

## **ABSTRACT**

PRITZL, THELMA JANE. The Effect of Experimentally Enhanced Daydreaming on an Electroencephalographic Measure of Sleepiness. (Under the direction of Dr. James W. Kalat and Dr. Slater E. Newman.)

Experimental evidence suggests that REM dreaming and daydreaming are related on a neuropsychological level. There is also suggestive experimental evidence that dreamlike mentation may serve to partly compensate for accumulated REM sleep “need.” The present study tested the hypothesis that daydreaming may partly compensate for sleep deprivation in healthy individuals. Its “daydream induction” group was created to replicate a pilot study in which an instructional manipulation designed to prevent daydreaming paradoxically increased it. Specifically, it was hypothesized that participants assigned to the daydream induction group would report a larger number of narrative-related daydreams and show greater decreases in initial level of sleepiness (as positively indexed by the EEG theta percentage/alpha percentage ratio) than participants assigned to the control group. It was also hypothesized that participants who began the study relatively sleepy, regardless of group assignment, would have a greater need for any restorative aspect of daydreaming and would thus report more narrative-related daydreams and show larger sleepiness difference scores but smaller ending theta/alpha percentage ratios than participants who began the study in a relatively alert state. This hypothesis was partially supported in that participants who began the study relatively sleepy did in fact report more narrative-related daydreams than those who began the study in a relatively alert state. The prediction that initial level of sleepiness and sleepiness difference scores would correlate positively was also borne out by the data.



While my initial finding of between-subject daydream induction was not replicated with a larger population sample, significant correlations between number of narrative-related daydreams reported and three measures of an encephalographic index of sleepiness were demonstrated. Qualitative within-subject daydream differences are discussed as a possible mechanism for a hypothesized sleepiness intensification effect.



**THE EFFECT OF EXPERIMENTALLY ENHANCED DAYDREAMING ON AN  
ELECTROENCEPHALOGRAPHIC MEASURE OF SLEEPINESS**

By

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My interest in psychology began at the age of 10, when adults began to tell me that my various complaints and difficulties were “all in your head.” By the age of 12, I was breeding pet mice as a hobby and watching their behavior with keen interest.

During my undergraduate studies in biology and psychology at Florida State University, I realized that imagination is the brain function that most clearly distinguishes the human from the nonhuman mind. As I studied human patients in a local sleep disorders center, I observed the profound physiological changes that occur when the function of imagination becomes unleashed during REM sleep. This observation convinced me that manipulations of the quality and quantity of waking imagination could have a profound effect on physiological functioning by virtue of their effect on the efficiency, intensity and timing of REM sleep.

After the birth of my first and only child in 2000, I realized that much of the resiliency of the developing mind comes from its frequent immersion in an enchanted state that closely resembles “sustaining” adult daydreams. I developed this study in order to find out whether daydreams really are, as the name implies, the waking correlate of nightly dreams.



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## The Effect of Experimentally Enhanced Daydreaming on an Electroencephalographic Measure of Sleepiness

There are numerous studies indicating that one function of dreaming is the modulation and regulation of waking emotional intensity (see review by Perlis and Nielsen, 1993, Kramer 1993, Kuiken et al., 1991). In 1973, Beaver hypothesized that the coupling of anxiety-provoking dream stimuli with the somatic state of muscular atonia characteristic of REM sleep produces affect desensitization, and that the symbolic features of dreaming mediate this anxiety-reduction process. As predicted by his hypothesis, experimental studies have found that dream incorporation of stress-inducing characters is positively correlated with long-term waking happiness (Cartwright, 1991), that amount of facial atonia during REM is negatively correlated with scores on Beck's Depression Inventory (Perlis et al., 1995). Under conditions of emotional trauma, dreaming appears to serve a compensatory function characterized by the inverse incorporation of evening mood into dreaming and by direct accommodation of dreaming emotional valence into morning mood. Specifically, Punamaki (1999) found that, for a large sample of chronically traumatized children, presleep negative mood is positively correlated with number of reported happy and recreational dreams and with positive mood on the evening following dream report. Although it is reasonable to suppose that such anxiety reduction conserves neural energy, there is only suggestive evidence that dreams can contribute to the neural restoration processes that occur



during sleep. Thus, the present study, which hypothesizes that daydreams can contribute to neural restoration processes in the absence of sleep, is an exploratory study.

We begin with a possible definition of (or criteria for) daydreams. A good definition or criterion will give us a measurement that is useful because it correlates with other important variables. As Klinger (1979) noted, there are three main types of undirected thought that we normally think of when we use the word “daydream”: spontaneous fantasy with a plot not based on current reality, fantasy (thought that does not conform to natural laws and social roles) initiated for self-encouragement or self-entertainment, (later described by Zelin et. al (1983) as “sustaining fantasy”), and mindwandering about the realities of one’s life such as a professional deadline or interpersonal problem. All three types share the characteristic of stimulus independence, which was operationally defined by Singer and Antrobus (1972) as any thought not related to the current stimulus situation. They used this definition of stimulus independence as a fundamental dimension of daydreaming in their construction of the 29-scale, 348-item Imaginal Processes Inventory (IPI), a clinical questionnaire used to identify affect-based daydreaming styles. Using the Imaginal Processes Inventory, Starker (1974) found that an individual’s characteristic affective daydream style also characterized that individual’s characteristic affective nocturnal dream style. In fact, the IPI proved to be so useful for making reliable and valid correlations between daydreaming styles and overall personality assessments that in 1981 Huba et al. constructed a 45-item short version of the IPI for broader use. Thus, the present study defines daydreaming as thought that is stimulus-independent and undirected (although not



necessarily unmotivated, as in the case of sustaining daydreams). Since the present study hypothesizes a restorative function of daydreaming, it proposes a daydreaming correlate that might also serve as an index of neural restoration, i. e., of increased available neural energy. That correlate is decrease of later sleepiness.

Actually, not much is known about the restorative functions of real dreams, although data do suggest some such functions. For example, in a study of the intercorrelations between the KJP Dream Inventory, the Stanford Sleepiness Scale, and the Brayfield-Rothe job Satisfaction Questionnaire, Kroth et al. (2002) found correlations between types of dreams and levels of daytime sleepiness, suggesting that certain types of dreams are more restorative than other types. A restorative effect of daydreaming was suggested by the work of Cicogna et al. (1986), who elicited daydreams by asking participants to “Try to invent a dream and tell me it as you go along.” They then divided participants’ free associations to their own sleep onset (SO) dreams, REM dreams, daydreams and to externally generated narrative (short films) into three categories: autobiographical episodes with precise spatiotemporal coordinates, references to the participants’ general self-knowledge, and elements of knowledge about the world, including the lives of others. These three categories represented three respective memory sources of the free associations: episodic, semantic/self and semantic/nonself. After finding that free associations to SO dreams and to daydreams, unlike those to REM dreams and films, were mainly episodic, they concluded that daydreaming and sleep onset involve access to similar types of memory representation.



If their conclusion was correct, then perhaps the act of internally accessing episodic memory representations during daydreaming allows daydreaming to provide neural restoration such as is currently associated with stage two sleep onset. Specifically, extremely brief periods of stage two sleep onset (10 minutes duration) have recently been shown to yield restoration (significant increases in subjective alertness, mood and cognitive performance) equal to that from a 30-minute nap, and lasting at least an hour (Tietzel and Lack, 2001). If the present study demonstrates that daydreams do in fact provide some restorative function, then both the usefulness of daydreaming and the validity of the proposed definition of daydreams will have been demonstrated as well. If, on the other hand, the present study fails to demonstrate any restorative function of daydreaming, we will not have disproved the hypothesis of restorative daydream effects due to the possibility that such negative findings could have resulted from an inadequate definition and/or measure of daydreaming.

First, let us consider previous attempts to study the phenomenon of daydreaming. The first experimental evidence that dreaming and daydreaming might complement each other came in 1964, when Antrobus, Antrobus and Singer discovered that sleeping dream imagery is greatest during rapid eye movements (REMs) and fast brain waves, while daydream imagery is greatest during slow eye movements and slow brain waves. When Singer and Antrobus followed up in 1965 with a study utilizing oculogram polygraphy as a more precise measurement of human eye movement frequency, they discovered that eye movements become virtually nonexistent during daydreaming. With regard to brain



functioning, the cessation of eye movements suggested that daydreaming might be an energy conservation mode. In 1971, Singer et. al demonstrated that daydreaming involves detachment from the external perceptual environment by showing that daydreaming, unlike daydream suppression or problem solving, is associated with the cessation of induced optokinetic reflexes. Since perceptual detachment requires less effort than does perceptual monitoring, this finding also suggested the possibility that the brain saves energy during daydreaming. In 1974, Singer measured changes in heart rate (HR) and galvanic skin response (GSR) during daydreaming, expecting to find a reduction in these physiological measures of arousal that corresponded to the occurrence of daydreaming and its associated reduced eye movements. While he did not find the expected decrease, he did find that the transition from daydreaming to non-daydreaming (and vice-versa) resulted in the greatest HR, GSR and eye movement measures for a particular participant. These results could be interpreted as suggestive evidence that there is an additional energy cost to the brain for frequent switching from daydreaming to non-daydreaming forms of mental activity versus engaging in either type of mental activity for an extended period of time. If such a cost for frequent switching exists, it would explain why even frequent daydreamers (those who report daydreaming for 2 hours or more per day) also report that their naturally occurring daydream episodes are often separated by two or more hours (Anthony and Gibbin, 1992).

In my dissertation pilot study, I used a well-established biological approach to gauging the degree of arousal or relaxation induced by altered states of consciousness. That is, I monitored the effect of incidental, intrusive stimuli (tones) on a measure of neural



function (electrodermal orienting reaction, or EOR.) The EOR, a transitory increase in galvanic skin response concomitant with the abrupt onset of a sensory stimulus, is a widely used biological index of focused attention, and the speed of EOR habituation (loss of the EOR as a stimulus is repeated) is used as a biological index of selective attention (Gruzelier and Brow, 1984). My dissertation pilot study sought to determine whether habituation of the GSR (an indicator of decreased energy expenditure due to decreased sympathetic nervous system activity) to an auditory tone could be used as a physiological correlate of daydreaming. I expected to find that participants in the daydream prevention group would take longer to habituate to the tone than participants in the control group, who were presumably daydreaming more, i. e., were more perceptually detached, than the prevention group. There was a trend for this to happen (prevention group heard an average of 30 percent of the tones before habituation and control group heard an average of 27 percent of tones before habituation). However, I failed to find the expected negative correlation between number of daydreams reported and number of tones to habituation, so I did not include the GSR measure in my full-scale study.

Proceeding with the analysis of daydreaming as a potential regulator of neural energy expenditure, it is very likely that there is an energy cost to daydreaming that may vary according to the qualitative nature of the daydreaming in question. For example, daydreams that generate emotional responses may require the expenditure of more neural energy than daydreams that do not generate emotional responses. Evidence for such an effect in the case of externally generated images was found by Robbins and McAdam (1974) but has yet to be



determined in the case of internally generated images such as those produced during daydreaming and sleep. In fact, experimental evidence has suggested that daydreaming and dreaming, which occurs chiefly during the state of greatest sleeping cortical activation, REM, (Rechtschaffen and Kales, 1968, Buchsbaum et al, 1989, Madsen et al., 1991) are related on a neuropsychological level. In 1978, Kripke and Sonnenschein demonstrated both in the laboratory and in natural settings that the tendency to daydream, as measured from written mentation reports elicited by a periodic alerting sound, follows a cycle averaging about 90 minutes, similar to the tendency to enter the REM sleep state at night (Dement and Kleitman, 1957).

The qualitative similarities between daydream and dream content are numerous. Approximately 65 percent of daydream content reflects the independently listed current concerns of the daydreamer (Gold and Reilly, 1985), and a similar percentage (71 percent) has been found for the content of nightly dreams (Nikles et al., 1998). It is also the case that auditory imagery is reported for about one half of all daydreams, (Klinger, 1993), and a similar percentage (53%) has been obtained for reports of auditory experience in REM dreams (Zadra et al., 1998). Fiss et al. found in 1966 that stories generated in response to the Thematic Apperception Test, a projective measurement of waking fantasy, were indistinguishable from dream reports, suggesting that fantasy might serve a function similar to that of dreaming. Consistent with the hypothesis that fantasy and nocturnal dreaming are “analogous or parallel processes having a positive rather than an inverse relationship” (Starker, 1974), Faber et al (1983) discovered that inducing a waking fantasy using an



auditorily presented active imagination technique was associated with an increase in number of archetypal (symbolic and affectively toned) nocturnal dreams, relative to a control group. There is also suggestive experimental evidence that dreamlike mentation may serve to partly compensate for accumulated REM sleep “need.” Specifically, Cartwright and Monroe (1968) found that participants who were allowed to re-experience their own dreaming mentation by reporting it after REM awakenings in the first half of the night produced less REM rebound in the second half of the night than did participants whose digit rehearsal task prevented them from re-experiencing their own dreaming mentation. Thus, insofar as daydreaming may involve an attenuated re-experience of the nightly REM sleep state, it may also provide remediation from some of the known effects of REM sleep deprivation in chronically sleep deprived populations. These effects include significant decrements in problem solving (Cartwright, 1972), creativity, as measured by the Guilford’s Utility Test (Lewin and Glauberman, 1975), fluid (anagram) problem solving (Walker, et al., in press), in declarative memory for sentences and stories (Tilley and Empson, 1978), and in procedural memory for perceptual learning (Karni et al., 1994).

Past attempts to demonstrate any type of behavioral or experiential effect of daydreaming have suffered from three basic methodological shortcomings. Specifically, attempts to create a “no daydreaming” control group have all required some type of inhibitory task. Since all such tasks require at least some expenditure of mental energy, it is possible that any differential effect of daydreaming might have been due to the relatively greater opportunity for relaxation in the daydreaming group. In addition, the lack of a



physiological correlate of daydreaming that might corroborate verbal reports of daydreaming has left open the possibility that demand characteristics of the experimental setting have been at least partially responsible for any differential degree of daydreaming reporting obtained. Finally, the absence of verification that reported mentation actually met consensus-based criteria for daydreaming has called into question the validity of the primary dependent variable in many purported studies of daydreaming.

One alternative to the daydream prevention paradigm is the daydream induction paradigm. A daydream induction design avoids the need for a “no daydreaming” control group by assuming that both the experimental and control group participants are daydreaming, but that the experimental group is producing significantly more daydreams than the control group. Such a daydream induction effect was unexpectedly found in my previously noted pilot study that consisted of a daydream prevention group and a daydream group. The groups were treated identically except that the prevention group was falsely informed pre-exposure to hearing a series of short verbal vignettes that there would be a test of recall on the narrative contents of the auditory stimulus. Paradoxically, instead of preventing daydreaming, a type of “white bear” (Wegner, 1994) phenomenon occurred in which participants who presumably tried to verbally rehearse the narrative contents while inhibiting free associations to those contents reported approximately four times as many daydreams as those who were instructed simply to relax and listen to the vignettes. These vignettes, which I constructed from the mentation reports of relaxed supine participants from a prior study, all meet the definitive criterion of stimulus-independence, as described in



Klinger (1979). To provide an analogue to the wish-fulfilling function of dreaming hypothesized by Freud (1900) and supported by current investigatory research (Kroth et al., 2002, Johnson, 2001, Glucksman, 2001, Hartmann, 1995 ), all vignettes meet Zelin's 1983 criterion for "sustaining fantasy" Specifically, Zelin described sustaining fantasies as "repetitive, consistent, readily retrievable into consciousness, and containing cohesive themes and content over time." These ego-affirming themes largely involve triumph over adversity or competition, restitution, love and comfort, protection and security, self-admiration, God, or aesthetics. Since many of the paradoxically obtained daydreams from my daydream prevention group represented direct content matches with the vignettes, it is clear that at least this mentation also met the present criteria for daydreaming. To control for the fact that daydreaming can occur either as a response to situational cues, i.e., as a state, or independently of situational cues, i.e., as a trait, I obtained separate verbal report measures for the number of vignette-related daydreams and for the number of vignette-unrelated daydreams from each participant. Thus, any effects obtained with related daydreams but not with unrelated daydreams might reasonably be ascribed to daydreaming as a state, and any effects obtained with unrelated but not with related daydreams might similarly be ascribed to daydreaming as a trait.

The present study attempted to replicate the pilot study effect of daydream enhancement with a larger number of participants, using an electroencephalographic (EEG) index of sleepiness to determine whether a correlation exists between reported number of daydreams and initial level of sleepiness. To ensure that any failure to replicate the pilot



study effect did not result from the differential treatment of participants, all pilot study methodology except the actual GSR measurement was repeated in the present study. That is, the same sequence of tones that was used to measure EOR habituation in the pilot study was presented in an identical manner in the present study. The EEG transition from a predominance of alpha waves (8-12 Hz) to a predominance of theta waves (4-7 Hz) is the standard reference for the wake-sleep transition under the condition of eyes closed. (Krieger and Kurtz, 1978, Dement and Carskadon, 1982, Santamaria and Chiappa, 1987). With regard to a resting, eyes closed baseline EEG, there are no standard references for percentages of the various waveforms due to large and pervasive individual differences in waveform architecture for this condition. (Santamaria and Chiappa, 1987). Thus, the present study used a 5-minute baseline period during which participants rested with eyes closed in the absence of behavioral expectations and in the absence of the experimental narrative-based stimulus. This period permitted the individual calibration of EEG responses to the sleepiness effects and alpha suppression (Klimensch, 1999) that occur when participants change from the eyes open to the eyes closed condition. The ratio of percent theta to percent alpha in the awake EEG with eyes closed was then computed separately for the baseline and experimental period of each participant and used as a positive index of sleepiness in healthy individuals. While it has been shown that the awake EEG beta to delta ratio is significantly higher than the sleeping beta to delta ratio (Merica and Gaillard, 1992); it is the theta (4-8 Hz) and alpha (8-12 Hz) frequencies that intrude into the waking EEGs of experimentally sleep-deprived participants. (Akerstedt and Gillberg, 1990).



The final justification for the use of the percent theta/percent alpha ratio in this study is that it provides a more sensitive measure of sleep deprivation than theta or alpha power measured separately, since the separate measures differentiate sleep-deprived from control participants only at high levels of sleep deprivation (Akerstedt and Gillberg, 1990). The same EEG index of sleepiness was also used to determine whether exposure to the daydream enhancement (experimental) condition decreases initial level of sleepiness, which would suggest a restorative effect of daydreaming. Thus, the first experimental hypothesis to be tested was that participants assigned to the daydream enhancement group should report a larger number of daydreams than participants assigned to the relaxation group.

The second experimental hypothesis was that participants assigned to the daydream enhancement condition should show larger within-subject decreases in initial level of sleepiness, i.e., larger decreases in the theta percentage/alpha percentage ratio, than should participants assigned to the relaxation condition. The idea behind this hypothesis is that adult daydreaming can be a homeostatic, i. e., compensatory response to sleep deprivation.

The third experimental hypothesis was that ill-rested participants should have a greater need for the restorative aspects of daydreaming and should thus daydream more than well-rested subjects, thus securing a greater mitigation of sleepiness (i. e., a larger initial-final sleepiness difference score) than well-rested subjects. Thus, the third hypothesis predicts that, for all participants, number of reported daydreams should correlate positively with the baseline EEG index of sleepiness and positively with the initial -final sleepiness difference score (the difference between the sleepiness index as measured at the onset of the



narrative recording and the sleepiness index as measured at the end of the narrative recording.)

The fourth experimental hypothesis was that, for all participants, those reporting larger numbers of narrative-related daydreams should show a greater mitigation of sleepiness. That is, there should be a positive correlation between number of reported narrative-related daydreams and the within-subjects sleepiness difference scores. Mentation that meets the criterion of stimulus-independence, i. e., that is unrelated to the experimental task and that meets the criteria of “sustaining fantasy” (Zelin, 1983), is expected to produce a larger degree of sleepiness mitigation than mentation that does not meet this criterion. A one-way ANOVA ( $n = 60$ ) was carried out to verify that the average baseline sleepiness index was not significantly different between the two groups. As expected, there was no significant difference ( $p < .5343$ ,  $n = 60$ ) between mean baseline sleepiness for the control ( $X = 1.30$ ) and for the experimental group ( $X = 1.23$ ) (See Figure 2). Also as expected, there was no significant difference ( $p < .9600$ ,  $n = 60$ ) between number of hours slept in the past 24 hours for the control ( $X = 8.54$ ) and for the experimental group ( $X = 8.56$ ) (See Figure 1).

## Method

### Participants

Sixty female university undergraduate students enrolled in an introductory psychology course served as participants in this research. Only female participants were permitted to serve due to the potential occurrence of deliberate omissions in the case of male



participants being required to report personal fantasies to a female experimenter. Participants served as one means of satisfying the psychology department's research participation requirement for its introductory psychology course. Participants were required to be free of sleep or neurological disorders and to report all consumption of CNS-active substances during the 24 hours prior to participation.

### Procedures

Participants were randomly assigned to either the daydream induction (experimental) or the relaxation (control) group. All experiments were performed at the same times each day (1:15 p.m. and 2:45 p.m.), in order to minimize circadian effects on alertness. Before commencement of experimental procedures, all participants were required to indicate which hours had been spent awake and which had been spent asleep on a timeline of the past 24 hours. Procedures for both groups were identical except that the daydream induction group was misinformed that there would be a test of recall on the contents of an auditorily-presented "narrative." See Appendix III for the verbatim instructions to the two groups. This narrative consisted of 42 short daydream vignettes that were taken from actual daydream reports and paraphrased and/or edited to protect the privacy of the persons involved. These vignettes were all ego-affirming, i.e., met the criteria for "sustaining fantasy" outlined in Zelin et al. (1983). See Appendix II for a text of the vignettes.

All participants were instructed, as were participants in the pilot study, that they would be listening to some "short stories" narrated by the experimenter and to keep their eyes closed while maintaining wakefulness. The experimenter sat behind a computer on a



desk slightly in front of the participants that also faced the right side of the participants. This provided her with an unobstructed but unobtrusive view of the bodily movements of the participants, and also allowed her to ensure that all participants kept their eyes closed for the duration of the study. Three standard stainless steel cup EEG electrodes of ½ inch diameter were applied directly to the scalp with a paste adhesive at sites Cz, O1 and O2 of the International 10-20 System of Electrode Placement (Jasper, 1958), as these sites are optimal for two-channel (Cz/O1 and O2/A1) measurement of theta and alpha brainwave rhythms, as well as for detecting the alpha to theta (sleep onset) transition (Shea et al., 1999). An electrode of the same type was then attached to the skin covering the mastoid bone behind both ears, one to serve as the ground and the other as a reference electrode for the occipital channel. Participants were instructed that the purpose of the EEG hookup is to detect the unwanted occurrence of sleep onset. The five leadwires were attached to a biological data acquisition device known as WaveRider, Jr., manufactured by WaveAccess of Sebastopol, California. This device uses a fast Fourier transform that averages both frequency and power (amplitude squared) over forty 1-Hz frequency bins over a timebase of four seconds. It recorded the dependent variables of theta percentage and alpha percentage over successive 30-second epochs for five baseline minutes of habituation to nine quasirandomly delivered pure tones of precisely the same type and quality that were interspersed throughout the narrative vignettes. Participants were instructed to ignore these tones. Excel spreadsheets were used to calculate the ratio of theta percentage divided by alpha percentage for each 4-second unit of measure for each participant. While maintaining a reclining position,



participants were fitted with headphones and instructed to select a comfortable sound level that “sounds like a normal conversation”. Habituation took place with participants in a supine position of relaxed wakefulness on a reclining chair. They were then given a 30-minute auditory stimulus through the headphones consisting of a CD recording of short narrated daydream excerpts separated from each other with silence at quasi-randomized intervals of either 20, 30 or 40 seconds duration. (Appendix II contains the temporal pattern of interval presentation, which was: 20-40-30-40-20-30. ) Each daydream excerpt and the silent period immediately following it was quasi-randomly interspersed at intervals of either 20, 30 or 40 seconds duration with pure tones of 1 second duration and with controlled rise and decay times of 25 msec, following the protocol of Gruzelier and Brow (1985). This protocol produced a total of 55 tones for the 30-minute sequence of 42 narratives interspersed with silence and nine tones for the 5-minute baseline of silence. Participants were instructed to ignore these tones. Following the protocol of Gruzelier et al. (1984), 60 of these tones were presented at 1000 Hz. The pitch of the 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> tones was changed to 690 Hz to test auditory habituation and dishabituation to the tones. Theta/alpha percentage ratio was once again recorded continuously for 30 minutes of exposure to the auditory stimulus and kept on a WaveWare file separate from the file of the baseline recording. WaveAccess’s WaveWare 2.5 software was used to convert both files to the ascii format for export to a spreadsheet program. Following the protocol of the Multiple Sleep Latency Test (Carskadon and Dement, 1982), any participant who demonstrated a theta percentage of greater than 50 percent for more than 30 seconds was presumed to have



entered the first stage of sleep and was called by her first name. This participant was then informed that she had fallen asleep and that she must stay awake for the remainder of the experiment if she wished to participate. The two participants (one from the experimental group and one from the control group) who lapsed into sleep more than once were not included in the experimental analysis. After removal of the headphones, participants were required to verbally respond to the following five questions from a post-exposure questionnaire: 1.) “During the last 30 minutes, while you were listening to the short narratives, did you daydream? By “daydreaming,” I mean any thoughts or images that seemed to come spontaneously, without being directed by your mind.” 2.) Can you give me an approximate number for how many daydreams you had that were related to any of the narratives? 3.) Can you give me an approximate number for how many daydreams you had that were not related to any of the narratives? 4.) Can you give me an example of one of the related daydreams? 5.) Can you give me an example of one of the unrelated daydreams? The last two questions were asked in order to verify that daydreams reported as related did in fact share content with the narratives and that daydreams reported as unrelated did not share content with the narratives. The four participants who answered “no” to the first question were prompted with a reiteration of the definition of daydreaming with emphasis on the fact that daydreams can include episodic memories, provided that the memories are not goal-directed. Due to the unexpected nature of the first question, participants lacked a frame of reference for retrospectively assessing the number of daydreams experienced during the previous 30 minutes. After my first few pilot study participants expressed total uncertainty



about a numerical estimate of daydreaming and reluctance and/or inability to provide such an estimate, I added a numerical elicitation protocol for all remaining participants. Specifically, immediately after asking the first question, I administered the following six-point verbal scale: “Would you say that you had between 0 and 5, between 10 and 20, between 20 and 30, between 30 and 40, between 40 and 50, or more than 50 daydreams? If, for example, the participant responded “between 20 and 30”, I then asked her, “If you had to pick one number between 20 and 30 to describe the number of daydreams you had, what would it be?” In all cases, participants were able to provide a single number within several seconds and without further questions or expressions of uncertainty. See Appendix I for a timeline of the experimental procedures.

## Results

Seven measures of the dependent sleepiness variable, theta percent/alpha percent, were taken: a baseline average score, an initial auditory exposure score (measured just before the onset of the first tone in the vignettes), a final auditory exposure score, an initial minus final auditory exposure difference score, an auditory exposure average score, a baseline average minus auditory exposure average difference score, and a baseline average minus final exposure score. Three measures of the dependent variable degree of daydreaming were taken: number of reported daydreams related to narrative themes, number



of reported daydreams unrelated to narrative themes, and total number of reported daydreams.

A 1-way ANOVA was performed on all ten dependent variables, with type of instruction (misinformed or correctly informed) as the factor for group. This produced a total of ten ANOVAs, none of which revealed significant group mean differences at the .02 p-value criterion for statistical significance. The .02 criterion was chosen to reduce the possibility of finding support for one of the four experimental hypotheses due to the chance factor involved in testing multiple hypotheses at the .05 level. All ten ANOVA tables are provided in Appendix IV, and the ten associated graphical comparisons of the group means are presented at the end of the Results section as Figures 1 through 10. The individual participant scores on each of the ten dependent variables are presented separately for the experimental and control groups in Appendix V. Thus, the first and second experimental hypotheses, which predict that mean number of total reported daydreams (see Figure 10), initial-final sleepiness difference score (see Figure 7), and baseline average-narrative average sleepiness difference score (see Figure 5) should be significantly different between the groups, were not supported by the data.

The third hypothesis predicts that a significantly positive correlation coefficient should be obtained, irrespective of group assignment, between the dependent measures of initial sleepiness index and degree of daydreaming. Indeed, a significant positive correlation of .31 ( $p < .0149$ ,  $n = 60$ ) was obtained between initial sleepiness index and number of narrative-related daydreams (see Figure 12). It also predicts that a significantly positive



correlation coefficient should be obtained, irrespective of group assignment, between the dependent measures of initial - final sleepiness difference score and degree of daydreaming. Pearson's Correlation Coefficients were calculated for all six of these data sets to determine the magnitude and direction of these six dependent variable correlations. No significant correlation between baseline average sleepiness and any of the measures of degree of daydreaming was obtained, nor was any significant correlation between initial – final sleepiness difference score and number of unrelated or total number of daydreams found.

However, with regard to the overall analysis ( $n = 60$ ) of sleepiness difference scores and number of narrative-related daydreams, the third and fourth hypotheses predict that the largest initial – final sleepiness difference scores, i. e., those that come from the participants with the largest positive initial – final sleepiness difference scores due to having become much less sleepy as the study progressed, will be associated with the greatest reported numbers of narrative-related daydreams. Thus, the fourth hypothesis predicts a positive correlation between the 60 sleepiness difference scores and number of narrative-related daydreams reported. In direct opposition to the fourth hypothesis, a highly significant ( $p < .0001$ ) negative association of  $-.4785$  between initial minus final sleepiness difference score and number of narrative-related daydreams reported was obtained (see Figure 11). That is, participants with the smallest (most negative) initial-final sleepiness difference scores (due to having become much more sleepy as the study progressed) were associated with the greatest reported numbers of narrative-related daydreams. To verify that this highly significant negative association was not reached in error, correlational analyses ( $n = 60$ ) between initial-



final sleepiness difference score and both initial and final sleepiness score were carried out. As expected, a highly significant positive correlation ( $r = .38, p < .0029$ ) between initial – final sleepiness difference and initial sleepiness score was obtained, as well as a highly significant negative correlation ( $r = -.35, p < .0055$ ) between initial – final sleepiness difference and final sleepiness score. Thus, smaller (more negative) initial- final sleepiness differences (due to becoming more sleepy) were associated with smaller initial sleepiness scores and with larger final sleepiness scores, while larger initial-final sleepiness differences (due to becoming less sleepy) were associated with larger initial sleepiness scores and smaller final sleepiness scores. Consistent with the main finding of a large association between becoming progressively sleepier and reporting more narrative-related daydreams, a significant positive correlation of .31 ( $p < .0149, n = 60$ ) was obtained between initial sleepiness index and number of narrative-related daydreams (see Figure 12), and a significant positive correlation of .32 ( $p < .0128, n = 60$ ) was obtained between final sleepiness index and number of narrative-related daydreams (see Figure 13). That is, participants who were the sleepiest both at the beginning and at the end of exposure to the ego-affirming daydreams were also those who reported the most narrative-related daydreams. To confirm that the participants who were the sleepiest at the beginning of the study were largely the same participants who were sleepiest at the end of the study, a correlational analysis was performed with initial and final sleepiness indices as dependent variables. As expected, a highly significant positive correlation of .72 ( $p < .0001, n = 60$ ) was obtained and direction of these dependent variable correlations (see Figure 14).



None of the experimental hypotheses made any predictions about the relative effects of state daydreaming (daydreaming induced as a result of exposure to the daydream narratives) and trait daydreaming on any of the dependent variables. However, in addition to the expected evidence of state daydreaming, the present study found evidence of the occurrence of trait daydreaming in that participants who reported greater numbers of narrative-related daydreams also tended to report greater numbers of narrative-unrelated daydreams. Specifically, the correlational analysis using number of narrative-related daydreams and number of narrative-unrelated daydreams as dependent variables produced a significantly positive correlation of .37 ( $p < .0034$ ,  $N = 60$ ) (See Figure 15). All correlation matrices are provided in Appendix IV, and scatterplots of the significant correlations are provided at the end of the Results section as Figures 11 through 15. An analysis of covariance using number of hours slept in the past 24 hours and caffeine consumption as covariates did not reveal any significant linear relationships between the covariates and any of the ten dependent variables. All four participants (three from the experimental group and one from the control group) who initially reported having had no daydreams during the preceding 35 minutes reported having had daydreams upon administration of the prompt. Their averages on the 3 daydreaming measures were computed separately and compared to the corresponding 3 averages for the 56 non-prompted participants. The respective prompted versus non-prompted averages were as follows: 21.25 versus 18.01 for number of related daydreams, 2 versus 11.55 for number of unrelated daydreams, and 23.25 versus 28.17 for total number of daydreams. Evidently, those participants who needed prompting were also



those who had relatively few unrelated daydreams. Prompted participants are indicated in Appendix V with a 'P' in front of the participant's randomly assigned identification number.

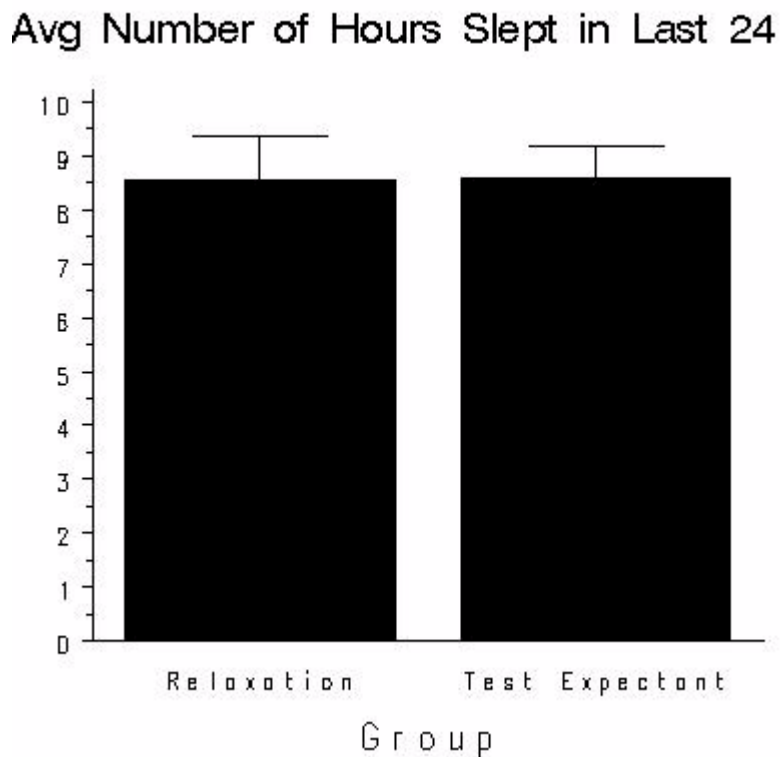


Figure 1. Average total number of hours slept in the 24 hours prior to participation for control (relaxation) and experimental (test expectant) groups. This total includes all naps of 30 minutes or greater duration. The standard deviations of these means, which are indicated by vertical distance on the y-axis between the top of the bar graph and the top of the error bar, are also approximately equal for the two groups.



Average Theta/Alpha % During Baseline

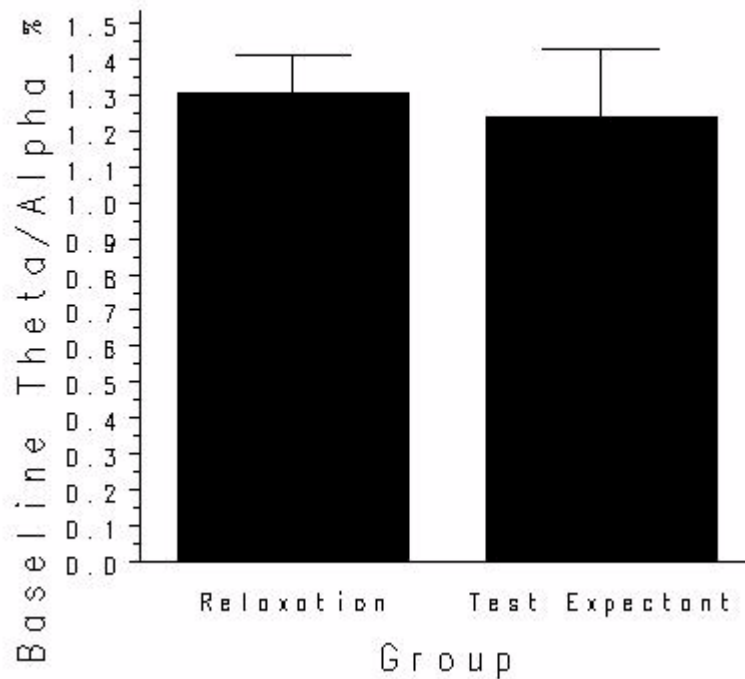


Figure 2. Average percent ratio of theta band (3-7 Hz) to alpha band (8-14 Hz) EEG activity during the first five (baseline) minutes of the study for control (relaxation) and experimental (test expectant) groups. The stimulus during this period was the same pattern of quasi-randomly presented tones that was embedded in the daydream narratives and silent periods that were presented immediately afterwards.



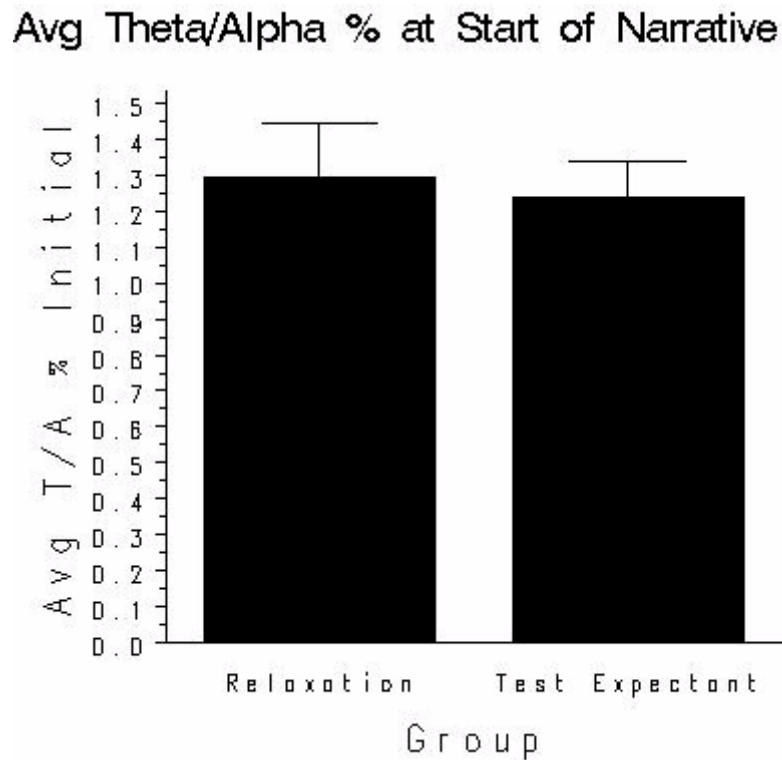


Figure 3. Average percent ratio of theta band (3-7 Hz) to alpha band (8-14 Hz) EEG activity at onset of the 30-minute narrative portion of the auditory stimulus for control (relaxation) and experimental (test expectant) groups. The narrative portion consisted of 42 daydream vignettes separated by silent periods of 30 seconds average, presented in the pattern 20-40-30-40-20-30. Both baseline and narrative portions were interspersed with pure tones presented in the same quasirandom pattern, every 30 seconds on average.



## Average Theta/Alpha % During Narrative

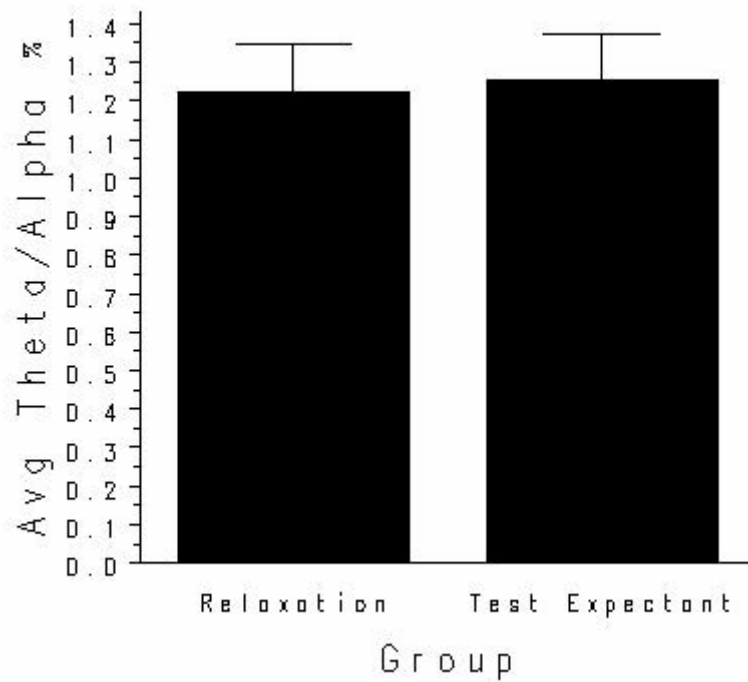


Figure 4. Percent ratio of theta band (3-7 Hz) to alpha band (8-14 Hz) EEG activity, averaged over the entire 30-minute narrative portion of the auditory stimulus for control (relaxation) and experimental (test expectant) groups.



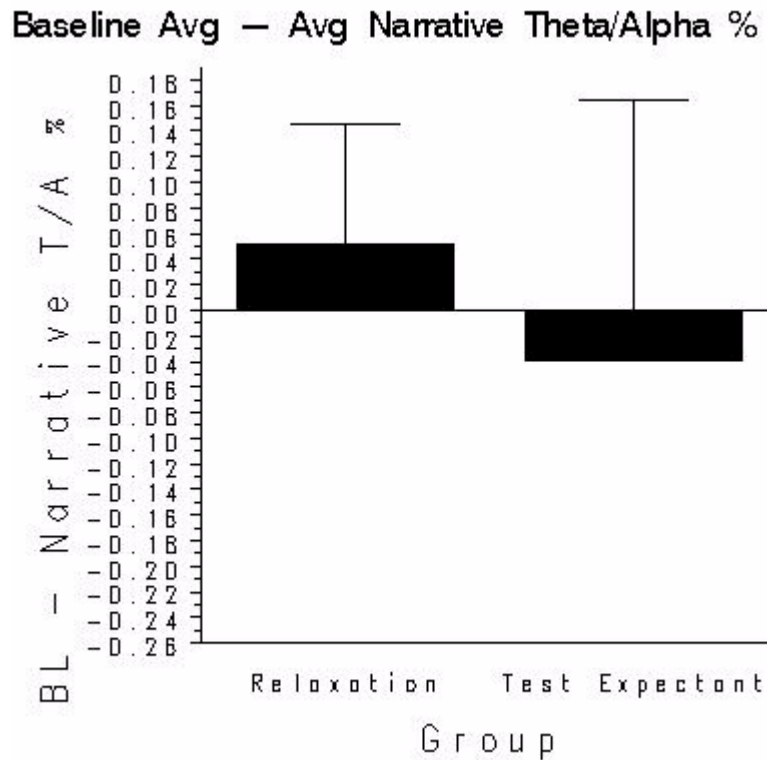


Figure 5. Baseline Theta/Alpha percent ratio, as described in Figure 2, minus Narrative Theta/Alpha percent ratio, as described in Figure 4, for control (relaxation) and experimental (test expectant) groups. This difference was slightly positive for the control group, and slightly negative for the experimental group, suggesting a slight tendency for control subjects to become more awake as the study progressed and for experimental subjects to become more sleepy as the study progressed. Thus, it is certain that the present study did not suffer from the common methodological flaw of creating a supposedly neutral control condition that in fact has an inhibitory effect on alertness.



Avg Theta/Alpha % at End of Narrative

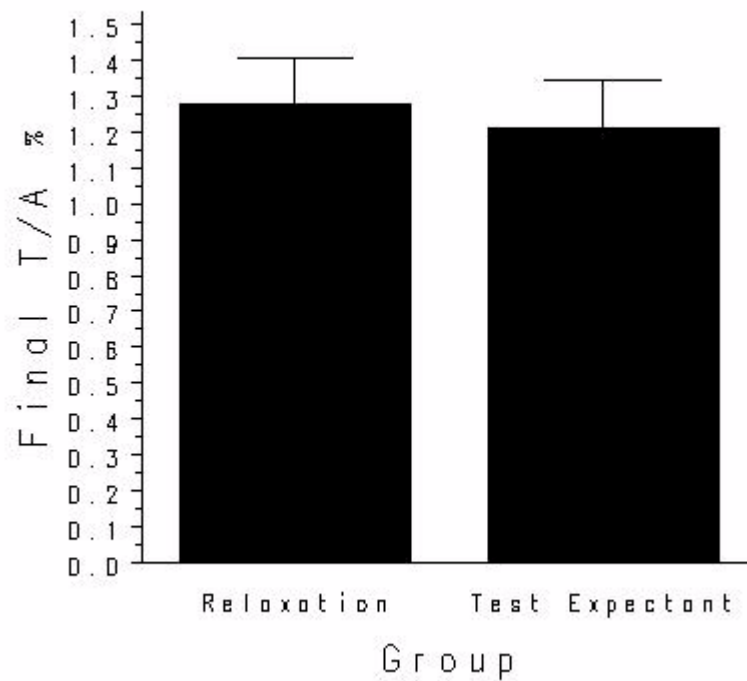


Figure 6. Percent ratio of theta band (3-7 Hz) to alpha band (8-14 Hz) EEG activity, 30 seconds prior to offset of the 30-minute narrative portion of the auditory stimulus for control (relaxation) and experimental (test expectant) groups.



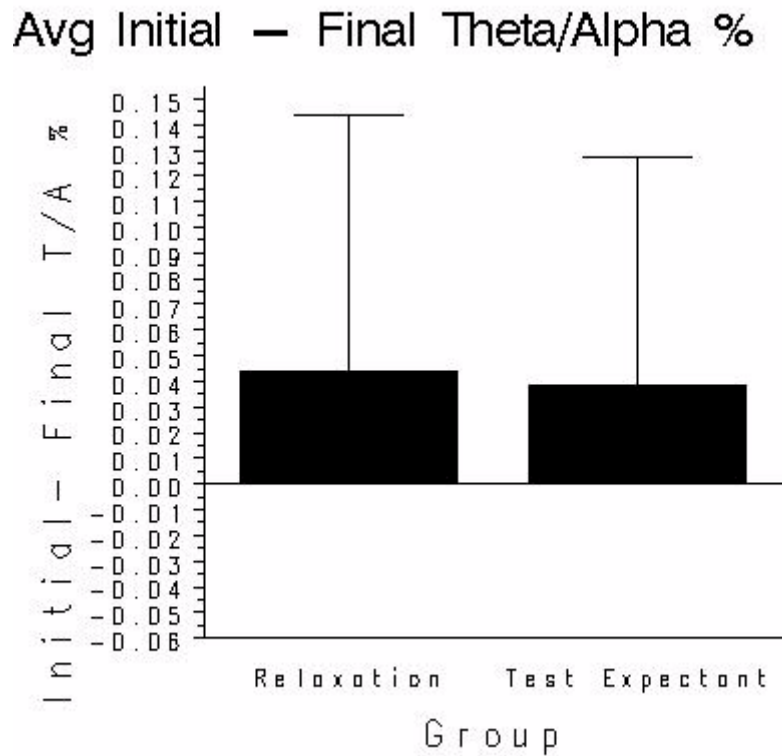


Figure 7. Initial Theta/Alpha percent ratio, as described in Figure 3, minus Final Theta/Alpha percent ratio, as described in Figure 6, for control (relaxation) and experimental (test expectant) groups. This difference did not differ significantly from zero based on different between-group participant expectations. That is, participants in the relaxation group were correctly informed that their only task would be to listen, while those in the test expectant group were misinformed that they would be given a test of recall on the contents of the narratives. Given the large correlation that was found between this sleepiness difference measure and number of narrative-related daydreams,



it is likely that significant group differences in initial minus final sleepiness difference exist that were obscured by the large standard deviations of these group means.

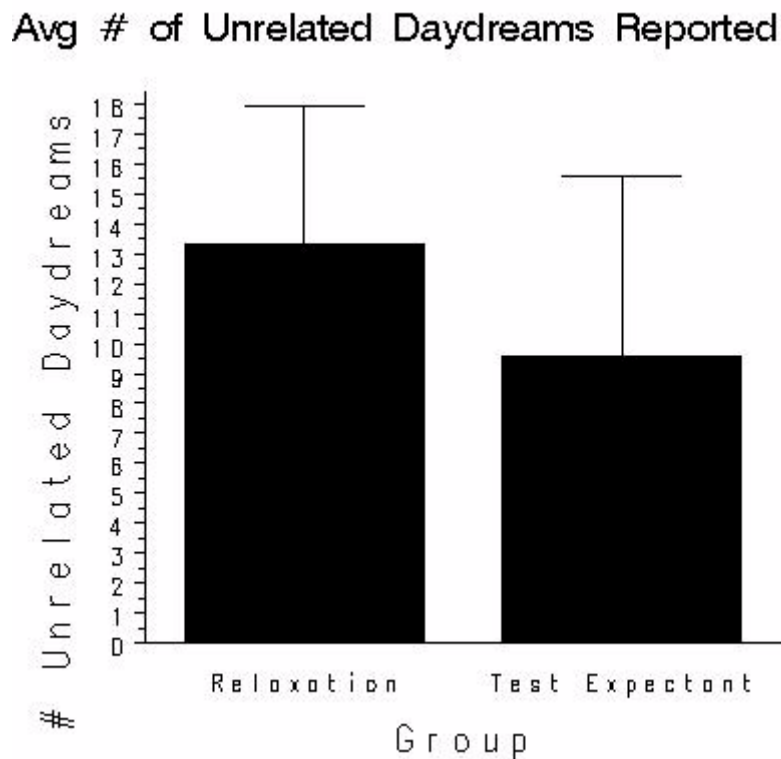


Figure 8. Average number of narrative-unrelated daydreams reported to have occurred during the 30 minutes of exposure to the 42 daydream narratives, for control (relaxation) and experimental (test-expectant) groups. The larger number of unrelated daydreams reported by the control group appears to be significant, but the 1-way ANOVA obtained a p-value  $<.2281$ . As mentioned in the Results and Discussion sections, it is likely that there is a reporting bias for



unrelated daydreams, since these are often personal episodic memories that tend to be discounted as daydreams.

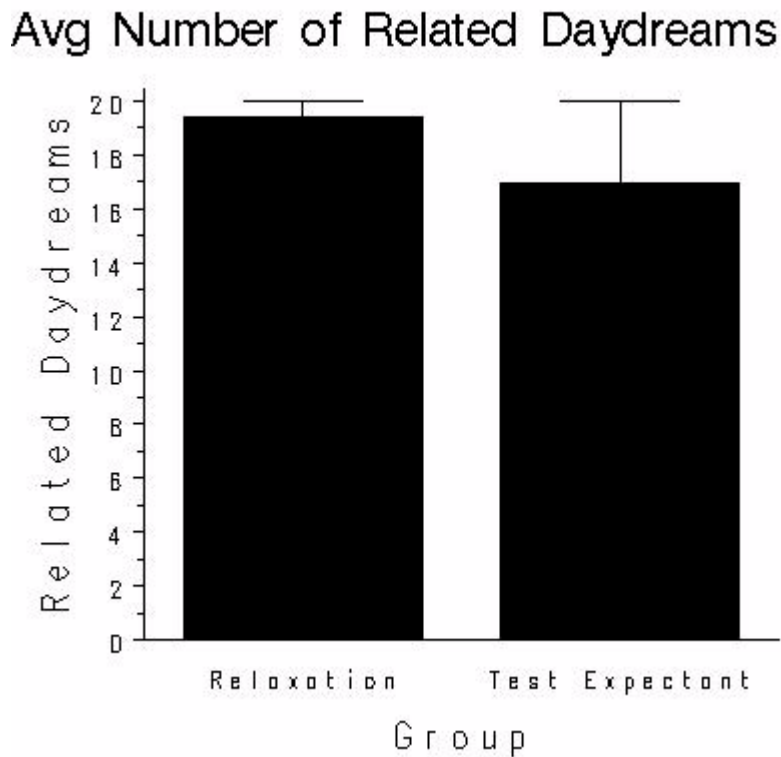


Figure 9. Average number of narrative-related (sustaining) daydreams reported to have occurred during the 30 minutes of exposure to the 42 daydream narratives , for control (relaxation) and experimental (test expectant) groups. As originally hypothesized in my pilot study, the test expectancy condition is inhibitory to daydreaming, although not significantly.



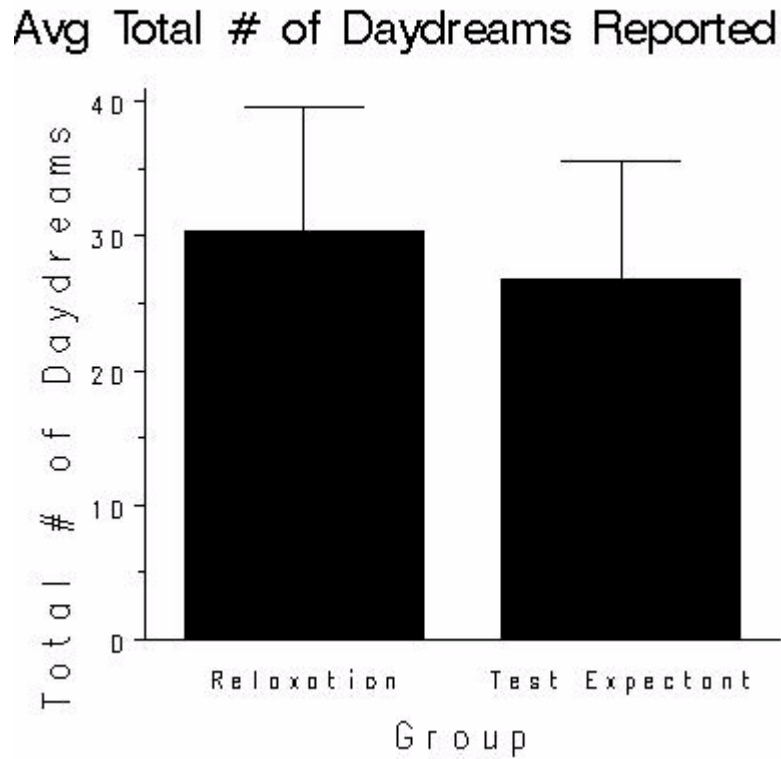


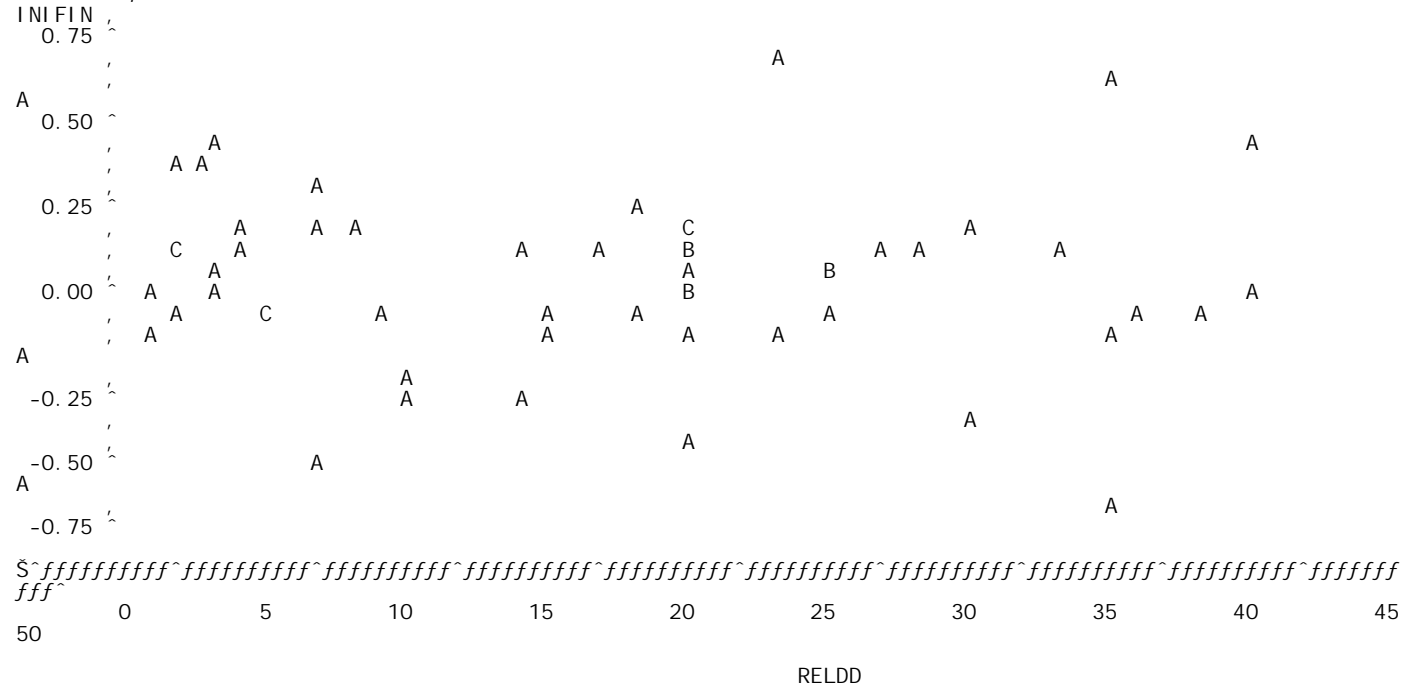
Figure 10. Average total number of daydreams (number of narrative-unrelated daydreams plus number of narrative-related daydreams) reported as having occurred during the 30 minutes of exposure to the 42 daydream narratives, for the control (relaxation) and experimental (test-expectant) groups. As originally hypothesized in my pilot study, the test expectant condition is inhibitory to daydreaming, although not significantly.



### Scatterplot for Initial - Final %Theta/%Alpha (Sleepiness) Ratio and Number of Related Daydreams

Legend: A = 1 obs, B

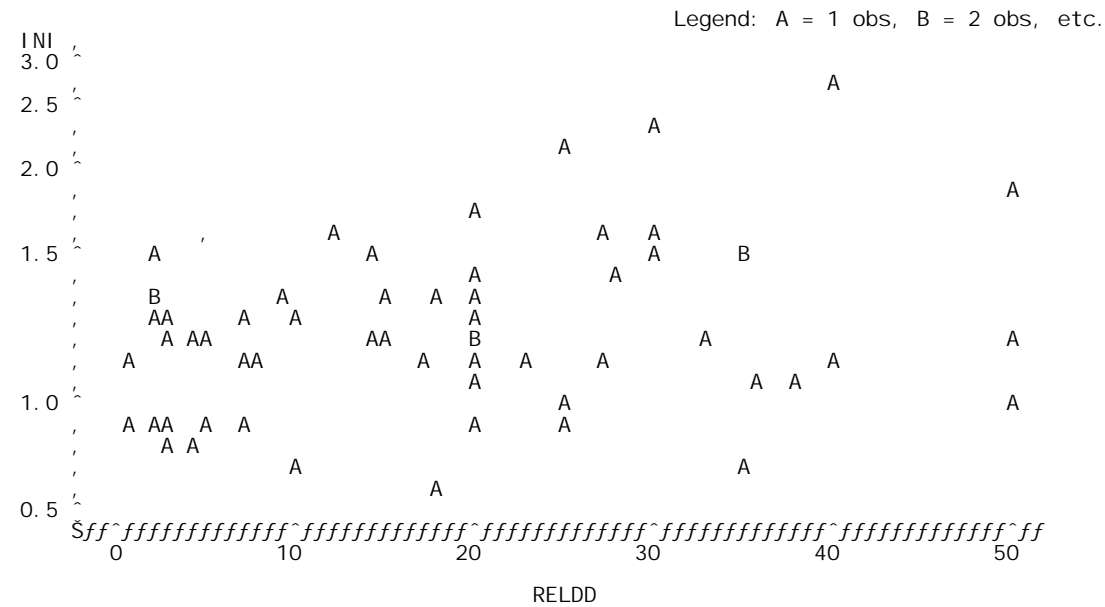
= 2 obs, etc.



**Figure 11.** Participant change in sleepiness index (%Theta/%Alpha ratio at onset of narrative portion of stimulus minus %Theta/%Alpha ratio 5 seconds prior to offset of narrative portion of stimulus) plotted against number of narrative-related daydreams reported, for all 60 participants.



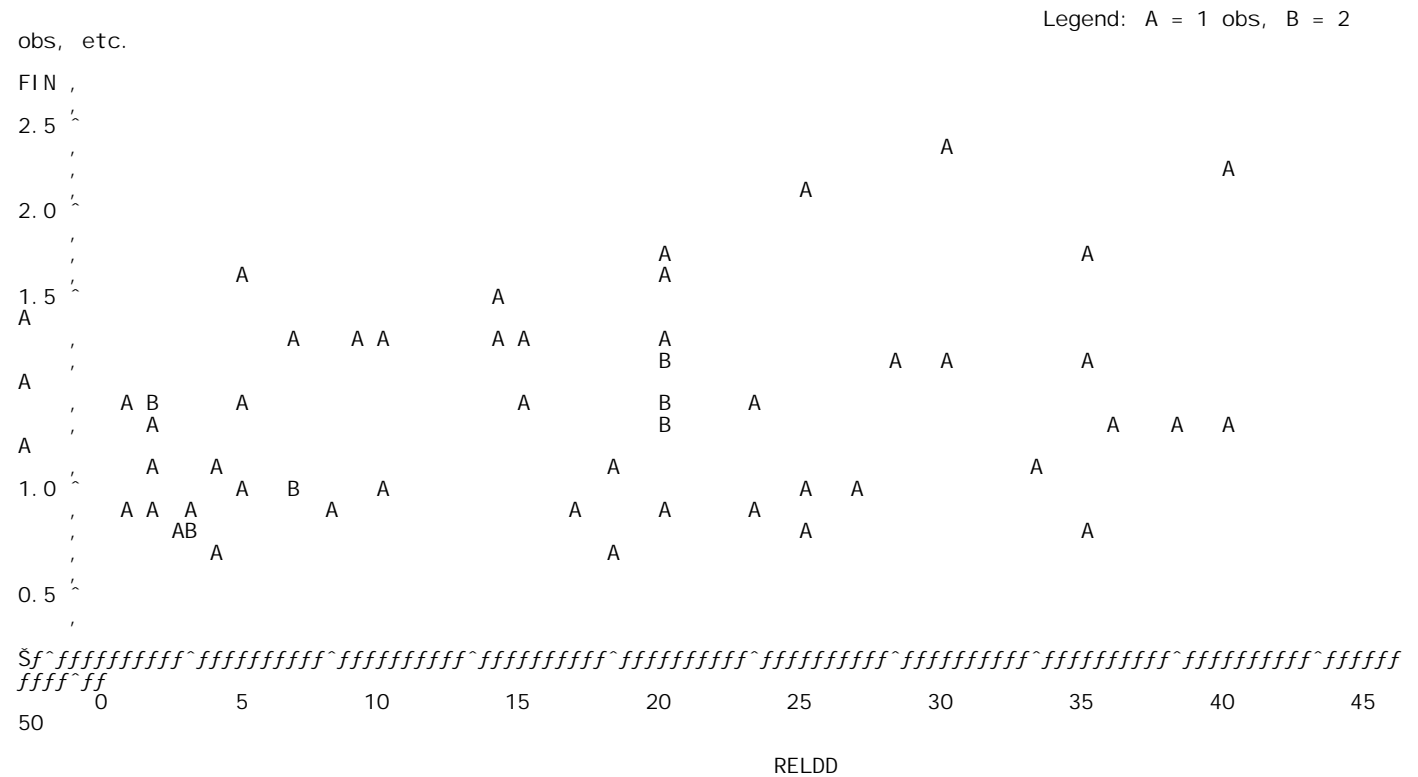
### Scatterplot for Initial %Theta/%Alpha (Sleepiness) Ratio and Number of Related Daydreams



**Figure 12.** Participant sleepiness index (%Theta/%Alpha ratio) at onset of narrative portion of stimulus plotted against number of narrative-related daydreams reported, for all 60 participants

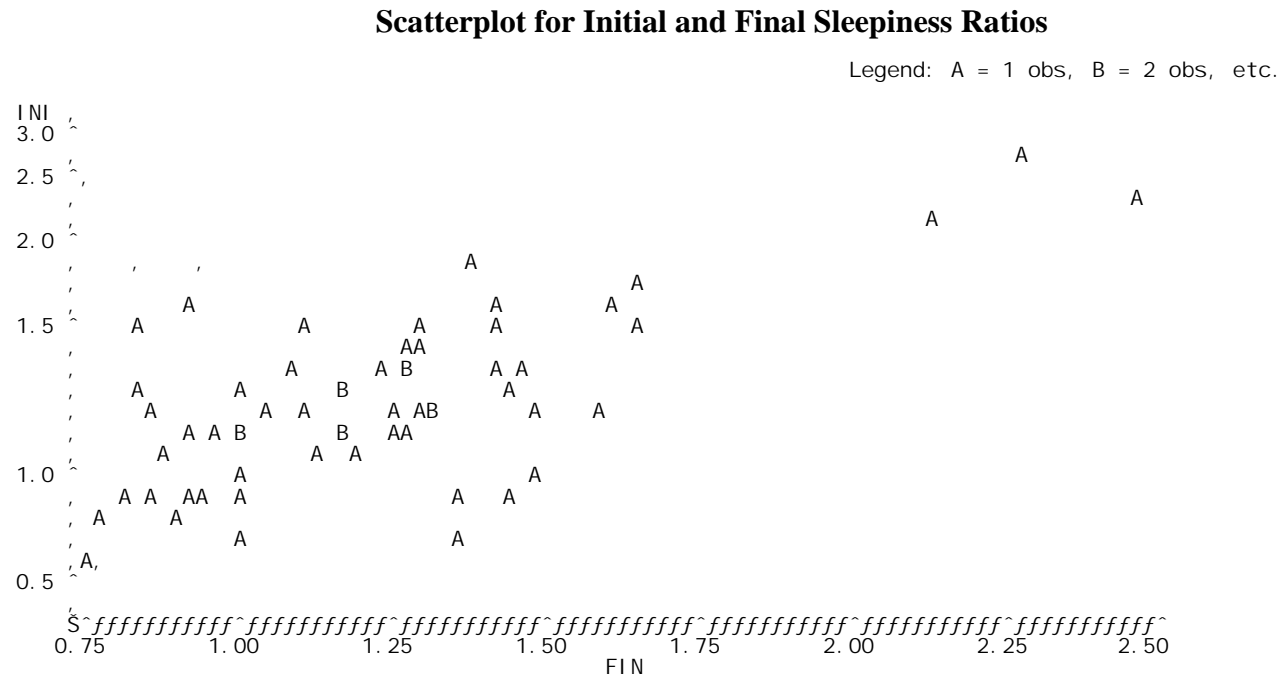


### Scatterplot for Final %Theta/%Alpha (Sleepiness) Ratio and Number of Related Daydreams



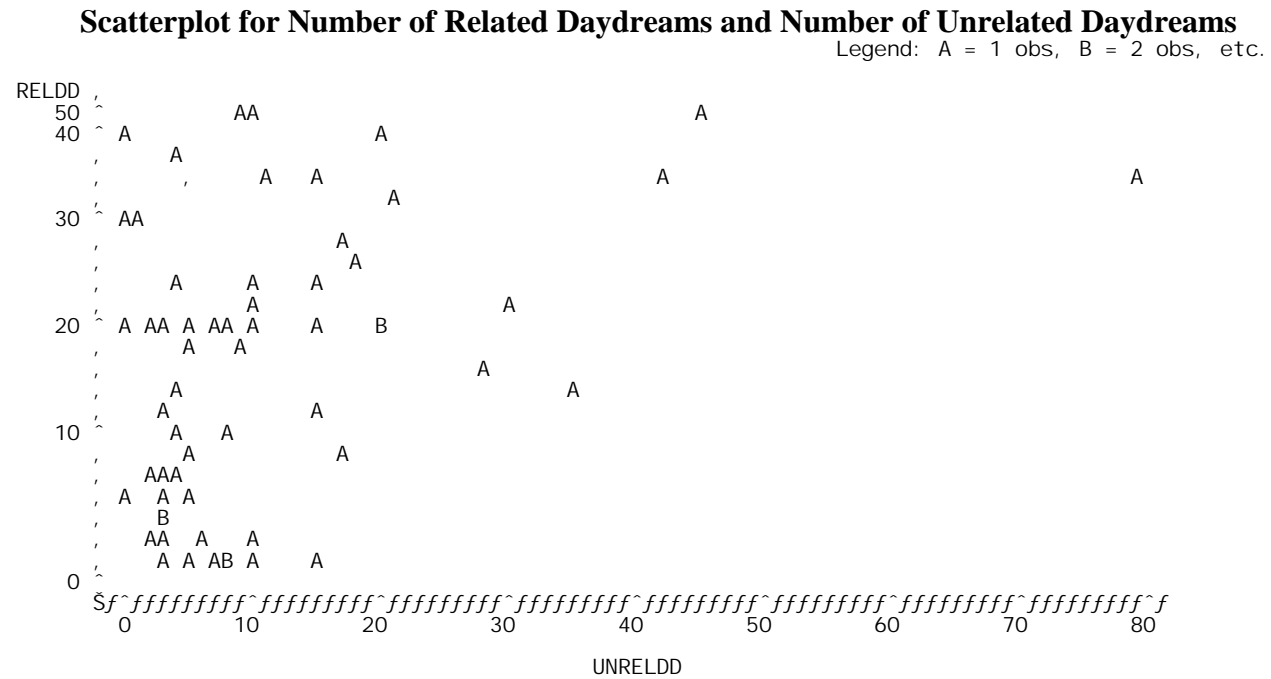
**Figure 13.** Participant sleepiness index (%Theta/%Alpha ratio) 5 seconds prior to offset of narrative portion of stimulus plotted against number of narrative-related daydreams reported, for all 60 participants.





**Figure 14.** Participant sleepiness index (%Theta/%Alpha ratio) at onset of narrative portion of stimulus plotted against participant sleepiness index (%Theta/%Alpha ratio) 5 seconds prior to offset of narrative portion of stimulus, for all 60 participants.





**Figure 15.** Number of narrative-related (sustaining) daydreams reported plotted against number of narrative-unrelated daydreams, for all 60 participants.



## Discussion

The main hypothesis of this study, that experimental subjects would show larger within-subject decreases in initial level of sleepiness than control subjects, rested upon the idea that adult daydreaming can be a homeostatic compensatory response to sleepiness. The main finding of this study was that the experience of narrative-related, i. e., sustaining daydreams, in direct opposition to my third and fourth hypotheses, is associated with decreased participant levels of alertness as indexed by EEG. Specifically, participants who were the sleepiest at either the beginning or at the end of the narratives reported more narrative-related daydreams than participants who were more alert at these times. Therefore, while this study did not succeed in demonstrating that daydreaming can be a compensatory response to sleepiness, it did succeed in demonstrating that daydreaming can be a response to sleepiness. In addition, the within-subjects correlation between initial and final sleepiness scores was highly significant. Thus, the people who were the sleepiest at the beginning of the study were almost always the same people who were the sleepiest at the end of the study. As discussed in the Introduction section, any effect seen with narrative-related but not with narrative-unrelated daydreams can reasonably be ascribed to state daydreaming rather than to trait daydreaming. This being the case, the present study has revealed an intriguing relationship in that it has demonstrated a positive association between the initial condition of sleepiness and later state daydreaming. While my fourth hypothesis did not predict the direction of this relationship, it did predict that it would occur. Although it is presently unclear whether the initial sleepiness was trait-related (either related to chronic sleep



deprivation or unrelated to sleep deprivation) or state-related (related to acute sleep deprivation), future studies could clarify this issue. Furthermore, it is possible that the failure of the present study to find significant group differences in any of the sleepiness measures was due to its failure to control for these basic etiologies of sleepiness.

The positive correlation between sustaining daydreams and sleepiness suggests an explanation for the 1986 finding of Cicogna et al. that free associations to both sleep onset dreams and daydreams are mainly episodic. Specifically, both findings can be explained by positing that episodic mentation tends to occur whenever neural activation levels decrease below those of full alertness prior to the onset of complete thalamocortical synchronization and slow-wave sleep. If so, then it might have been the episodic nature of the sustaining daydreams that resulted in sleepiness intensification. This model would explain why participants who were relatively alert were protected from the sleepiness intensification effect of ego-affirming daydreams, since alert participants would be relatively unlikely to experience episodic mentation. It would also explain the common practice of reading an epic novel to overcome occasional insomnia, since the act of reading would induce an alert person to produce episodic mentation. However, this model is based on the assumption that participants' narrative-unrelated daydreams, in contrast to their narrative-related daydreams, tended not to be episodic. Thus, the present study would have been better suited to test this model of daydream-related neural deactivation had it collected qualitative data on daydream mentation that would have allowed the mentation to be classified as episodic or non-episodic.



While this study was successful in demonstrating a physiologically-based experiential effect of daydreaming for at least one type of daydream (sustaining), it failed to demonstrate any effect of being placed in the experimental “daydream induction” group. From a quantitative standpoint, a group effect could have been obscured by the limited range of amplitude and frequency that occurs in the waking EEG. Specifically, compared to the sleep EEG, which ranges from 10 to 200 microvolts in amplitude and from .5 to over 25Hz in frequency, the waking EEG ranges from about 10 to 50 microvolts in amplitude and from about 8 to 30 Hz in frequency (Rechtschaffen, 1976). From a qualitative standpoint, post-experimental interviews indicated that, despite being given a broad definition of daydreaming, i.e., any undirected thought or image, many participants erroneously believed that veridical memories do not count as daydreams. In fact, the four participants who initially reported no daydreams during the 35-minute supine period were then prompted with the information that daydreaming includes undirected memories. All four participants subsequently reported daydreams. For this limited sample of four, the averages for number of related daydreams reported and total number of daydreams reported did not differ significantly from the averages for the other participants. However, the average for number of unrelated daydreams reported was significantly decreased relative to the average number of unrelated daydreams reported for the 56 non-prompted participants. Thus, participants’ estimates of number of unrelated daydreams may have been unduly influenced by a popular notion of daydreaming that excludes the veridical re-experience of events from the daydreamer’s past. If so, then any future research on the potential of daydreams to alter



neural activation levels will need to expressly include undirected memories in the pre-experimental instructions to participants. Finally, it is possible that the effects of daydreaming on sleepiness are dependent upon the qualitative nature of the sleepiness, e.g., whether it is caused by chronic sleep deprivation, acute sleep deprivation, or unrelated to sleep deprivation. To the credit of the present study, the lack of a significant group effect of participant test expectations (rehearsal or relaxation) on degree of cortical arousal demonstrates that it successfully avoided the methodological pitfall of inducing greater neural expenditure in the experimental group relative to the control group.

With regard to directions for future research, a more accurate measure of daydreaming would also allow a more direct test of the hypothesized restorative function of daydreaming. Specifically, if daydreaming is restorative, then REM sleep-deprived participants who daydream more should show smaller decrements in performance on tests of functions known to decline with REM sleep deprivation than sleep-deprived participants who daydream less. As noted in the Introduction section, these tests would include Guilford's Utility Test for creativity, anagram tests of fluid problem solving, tests of declarative memory for sentences and stories, and tests of procedural memory for perceptual learning. Even in the absence of a more accurate measure of daydreaming, a future study could validate the unexpected results of the present study if it could demonstrate that experimentally sleep deprived participants report a greater number of sustaining daydreams than do control participants confirmed by polysomnography or wrist actigraphy to be rested.



This type of study would also allow the experimenter to control for the effects of chronic versus acute sleep deprivation.



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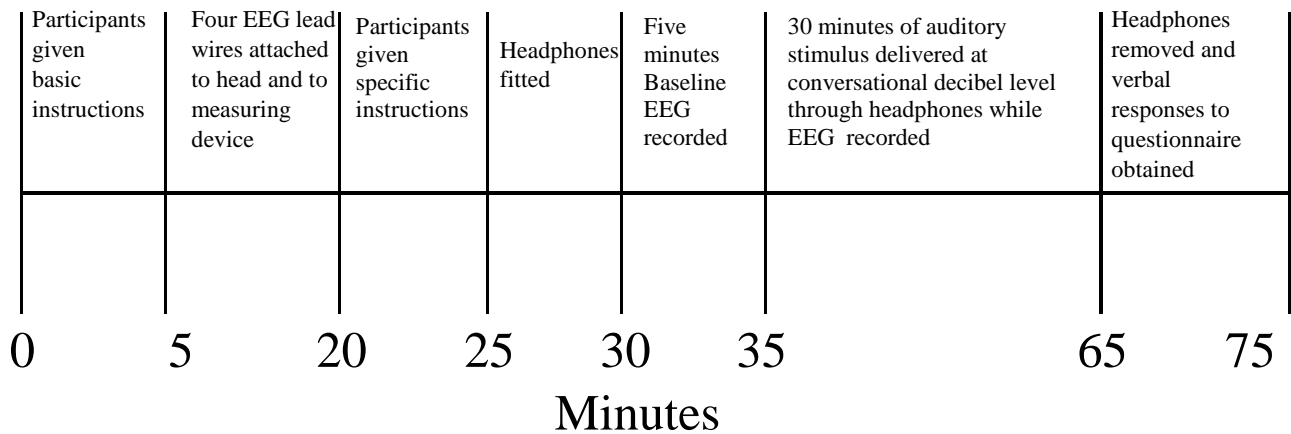


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## Appendix I

### Timeline of Experimental Procedure





## **Appendix II**

### **Script of Narrative Recording of Sustaining Fantasies**

I remember the last time I saw a guy I used to date and the words that we exchanged about when he would be coming back into town.

(20-sec. pause)

I remember a night in the park with friends that lasted until 4 am. The park was very woodsy and people kept arriving out of nowhere. I was wearing my favorite shirt.

(40- sec. pause)

I remember going swimming with our clothes on just for the fun of it.

(30-sec. pause)

I am trying to visualize what my friends might be doing at this exact moment; it makes me feel closer to them.

(40-sec. pause)

I am driving a red convertible sports car and noticing how cool I look with my sunglasses on and my hair blowing straight back.

(20-sec. pause)

It would be great to be a famous disk jockey, getting paid lots of money just for spinning a few recordings.

(30-sec. pause)

I see myself wearing the perfect bathing suit that was made just for me that also makes my figure look perfect.

(20-sec. pause)

I am having a romantic candlelit dinner with my favorite date in an exciting city that neither of us has been in before.

I am watching my favorite band in concert and I have front-row seating.



(40-sec. pause)

I am bathing under a waterfall fed from a mountain stream. The water is splashing and sparkling.

(30-sec. pause)

I am housesitting in an old-fashioned country house with crickets chirping all around me.

(40-sec. pause)

I have my own private airplane and can use it whenever I want to go anywhere I want.

(20-sec. pause)

I am doing a dance number in a large dance studio with my favorite friend. From the mirror, I can see that our movements are in perfect time with each other.

(30-sec. pause)

I am on a tropical island and there is nothing but blue sky and white beach. I am making sand castles and watching clouds and people go by.

(20-sec. pause)

I am looking through the Universe; I see Saturn with its rings and the most amazing colored particles are floating around the rings.

(40-sec. pause)

I am watching a sunset from the beach. A thunderstorm is approaching as the sky turns from orange to pink to purple.

(30-sec. pause)

I am remembering the Easter egg hunts that we used to have as kids.

(40-sec. pause)



I have just gotten named “Sweetheart of the Dance” at my first formal dance, and my date’s parents are hugging me in congratulations.

(20-sec. pause)

I am singing popular songs and playing the guitar on a large stage. The audience listens in rapt attention, then breaks out into cheers and applause when I finish.

(30-sec. pause)

I am touring a strange city and am marveling at the many beautiful marble towers, fountains and statues. There is no traffic on the wide, brick-paved streets except carriages and push-carts.

(20-sec. pause)

I am hang-gliding through the Grand Canyon. Now, I am landing in a field of densely-packed fragrant flowers.

(40-sec. pause)

I am remembering my favorite blanket as a child. It was very soft and smelled very sweet because of the special softener my Mom put in the laundry.

(30-sec. pause)

I am bending repeatedly over a pool table, surrounded with completely amazed men as I call and make shot after shot, sinking all of the colored balls into the proper pockets effortlessly.

(40-sec. pause)

I am remembering how my best friend has always defended me against criticism and has always been accepting of my faults, and how comforting it is to know that she will always be my friend.

(20-sec. pause)

I have just cooked Thanksgiving dinner for my family and they are eating with the reckless abandon of a kid in a high chair; their enjoyment of the meal is obvious by their absorption in eating. My sister tells me that it is even better than what Dad used to make, and Dad is a professional cook.

(30-sec. pause)



I am watching the sun light up the colorful stained glass windows in an old historic church.

(20-sec. pause)

I am remembering the sweetest little 3 year-old child who latched onto my hand while I was working at a sports event. She stayed by my side all night long.

(40-sec. pause)

I am remembering what the inside of my best friend's parent's house used to look like and am going in and out of each room, remembering what kinds of furniture, decorations and carpeting were in each room, and where the furniture was located.

(30-sec. pause)

I am being handed my college diploma and shaking the Dean's hand while my parents take pictures. Some of my friends throw flowers on the runway as I make my exit.

(40-sec. pause)

I am strolling around a lake that is completely encircled by a sidewalk. I stop every once in a while to feed a duck or another bird that has flown in. All that I can see is the deep blue sky reflecting off the lake and the wind moving the leaves on the trees.

(20-sec. pause)

I am remembering opening my Christmas presents as a child and how wonderful the tree and candles smelt and stacking the opened and examined treasures neatly in a pile and thinking how much better my gifts were than those of my brothers and sisters.

(30-sec. pause)

My Psychology professor is announcing to the class that she cannot curve the last exam grade because someone in the class got a perfect score on it. She is looking right at me, and there are gasps of disbelief from the back of the room, because it was a very difficult test.

(20-sec. pause)

I am floating down a river of crystal-clear spring water in a large intertube from an old tire. I am on my stomach and can see face down into the water through my mask. A turtle paddles slowly by.



(40-sec. pause)

I am practicing blowing smoke rings and trying to teach my sister how to do it.

(30-sec. pause)

I am a mermaid at the bottom of the sea. It is quiet and cool. Moving is effortless, and all of the sea creatures can read my thoughts and obey my wishes.

(40-sec. pause)

I am a children's rights advocate, teaching neglected children how to understand themselves and the world so that they will not grow up to be behavior-disordered.

(20-sec. pause)

I am working out on the Stairmaster fitness machine at the gym. I can tell that the guy on the machine next to mine is very winded and short of breath, but is trying to outdo me on the machine. Finally, when he sees that I am not getting tired, he gives up and steps off of his machine in defeat.

(30-sec. pause)

I have just won the lottery for \$20 million and I am thinking of all of the possible places in the world that I might decide to move to, now that I can afford to live anywhere I choose to.

(20-sec. pause)

I am now interviewing potential employers in my chosen field of work to determine which will be the institution fortunate enough to gain both my expertise and my \$10 million capital infusion into its financial assets.



### **APPENDIX III**

#### **PRE-AUDITORY STIMULUS INSTRUCTIONS**

##### **CONTROL (RELAXATION) GROUP**

**For the first 5 minutes, you will hear a short, randomly presented musical tone which you are to ignore. For the next 30 minutes, you will hear a CD recording of my voice with silent pauses in between narrations. It is important that you can understand the words that I am saying, so please raise your hand if you have any difficulty understanding them. During both my voice and the pauses you will sometimes hear a short musical tone. Ignore the tone and feel free to let your mind wander as you listen through the headphones for the next 30 minutes. Your brainwaves are being recorded in order to detect the occurrence of sleep onset, because your data will be useless to me if you fall asleep while listening.**

##### **EXPERIMENTAL (DAYDREAM ENHANCEMENT) GROUP**

**For the first 5 minutes, you will hear a short, randomly presented musical tone which you are to ignore. For the next 30 minutes, you will hear a CD recording of my voice with silent pauses in between narrations. It is important that you can understand the words that I am saying, so please raise your hand if you have any difficulty understanding them. During both my voice and the pauses you will sometimes hear a short musical tone. Ignore the tone but be advised that you will be given a test of recall on the contents of the narratives that you are about to hear. . Your brainwaves are being recorded in order to detect the occurrence of sleep onset, because your data will be useless to me if you fall asleep while listening.**



## TABULAR RESULTS FROM STATISTICAL DATA ANALYSES

**Table 1. ANOVA Results for Group Means on 7 Dependent Variables of Sleepiness and 3 Dependent Variables of Daydreaming Amount**

Dependent Variable: **Average Sleepiness Index During Narrative** (AUDAVG)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.01545262	0.01545262	0.15	0.6979
Error	58	5.88850604	0.10152597		
Total	59	5.90395866			
	R-Square	C.V.	Root MSE	AUDAVGMean	
	0.002617	25.71433	0.31863140	1.23912010	

Dependent Variable: **Baseline Sleepiness Index – Narrative Sleepiness Index (BASEAUD)**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.12486759	0.12486759	0.67	0.4167
Error	58	10.82440191	0.18662762		
Total	59	10.94926950			
	R-Square	C.V.	Root MSE	BASEAUD Mean	
	0.011404	8461.623	0.43200419	0.00510545	



Dependent Variable: **Baseline Sleepiness Index** (BASELINE)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.06822298	0.06822298	0.39	0.5343
Error	58	10.12319998	0.17453793		
Total	59	10.19142295			
	R-Square	C.V.	Root MSE	BASELINE Mean	
	0.006694	32.90044	0.41777737	1.26982317	

Dependent Variable: **Final Sleepiness Index** (at end of narrative) (FIN)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.03360334	0.03360334	0.29	0.5921
Error	58	6.71243844	0.11573170		
Total	59	6.74604178			
	R-Square	C.V.	Root MSE	FIN Mean	
	0.004981	27.75234	0.34019362	1.22581967	

Dependent Variable: **Number of Hours Slept in Last 24** (HRSLEPT)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00937500	0.00937500	0.00	0.9600
Error	58	214.75208333	3.70262213		
Total	59	214.76145833			
	R-Square	C.V.	Root MSE	HRSLEPT Mean	
	0.000044	22.49453	1.92421987	8.55416667	



Dependent Variable: **Initial Sleepiness Index** (at beginning of narrative) (INI)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.04906444	0.04906444	0.41	0.5261
Error	58	6.99526244	0.12060797		
Total	59	7.04432689			
R-Square		C.V.	Root MSE	INI Mean	
0.006965		27.45372	0.34728659	1.26498917	

Dependent Variable: **Initial Sleepiness Index – Final Sleepiness Index** (INIFIN)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00041496	0.00041496	0.01	0.9364
Error	58	3.74238908	0.06452395		
Total	59	3.74280404			
R-Square		C.V.	Root MSE	INIFIN Mean	
0.000111		622.0004	0.25401565	0.04083850	

Dependent Variable: **Number of Narrative-Related Daydreams Reported** (RELDD)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	91.49169911	91.49169911	0.49	0.4874
Error	58	10862.72080089	187.28828967		
Total	59	10954.21250000			
R-Square		C.V.	Root MSE	RELDDMean	
0.008352		75.09098	13.68533119	18.22500000	



Dependent Variable: **Total Number of Daydreams Reported (TOTALDD)**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	196.20416667	196.20416667	0.40	0.5314
Error	58	28703.20833333	494.88290230		
Total	59	28899.41250000			
	R-Square	C.V.	Root MSE	TOTALDD Mean	
	0.006789	79.94956	22.24596373	27.82500000	

Dependent Variable: **Number of Narrative-Unrelated Daydreams Reported (UNRELDD)**

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	228.15000000	228.15000000	1.48	0.2281
Error	58	8918.93333333	153.77471264		
Total	59	9147.08333333			
	R-Square	C.V.	Root MSE	UNRELDD Mean	
	0.024942	113.5932	12.40059324	10.91666667	



**Table 3. Results of Correlational Analyses between 7 Dependent Variables of Sleepiness and 3 Dependent Variables of Daydreaming Amount**

**Pearson Correlation Coefficients (r), where  $p = \text{Prob} > |R|$  under  $H_0: \text{Rho} = 0$**

**\*\* = significant correlation**

**Correlation of**

<b>Narrative Sleepiness Index and:</b>	<b>Number of Related Daydreams</b>	$r = .239$	$N = 60$	$p < .0653$
	<b>Number of Unrelated Daydreams</b>	$r = .033$	$N = 60$	$p < .7984$
	<b>Total Number of Daydreams</b>	$r = .132$	$N = 60$	$p < .3145$
<b>Baseline – Narrative Sleepiness Difference and:</b>	<b># of Related Daydreams</b>	$r = -.054$	$N = 60$	$p < .6778$
	<b># of Unrelated Daydreams</b>	$r = .000$	$N = 60$	$p < .9960$
	<b>Total # of Daydreams</b>	$r = -.034$	$N = 60$	$p < .7930$
<b>Baseline Sleepiness Index and:</b>	<b>Number of Related Daydreams</b>	$r = .200$	$N = 60$	$p < .1238$
	<b>Number of Unrelated Daydreams</b>	$r = -.001$	$N = 60$	$p < .9947$
	<b>Total Number of Daydreams</b>	$r = .125$	$N = 60$	$p < .3376$
<b>Final Sleepiness Index and:</b>	<b>**Number of Related Daydreams</b>	$r = .319$	$N = 60$	$p < .0128$
	<b>Number of Unrelated Daydreams</b>	$r = .017$	$N = 60$	$p < .8916$
	<b>Total Number of Daydreams</b>	$r = .212$	$N = 60$	$p < .1027$
<b>Number of Hours Slept in Last 24 and:</b>	<b>Number of Related Daydreams</b>	$r = .014$	$N = 60$	$p < .9099$
	<b>Number of Unrelated Daydreams</b>	$r = -.129$	$N = 60$	$p < .3258$
	<b>Total Number of Daydreams</b>	$r = -.076$	$N = 60$	$p < .5618$
<b>Initial Sleepiness Index and:</b>	<b>**Number of Related Daydreams</b>	$r = .312$	$N = 60$	$p < .0149$
	<b>Number of Unrelated Daydreams</b>	$r = .001$	$N = 60$	$p < .9935$
	<b>Total Number of Daydreams</b>	$r = .235$	$N = 60$	$p < .0703$
	<b>**Final Sleepiness Index</b>	$r = .721$	$N = 60$	$p < .0001$
<b>Initial – Final Sleepiness Difference and:</b>	<b>**Number of Related Daydreams</b>	$r = -.474$	$N = 60$	$p < .0001$
	<b>Number of Unrelated Daydreams</b>	$r = -.026$	$N = 60$	$p < .8423$
	<b>Total Number of Daydreams</b>	$r = -.047$	$N = 60$	$p < .7214$
	<b>**Initial Sleepiness Index</b>	$r = .378$	$N = 60$	$p < .0029$
	<b>**Final Sleepiness Index</b>	$r = -.354$	$N = 60$	$p < .0055$
<b>Number of Unrelated Daydreams and:</b>	<b>**Number of Related Daydreams</b>	$r = .372$	$N = 60$	$p < .0034$
<b>Neg Initial–Final Sleepiness Difference and: Number of Related Daydreams</b>				
		$r = -.303$	$N = 25$	$p < .1414$
<b>Pos Initial–Final Sleepiness Difference and: Number of Related Daydreams</b>				
		$r = .247$	$N = 34$	$p < .1593$
<b>Neg Baseline–Narrative Sleepiness Difference and: # of Related Daydreams</b>				
		$r = -.054$	$N = 19$	$p < .8269$
<b>Positive Baseline –Narrative Sleepiness Differences and: # of Related Daydreams</b>				
		$r = -.186$	$N = 39$	$p < .2564$



## APPENDIX V

### Participant Scores By Group on Three Verbal Report and Seven EEG Dependent Variables

Table 4. Control (Relaxation) Group Scores

(DD=daydreams, HRS= hours slept, SI=sleepiness index, BL=baseline, N=narrative, P=participant, INI=initial, FIN=final)

P	Rel DD	Unrel DD	HRS	Total	DD	BL SI	INI -FIN SI	BL-N SI	INI SI	FIN SI	N SI	BL-FIN SI
127	33	21	7.50	54		1.12	0.09	0.01	1.23	1.10	1.13	0.00
130	20	20	7.00	40		1.13	-0.09	-0.12	1.21	1.30	1.26	-0.16
147	50	45	7.50	95		1.19	-0.47	0.09	1.00	1.47	1.09	-0.27
175	20	5	11.00	25		1.35	0.13	-0.02	1.55	1.41	1.38	-0.05
001	3	10	9.50	13		0.91	0.08	0.04	0.90	0.81	0.87	0.10
002	4	3	9.75	7		1.03	0.10	0.19	0.86	0.77	0.83	0.27
006	50	10	9.75	60		1.22	0.59	0.14	1.76	1.17	1.07	0.04
007	14	15	4.50	29		1.52	0.11	0.06	1.52	1.41	1.45	0.11
011	25	4	9.50	29		1.98	-0.07	0.00	2.04	2.12	1.97	-0.14
016	25	15	5.00	40		1.07	0.08	-1.05	1.0	1.0	1.05	0.07
029	17	28	8.00	45		1.19	0.15	0.18	1.11	0.95	1.01	0.24
038	40	20	7.00	60		2.00	0.46	0.15	2.73	2.27	2.15	-0.27
039	15	4	8.00	19		1.38	-0.08	0.17	1.2	1.28	1.20	0.09
052	7	2	7.00	9		1.06	-0.47	0.15	0.95	1.42	0.91	-0.35
055	5	0	13.50	5		1.00	-0.05	0.09	0.95	1.0	0.91	0.00
056	1	7	9.00	8		1.29	-0.10	0.16	1.15	1.26	1.13	0.03
057	15	35	8.00	50		1.72	-0.13	0.26	1.32	1.45	1.45	0.26
059	3	6	7.50	9		1.29	0.41	0.34	1.25	0.84	0.95	0.45
060	8	5	12.00	13		1.11	0.21	0.06	1.14	0.92	1.18	0.19
079	10	8	7.00	18		1.13	0.24	0.25	0.75	1.0	0.87	0.13
082	20	8	9.25	28		1.33	0.35	0.02	1.23	1.58	1.36	-0.24
P085	30	1	9.50	31		1.61	0.17	0.09	1.47	1.3	1.51	0.31
088	20	20	12.00	40		1.26	0.13	0.03	1.30	1.17	1.22	0.08
092	14	3	8.50	17		1.42	0.26	0.11	1.21	1.47	1.31	-0.04
197	28	17	9.50	45		1.37	0.10	0.05	1.4	1.29	1.32	0.08
135	35	35	8.00	70		1.22	0.63	0.23	1.47	0.84	0.99	0.38
176	2	15	5.50	17		1.14	0.14	0.15	1.31	1.17	1.29	-0.03
102	27	18	6.50	45		1.14	0.13	0.20	1.13	1.0	0.93	0.14
101	3	2	12.50	5		0.90	0.00	-0.01	0.88	0.89	0.91	0.01
129	35	4	7.00	39		1.88	-0.12	0.04	1.52	1.64	1.8	0.23
Mean	19.04	12.86	8.54	29.63		1.30	0.0	0.05	1.29	1.24	1.22	0.05
S.D.	13.73	11.38	2.16	23.03		.28	.26	.24	.40	.35	.32	.19



Table 5. Experimental (Daydream Enhancement) Group Scores

P	Rel DD	Unrel DD	HRS	Total DD	BL Avg SI	INI -FIN SI	BL-N INI SI	FIN SI	N SI	BL-FIN SI	
158	18	5	10.0	23	0.73	0.08	0.02	0.66	0.75	0.71	-0.01
165	25	10	11.0	35	0.83	0.06	0.03	0.92	0.85	0.79	-0.01
P178	5	5	8.0	10	2.04	-0.03	0.11	1.56	1.60	1.93	0.43
189	2	3	4.0	5	1.16	0.40	-0.05	1.5	1.09	1.21	0.06
008	5	3	6.50	8	1.24	-0.05	0.12	1.2	1.25	1.12	0.00
P022	30	0	8.75	30	2.17	0.32	-0.08	2.13	2.45	2.25	-0.28
027	2.5	2.5	8.75	5	1.35	0.37	0.28	1.22	0.85	1.0	0.50
030	20	10	5.50	30	0.40	-0.01	-1.77	0.9	1.35	1.36	1.76
031	23	30	9.50	53	1.31	-0.13	0.01	1.1	1.25	1.29	0.06
035	20	15	10.25	35	1.66	0.08	-0.0	1.7	1.64	1.68	0.01
047	9	17	8.50	28	1.20	-0.05	-0.1	1.3	1.41	1.32	-0.21
058	7	3	6.75	10	1.17	0.31	0.18	1.3	1.04	0.99	0.17
P065	20	2	10.25	22	1.53	0.16	0.11	1.3	1.22	1.42	0.31
072	18	9	9.25	27	1.12	0.25	-0.08	1.3	1.08	1.20	0.03
074	1	10	8.25	11	1.11	0.00	-0.00	0.91	0.91	1.11	0.19
075	2	5	10.00	7	1.11	-0.03	0.08	0.9	0.94	1.02	0.16
076	7	4	7.50	11	1.20	0.17	0.06	1.1	1.06	1.14	0.2
078	35	7.5	7.00	42.5	1.00	-0.58	-0.0	0.7	1.35	0.76	-0.34
084	20	3	11.00	23	1.16	0.00	-0.03	1.16	1.15	1.20	0.01
086	20	0	8.00	20	1.93	0.18	0.42	1.4	1.26	1.51	0.67
089	50	9	8.25	59	1.38	-0.10	0.08	1.21	1.31	1.30	0.06
094	20	7	8.50	27	1.31	0.17	-1.18	1.05	0.88	1.18	-0.88
097	10	4	9.00	14	1.69	-0.21	1.69	1.27	1.44	1.33	0.24
131	23	10	9.00	33	1.61	0.67	0.24	1.6	0.92	1.37	0.69
122	40	0	8.00	40	1.16	0.00	0.02	1.16	1.15	1.13	0.01
172	38	4	12.00	42	1.18	-0.08	-0.11	1.04	1.13	1.10	0.05
132	3	7	8.00	10	1.10	0.16	-0.15	1.41	1.25	1.28	-0.18
184	4	3	8.50	7	0.03	0.17	-1.13	1.22	1.04	1.23	-1.08
106	36	72	9.00	108	1.23	-0.08	0.05	1.10	1.18	1.18	0.04
174	2	8	8.00	10	1.20	0.10	-0.03	1.37	1.27	1.23	-0.07
Mean	16.94	9.10	8.56	25.98	1.23	0.03	-0.03	1.23	1.20	1.20	-0.02
S.D.	13.63	13.55	1.64	21.80	.51	.23	.55	.27	.33	.31	.49