional Intensity	3.86 (2.79)	3.80 (3.74)	4.25 (2.91)	4.00 (3.33)
Stressfulness	3.14 (3.49)	3.10 (3.25)	3.38 (3.28)	2.93 (2.87)
Importance	3.71 (3.30)	3.70 (3.47)	4.19 (3.33)	3.43 (2.95)

Using Roy's largest root, there was a significant effect of time of night on the 12 dream content variables, $\Theta = .99$, $F(12, 34) = 2.82$, $p < .01$, $\Pi_p^2 = .51$. Separate univariate analyses on the dependent variables revealed that the only variable for which there was a significant time of night effect was bizarreness $F(3, 43) = 3.22$, $p < .05$. Games-Howell post-hoc (for unequal population variances) tests, however, found no significant differences between the times of night; only the difference between Early and Late sleep approached significance ($p = .07$, $\Pi_p^2 = .19$), with late-night dreams rating higher for bizarreness than early night dreams.

1.3.2 The effect of time of night on waking-life elements

Table 2 displays the means and standard deviations for the seven variables.

Table 2 – Means (SDs) of the frequency of the seven waking-life elements

	Early	Early-Mid	Mid-Late	Late
Concerns	1.71 (2.42)	1.08 (1.16)	1.19 (0.91)	1.43 (1.45)
Activities	1.14 (1.07)	0.92 (0.67)	1.13 (0.89)	2.14 (1.35)
Emotions	1.43 (1.72)	1.00 (0.95)	1.00 (1.03)	0.93 (1.20)
Characters	1.14 (1.86)	1.08 (0.90)	1.50 (0.90)	1.86 (1.41)
Objects	0.71 (1.11)	0.08 (0.29)	0.63 (0.81)	1.14 (1.17)
Media	1.00 (0.82)	0.42 (0.67)	0.19 (0.40)	0.29 (0.61)
Thoughts	1.14 (1.07)	0.83 (0.71)	1.00 (0.63)	1.00 (1.11)

Bold indicates a significant difference at the $p < .05$ level.

Using Roy's largest root, there was a significant effect of time of night on the seven waking-life element variables, $\Theta = .73$, $F(7, 41) = 4.30$, $p < .01$, $\Pi_p^2 = .42$. Separate univariate analyses on the dependent variables revealed that the three variables for which there was a significant time of night effect were Activities, $F(3, 45) = 3.86$, $p < .05$, $\Pi_p^2 = .20$, Objects, $F(3, 45) = 3.06$, $p < .05$, $\Pi_p^2 = .17$, and Media, $F(3, 45) =$

3.17, $p < .05$, $\eta_p^2 = .17$. Games-Howell post-hoc tests showed that for Activities, there was a significant difference between Early-Mid and Late night dreams ($p < .05$), with more activities in Late than Early-Mid dreams; for Objects, there was a significant difference between Early-Mid and Late night dreams ($p < .05$), with more objects in Late than Early-Mid dreams; and for Media there was a significant difference between Early and Mid-Late night dreams ($p < .05$), with more media references in Early than Mid-Late night dreams.

1.3.3 The effect of time of night on time referents

Table 3 displays the means and standard deviations for the three time referents for experiences and thoughts.

Table 3 – Means (*SDs*) of the frequency of the three time referents

		Early	Early-Mid	Mid-Late	Late
Cognitions	Day Residue	2.71 (2.63)	1.42 (1.16)	2.53 (1.88)	3.50 (2.74)
	Recent Residue	1.57 (0.77)	1.58 (1.16)	1.47 (1.25)	2.07 (1.69)
	Remote Residue	0.00 (0.00)	0.33 (0.89)	0.20 (0.41)	0.37 (0.63)
Experiences	Day Residue	3.43 (3.55)	2.25 (2.05)	3.33 (1.91)	4.71 (2.73)
	Recent Residue	1.14 (1.07)	1.17 (1.19)	0.87 (0.83)	1.43 (1.95)
	Remote Residue	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Using Roy's largest root, there was a non-significant effect of time of night on the three waking-life time referents for experiences, $\Theta = .17$, $F(3, 44) = 2.29$, $p > .05$, $\Pi_p^2 = .15$, and for cognitions, $\Theta = .16$, $F(3, 44) = 2.31$, $p > .05$, $\Pi_p^2 = .14$.

A post-hoc power analysis was conducted to investigate whether the sample size provided enough power to detect an effect of time of night on waking-life time referents. With $1-\beta = .8$, $\Pi_p^2 = .15$, and $p = .05$, it was found that 24 participants would have been needed to detect an effect. Thus, a moderate effect of time of night on waking-life time referents may yet exist, but a larger sample size would be required to detect it.

1.3.4 Correlations between continuity variables

Correlational analyses were performed to explore the general profile of early-night and late-night dream characteristics. Due to the low number of cases for the four time of night categories, the data were split into two time of night variables for the correlational analyses. Early and Early-Mid night dreams were combined, incorporating dreams from between 30 minutes and 4 hours after participants' bedtime, and became 'Early' (N=19), and Mid-Late and Late night dreams were combined, incorporating dreams from between 4.5 hours and 8 hours after participants' bedtime, and became 'Late' (N = 30).

Spearman's non-parametric tests were used for both correlations due to the non-normality of the data, tested with a Shapiro-Wilk test of normality. Tables 4 and 5

display the correlation matrices. Significance values were determined with the sequential Bonferroni method (Holm, 1979) to correct for the inflated risk of Type 1 error, whilst simultaneously avoiding concomitantly inflating risk of Type 2 error.

Table 4 – Correlation matrix: relationships between dream variables of early night dreams

	R.C.	D.C.	F.C.	G.C.	Sim.	M.C.	E.C.	Biz..	E.I	Str.	Imp.
Present Continuity	.40*	.24	.05	.22	.28	-.10	.16	-.13	.11	.17	.26
Recent Continuity		.41*	-.35	.16	.11	-.19	-.10	.11	.31	.15	.09
Distant Continuity			-.55**	-.09	.44*	-.20	-.03	-.31	.27	.16	.24
Future Continuity				.34	-.43*	.50*	.47*	.52*	.09	.24	.19
General Continuity					.24	.23	.53*	.33	.32	.29	.25
Similarity						-.42*	.26	-.36	.37	.26	.13
Metaphorical Continuity							.49*	.60**	.35	.40*	.54**
Emotional Continuity								.50*	.65***	.74***	.67***
Bizarreness									.38	.43*	.43*
Emotional Intensity										.93***	.78***
Stressfulness											.81***

Bold indicates correlation is significant at alpha level corrected by sequential Bonferroni method (Holm, 1979)

* = Correlation is significant at $p < .05$ level.

** = Correlation is significant at $p < .01$ level.

*** = Correlation is significant at $p < .001$ level.

P.C.	= Present Continuity
R.C.	= Recent Continuity
D.C.	= Distant Continuity
F.C.	= Future Continuity
G.C.	= General Continuity
Sim.	= Similarity
M.C.	= Metaphorical Continuity
E.C.	= Emotional Continuity
Biz.	= Bizarreness
E.I.	= Emotional Intensity
Str.	= Stressfulness
Imp.	= Importance

Table 5 – Correlation matrix: relationships between dream variables of late night dreams

	R.C.	D.C.	F.C.	G.C.	Sim.	M.C.	E.C.	Biz..	E.I	Str.	Imp.
Present Continuity	.66***	.21	.47**	.74***	.74***	-.25	.60***	-.34*	.25	.10	.26
Recent Continuity		.21	.36*	.62***	.52**	-.13	.55**	-.25	.15	.01	.19
Distant Continuity			.07	.16	-.24	.18	.15	.11	.36	.42	.27
Future Continuity				.51**	.54**	-.01	.47	-.00	.15	.04	.24
General Continuity					.58***	-.04	.53**	-.16	.33*	.16	.21
Similarity						-.55**	.59***	-.52**	.07	-.09	.11
Metaphorical Continuity							-.08	.72***	.51**	.58***	.47**
Emotional Continuity								.05	.42*	.34*	.39*
Bizarreness									.46**	.57***	.41*
Emotional Intensity										.86***	.91***
Stressfulness											.75***

Bold indicates correlation is significant at alpha level corrected by sequential Bonferroni method (Holm, 1979)

* = Correlation is significant at $p < .05$ level.

** = Correlation is significant at $p < .01$ level.

*** = Correlation is significant at $p < .001$ level.

P.C. = Present Continuity
R.C. = Recent Continuity
D.C. = Distant Continuity
F.C. = Future Continuity
G.C. = General Continuity
Sim. = Similarity
M.C. = Metaphorical Continuity
E.C. = Emotional Continuity
Biz. = Bizarreness
E.I. = Emotional Intensity
Str = Stressfulness
Imp. = Importance

In early- but not late-night dreams, Emotional Continuity was related to Stressfulness. Thus, when dreaming of one's waking-life emotions, the dream was more likely also to be stressful at the beginning but not the end of the night. In late-night dreams there were many more much larger and significant correlations than early-night dreams. For example, Present Continuity was positively correlated with Recent, General, and Emotional Continuity, and Similarity, in the late but not early night, as were Recent and General Continuity, Similarity and General Continuity, and Similarity and Emotional Continuity. This implies that continuity was generally more integrated in the later portion of the night than the earlier portion.

In addition, there were some differences evident in the size and/or direction of correlations between the early and late night dreams. Differences in the size of correlations that exceeded .4 were searched for and tabulated. Table 6 displays variables that were correlated: (a) positively in the early night dreams but either negatively or very weakly in the late night dreams, (b) positively in the late night dreams but either negatively or very weakly in the early night dreams, and (c) negatively in the early night dreams but very weakly in the late night dreams. Note that these tables simply describe size and/or direction differences, and do not describe significant correlations.

Table 6 – Differences in correlations between early- and late-night dreams

Variables	Early Night	Late Night	Difference
*Distant Continuity with Similarity	.44	-.24	.68
*Future Continuity with Metaphorical Continuity	.50	-.01	.51
*Future Continuity with Bizarreness	.52	-.00	.52
*General Continuity with Bizarreness	.33	-.16	.49
*Metaphorical Continuity with Emotional Continuity	.35	-.08	.43
*Emotional Continuity with Bizarreness	.50	.05	.55
**Present Continuity with Future Continuity	.05	.47	.53
**Recent Continuity with Future Continuity	-.35	.36	.71
**Recent Continuity with Emotional Continuity	-.10	.55	.65
**Future Continuity with Similarity	-.43	.54	.97
+Distant Continuity with Future Continuity	-.55	.07	.62
+Distant Continuity with Bizarreness	-.31	.11	.42

Key:

* variables positively correlated early in the night but negative or weak late in the night

** variables positively correlated late in the night but negative or weak early in the night

+ variables negatively correlated early in the night but weak late in the night.

1.4 Discussion

1.4.1 The effect of time of night on continuity and other dream variables

Late-night dreams showed a trend towards being more bizarre than those in the early night, in line with previous research (Fosse et al., 2004; Payne, 2010; Wamsley et al., 2007). It was hypothesised that other features of dreams would increase across the night, such as emotionality, and that some would be higher in the early night, such as present continuity, but this was not upheld. It may be that there was no effect for emotionality because emotionality only increases across the night in REM sleep (Wamsley et al., 2007). The small samples in each grouping may also account for the lack of more significant effects – some continuity variables changed in the predicted direction but without reaching significance, such as a decrease in present continuity – so further investigation with larger samples is required.

1.4.2 The effect of time of night on frequency of waking-life elements

Waking-life activities and objects appeared significantly more frequently in the late than early-mid night dreams, and media in the early than mid-late night dreams. For the former, a simple explanation of the higher incidence later on is that late night dreams are known to be longer (Hobson et al., 2000), and there is likely to be more of any element in longer than shorter dreams (Wamsley et al., 2007); but since there were no differences in word length, this is unlikely to explain this result. The greater occurrence of activities and objects in later dreams, but not of concerns or thoughts, may be due to the fact that dreams later in the night are more imagistic and visual

(Casagrande et al., 1996), and concerns and thoughts are thought-based rather than imagistic or perceptual like activities and objects. Since it is known that late-night dreams are typically longer (despite not being found in the present data) and thus more of any element is likely for this reason, it is particularly interesting that there were more references to media in early than mid-late sleep. This could be explained by proximity: it may be that dreams of the early night are particularly influenced by media that has been experienced the evening prior to sleep.

In a similar vein to the expectation that dream emotionality would increase across the night, it was hypothesised that there would be more references to waking-life emotions later in the night, based on the speculation that if dreams are more emotional later in the night, they may relate to waking-life emotions. The explanation for the null finding for waking-life emotions may be the same as the explanation for the null finding for dream emotionality: the over-representation of late-night NREM dreams, since emotionality is known to increase only in REM dreams across the night. Alternatively, it may be that whilst late-night dreams are typically emotional, this might not be a result of wake-dream continuity per se.

These differences in the composition of dreams across the night likely relate to the memory sources of dreams, and as such can be interpreted in light of previous research in this area: for example, that, episodic memory sources are relatively prevalent in NREM dreams and semantic sources in REM dreams (Baylor & Cavallero, 2001; see also Malinowski & Horton, 2014).

1.4.3 The effect of time of night on time referents

There were no time of night effects on the time referents of waking-life elements, in contrast to previous research that has found that there are more recent memory referents in early than late sleep (Battaglia et al., 1987; Verdone, 1965). Similarly, Blagrove et al. (2011) demonstrated that the dream-lag effect was evident in REM but not NREM dreams, potentially demonstrating time of night effects also. In the present study, power analyses suggest that the small sample sizes may account for the null finding; however, Hall (1966, cited in Domhoff, 2003) did not replicate Verdone's findings, and significant results were found for other analyses with small samples in the present study, so this matter is still unresolved and is certainly worthy of further investigation. However, the variability of findings may indicate that there are potential confounds or third variables acting upon these time of night effects, such as the age of the dreamer. For example, the reminiscence bump, the tendency for older adults to recall a disproportionate number of memories from the late-teen years, has been evidenced within dream recall (Grenier et al., 2005).

1.4.4 The difference in correlations between continuity variables in early and late night dreams

Some correlations were inverted from the early- to late-night dreams, as follows. (Note the following describes differences in magnitude of correlations, but is not limited to significant correlations.) In the early night only, future continuity was positively related to bizarreness and metaphoricalness and not related to other time referents of continuity; it was also negatively related to distant continuity. Conversely, in the late night only, future continuity was positively related to similarity and other time referents of continuity (such as present). In a similar way, in the early night only,

distant past continuity was positively related to similarity and negatively to future continuity and bizarreness, but in the late night only it was negatively related to similarity, and was not related to future continuity or bizarreness. A more sophisticated statistical analysis with a larger sample needs to be undertaken to illustrate which of these variables cluster or factor together, but these preliminary findings may indicate that continuity manifests differentially dependent on time of night. For example, future continuity may manifest in bizarre and/or metaphorical ways in the early night, but in a way that is more similar to waking life in the late night. In addition, dreaming of waking life seemed to be more likely to refer independently to one type of continuity or another in the early than the late night: all of the correlations between the continuity variables in the early night were either relatively small and positive or small and negative, whereas in the late night there were much larger positive correlations between them.

Taken together, we could try to assimilate these depictions of continuity with the literature concerning the memory sources of dreaming, the latter of which has evidenced that NREM dreams are more likely to feature episodic elements of waking life, with REM or late night dreams being more fragmentary (Baylor & Cavallero, 2001; Malinowski & Horton, 2014). However, there are two major differences between the present findings and the memory sources field. Firstly, we investigated time of night effects rather than comparing REM with NREM dreams. Secondly, we present a method for investigating characteristics of continuity that goes far beyond the reductionist method of exploring memory sources of dreams.

The pattern described above implies two potential alterations from early- to late-night dreams: the way in which distant and future continuity are dreamt of switches place (similar to waking life versus metaphorical and bizarre), and dreaming of waking-life

time referents moves from independent to integrated dreaming. Due to the low sample this suggestion is presented cautiously and with the caveat that it needs testing with a larger sample.

The results presented illustrate novel evidence for time of night effects on continuity: waking-life elements are represented with differing frequency from the early to the late night; late-night dreams are more bizarre; and the correlations between continuity variables (such as future) with each other and dream quality variables (such as bizarreness) change across the night. It is likely that these differences portray subjective mental representations that are reflective of physiological changes across night, such as cortisol levels (Payne, 2010), which in turn may reflect sleep-dependent processes such as memory consolidation and integration. For example, it has been shown that associative memory is selectively activated during REM sleep (Cai et al., 2009), which may be demonstrated in the present study by the more integrative activation of memories in the late night, where REM dominates. Future studies should continue to look for stage of sleep and time of night effects on continuity, and consider the implications they may have for the dreams reflecting differentiated memory consolidation and/or integration processes across the night.

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Appendix: Dream questions form

Think about all the ways in which your dream shares elements with waking life. Does the dream contain people you know, places you've been, things you've done, things you're worried about? Think carefully through each part of the dream and identify how it relates to your waking life, then list as follows. [NB the time you last experienced something may be different to when you last thought about it – e.g. you saw a movie a couple of weeks ago, but talked about it with a friend the night before a dream about it.] Play the dream to yourself as many times as you need to and please try to complete the lists as fully as possible, so that every part of the dream that you recognised from your waking life is accounted for.

1. List any waking life worries or concerns the dream relates to, such as relationships, friendships, money, work or studies, life upheavals such as moving house, health, or any other worries or concerns. These can be things you are currently worried about, or have happened in the past. State when you last experienced this worry or concern and when you last thought about this worry or concern (e.g. last night, last week, a year ago, etc). If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Worry or concern</u>	<u>Experienced</u>	<u>Thought about</u>
Revising for exams	Three days ago	Last night

2. List any waking life activities the dream relates to, such as socialising, hobbies, sports / exercise, work or studies, daily activities including travelling and eating, shopping, etc. These can be activities you have engaged in recently or longer ago. State when you last experienced this activity and when you last thought about this activity. If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Activity</u>	<u>Experienced</u>	<u>Thought about</u>
Went shopping with my mum	Last weekend	Last weekend

3. List any waking life emotions the dream relates to, such as anger, sadness, fear, guilt, happiness, surprise, sexual arousal, annoyance, worry, etc. State when you last experienced this emotion

and when you last thought about this emotion. If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Emotion</u>	<u>Experienced</u>	<u>Thought about</u>
Angry at someone who cut me up driving	A week ago	Two days ago

4. List any waking life characters the dream relates to, including family members, friends, people from work, famous people e.g. film/TV stars, fictional people e.g. characters from film/TV, animals such as pets, etc. They can be people you have met or not, and it doesn't matter when you last saw them. State when you last saw them, and when you last thought about them. If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Character</u>	<u>Experienced</u>	<u>Thought about</u>
Janine (housemate / best friend)	Last night	Last night

5. List any waking life objects the dream relates to, such as clothing, books, furniture, and vehicles. State when you last came into contact with the object, and when you last thought about it. If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Object</u>	<u>Experienced</u>	<u>Thought about</u>
Desk in my room at my parents' house	A month ago	A month ago

6. List any waking life media the dream relates to, such as TV shows, books, films, and music. It can be a character, a location, a plot, a song, or anything else. State when you last saw/read/heard it, and when you last thought about it. If there are none, write N/A in the second box. An example is given for you in **red ink** in the first box.

<u>Media</u>	<u>Experienced</u>	<u>Thought about</u>
Saw 'Sherlock Holmes' at cinema	Two weeks ago	Yesterday

7. List any waking life thoughts the dream relates to, such as something you need to do, something you believe (e.g. religion or politics), or anything else you have been thinking about. State when you last thought about it. If there are none, write N/A, in the second box. An example is given for you in red ink in the first box.

<u>Thoughts</u>	<u>Experienced</u>	<u>Thought about</u>
Need to collect prescription from pharmacist	Yesterday	Yesterday

Now please think about how your dream relates to your waking life *overall*. Note that sometimes you may have dreams that are *literally* related to your waking life – such as dreaming that you turned up to the wrong exam, during your exam revision time. Other times you may find that dreams are related to your waking life, but in less literal ways: for example, you may dream of being lost if you are feeling lost; or you may dream about your studies, but in a strange way that is not at all like waking life. For the following questions, please try to think about how related to your waking life the dream is *regardless of whether the relation is literal or not*.

- How related is the dream to your *present* (within the last month) waking life on a scale of 0-9, where 0 = no part of the dream is related to your present waking life, and 9 = every part of the dream is related to your present waking life? **Answer:**
- How related is the dream to your *recent past* (a month or longer ago, but not childhood) waking life on a scale of 0-9, where 0 = no part of the dream is related to your recent past waking life, and 9 = every part of the dream is related to your recent past waking life? **Answer:**
- How related is the dream to your *distant past* (childhood) waking life on a scale of 0-9, where 0 = no part of the dream is related to your distant past waking life, and 9 = every part of the dream is related to your distant past waking life? **Answer:**

4. How related is the dream to your *future* waking life (i.e., things you are anticipating for the future) on a scale of 0-9, where 0 = no part of the dream is related to your future waking life, and 9 = every part of the dream is related to your future waking life? **Answer:**

5. How related is the dream to your waking life *in general* (present, past, or future) on a scale of 0-9, where 0 = no part of the dream is related to waking life, and 9 = every part of the dream is related to waking life? **Answer:**

For the next two questions, please think more about whether the dream is *literally* related to your waking life or *not literally* related to your waking life. If it is literally related, you could say the dream is *similar* to your waking life. If it is not literally related, you could say the dream is *metaphorical* for your waking life.

6. How similar is the dream to your waking life *in general* (present, past, or future) on a scale of 0-9, where 0 = no part of the dream is similar to your waking life, and 9 = every part of the dream is similar to your present waking life? **Answer:**

7. How metaphorical is the dream to your waking life *in general* (present, past, or future), on a scale of 0-9, where 0 = no part of the dream is metaphorical for waking life, and 9 = every part of the dream is metaphorical for waking life? **Answer:**

You may have found that emotions in your dream relate to emotions in your waking life: for example, if you're feeling guilty about something, you might feel guilty in your dream; or if you feel anxious about something, you might feel anxious in your dream, and so on. If doesn't matter if the dream is similar to waking life or a metaphor for waking life – please just think about the emotion.

8. How emotionally continuous is the dream to your waking life *in general* (present, past, or future), on a scale of 0-9, where 0 = no part of the dream is emotionally continuous with waking life, and 9 = every part of the dream is emotionally continuous with waking life? **Answer:**

Finally, please answer the following questions:

9. How bizarre is the dream on a scale of 0-9, where 0 = there are no bizarre elements at all to the dream. 9 = dream is as bizarre as it can be? **Answer:**

10. How emotionally intense was your dream on a scale of 0-9, where 0 = not at all emotional, and 9 = as emotional as it is possible to be? **Answer:**

11. Would you say the overall emotional tone of the dream was positive, negative, or neutral?
Answer:

12. How stressful was your dream scale on a scale of 0-9, where 0 = not at all stressful, and 9 = as stressful as it is possible to be? **Answer:**

13. How important would you say your dream was to you on a scale of 0-9, where 0 = not at all important, and 9 = as important as it is possible to be? **Answer:**