Longitudinal studies of gender differences in cognitional process in dream content

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Summary. We collected dream series over two years from 37 men and 46 women from the dream posting website dreamboard.com. We applied mixed effect regression modeling techniques to assess the effects of a dream content variable "cognitive processing" on other dream content variables in men vs women. We found that on a month by month basis cognitive processing was significantly associated with markers of grammatical complexity (verbs and function words), the personal pronoun I, social processes, perceptual processes, health and emotion (both negative and positive) with men having a greater association to processing resources with these matters than women. Men exhibited a significantly positive rate of change in cognitive processing on a monthly basis, while women did not show a significant rate of change over time. Results suggest that people do in fact use dreams to cognitively process emotional information over time with men using dreams more intensively than women.

Keywords: Dreaming, longitudinal studies, gender differences, cognitional process,

1. Introduction

Cross sectional studies have documented gender differences in dream content. Hall and Van de Castle (1966) studied content of five dreams of each of 100 male and 100 female college students (N = 1000), which had been collected in the years 1948 to 1952. They found that unfamiliar, outdoor settings were present more often in men's versus women's dreams and that there was a higher proportion of male dream characters, unknown characters, more physical aggression, weapons, and sexuality in men's vs women's dreams.

These basic cross sectional content differences between the dreams of men and women have largely been confirmed in more recent studies (Domhoff, 1996 Schredl et al., 1998) but there have been, to our knowledge, no longitudinal studies of gender differences in dream content among adults.

If people utilize dreams to process or work through emotional issues as several investigators have argued (e.g. Kramer, 1993; Levin and Nielsen, 2007; Hartmann, 1998; Walker and van der helm, 2009) then it may be that cognitive processing of emotional content may differ for men and women. Recent findings concerning emotional memory consolidation associated with REM sleep are consistent with the idea that dreams are utilized to process emotional information (e.g. Walker, 2009). If emotional information is being processed in dreams it is possible that the content of dreams will reflect that processing and therefore change with time.

The purpose of this study was to take advantage of a unique data source, an online dream posting website (www.dreamboard.com) to assemble a collection of dream series in order to examine the issue as to whether men and women use dreams differentially to process emotional information. We assume that if our index of "cognitive processing" (see below our operational definition of this term) changes with time in dreams then it points to the possibility that differing amounts of cognitive processing are occurring over time—presumably in relation to emotional issues. We assume that word classes or reflect the types of the corresponding mental processes as it is counterintuitive to suppose that the occurrence of emotion words or words indicating cognitive processes would reflect the lack of emotions or cognitive processing. Further, if words indicating cognitive processing occur more frequently in some dreams than in others we assume that the greater frequency of such words indicates that greater amounts of cognitive processing is occurring in those dreams. If in addition those words occur in correlation with other word class types (e.g. sexual words or emotion words or social words etc) then it is possible that dreams are being used to process the types of information indexed by those word classes. If for example, words denoting cognitive mechanisms occur significantly often in relation to emotion words in some dreams rather than in others then it is possible that those dreams may be involved in processing emotional memories. We therefore predict that by assessing the lagged relationships between gender, the cognitive processing variable and change in other content variables we can identify whether men and women use dreams differently in terms of content items that are associated with cognitive processing.

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2. Method

2.1. Participants and Procedure

Eighty-two (82) individuals who had posted dreams between January 2012 and December 2014 were selected from a dream diary internet posting site (www.dreamboard.com) or application. There were 37 men and 45 women. We selected these individuals based upon selection criteria described below. Dreamboard is an online forum in which users can record and track their dreams over time via a phone application or online. Dreamboard.com began in 2012, and without any advertisement, grew tremendously thereafter. These posting entries consist of a combination of standardized fields and free text to capture individual dream narrative and themes. Once entered into the database they are assigned an identification code to protect the anonymity of the dreamer. In 2013, the company made available to the authors a database of approximately 175,000 dreams posted from 2012 to 2014. As of this writing [November 2015], there are over 200,000 registered users of the Dreamboard.com application with almost two thirds classified as regular users, i.e., 3 or more dreams entered during given period. Dreamboard.com itself is available for use all over the world. While most dreams are posted in English, a substantial proportion are not, thus, substantially increasing the cross-cultural data available for studies of dreams and nightmares. We, however, focused on dreams posted in English in this study.

Selection criteria

Participants had to have posted at least 3-4 dreams per month for two years between January 2012 and December 2014. In addition the narratives these individuals posted had to have word counts between 40-175 as this word count range provided enough text to do valid content analyses with the word count program we used (LIWC-see below). In total, there were 5,967 dreams across the 82 individuals (roughly 73 dreams per individual). A breakdown of dreams per month for each participant and total dreams for each participant can be found in Table 1. The gender, birthdate, and age are included. Table 2 contains the mean and standard deviation of dreams per month by each of the three years of the study. The means and standard deviations of all users' dreams for each month are found in Table 3.

Each narrative was run through the linguistics program, LIWC (www.liwc.net), to obtain word count values for the following word categories: cognitive mechanisms; I (personal pronoun), anxiety, function words, verbs, social words, positive emotion words, negative emotion words, words indicating percepts, and words concernining health.

Linguistic Inquiry and Word Count is a simple word counting software tool. It classifies words into super-ordinate categories. LIWC reports the percentage of words in each of 68 categories thereby controlling for word length differences across narratives. LIWC categories were validated against a wide array of texts and text types during LIWC development.

The **cognitive processes** (cogmech) category is our operational definition of cognitive processing that we believe captures words indicating a change in cognitive processing in dreams. The cognitive processes category picks up words indicating insight, causation, discrepancy, tentativeness, certainty, inhibition, inclusion, and exclusion. To supplement the main cognitive processing variable (cogmech) we added the **function word** category which is made of words that function as grammatical markers. We thought that as narratives contain increased numbers of syntactical markers so too would cognitive processing increase. Similarly, the **verb** category refers to "common" verbs such as walk, went, see, and includes verbs in all tenses, i.e., past tense (went, ran, had), present tense (is, does, hear), future tense (will, gonna). Not included under the verb category are auxiliary verbs (am, will, have). The verb analysis would capture additional evidence of grammatical processing thus adding to confidence that cognitive processing was being accurately captured with these analyses. In addition the verb variable would, of course, capture changes in frequency of actions in a dream. The **perceptual process** category contains words indicating seeing, hearing and feeling/touching. The target category, **personal pronouns**, is made up of social pronouns (e.g., I, me, he, she, it, etc. 1st person plural, 2nd and 3rd person pronouns), communication verbs (e.g., "talk," "share"), and references to family, friends, and other humans. We focused on **first person singular personal pronoun or "I"**. The personal pronouns category would capture changes in sense of self and interactions with others. The **health** category is made of words referring to health and illness. The **social** category refers to social interactions (e.g., mate, talk, they, child), and is an overarching category for family, friends and humans. These include words such as daughter, husband, aunt (family), buddy, friend, neighbor (friends), adult, baby, and boy (social). Also included in the social category are words that imply human interaction (e.g., sharing, talking) as well as all non-first-person-singular pronouns. The social category would capture changes in frequency of social interactions. The **negative emotion** category is a subset of the affect category of LIWC. The affect category contains 615 words drawn from two subcategories called Positive Emotions and Negative Emotions. Examples of Negative Emotion words include "hate", "worthless", and

Table 1. Demographics and Dream Statistics by Gender

Group	Age at first dream	Number of dreams per participant	Range of dreams per participant
All	28.06 ± 12.78	72.77 ± 49.68	6-262
Male	29.48 ± 14.26	65.05 ± 39.84	17-189
Female	27.00 ± 11.63	79.11 ± 56.17	6-262

Note. Six participants (four men, two women) did not report age

Table 2. Descriptive Statistics for Dreams by Month and Year for all participants

Time	Number of dreams per month	Range of dreams (month)
Year 1	39.92 ± 77.62	1-268
Year 2	250.17 ± 64.12	149-213
Year 3	207.17 ± 70.09	3-323
All Years	165.75 ± 114.85	1-361

Table 3. Dreams per Month by Gender

	All			Male			Female		
Month	**Total**	**Mean (SD)**	**Range**	**Total**	**Mean (SD)**	**Range**	**Total**	**Mean (SD)**	**Range**
Jan '12	2	0.02 (0.22)	0-2	0	0 (0)	0	2	0.04 (0.30)	0-2
Feb '12	6	0.07 (0.49)	0-4	0	0 (0)	0	6	0.13 (0.66)	0-4
Mar '12	7	0.09 (0.67)	0-6	0	0 (0)	0	7	0.16 (0.90)	0-6
Apr '12	3	0.04 (0.19)	0-1	0	0 (0)	0	3	0.07 (0.25)	0-1
May '12	2	0.02 (0.16)	0-1	0	0 (0)	0	2	0.04 (0.21)	0-1
Jun '12	2	0.02 (0.16)	0-1	0	0 (0)	0	2	0.04 (0.21)	0-1
Jul '12	1	0.01 (0.11)	0-1	0	0 (0)	0	1	0.02 (0.15)	0-1
Aug '12	12	0.15 (1.04)	0-9	0	0 (0)	0	12	0.27 (1.40)	0-9
Sep '12	28	0.34 (1.68)	0-12	6	0.16 (0.99)	0-6	22	0.49 (2.08)	0-12
Oct '12	49	0.6 (2.73)	0-22	0-13	0.35 (1.38)	0-8	36	0.80 (3.47)	0-22
Nov '12	98	1.20 (2.91)	0-16	0-48	1.30 (3.24)	0-16	50	1.11 (2.64)	0-14
Dec '12	269	3.28 (5.72)	0-29	0-100	2.70 (5.23)	0-22	169	3.76 (6.11)	0-29
Jan '13	315	3.84 (6.30)	0-30	0-155	4.19 (6.70)	0-22	160	3.56 6.02)	0-30
Feb '13	271	3.30 (5.70)	0-41	0-123	3.32 (7.31)	0-41	148	3.29 (4.00)	0-15
Mar '13	362	4.41 (6.47)	0-27	0-143	3.86 (6.81)	0-27	219	4.87 (6.23)	0-23
Apr '13	252	3.07 (4.25)	0-18	0-87	2.35 (3.63)	0-14	165	3.67 (4.66)	0-18
May '13	285	3.48 (6.44)	0-44	93	2.51 (4.11)	0-16	192	4.27 (7.82)	0-44
Jun '13	295	3.60 (6.17)	0-43	97	2.62 (3.74)	0-13	198	4.40 (7.56)	0-43
Jul '13	223	2.72 (4.99)	0-35	89	2.41 (3.86)	0-15	134	2.98 (5.79)	0-35
Aug '13	149	1.82 (2.95)	0-13	57	1.54 (2.76)	0-13	92	2.04 (3.10)	0-11
Sep '13	168	2.05 (3.49)	0-18	69	1.86 (3.73)	0-18	99	2.20 (3.31)	0-13
Oct '13	167	2.04 (3.48)	0-19	66	1.78 (3.78)	0-19	101	2.24 (3.24)	0-11
Nov '13	250	3.05 (5.63)	0-29	123	3.32 (7.22)	0-29	127	2.82 (3.93)	0-14
Dec '13	265	3.23 (5.55)	0-27	143	3.86 (6.90)	0-27	122	2.71 (4.15)	0-16
Jan '14	257	3.13 (5.19)	0-33	121	3.27 (6.38)	0-33	136	3.02 (4.03)	0-15
Feb '14	276	3.37 (6.24)	0-41	120	3.24 (5.73)	0-22	156	3.47 (6.69)	0-37
Mar '14	326	3.98 (6.94)	0-39	146	3.95 (7.36)	0-39	180	4.00 (6.65)	0-37
Apr '14	251	3.06 (4.85)	0-24	118	3.19 (5.88)	0-24	133	2.96 (3.88)	0-13
May '14	187	2.28 (3.87)	0-18	71	1.92 (4.16)	0-18	116	2.58 (3.63)	0-14
Jun '14	242	2.95 (5.26)	0-26	107	2.89 (6.37)	0-26	135	3.00 (4.21)	0-16
Jul '14	253	3.09 (5.95)	0-31	111	3.00 (6.35)	0-27	142	3.16 (5.67)	0-31
Aug '14	188	2.29 (4.07)	0-18	67	1.81 (3.16)	0-13	121	2.69 (4.68)	0-18
Sep '14	138	1.68 (3.17)	0-14	32	0.86 (2.20)	0-12	106	2.36 (3.67)	0-14
Oct '14	139	1.70 (3.70)	0-17	48	1.30 (2.96)	0-12	91	2.02 (4.21)	0-17
Nov '14	121	1.48 (3.49)	0-20	27	0.73 (1.76)	0-7	94	2.09 (4.36)	0-20
Dec '14	108	1.32 (3.71)	0-26	27	0.73 (1.50)	0-6	81	1.80 (4.79)	0-26
All Months	5967	72.77 (49.69)	6-268	2407	65.05 (39.84)	17-206	3560	79.11 (56.17)	6-268

Note. Month includes average, standard deviation, and range of number of dreams per subject per month

"enemy." The category of Negative Emotion also includes three subcategories of Anxiety / Fear (e.g., "nervous"), Anger (e.g., "hate", "pissed"), and Sadness / Depression (e.g., "cry"). **Positive Emotions** is further divided into two subcategories of "Positive Feelings" (e.g., "happy", "joy", "love") and "Optimism and Energy" (e.g., "win", "excitement

In the Affect category, we focused on two subcategories: Positive Emotion and Negative Emotion. The rationale for this is that there is considerable evidence that the neural correlates of emotion processing may be valence-specific, e.g., processing of negative emotions may be dissociated from processing of positive emotion. Our basic predictions

were as follows:

1) Cognitive processing should change over time in relation to other word categories if dreamers use dreams to process issues of concerns (e.g. emotional or social or health issues etc.)
2) Verb and function word usage will be used as an index of grammatical complexity in a narrative and therefore the dreamer's thinking and actions in the dream. Verb and function words should increase as cognitive complexity increases. They should track with the cognitive processing variable thereby increasing confidence in the cognitive processing variable.
3) Personal pronoun "I" is an index of the dreamer's sense of self and participation in the dream. Therefore frequency of personal pronouns should be associated with the cogmech variable over time if dreamers use dreams to process information about self.
4) Negative emotion should be associated with cogmech over time if cognitive processing is used to process negative emotions
5) Positive emotion should be associated with cogmech over time if cognitive processing is used to process positive emotions
6) Social: should be associated with cogmech over time if cognitive processing is used to process information about social interactions.
7) Perceptual processes should be associated with cogmech over time if cognitive processing is used to process perceptual information

2.2. Statistical Analyses

Due to the need to include covariates in the analysis, multivariable mixed-effects linear regression models were used to determine longitudinal effects of changes for cognitive processing. We ran separate mixed effect regressions for each cognitive mechanism as independent variable and cogmech as the outcome. This model included age and gender as covariates. Furthermore, we include interactions of the cognitive mechanism and gender to measure differences of the effect of cognitive mechanisms on content. Longitudinal changes are modeled by including time (month) as an independent variable in the models. Parameter estimates for time can then be interpreted as average effects of change over time. Mixed effects regression models were also used to assess differences in the average effects of change over time between genders. These models also included an interaction of age and time to account for possible effects of age on the rate of dream content change over time. Models also adjusted for correlations between outcomes from the same subject to account for possible inflation of Type I error. Since we consider a large number of statistical tests simultaneously which lead to an inflation of Type I error, all p-values were further adjusted for multiple comparisons using the Benjamini & Hochberg (1995) method, which control the false discovery rate. All analyses were conducted using SAS 9.4 and R programming language (R core team 2014).

To control for differing dream narrative word counts LIWC returns percentage word counts, not raw word counts. In addition to control for differing baseline content frequency in the cognitive processing variable (cogmech) we used the first three months of an individual's dreams as a baseline against which we assessed changes over the rest of the 21 months for which we had data. We also adjusted for age in all analyses.

Table 4. LIWC Means and Standard Deviations by Gender

LIWC category	Males (n=36)	Females (n=45)
Function Words	57.63(6.68)	59.46(6.08)
Anxiety	0.33(0.72)	0.40(0.79)
First Person Singular Pronouns	7.08(3.93)	7.81(3.73)
Verb	13.91(4.15)	14.99(3.99)
Social Words	9.52(5.27)	9.72(5.32)
Positive Emotions	1.95(2.00)	2.04(2.03)
Negative Emotions	1.71(1.89)	1.73(1.81)
Cognitive Mechanisms	16.07(5.01)	16.13(4.92)
Perceptual Processes	2.62(2.36)	2.78(2.38)
Health	0.34(0.88)	0.38(0.89)

Table 5. Effect Cognitive Mechanisms on Content Each Month

Effect	Estimate of effect on cognitive mechanism	Standard Error	Degrees of Freedom	T-test statistic	p-value adjusted for multiple comparisons
anx	3.7807	0.5093	835	7.42	<.0001
i	1.6697	0.05581	835	29.92	<.0001
funct	0.3175	0.003577	835	88.74	<.0001
verb	1.2189	0.01965	835	62.04	<.0001
social	1.0377	0.02336	835	44.42	<.0001
posemo	2.1528	0.1912	835	11.26	<.0001
negemo	3.176	0.1816	835	17.49	<.0001
percept	1.2575	0.1641	835	7.66	<.0001
health	0.697	0.4501	835	1.55	0.1334

Note. All models include time (month), gender, age and gender-age interaction

3. Results

The LIWC means and standard deviations for the categories are presented in Table 4. We first examined the effect of cog mech on other content variables for each month. We quantified coincident relationships between cog mech and other content variables, i.e whether the current cog mech content variable predicts negative emotion or social processes etc at the same month. The results are shown in Table 5. Interestingly, cog mech content is significantly associated with high verb and function word content at the same month. Additionally, significant association was seen between cog mech and personal pronoun I, cog mech and social processes, cog mech and anxiety, cog mech and positive emotions, cog mech and negative emotions, and cog mech and perception.

Table 6 displays male vs female differences in these monthly effects. There were significant differences in monthly trajectories for male vs females for the monthly associations between cog mech and function words, cog mech and verbs, cog mech and use of personal pronouns, cog mech and social processes, cog mech and negative emotions, cog mech and positive emotions, and cog mech and health.

To explore trajectories over time for the cognitive mechanisms variable for men vs women using the first three month of cog mech for the baseline, we display plots of change relative to baseline in the cognitive mechanisms variable in Figure 1. Male trajectories of cog mechanisms are on the left panel and females on the right panel. It can be seen that relative to the first three months as baseline cognitive processing decreases constantly but insignificantly for women over time (beta=-0.2523, SE=0.1643, df=835, t=-1.54, p=0.1251, adj p=.5023) but increases significantly over time for men (beta=0.5069, SE=.1819, df=835, t=2.79, p=.0054, adj p=0.0111). The difference between males vs females in trajectories for the cognitive mechanisms variable was significant (beta= 0.7591, SE=2448, df=835, t=3.1, p=0.002, adj p=0.0139).

Slope for men (SE): 0.51 (0.18), p-value=0.0111. Slope for women (SE): -0.25 (0.16), p-value=0.1251.

4. Discussion

In examining the longitudinal effects of our cognitive processing variable (cog mech) on other dream content variables in dream series collected over two years from 37 men and 46 women, we found that on a month by month basis cognitive processing is significantly associated with markers of grammatical complexity (verbs and function words), the personal pronoun I, social processes, perceptual processes, health and emotion (both negative and positive). All but the perceptual processes variables had a significantly different effect on cognitive processing for men vs women with men having a greater association to processing resources with these matters than women.

The rate of change on a monthly basis for cognitive processes differed significantly for men vs women. Men exhibited a significantly positive rate of change in cognitive processing on a monthly basis, while women did not show a significant rate of change over time. Moreover, the difference in the rate of change in words denoting cognitive processing differed significantly in men compared to women.

Pulling these results together suggests that people do in fact use dreams to “work through” or cognitively process selected types of emotional information and the rate at which they do so appears to increase, at least for men. The topics subject to or associated with cognitive processing in dreams appears to be concerned primarily with emotional and personal and social processes rather than health or perceptual processes.

Why might men evidence increasing rates of cognitive processing around emotions over time, while women’s rate of cognitive processing remains relatively constant over time? It cannot be due to differences in frequencies of baseline content variables as we adjusted for baseline frequencies of words denoting cognitive processing in our analyses. Nor can it be due to age differences among males versus females as we adjusted for age in our analysis.

The continuity hypothesis on dream content states that dream content largely reflects waking-life. The continuity hypothesis is broadly supported by empirical evidence (Schredl and Hoffman, 2003; Domhoff, 2011). It may be that women devote much of their waking lives to processing

Table 6. Male vs Females on Effect of cog mechanism on content each month

Effect	Gender differences in the estimate of effect on cognitive mechanism (Men- Women)	Standard Error	Degrees of Freedom	T-test statistic	p-value adjusted for multiple comparisons
anx	11.0392	1.0201	834	10.82	<.0001
i	2.4101	0.09561	834	25.21	0.0002
funct	0.1158	0.02973	834	3.89	<.0001
verb	1.1547	0.05895	834	19.59	<.0001
social	1.23	0.04928	834	24.96	<.0001
posemo	4.4901	0.3594	834	12.49	<.0001
negemo	6.2581	0.3071	834	20.38	<.0001
percept	3.4122	0.3138	834	10.87	<.0001
health	1.5567	0.9072	834	1.72	0.1005

Note. All models include time (month), gender, age and gender-age interaction

emotional content while men prefer to process emotional content "off-line".

Results from our analyses provide partial support for continuity but also raise significantly new issues regarding the way men and women use dreams to process emotional concerns as men appear to engage in increasing amounts of cognitive processing around emotional information over time than do women. It may be that the increase in processing of emotional content among men is due to increasing complexities in men's lives over time. The same increase in complexity no doubt also occurs in women's lives, but as mentioned above women may additional prefer to process those increasing complexities outside of their dreams in their waking lives while men reserve their dreams for that task.

Disclosure

Patrick McNamara is Chief Science Officer for DreamBoard.com Inc.

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