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Effects of Environmental Context and Cortical Activation on Thought

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This paper describes two experiments that examine the relationship between external auditory non-specific stimulation and disruption of the thematic sequencing of spontaneous thought and imagery. It is proposed that such external stimulation disrupts the flow of spontaneous mentation, resulting in more and briefer thematic sequences per unit of time. It is assumed that the long thematic sequences of REM sleep, in contrast to waking, are achieved, in part, because of the high perceptual thresholds of that state, which prevent the disruption of mentation sequences by external stimuli. The two experiments simulate the long thematic sequences of dreaming in the waking state by comparing the disruptive effects of two levels of ambient auditory stimulation.

This paper describes two experiments that evaluate the effect of environmental stimulation on thought and imagery in a state of cortical activation, namely the waking state. The waking fantasy reports are interpreted using sleep stages 1-REM and 2 as reference points. The paper also addresses methodological issues pertinent to the comparison of mentation in sleep and waking states.

In making these between state comparisons some points of methodology must be considered. First is the necessity of obtaining appropriate control data to use in evaluating sleep mentation reports. Unfortunately, it has not been common practice to obtain mentation reports from waking subjects in laboratory environments similar to those used in sleep mentation studies. To do so, one must examine the effect of the duration of the pre-report interval (i.e., the time between successive reports). How do the characteristics of the mentation report vary with the length of the preceding interval? Does the duration of the pre-report interval have such a profound effect on the mentation report that there is no basis for comparing the waking and sleep reports? It should be kept in mind that the pre-report interval in sleep is indeterminate, in most cases. One cannot even be certain that the pre-report interval begins with a new sleep stage. If the parameters of the waking report

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increase linearly with the pre-report interval, then it would be impossible to determine a waking standard with which to compare the REM and Stage 2 reports. If, however, imagery and thought generated earlier in the report interval are progressively lost as the report interval increases in duration, reports of thought processes may asymptote to a constant maximum limit. That is, increasing the report interval beyond some point in time may no longer be accompanied by further increases in recall of content. This is an empirical question which is addressed in Experiment 1.

It should be noted that Foulkes and his colleagues (Foulkes and Fleischer, 1975; Foulkes and Scott, 1973) were the first to examine mentation reports in a low stimulation environment. It has generally been assumed that waking mentation is characterized by deliberate thought and is, therefore, more like Stage 2 mentation (where subjects frequently report that they were thinking) than Stage 1-REM mentation. Contrary to expectation, Foulkes and his colleagues found that wakeful subjects reported dramatic, bizarre, visual hallucinatory experiences. The authors did not, however, study the effect of interval duration between successive reports. In view of the previous assumptions about waking thought, it is surprising that subsequent sleep mentation studies have not routinely included waking state control conditions.

The model proposed by Antrobus (this volume) makes several predictions about the effects on thought processes of ambient stimulation levels and state dependent changes in cortical activation. These predictions can be operationalized in terms of the specific variables examined in the two experiments to be described below. The number of thematic sequences in the report, Topic Units (TU), is assumed to reflect the effect of environmental stimulation, and should be sensitive to manipulations of auditory stimuli in the waking state. Total Recall Count (TRC) is presumed to index changes in cortical activation, and has been shown to discriminate between REM and Stage 2 sleep reports (Antrobus, 1983). The ratio of recalled content per topic unit (TRC/TU) measures the length of individual thought segments. Since the ratio TRC/TU can be increased by cortical activation which, we assume, is highest in waking, and also by decreasing TU, which is smallest in sleep, it is difficult to predict whether the ratio will be highest in waking or REM sleep. The model states that where neither the discipline of pen and pencil nor the attentive support of a listener are available to restrain wandering from one topic to another, the longer the thought unit, the more dreamlike it will become. Inasmuch as Stage 1-REM sleep is well documented as the most dreamlike state, one may assume that TRC/TU will be highest in that state.

These variables, TRC, TU and the ratio TRC/TU, can be examined to test several of the predictions of the model proposed by Antrobus (this volume).

1. The model requires that TU decrease if ambient stimulation in the sub-

ject's environment, particularly auditory stimulation, is decreased. If auditory stimulation is reduced while cortical activation remains constant, TU should decrease faster than TRC, and thus TRC/TU should increase as environmental stimulation decreases. That is, report length per topic should increase as the environment becomes less disruptive.

2. The global construct of "dreaming" suffers from a lack of operational specificity. Judges vary in their definition of what constitutes a "dream." Antrobus (1983) has demonstrated that TRC is the major component of the Stage 1-REM pre-eminence in dreaming. Does TRC/TU covary even more closely with the construct of "dreaming"?

3. Finally, it remains to determine how well TRC and TRC/TU distinguish between waking and sleep states, compared to traditional variables such as "Dreamlike Quality" and "Bizarreness." REM sleep, which has high cortical activation and minimal response to ambient stimulation, should yield the lowest TU estimates, high TRC, and TRC/TU ratios similar to those in sound-attenuated waking environments or, perhaps, even higher.

The two experiments presented here employ moderate and low levels of auditory ambient stimulation in the absence of visual illumination. In Experiment 1, the subject lay in a darkened room. Ambient street sound was moderately attenuated but no laboratory sounds were audible to the subject. We will call this the Moderate Stimulation environment. In Experiment 2, both light and sound were maximally attenuated by the use of a sound- and light-shielded chamber. We will call this the Minimal Stimulation environment.

Hypotheses

(1) Because of the activating effects of any auditory stimulation, it is predicted that TRC will be higher in the Moderate environment of Experiment 1 than in the Minimal environment of Experiment 2.

(2) Because of the greater cortical activation in the Waking State, it is predicted that TRC will be greater in both Waking conditions, than in REM or Stage 2.

(3) Following the assumption that ambient stimulation will break up the associative train of thought, it is predicted that there will be more TUs per unit time in the Moderate than Minimal environments.

(4) Finally, with similar sensory thresholds in both sleep stages but greater cortical activation in REM sleep, it is predicted that the ratio TRC/TU, or where appropriate, TRC with the effect of TU partialled out, will be higher in Stage 1-REM than Stage 2.

Experiment 1

Method

Subjects. Twelve volunteer subjects between the ages of 20 and 30, all college students and native English speakers, came to the sleep laboratory during an afternoon. They were invited to lie down and relax in the experimental room, without falling asleep. The experimental session lasted less than one hour.

Experimental room. The experimental room was arranged similar to a private bedroom. It was mildly sound-attenuated and located a short distance from the experimenters' control station. The only contact between experimenters and subjects during the experiment was via a two-way intercom system.

Electrode placement. In order to assure that no subjects fell asleep during the experimental sessions, EEG was monitored by central and occipital electrodes (C3 and O2 referenced to linked mastoids) according to the International 10/20 electrode system. EOG was also monitored. Sleep onset was judged according to the criteria of Rechtschaffen and Kales (1968); any interval where the subject fell asleep was to be eliminated from the data analysis. In practice, this eventuality never occurred.

Procedure. Subjects were asked to lie down in the experimental room, keeping their eyes open. The lights were turned off and the door closed. Subjects were contacted by intercom for mentation reports at intervals varying randomly around a mean of five minutes, with a range from two to eight minutes. (The variable interval length was used so that subjects would not be able to anticipate when mentation reports would be requested.) Mentation reports were solicited by standardized questions as follows: (1) "Please tell me everything that was going through your mind before I called you;" and (2) "Was there anything else?" Subjects' reports were tape recorded and transcribed without editing or punctuation.

Mentation reports were analyzed using the word count variables of the *Psycholinguistic Coding Manual* (Antrobus, Schnee, Lynn, Silverman, and Offer, 1976). The rating scales of this manual were developed as a method of reliably counting the words in several classes relevant to sleep mentation reports. Each category (e.g., visual nouns, spatial relations, explicit speech) is given a formal definition followed first by unequivocal and then borderline examples together with commentary. Judges were required to score a separate test set of 30 reports and obtain a correlation greater than .90 with criterion scores on Total Recall Count, the most complex of the variables.

The transcribed mentation reports were given to two independent judges who first counted the total number of words in the report (Total Word Count, TWC). The reports were then edited to remove non-content material such

as interjections, redundant words, disclaimers, corrected words and all commentary on the experience, the report, or the current status of the subject. What remained after this editing process should be exclusively a description of the experience that had occurred during the mentation interval. A count was then made of the number of words in the content-edited reports (TRC). Since word count scores are generally positively skewed, the TWC and TRC scores were normalized by the log (X+1) transformation and averaged between the two judges. All data analyses were conducted on the log transformed scores.

Reports were further divided into independent "Topic Units" according to the method described by Klinger (1971). Each TU contains a distinct, thematically homogeneous ideational sequence. Judges' ratings of TU demonstrated high reliability. In addition, a ratio was computed to index the average number of words per TU (log TRC/log TU).

Treatment of waking reports for comparison with sleep mentation reports. Since previous research failed to find a difference between individual mentation reports over the course of the experimental session, the first four waking mentation reports from each subject were averaged to provide one data point per subject in the analysis. The mean pre-report interval for this data set was approximately five minutes.

Sleep mentation reports. To provide a pool of sleep reports for comparison to the waking data, 50 REM and 50 NREM mentation reports were chosen from a collection of paired reports from sleep laboratories across the United States. Each pair of REM/NREM reports was contributed by a single subject and was drawn from approximately the same time of night. Reports without recalled content were excluded from this data set.

Results

Effect of interval duration prior to reporting. Figure 1 shows the relationship of TWC, TRC, TU and TRC/TU to interval size. Note that TRC shows little increase over the longer intervals although TU does tend to increase. The decrement in TRC/TU suggests that while subjects report approximately the same amount of information each time they are interrupted, when they have more topics to report they tend to provide less detailed information on each one.

Between-state differences. Table 1 compares the means of these variables in both Experiment 1 and Experiment 2 with those derived from REM and Stage 2 sleep mentation reports.

Comparison of Waking versus REM mentation reports. Independent *t*-tests were conducted to compare the REM reports ($n=50$) and the Waking reports ($n=12$). The predictions of the model were supported. Both TWC and TRC were significantly higher in Waking than in REM, reflecting the greater cor-

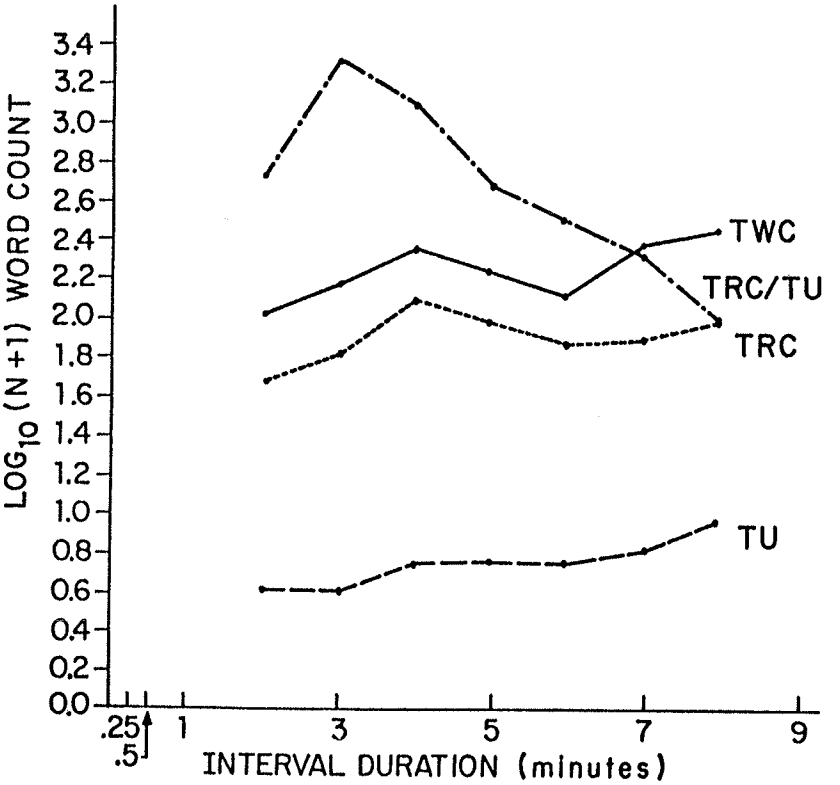

Figure 1. Waking Fantasy Experiment I: Log Word Count Variables as a function of interval duration prior to soliciting a mentation report.

tical activation of the waking state. Significantly more Topic Units were present in Waking mentation reports, due to the effect of ambient auditory stimulation. Total Recall Count per Topic Unit (ratio log TRC/log TU) was significantly higher in REM sleep than in Waking. All these comparisons were significant at better than the .001 level.

Comparison of Waking versus NREM mentation reports. Similarly, independent *t*-tests were computed between all variables for Waking and Stage 2 reports. Again, TWC and TRC were significantly higher in Waking. Mentation reports contained significantly more Topic Units in Waking than in Stage 2. The ratio TRC/TU was also greater in waking than in sleep ($p = .05$). Again, comparisons were significant at better than the .001 level, except as noted.

Comparison of REM versus NREM reports. Since REM and NREM reports were drawn from the same subjects, correlated *t*-tests were computed between these measures. TWC and TRC were both significantly higher in REM reports. Although Topic Units were significantly more numerous in REM

Table 1

Comparison of Means and Standard Deviations of Log Word Count Variables from Waking, Stage 1-REM and Stage 2 Sleep

	STATE							
	Waking with Moderate Stimulation (n=12)*		*Waking with Minimal Stimulation** (n=14)*		*Stage 1-REM Sleep (n=50)*		*Stage 2 Sleep (n=50)*	
Variable	*Mean*	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*
LOG TWC	2.34	0.25	2.18	0.34	1.89	0.46	1.54	0.50
LOG TRC	2.02	0.23	1.84	0.49	1.54	0.48	0.85	0.62
LOG TU	0.81	0.20	0.57	0.17	0.44	0.18	0.35	0.20
LOG TRC/LOG TU	2.58	0.61	3.34	1.48	3.69	1.44	2.07	1.32

*Waking Fantasy Experiment I (Spring/Summer 1982; average of 4 reports varying around a 5-minute mean interval)

**Waking Fantasy Experiment II (Fall/Spring 1983; 5-minute condition)

reports, the ratio of TRC/TU was also significantly higher in REM reports than in Stage 2. Although the larger number of Topic Units in REM reports tended to lower the TRC/TU ratio, the REM recall count was so much higher that the ratio was almost twice as high in REM as in Stage 2. These findings were significant at the .005 level or better.

Discussion of Experiment 1

Experiment 1 demonstrates that mentation reports obtained during the waking state in an environment similar to that of the sleep laboratory can be used to make meaningful comparisons with sleep mentation reports. Although all of the waking variables changed as a function of recall interval size, REM and Stage 2 values differed from waking values, regardless of which interval was compared. That TRC was higher in Waking than in REM or Stage 2 suggests that the cognitive system that creates and stores the mentation is more active in waking (despite the EEG spectral similarities with REM). The smaller TU values in both sleep stages reflect the higher auditory thresholds of sleep as compared to the awake state. That TRC/TU is higher in REM sleep than any interval of waking, fully supports the cognitive model proposed by Antrobus (this volume).

Experiment 2

The second experiment was made possible by the construction of high-sound-attenuation acoustic sleep chambers that permitted a more powerful

test of the effects of ambient sound on TU and TRC/TU. It was predicted that TU should be lower, and therefore, TRC/TU should be higher, in the acoustic chambers of Experiment 2 than in the moderately sound-attenuated room of Experiment 1. A second goal of this experiment was to determine if the interval duration results of Experiment 1 were indeed reliable. Specifically, interval length was systematically manipulated over a range of 15 seconds to nine minutes. The shorter interval lengths were included in order to test the possibility that the reports obtained in Experiment 1 had already reached an asymptote by the shortest two minute report condition. On the basis of the findings in Experiment 1, it was predicted that TWC and TRC would remain fairly constant over the various interval lengths, but that Topic Units would increase, and TRC/TU, the number of content words per topic, would decrease as a function of increasing interval duration.

Method

Subjects. Fourteen young adults, all native English speakers and college or graduate students, participated in one afternoon session each. The experimental session was less than one hour in duration and included seven mentation reports.

Procedure. All communication between experimenter and subjects was exclusively conducted by intercom system. Mentation reports were solicited utilizing the same procedure as in Experiment 1, with the addition of a third question asking for a numerical rating of the subject's arousal level.

Interval length was systematically manipulated using seven conditions: 15 seconds, 30 seconds, 1 minute, 3 minutes, 5 minutes, 7 minutes and 9 minutes. Order of presentation was randomized over the 14 subjects, using a Latin square design such that each interval occurred twice in each position within the sequence of mentation reports.

The transcribed mentation reports were given to two independent judges and were rated for the same word count variables as in Experiment 1, using the *Psycholinguistic Coding Manual* (Antrobus, Schnee, Lynn, Silverman, and Offer, 1976). Reliabilities between the judges were .9 or above on all variables.

Analysis of Bizarreness and Dreamlike Quality. Many readers will undoubtedly be more familar with the global variables of "Dreamlike Quality" and "Bizarreness" than with the word count technique used in these studies. Counts of bizarre incidents and ratings of Dreamlike Quality were specifically compared with the word count variables in order to ascertain which sets of variables were best able to discriminate between mentation reports from the various states of consciousness. Bizarreness was coded as the sum of "Discontinuities" in the narrative and "Improbable Combinations" and "Identities", using the *Psycholinguistic Coding Manual.* Dreamlike Quality was scored us-

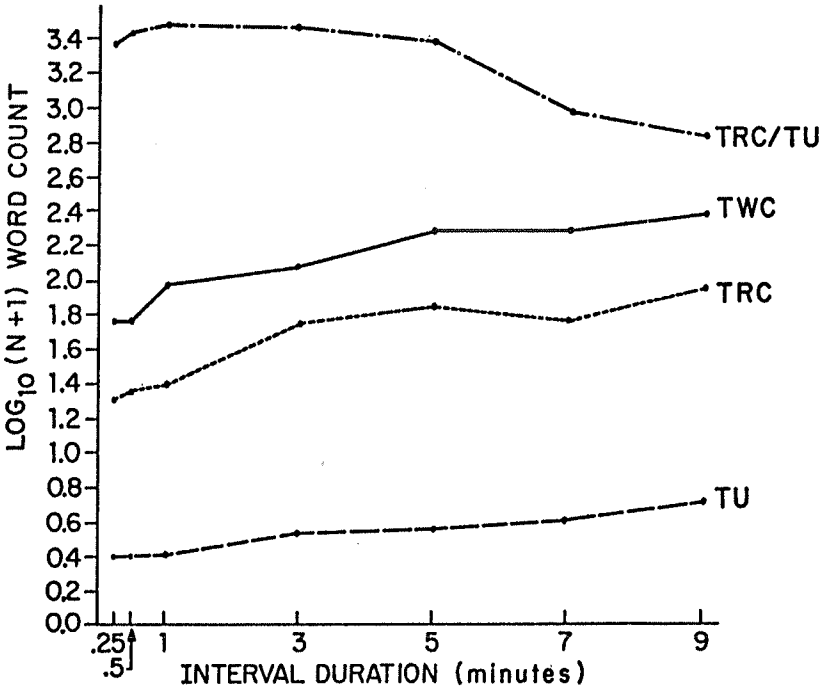

Figure 2. Waking Fantasy Experiment II: Log Word Count Variables as a function of interval duration prior to soliciting a mentation report.

ing a forced normal sort with an interval width of 0.75 standard deviation units. Judges were instructed to place a specified number of reports into eight categories of increasing dreamlikeness. This procedure yields a normal distribution of the reports along the sorted dimension. Eighty-four mentation reports were sorted, consisting of 28 from the Minimal Stimulation condition of Experiment 2, plus an equal random sample of reports from both Stages 1-REM and 2 drawn from the pool of 100 reports used in the comparisons of Experiment 1.

Results

Effect of interval duration. Figure 2 presents the log word count variables as a function of report interval duration. It is clear that the results essentially replicate the findings of Experiment 1 (see Figure 1). However, the reduced auditory stimulation in Experiment 2 results in lower values for recalled content and TU than were observed in Experiment 1. These differences are consistently maintained across all interval durations. The differences between the environmental conditions are reflected most noticeably in the ratio of

TRC/TU. In Experiment 1, TRC/TU showed an initial increase followed by a steep decline across the longer intervals. In the sound-attenuated environment of Experiment 2, TRC/TU shows a much flatter course. The flatter curve of TRC/TU in Experiment 2 implies a more constant process of generation and/or retrieval of mentation in the absence of disruptive auditory stimulation. A trend analysis for the effect of trial duration found significant but modest linear trends for all report variables. The ratio of TRC/TU was the only variable to possess significant quadratic and cubic components, first decreasing then levelling off at the longer intervals. That is, as trial duration increases, subjects recall more topics and more words, but the number of words per topic decreases over time. This suggests that as the recall interval increases, subjects either forget more, or report less of what they recall. The latter alternative could be accomplished if there is a tendency for subjects to report less detail on the longer reports, summarizing the content so as to restrict the length of the narrative within socially appropriate bounds.

Waking conditions compared to sleep mentation. Figure 3 compares the two waking conditions with Stage 1-REM and Stage 2. The values for all variables in Stage 2 are significantly lower than REM and both waking conditions.

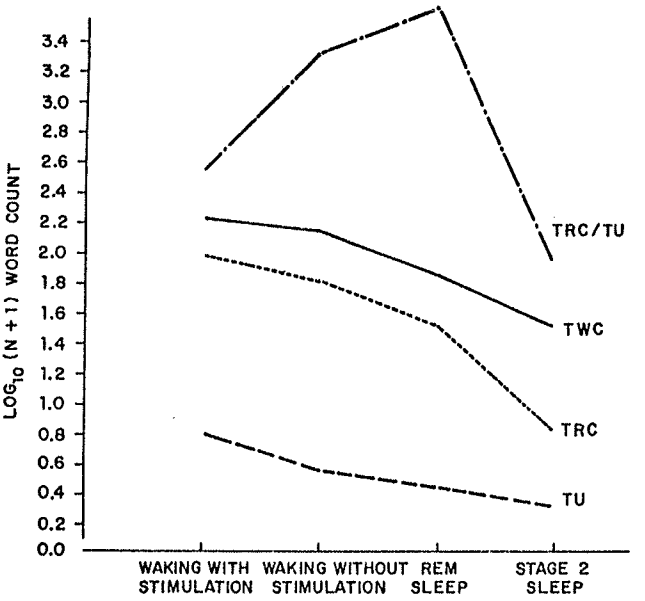

Figure 3. Comparison of Log Word Count Variables across Conditions: Experiment I (Waking with Moderate Stimulation), Experiment II (Waking with Minimal Stimulation), Stage 1-REM Sleep, and Stage 2 Sleep.

As we might expect, TRC was higher in the moderately stimulated environment of Experiment 1. At the same time, moderate stimulation was effective in increasing TU, as predicted by the model. More importantly, TRC/TU was significantly higher in the less stimulated waking environment at all intervals, as required by the model. As predicted, the minimally stimulated waking condition produced more recalled content and more TU than found in REM sleep ($p < .05$) or in Stage 2 sleep ($p < .001$). However, the difference in the TRC/TU ratio was not significant in Experiment 2 (3.34) as compared to Stage 1-REM (3.70). Thus, with the attenuation of auditory stimulation in the waking state, we succeeded in duplicating the higher auditory thresholds of REM sleep and have produced in waking the longer thematic sequence of words/topic that is characteristic of REM sleep and may indeed be the hallmark of REM's "storylike" narrative quality.

Summary. The predictions of the revised ACT* model proposed by Antrobus (this volume) have been answered in the affirmative. First, a decrease in ambient environmental stimulation is accompanied by a decrease in topic units. Accordingly, with cortical activation remaining relatively constant in the waking conditions being compared, the ratio of TRC/TU increases as auditory stimulation decreases. Second, TRC/TU covaries closely with the concept of "dreaming." Reaching its highest value in REM sleep, TRC/TU increases in waking without auditory stimulation to a point where it is no longer significantly different from its level in REM sleep. This finding is independently confirmed by the judges' ratings of Dreamlike Quality, which show an inability to discriminate between Waking and REM reports (see Table 2 below). Third, the predictions for the relative positions of TU, TRC and TRC/TU across the states of consciousness have been confirmed. Stage 2 sleep shows the lowest values on all variables across the board. Comparing the two waking conditions, the absence of auditory stimulation decreases TU and TRC but increases the TRC/TU ratio to a level second only to that observed in Stage 1-REM sleep. Comparing REM to waking without stimula-

Table 2

Mean Scores for Bizarreness and Dreamlike Quality in Waking, Stage 1-REM, and Stage 2 Reports

	*Waking** ($n=28$)	*Stage 1-REM* ($n=28$)	*Stage 2* ($n=28$)
Bizarreness	1.74	0.70	0.42
Dreamlike Quality	5.06	4.80	3.57

*Waking reports are 5 and 7 minute conditions from Experiment 2.

tion, REM shows, as predicted, lower TU, lower TRC, and a (non-significantly) higher TRC/TU ratio.

The formal hypotheses stated at the outset have been unequivocally supported.

(1) TRC in waking is higher with auditory stimulation present than in its absence.

(2) TRC is higher in both waking conditions than in either sleep stage.

(3) TU increases in waking with auditory stimulation present.

(4) The TRC/TU ratio is higher in REM than in Stage 2, and higher in REM than in waking with auditory stimulation present. In the absence of auditory stimulation, TRC/TU in waking does not differ significantly from REM sleep.

Discussion of Experiments 1 and 2

The results show that even moderate magnitudes of ambient auditory stimulation are sufficient to disrupt the train of thought in the waking state. The finding that REM TRC lies midway between Stage 2 and waking suggests that the cortical activation associated with the generation and storage of this mentation also lies midway between Stage 2 and waking. The fact that the REM TRC/TU ratio is higher than that obtained in a minimal auditory stimulation environment indicates that the REM report comes from a state of both high cortical activation and minimal perceptual response to environmental stimuli.

Comparison of Bizarreness and Dreamlike Quality in reports from sleep and waking. Table 2 presents the ratings of Dreamlike Quality and Bizarreness for the different conditions. Since each subject did not go through all three conditions, the more powerful within-subject statistical analysis could not be used and the size of between state effects was smaller than those found by Antrobus (1983). Nevertheless, the results give striking confirmation to the predictions of the model. Waking reports are judged to be both more dreamlike and more bizarre than reports from REM or Stage 2 sleep. The model accounts for these findings by crediting the higher cortical activation of waking for the increased Dreamlike Quality, and the higher level of auditory stimulation in the waking environment for the disruptions leading to increased Bizarreness.

Figure 4 presents a graphic comparison of the Bizarreness and Dreamlike Quality ratings from the waking and sleep conditions. The most intriguing result of this analysis is that waking reports were rated as more dreamlike and bizarre than REM reports. A multiple regression comparison of waking and Stage 1-REM shows that TU is the best discriminator of the two conditions. Even TRC does not add significantly to the variance accounted for by TU. By contrast, when comparing REM and Stage 2, TU does not

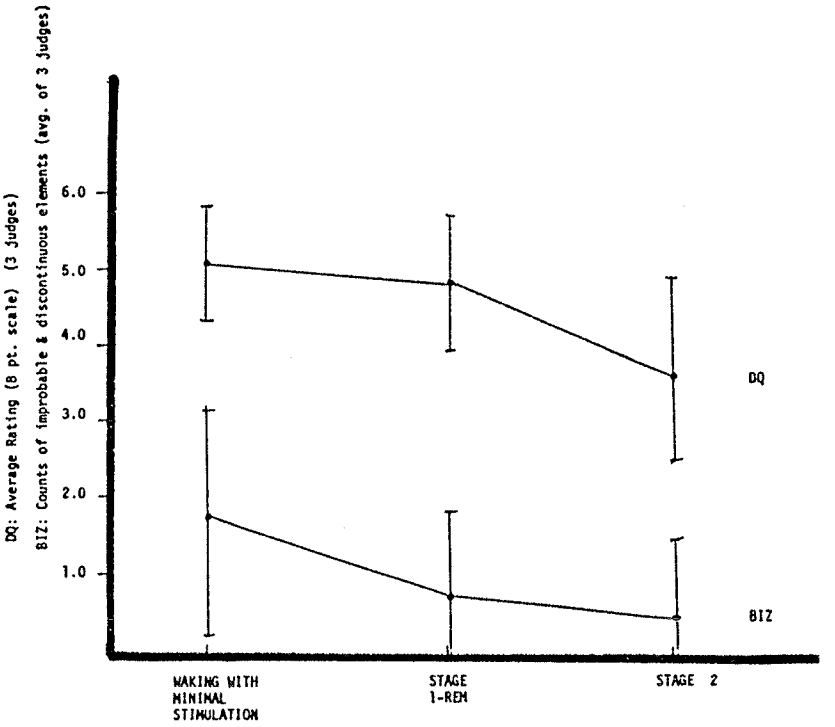

Figure 4. Dreamlike Quality and Bizarreness ratings by condition (waking data are combined means, 5 and 7 minute conditions, Experiment II).

discriminate significantly between the stages. This can be attributed to the increased auditory thresholds in sleep which make TU a less relevant variable in sleep mentation. On the other hand, the cortical activation variable as represented by TRC accounts for 28% of the variance of Dreamlike Quality in waking and slightly over two-thirds of the variance in both sleep stages. In waking, the influence of cortical activation is modified by the presence of environmental stimulation; whereas in sleep, with the higher auditory thresholds, cortical activation (TRC) becomes the best discriminator beween the sleep stages.

General Discussion

The construction of a neurocognitive model that describes dreaming and other private mental productions has been handicapped by unusual measurement problems. Private mental productions cannot be directly observed and

inferences based on verbal reports are notoriously subject to error. Reports are based on information retrieved from a different (non-awake) state so that state-context retrieval cues are scarce or unavailable (Koukkou and Lehmann, 1980). Further, experimental cognition research techniques that have been so successful in testing cognitive models in the waking state cannot be used without disrupting the subject's sleep state. Inasmuch as invasive neurological measures cannot be obtained from sleeping human subjects, estimates of subcortical neural activity are very difficult to obtain.

This paper is based on the premise that a model of dreaming and related forms of spontaneous mentation cannot be constructed exclusively from sleep report data. Rather, it must be built upon models that have been developed from the more precise data bases that exist in experimental studies of waking cognitive processes. The present paper has demonstrated that extensions of Anderson's (1983) ACT* model, modified by neurophysiological and nonspecific environmental considerations, account rather nicely for several structural characteristics of sleep and waking mentation.

The two experiments presented here have demonstrated that the empirical study of some processes associated with the production of dreamlike mentation can be carried out in the waking state. In fact, judges found waking mentation under conditions of reduced environmental stimulation to be even more dreamlike and bizarre than Stage 1-REM reports. Apparently the length of the mentation report and the consequent storylike quality were of equal salience to the judges as the quality of bizarreness.

Use of Waking Reports as Controls for Sleep Mentation

It was also demonstrated that mentation reports obtained from the waking state could be used as reference points for the purpose of studying sleep mentation reports. Our concern that waking reports would increase linearly in length as a function of time since last interruption was allayed. The linear trends for word count variables are significant but of low slope. That is, within the four to eight minute interval, the length of the interval has little effect on the magnitude of the report measures. In the absence of stimulation (Experiment 2), the number of TRC per TU shows signs of reaching an asymptote at longer intervals between successive reports. In spite of the modest linear trend in TU, the between stage differences are maintained. TUs are equally frequent in waking and REM for intervals shorter than two minutes, and are more frequent in waking than in Stage 1-REM and Stage 2 at all intervals over three minutes. Since it is common practice to wait five to ten minutes into a sleep stage before soliciting a mentation report, these findings imply that reports taken from comparable intervals in the waking state constitute an appropriate set of control data.

Duration of Non-Perceptual Mentation

The proposed modification of the ACT* model says that as the duration of time since the last perceptual-cortical response increases, the probability of storylike, hallucinatory mentation will increase. This notion differs from the usual position regarding dreaming and sensory thresholds in that it distinguishes (1) between early sensory-brain stem responses and later cortical responses associated with the perceptual recognition of the stimulus, and (2) between the perceptual response and whether that response is stored in working memory.

"Threshold" models in sleep mentation studies have rarely specified the point in the sensory-motor system at which the "response" occurs. The perceptual threshold paradox appears to occur with the late cortical components of the evoked response. The brain stem components (<50 msec.) of the auditory system, in fact, show little or no change from waking to sleep, nor do they vary with REM density within Stage 1-REM as expected from the inhibitory effects of spontaneous middle ear muscle activity (Mendel and Kupperman, 1974; Pessah and Roffwarg, 1972). Reduced middle and later components of the auditory evoked potentials in Stage 1-REM may be attributed to impaired functioning of cortical processes required for perceptual recognition (Amadeo and Shagass, 1973; Buchsbaum, Gillin, and Pfefferbaum, 1975; Mendel and Kupperman, 1974; Townsend, House, and Johnson, 1976).

"Duration of time" since last perceptual response is important: time not spent in processing external stimuli is always spent processing information previously stored in memory (Antrobus, 1977; 1979; Antrobus and Singer, 1964). The longer the time spent processing such stored memory information, the greater the interference with the consolidation of the memory of perceptual responses. Since interference is the chief vehicle of forgetting (Peterson and Peterson, 1959), the greater this interval, the greater the probability that the individual will forget the immediate external environmental context. Simultaneously, private thoughts and images will increasingly become the perceptual context in which all information currently retrieved from older memory stores is processed. No longer processing or retrieving information from the external world, the individual is obliged to believe the privately constructed images, thereby creating an "hallucinatory" train of thought: a "dream."

Activation and Thresholds

Previous research (Antrobus, 1983) supports the position that the storylike and hallucinatory characteristics of REM mentation are fundamentally dependent on a moderately activated cortex which supports the modest sized ACT* working memory required to carry out the cognitive operations, notably, the

construction of long, thematically related sequences. This notion is consistent with Rechtschaffen's (1978) observation of the "single-mindedness" of dreams: "a single train of related thoughts and images (tends) to persist over extended periods without disruption or competition from other simultaneous thoughts and images" (p. 97).

The two experiments reported here support the position that the auditory distraction characteristic of the waking environment periodically interrupts what would otherwise be a continuous associative flow of cognitive events. In a comparison of mentation reports of waking subjects with those of subjects awakened from REM and NREM sleep, the present studies support this ACT* model-extension with the findings that whereas Total Recall Count is greater in Waking than in Stage 1-REM, it was the number of topics per report (TU), that was the best discriminator of the two states. Consequently, the length of individual thematic segments tends to be greater in Stage 1-REM than in waking, where the waking environment included modest auditory distraction.

In summary, this paper offers evidence that the process of REM mentation as distinguished from Stage 2 sleep mentation on the one hand, and waking mentation on the other hand, in understimulated as well as stimulated contexts, can be accounted for by two factors which modify waking cognitive processes: (1) cognitive activation and (2) perceptual thresholds. It is postulated that these two factors influence memory for recent non-specific perceptual responses, thereby creating an hallucinatory context for endogenous image generation which supplants the awareness of the external environment. The reduction in responsiveness to external stimulation allows this image generation process to proceed without interruption for much longer than in the waking state, creating the "storylike" quality of REM narratives. Empirical evidence has been presented which indicates that these perceptual conditions of REM sleep can be duplicated in waking, with a consequent increase in both the dreamlike quality and bizarreness of the thought process, over and above the levels generally observed in Stage-1 REM "dreams".

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