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**The effects of a recent mathematical experience on REM and
NREM mentation**

Klein, Diane Niederhoffer, Ph.D.

City University of New York, 1987

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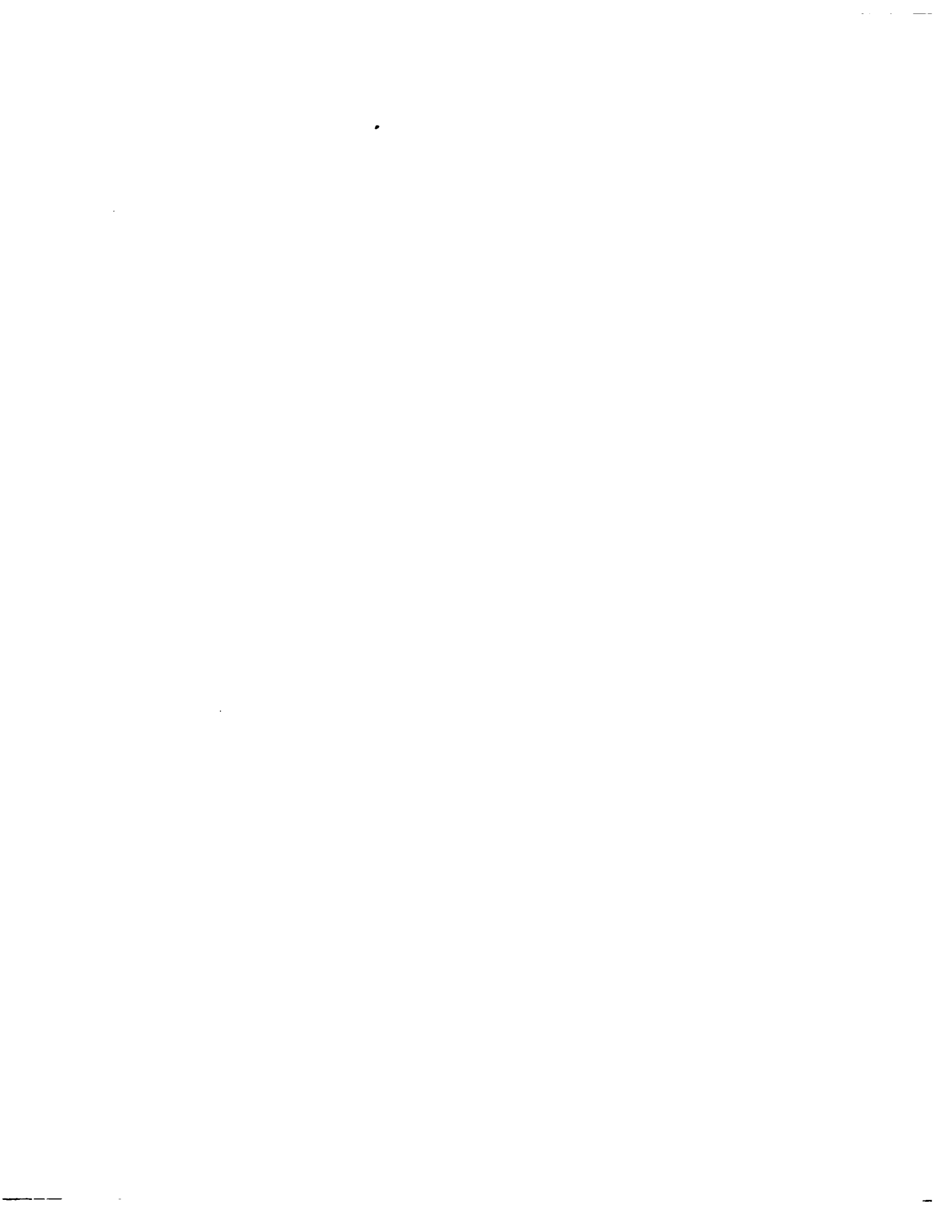


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THE EFFECTS OF A RECENT MATHEMATICAL EXPERIENCE

ON REM AND NREM MENTATION

by

DIANE NIEDERHOFFER KLEIN

A dissertation submitted to the Graduate
Faculty in Psychology in partial fulfillment
of the requirements for the degree of Doctor
of Philosophy, The City University of New
York.

1987

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Dedication

To the memory of Dr. Arthur Arkin and my father,
Dr. Arthur Niederhoffer

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CHAPTER I

Introduction

Dreams are a phenomenon as old as mankind and have always been imbued with special significance. From primitive times when dreams were understood as extensions of the adventures of everyday life, to their function as sources of prophecy to guide action, to their depiction in great works of art and culture, the importance of penetrating the meaning of dreams has been realized. Even today from the intensity with which dreams are worked with in psychoanalysis to the excitement with which an intriguing dream is related to a friend, the question remains: how to make sense out of mental activity at once so similar and remote from waking thought.

Inextricably bound to questions about the meaning of dreams are questions about dream formation. How are dreams constructed out of the threads of daily experience, conscious and unconscious concerns, and early memories? In the early years of dream research Shevrin and Luborsky (1958) described dream production as a "kind of dark room procedure, developing . . . exposed but heretofore undeveloped and unprinted 'film' according to its own laws rather than the laws of the

waking state " (p. 285). While notions of "dark room procedures" have been superseded by sophisticated neuropsychological and cognitive models of dreaming (Antrobus, 1986; McCarley & Hobson, 1977; McCarley & Hoffman, 1981) provocative questions remain about the production of dream material. A significant area of inquiry involves the effects of recent experience on the dream. How despite the increased sensory thresholds and the complex neural activations within the brain (Hobson & McCarley, 1977) does external experience impinge on and get translated into elements of the dream narrative? The current investigation contributes to a more detailed understanding of the role of recent experience in the production of the dream scene.

This research studies dream formation by examining the mentation of twenty subjects who computed simple math problems in the course of several nights in the sleep laboratory. An examination is made of the mentation of Stage 1 REM sleep and of Stage 2 NREM sleep in terms of the representation of this experience and of the experiment in general. The relationships between these aspects of dream production and personality style are investigated to enhance existing

knowledge about the role of subjective and external factors in the production of the dream. It is expected that experimental results will demonstrate qualitative differences in REM and NREM mentation and that individual variations will be explicable in terms of characteristic differences in personality and cognition.

This study reflects the development of major themes that have emerged in the history of sleep research. The study of the dream work has been a major area of interest to psychologists ever since Freud (1900/1965) presented his ideas about dream formation and interpretation at the turn of the century. Freud underscored both the commonalities between dream thought and everyday life (i.e., its links with everyday concerns, conflicts, and events of our daily lives) and the dream's idiosyncracies (i.e., its reliance on the peculiar logic of the primary process). Freud's discovery that it is often seemingly insignificant and indifferent impressions of the previous day that form the day residue of the dream and Poetzl's (1917) finding that aspects of a subliminally perceived picture not consciously recalled appear in subsequent dreams have spurred interesting research

about how these elements of experience are transformed into aspects of dreams.

Studies have been made of the incorporation in dreams of stimuli as varied as the imaginations of the investigators. Subjects in the sleep laboratory have been exposed to tachistoscopic stimuli, water sprays, sexually exciting films, and salty dinners. As Stross and Shevrin (1965) point out, underlying this area of research is the belief that "by introducing a stimulus into the psychic apparatus" and watching the transformations undergone as they emerge in dreams (p. 272), crucial aspects of the thought processes "which regulate and determine mental contents" may be understood (p. 274). Some researchers have underscored the importance of viewing the presleep stimulus as a "tracer element" (Witkin & Lewis, 1965) that allows experimenters to probe the processes involved in the production of dreams much as radioactive isotopes allow the study of metabolic processes (Stross & Shevrin, 1965).

Stimulus incorporation experiments in the sleep laboratory have produced a wealth of data with often contradictory results, ranging from strong percentages of incorporation to no relationship at all between

stimulation and mentation. Some of the experimental findings are surprising. Several authors (Cartwright, 1974; Roffwarg, Herman, Bowe-Anders, & Tauber, 1978; Witkin & Lewis, 1965) have discussed the questions that emerge about why elements from seemingly innocuous material such as subliminal pictures used in Fisher's (1957, 1960, 1965) and Fisher and Paul's (1959) experiments exert a strong influence on dreams while aspects of more emotional and provocative material such as the aggressive films used by Foulkes and Rechtschaffen (1964) elude expression in dreams. Freud (1900/1965) suggested that recent impressions could be woven into the fabric of the dream to the extent that they could be linked to emotionally significant thoughts or memories. However, some research from the sleep laboratory suggests that the personal significance or level of emotional arousal associated with a stimulus does not influence its occurrence in dreams (Berger, 1963). Other authors have examined the effects of certain physiological need states on dream mentation with the belief that this aspect of experience may be a significant factor in determining dream content. However, Dement and Wolpert (1958) found no clear evidence of the effects of thirst in the

REM mentation of their three fluid deprived subjects. On the other hand, Bokert (1968) in his study of 18 nurses showed that 24 hours without food or drink topped by a salty spaghetti dinner definitely stimulated an increase in thirst related content in REM mentation. Baldrige (1966) found too that hunger is reflected in the REM mentation of food deprived subjects.

Examination of this research reveals a melange of results which defies simple explanation. While few would argue with the belief that some perceptual and experiential processing occurs during sleep and that dream content will reflect this, the questions of how and to what extent this happens have not been resolved. Definitive answers to these questions are obscured by the difficulty of comparing studies so disparate in focus and methodology. Results must be evaluated from investigations utilizing different forms of stimulation, variations in the number of nights spent in the laboratory, and a range of criteria for scoring stimulus representations from the most concrete to symbolic.

As is true throughout the sleep literature, experiments on stimulus incorporation in dreams have

emphasized the study of REM dreams to the relative neglect of NREM mentation (Freeman, 1972, p. 28). Historically, this reflects the excitement generated by Aserinsky and Kleitman's (1953) discovery of the occurrence of rapid eye movements during Stage 1 sleep and their simultaneous relationship to reports of dreaming. In the early 1950's it was thought that REM sleep and dreaming were in fact "synonymous," and that non-rapid eye movement sleep was a "mental void--an oblivion" (Dement, 1974, p. 39). However, it emerged later that although mentation from REM periods was more likely to form a coherent narrative and to be picturesque, perceptually and affectually vivid, and sometimes bizarre (Foulkes, 1962, 1966; Rechtschaffen, Verdone, & Wheaton, 1963), mentation could also be recalled during NREM sleep. The NREM reports were more typically conceptual, thoughtlike, and more fragmented than their REM counterparts (Foulkes, 1962, 1966). REM reports seemed to some investigators to tap more personal, pre-determined content (Rechtschaffen, 1978) whereas NREM reports seemed more permeable to everyday concerns. A quite recent analysis of REM and NREM sleep mentation confirmed that even when controlled for length, REM reports are, to put it simply, just more

dreamlike than their NREM counterparts (Foulkes & Schmidt, 1983). The evidence has suggested to some researchers that a relationship exists between REM reports and the mechanisms described by Freud (1900/1965) as characterizing the primary process (displacement, condensation, overdetermination, symbolism) and NREM reports and "the mechanisms of logical thought" of the secondary process (Shevrin & Fisher, 1966, p. 366). While stimulus incorporation studies offer an ideal medium for examining different features of REM and NREM mentation only a few researchers (Castaldo & Shevrin, 1970; Foulkes & Rechtschaffen, 1965; Shevrin & Fisher, 1966) have pursued this line of study. An examination of REM/NREM differences is an important focus of this research on the incorporation of a mathematical stimulus experience in mentation.

It is interesting that in the course of decades of study in the sleep laboratory researchers have discovered an iatrogenic problem in the sleep laboratory that mirrors the important discovery of the transference relationship in psychoanalysis. It has been demonstrated that the interaction of the subject and experimenter and the impact of the experimental

setting so powerfully affect the subject's experience in the laboratory that they significantly color the mentation obtained there. The study of these influences on dreams has become a subject of inquiry in its own right (Baekeland 1971; Baekeland, Resch & Katz, 1968; Dement, Kahn & Roffwarg, 1965; Domhoff & Kamiya, 1964; Hall, 1967; Whitman, 1963; Whitman, Pierce, Maas, & Baldrige, 1962, etc.). While the influence of the experimental situation on dreams has been noted by some researchers in their investigations of stimulus incorporation, the present study addresses the need for more information about subjects' proneness to incorporate a particular stimulus experience, general aspects of the experiment, or both.

The examination of individual differences in the tendency to utilize recent experience as the material for dreams is best approached through the utilization of relevant personality data. MMPI scales and TAT and Rorschach analyses have frequently been used to provide personality ratings about subjects in sleep research (Breger, Hunter, & Lane, 1971; Cartwright, 1974; Cartwright, Monroe, & Palmer, 1967; Cartwright & Ratzel, 1972; Foulkes & Rechtschaffen, 1964; Pivik & Foulkes, 1966, etc.). In addition, researchers

studying the relationship between external stimuli and sleep experiences have often employed a measure of perceptual style, the tendency to be field dependent or independent (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin & Goodenough, 1981; Witkin et al., 1954). Utilizing the construct of psychological differentiation, Witkin and Lewis (1965) designed tests including the Rod and Frame test to assess how persons experience parts of a field whether as discrete elements (field independence) or "fused with background" (field dependence) (p. 823). Singer (1984) has suggested that these dimensions can be understood as styles of information-processing, some subjects relying on "external cues and particularly, interpersonal sources of information (field dependence)," and others relying "more on cognitive-restructuring, that is, upon more extensive reshaping of information based on one's own experiences, memories, expectations drawn from formal knowledge or from self-awareness (field-independence)" (p. 14). Other useful dimensions for scoring personality data in studies of dreams are based on the daydreaming scales of the Imaginal Process Inventory (IPI) of Singer and Antrobus (1970, 1972). The Imaginal Process Inventory

was designed to assess aspects of the subjective experience of fantasy and daydreaming and its constructs have provided a range of personality correlates relevant to the study of sleep (Schwartz, 1979; Starker, 1974; Weinstein, 1982). The MMPI, Rod and Frame test, and IPI provide particularly relevant data for examining subjects' tendencies to utilize the mathematical stimulus experience in their dreams.

The present research elaborates upon earlier work examining the effects of recent experience on mentation. It has implications for understanding experimental effects, sleep stage differences, and individual variations in the production of mentation. The experiment is designed to generate data about the impact of external influences on dreams within nights and over the course of several nights. Here is a rich testing ground for exploring whether subjects who incorporate math into their dreams are the same subjects who generally incorporate aspects of the experiment into their dreams, and what their personality characteristics are. The results of this investigation should amplify what is known about the production of dreams and their relationship to aspects of personality and cognitive style.

CHAPTER II

Review of the Literature

Stimulus Incorporation in Sleep Mentation

The study of the relationship between external experience and the internal production of the dream has been an important theme in the development of dream theory. Freud (1900/1965) points out that Aristotle, who was first to depart from a divine view of dreams and recognize their psychological origins, might be considered the first contributor to this field. Aristotle wrote "that dreams give a magnified construction to small stimuli arising during sleep. 'Men think they are walking through fire and are tremendously hot when there is only a slight heating about certain parts'" (Aristotle in Freud, p. 37).

In the Interpretation of Dreams Freud (1900/1965) presents a historical review of the works of authors concerned with the interaction between events of waking life and dreams. He describes the lively controversy among those who stressed the continuities between dreams and waking activities and those who saw the dream as separate from the events and concerns of daily life. He cites Hildebrandt's (1875) description of the contradictions involved in understanding dreams, " on

the one hand . . . the completeness with which dreams are secluded and separated from real and actual life and on the other hand . . . their constant encroachment upon each other and their constant mutual dependence (Freud, 1900/1965, p. 43).

It is interesting that to some extent this debate continues even today. For while most authors ascribe some role to recent impressions in the formation of dream content, others such as Rechtschaffen (1978) emphasize the dream's "singlemindedness and isolation from other areas of life" (p. 97). For each dream that seems to be a representation or continuation of some recent experience, other dream narratives seem to unwind without concern for or interference from the outside world.

The analysis of the role of recent impressions in dream formation was of particular significance in the evolution of Freudian dream theory. By studying how elements of daily life (recent, indifferent impressions of the dream day) appear in dreams, Freud began to understand how elements of the dream are used to represent other unconscious trains of thought. He derived the difference between the manifest and latent content of the dream and an understanding of the rules

of the dream work: displacement, condensation, symbolization, and multiple formation. Freud considered the day residue material the "instigator" of the dream and demonstrated clinically in the analysis of his own dreams how this material often provided the key to the dream's translation. He proposed that the dream may function as the "guardian of sleep" because of the disguise afforded by these trivial impressions substituting for the more psychologically significant.

Freud's review of many reports by "attentive observers" in which accidental stimuli (such as light, noise, odors, movements, changes in temperature, etc.) were reflected in subsequent dreams (p. 57) anticipates the thrust of a large body of sleep research of recent decades. Since Aserinsky and Kleitman's (1953) discovery of the synchronicity of rapid eye movements (REM's) and dreaming enabled the production of dreams to be studied in the sleep laboratory, researchers have found that the experimental study of the incorporation of external stimuli in dreams has been a valuable tool for the examination of the processes involved in dream formation. By exposing subjects to external stimuli systematically introduced and tracking the appearance of the stimuli in subsequent mentation, researchers

have attempted to gain information about the sources of dream material, the perceptual and cognitive processes of sleep, the representation of experience in dreams, individual differences, and defensive styles of dreamers.

Studies of the incorporation of external stimuli in dreams have varied according to the modality of stimuli introduced, the significance of the experience to the dreamer, and the experimental schedule of when the stimuli were introduced. As in most sleep experiments the experimental subjects have generally been young male adults and the emphasis has been on REM sleep. There have been few studies conducted on stimulus incorporation in the mentation of non-REM (NREM) sleep and the NREM findings seem incidental and fragmentary. Arkin and Antrobus (1978) have called attention to many of these methodological issues in their excellent discussion of the literature on stimulus incorporation in dreams (Arkin, Antrobus, & Ellman, 1978). In an earlier review of research in this area Tart (1965) noted several unanswered questions about the extent, differences, and degree of distortion involved when various forms of stimulation are incorporated in dreams (p. 88).

This chapter will examine the state of current knowledge about stimulus incorporation in dreams by assessing the significance and limitations of the experimental findings to date. A range of experiments will be reviewed to determine what three decades of scientific sleep research have demonstrated about the impact of various forms of stimulation on sleep mentation.

External Stimulation

Dement and Wolpert (1958) were the first to use the technology of the sleep laboratory to examine the effect of external stimulation on dream content. They utilized stimuli falling along a continuum of noxiousness: a tone, flashing light, and cold water spray and derived indexes of incorporation of 9%, 23% and 42%, respectively. The stimuli were applied predominantly during REM periods; the small percentage of experimental trials during periods of "ocular quiescence" yielded no instances of recall at all. The authors do not specify their experimental schedule or criteria for scoring incorporations and the rigor of their scoring system cannot be assessed. Their percentages of incorporation suggest a spectrum of results which demonstrate that perceptual processes can

occur during sleep and that dream content may reflect stimuli experienced during the night.

The limitations of Dement and Wolpert's (1958) study point to the complexities of data analysis inherent in experiments on stimulus incorporation. The development of a valid scoring instrument is critical because of the difficulties involved in judging whether dream content includes the incorporation of a given stimulus or reflects merely chance effects. Dement and Wolpert attempted to guard against the scoring of chance effects by examining the correspondence between the timing of stimulation and its appearance in the dream. However, they did not address some of the basic issues that must be confronted in scoring responses. A valid scoring system must address first the broad issue of what comprises the "codeable dream report" (Winget & Kramer, 1979, p.14) and then pose precise parameters as to what constitutes a scoreable response on the particular item under study. These methodological decisions are crucial to the scientific rigor of studies in this area. For as Fisher and Paul (1959) point out "by assuming a sufficient number of transformations almost any image can be alleged to correspond" to another (p. 38). On the other hand, it

is also possible that the original content of the stimulus experience may be so symbolically transformed in the dream that it eludes measurement on even the most carefully designed instrument (Stross & Shevrin, 1968).

One way to begin to insure the accurate assessment of stimulus effects is to utilize control groups to provide baseline norms with which experimental data can be compared. A major deficit in the Dement and Wolpert (1958) study is their failure to obtain baseline data. Koulack (1969) has criticized Dement and Wolpert's study additionally for failure to examine whether stimulus registration truly occurred at the cortical level during the experimental conditions. He suggests also that Dement and Wolpert may have unwittingly included instances of hypnopompic effects (particularly in the case of the water spray which may have left a residue) in their percentages of stimulus incorporation during sleep.

Koulack's (1969) examination of the impact of mild electrical shocks to the wrists on subjects' mentation constitutes a more rigorous inquiry into the effects of stimulus incorporation in dreams. His study carefully monitors the electroencephalographic (EEG) effects of

stimulation, utilizes subjects as their own controls, specifies experimental schedule and criteria for scoring. While stimulation was applied during both REM and NREM periods, mentation was obtained only from REM periods. Here as in Dement and Wolpert's (1958) study, the interest in NREM sleep was to see if stimulation applied during NREM initiated REM periods -- which in both studies it did not.

Koulack (1969) found that experimental stimulation resulted in an overall incorporation rate of 56% when categories of direct and indirect incorporations were combined for REM sleep. He discovered also that momentary awakenings at the time of stimulation enhanced incorporations, the percentage rising to 78%, an effect noted also by Dement and Wolpert (1958).

An examination of Koulack's (1969) scoring system suggests that his obtained percentages of incorporation may have been inflated by the over-inclusiveness of the dimensions used for scoring indirect incorporations. Under this rubric Koulack included references to the general laboratory situation, the occurrence of repetitive rhythmic events, sudden occurrences, and heightened bodily sensations. While it is possible that such elements of dream content reflected the

specific physiological stimulus experience utilized in this experiment it is likely that such content reflected also more general aspects of participation in the sleep study. As Foulkes (1970) has observed the employment of a separate control group to provide comparison data would have enhanced the credibility of these results.

The quantitative findings of this study are enriched by Koulack's discussion about whether the effects of stimulation on a dream are limited to their appearance in direct or indirect form in the manifest content of the dream. Koulack hypothesizes that other aspects of the dream might reflect the impact of stimulation, such as changes in the representation of the self or others in the dream. While his hypotheses about enhancement of the representation of the self were not confirmed, there were indications in the data that stimulation might increase the activity and centrality of other participants in the dream. Koulack links this finding with the Freudian notion of the dream as the guardian of sleep. He suggests "the specific expected effects of the stimulus are transformed to the 'other' in the dream in order to rob the stimulus of some of its significance to the dreamer

and permit him to continue sleeping" (p. 723).

Koulack's (1969) other findings of individual consistencies in the way particular subjects reacted to the stimulus situation introduces the theme of individual differences to this area of sleep research. He noted that some subjects tended primarily to utilize direct representations; other were awakened; others were acutely aware of the stimulus situation, while others denied it. These results suggest that interesting dimensions to understanding stimulus incorporation in dreams may emerge by the examination of the patterns of response in the mentation of individual subjects.

Auditory Stimulation

Berger's (1963) study on the impact on REM dreams of verbal stimuli extends the knowledge of how external stimuli may be represented in dreams. Rather than utilizing physical stimuli as in previous experiments. Berger examined the effect on dreams of emotionally significant and neutral names selected for his male and female subjects from presleep interviews. After dream reports were obtained, Berger found remarkable agreement between blind judges and subjects in their ability to link names with their respective dream

reports and arrived at an overall incorporation rate of 54%. While his results seem convincing, Berger overlooked the possibility that the pre-sleep interviews, however open-ended, may have led to associations which determined subsequent dream content, perhaps confounding his obtained percentages of incorporation.

Berger's (1963) study is notable for its cogent examples of how perceptual material is processed and transformed by the dream work. He discovered that assonant connections were most frequently utilized by the dream work, followed by direct, associational, and representational forms of the stimulus names. Berger connects these findings with the Freudian theory of the primary process and Jung's studies of language and thought. He comments also that significant stimuli may be misperceived by the dreamer "in such a way as to be compatible with the natural progress of dream events" (p. 723). Thus, as Koulack (1969) corroborated, there seems to be an internal press for the dream to continue undisturbed despite arousing stimuli.

Berger's (1963) results also showed that contrary to expectation the emotional significance of a name did not enhance its incorporation rate or effect cortical

responsiveness or galvanic skin reactions (GSR).¹ However, Berger noted that significant and neutral stimuli seemed to utilize different modes of entry into the dream. For example, only meaningful names were associated with classic Freudian sexual symbolism in the dream. Neutral stimuli were not transformed in this way.

Related to these studies of the effects of significant stimuli on dreams are Castaldo and Holzman's (1967, 1969) research on the effects of hearing one's own voice on REM mentation. Previous

¹A number of studies in which mentation reports were not obtained have examined physiological response to significant stimuli during sleep with varying results. Oswald, Taylor, and Treisman (1960) examined responses to hearing one's own name, others' names, and one's own name played backwards, during NREM sleep. They discovered that behavioral responses, GSR, appearance of alpha, and K complexes all differentiated hearing one's own name from the other stimuli employed. Frazier, McDonald, and Edwards (1968) examined responses to one's own name, others' names, and a tone and found autonomic variables, especially cardiovascular ones, discriminate responses to one's own name. The K complex and electrodermal reactions were not significant discriminators. McDonald et al. (1975) discovered subjects show distinctive responses in REM and NREM sleep to hearing one's own name, others' names, and the tone. Finger plethysmogram (FP) and heart rate (HR) indicators demonstrated the main effects.

studies had demonstrated that hearing one's own voice played back produces considerable psychophysiological activation and a range of effects discernible during interviews and free associations (Holzman & Rousey, 1966; Holzman, Rousey, & Snyder, 1966). In Castaldo and Holzman's studies the effects of hearing one's own voice during sleep resulted in dreams in which the dreamer or main dream character was represented as more active, assertive, and independent. Subsequent free associations also demonstrated the effects of greater activity when stimulation was in one's own voice. A problematic area was that no baseline mentation was obtained so that the results of experimental nights (in which one's own voice and others' voices were heard) could not be compared with control nights during which no stimulation was introduced. The highly significant differences in dream content when own voice, other voice dreams were compared by judges in these studies are surprising in view of the rather impressionistic scoring that their coding examples suggest.

Castaldo and Holzman (1967, 1968) do not provide their rationale for utilizing the series of words: fountain, pen, knee, and cap as their auditory stimuli. (These words have been utilized in previous experiments

by Shevrin and Fisher, 1966 and Shevrin and Luborsky, 1961 as visual stimuli designed to assess variations in mode of stimulus incorporation in dream content and will be discussed below in regard to the Poetzl phenomenon). Castaldo and Holzman found some stimulus incorporation in dream reports with repetition, condensation, and assonant effects noted as in Berger's (1963) study. While the findings on stimulus incorporation are incidental to the major focus of the research, it would have been very informative if the authors had examined whether hearing the stimulation in one's own voice rather than in another voice enhanced incorporation rates. If, for example, the processes that result in stimulus incorporation in dreams were particularly activated by stimulation in one's own voice, this would suggest another direction for understanding the connections between the dreamer, his perceptions, and experience during sleep.

Utilizing a similar paradigm to the Castaldo and Holzman (1967, 1969) studies, Castaldo and Shevrin (1970) examined how the four word auditory stimulus: fountain, pen knee, cap, is incorporated in REM and NREM sleep. This is the first study reviewed to consider differences between REM and NREM mentation in

a systematic way. Underlying this experiment is the hypothesis suggested by Shevrin and Fisher (1966) that REM and NREM mentation may be characterized by thought processes related to the "psychoanalytic concepts of primary-and secondary-process thinking," respectively (p. 363). Castaldo and Shevrin expected that REM mentation might resemble primary process thought and show rebus-like combinations of the stimulus words such as pen-knee, penny, or coins; and clang associations such as any and pennant. NREM mentation might show content more conceptually related to the stimulus series such as ink, paper, etc. (pp. 195-196).

The methodology of this experiment improved on the earlier Castaldo and Holzman (1967, 1969) research and utilized baseline data so that indices of incorporation from experimental nights could be compared to nights when no auditory stimulation was heard. The authors used an innovative scoring method in which judges rated the appearance of rebus, clang, and conceptual effects in mentation according to previously obtained lists of each subject's own free associations. While own voice, other voice tapes of the stimulus words were used here as in the previous studies, the authors do not report on how this may have affected results.

The data showed that Stage 2 mentation typically included content conceptually related to the stimuli. REM sleep did not show the expected rebus or clang effects. The authors suggest that the more reality oriented thought typical of Stage 2 was conducive to conceptual types of incorporations of the stimuli. They hypothesize that REM reports may have been more resistant to the expected effects because the "multiple repetitions" of the stimuli might have worked against primary process effects (p. 200). It is also possible that REM mentation may be characterized by such idiosyncratic transformations of stimuli that tracking the externally introduced content becomes elusive even when clang and rebus like associations are taken into account. Another possible interpretation of the results is that the mentation of REM sleep may be more generally resistant to recent perceptual input than the mentation of NREM sleep. However, other studies on the impact of auditory stimuli on REM sleep dispute this possibility.

Lasaga and Lasaga's (1973) study found more acute discrimination of auditory stimuli during REM sleep

than any other sleep stage.² Although the focus of inquiry was different, this research contributes evidence similar to Berger's (1963) about how external stimuli are transformed in mentation. These authors examined stimulus discrimination during sleep without

²In another study examining auditory perception during sleep Evans et al. (1970) found responsiveness to stimulus words during REM sleep. Subjects responded to word cues with appropriate behaviors that had been suggested in previous Stage 1 sleep in 21.2% of all cases. NREM sleep was studied only incidentally, and revealed little evidence of responsiveness to word cues. Zung and Wilson (1969) noted results similar to Lasaga and Lasaga (1973) that responsiveness to auditory stimulation is maximum in Stage 1 and decreases in line with the progress of sleep stages. Rechtschaffen, Hauri, and Zeitlin (1966) examined auditory perception during sleep in terms of auditory awakening thresholds (AAT's) and found similar AAT's for REM and Stage 2 with highest thresholds obtained during delta sleep. The research of Goodenough et al. (1965) and Watson and Rechtschaffen (1969) also suggests that auditory responsiveness may be greater in Stage REM and Stage 2 than the other sleep stages. Dement and Kleitman (1957) found higher auditory thresholds in REM sleep as had Jouvet (1965) with cats. Williams et al. (1964) found higher thresholds for Stage REM and Stage 4 than for Stages 2 and 3 when he studied behavioral and physiological responsiveness to auditory stimulation. When the effect of punishment on responsiveness was evaluated, greater responsiveness was found in REM sleep followed by Stage 2, 3, and 4. Most of these studies point to good evidence of auditory responsiveness during REM sleep with sensitivity to auditory stimuli present during Stage 2 as well.

obtaining dream narratives. Female subjects heard taped numbers played to them during sleep and completed multiple choice tests to assess perception. Lasaga and Lasaga discovered a "progressive blurring" of accurate discrimination with the descent from Stage REM to Stages 2,3, and 4 sleep (p. 56). Qualitative analysis of the results revealed that when subjects misperceived the numbers heard they tended to substitute and distort in ways that resembled the original stimuli. Lasaga and Lasaga demonstrate that transformations of stimuli in mentation can be detected even in the absence of dream narratives.

Most of the studies reviewed have considered the impact of auditory experience on sleep mentation. Research by De Koninck and Koulack (1975) demonstrated that even the brief playback of part of a soundtrack accompanying a visual stimulus enhances the incorporation rate of stimulus elements. In this study the authors utilized a film sequence of workshop accidents to examine aspects of dream content and subject adaptation to stress. De Koninck and Koulack noted that the incorporations of sound and film content that occurred in REM mentation were typically not in the form of direct representations and tended to

increase as the night progressed.

Visual Stimulation

A number of other studies have examined the influence of visual stimulation on sleep content. A historical basis for research in this area was set with Ladd's (1892) examination of the correspondence between retinal imagery and dreams. Dement and Wolpert (1958) included a flashing light in their examination of the effects of external stimulation and dreams. Rechtschaffen and Foulkes' (1965) contribution to the study of visual stimulation and dreams involved the exposure of five visual stimuli--a Do Not Disturb sign, a black X, a book on concentration camps, a white handkerchief, and aluminum coffee pot--to three subjects whose eyes were chemically dilated and taped open throughout the night. Each object was exposed twice, once during a REM and once during a NREM period. The method utilized for assessing incorporations involved two judges' attempts to match correctly stimulation object and mentation report. The authors found no statistically significant results of stimulus incorporation in either sleep period studied. In fact, the only instance in which experimenters detected the possibility of incorporation of the stimulus objects

was during one NREM period. However, they did note the representation of bright lights in 13% of their mentation reports and speculate that these might have been images of the light that illuminated the stimuli during the night. (This percentage for incorporation of a shining light must be compared to the 23% obtained by Dement and Wolpert, 1958, for incorporation of a flashing light.) Arkin and Antrobus (1978) suggest that some of the variations in evidence for visual incorporation effects may be due to differences in the visual neural circuitry involved in tracking the respective stimuli.

Noting the lack of relationship found between visual stimulation and dream content in their research, Rechtschaffen and Foulkes (1965) comment that the possibility remains that there is some correspondence between the pattern of external stimuli and the pattern of dream imagery, but that the condition of the visual system during sleep so dilutes or distorts the mental representations of the stimuli that their correspondence to the external stimuli is rendered undetectable by ordinary methods of comparison. If this were the case, however, it would speak more for the

influence of the diluting and distorting conditions of sleep than for the effect of external stimuli *per se*. (p. 1155).

While it is conceivable that the paucity of evidence found for incorporation of visual stimuli in sleep mentation is due to some breakdown in the visual system during sleep, the methodological limitations of this study indicate that these results are far from conclusive. Only three subjects were utilized and stimuli exposed only once per dream period.

Furthermore, some of the stimuli that were shown, (the Do Not Disturb Sign, the book on concentration camps, and the black X, for example) seem particularly conducive to personal associations that could have merged with reactions to the experimental situation and thus might not have shown up in mentation as purely visual references. Since the criteria used by the judges for matching mentation reports with visual stimuli are not specified, it is impossible to assess whether the evaluation of the data was of sufficient scope to detect such indirect references to the stimuli.

Roffwarg, Herman, Bowe-Anders, and Tauber (1978) examined the impact of visual stimulation on mentation

in an intriguing way which involved subjects wearing red goggles from waking until bedtime during the stimulation period. While the subjects, six women and three men, pursued their everyday lives, the goggles filtered out all color perception except for colors in the red band. The experiment provided not only a sustained period of visual alteration of five to eight days in contrast to the more typical brief experimental exposure, but also included baseline, control, and recovery conditions. Experimental awakenings were made during NREM as well as REM periods, but preliminary analysis of the NREM data showed weaker effects than those for REM and were not further described.

The longitudinal perspective of this study enabled several interesting effects of the visual stimulation condition on REM mentation to be discovered. First, the goggle condition exerted a pervasive effect on the mentation of experimental nights. An increase of 3.5 in the number of red tinted scenes described by subjects was noted on goggle nights, with the effect disappearing on recovery night. Analysis revealed a "time-of-night trend (recency phenomenon), and a night-in-phase trend (progressive increase in the whole night effect)" as the experiment proceeded (p. 332). In

essence, the goggle experience strongly colored the first REM periods of the early experimental nights and intruded into the majority of dreams by the fourth experimental night. The authors related their findings to Verdone's (1965) study on the sequencing of contemporary and noncontemporary material in dream periods throughout the night. Earlier REM mentation tended to reflect recent concerns and experience while later REM mentation tended to reflect more remote memories and unconscious themes.

The sustained exposure to the stimulus condition in the Roffwarg et al. study may be a key factor in explaining the strong results achieved in modifying dreams by visual input. Corsi-Cabrera et al. (1986) studied the effects of visual-inverting prisms worn for 5 hours of task performance and found few instances of incorporation of this experience in dream content. Another study of Foulkes and Rechtschaffen (1965) with a more rigorous methodology than their earlier research also failed to find significant numbers of incorporations of visual content in mentation. This research examined the effect of two films--one with aggressive content; the other, a comedy--on the mentation of 24 subjects, male and female. The movies

were shown to subjects prior to sleep and mentation from NREM as well as REM periods was collected.

Judges determined that only 9 (5%) of the mentation reports that were rated showed definitive evidence of incorporation of film elements. Seven of the reports with incorporations were from REM periods, two from NREM. It was found also that the showing of the aggressive film had no impact on the amount of violence depicted in subsequent mentation. However, viewing the aggressive film did affect mentation in other ways. REM reports after this film were more clear, vivid, imaginative, and longer than after the comedy, while no differences were found for NREM reports. Given the sensitivity of REM reports to these effects Foulkes and Rechtschaffen consider whether REM reports are particularly sensitive to arousal effects while NREM inhibitions may mediate against such influences. However, these speculations must be evaluated in light of other suggestions by Rechtschaffen (1978) about the relative impermeability of REM mentation.

A number of other studies have utilized films to assess the influence of visual content on dreams. An exploratory study by Witkin and Lewis (1965) reported on dreams obtained from only three of their subjects,

but found film elements may be incorporated in REM reports in disguised ways. In this research determinations about film incorporations were often made on the basis of "intuitive interpretation(s) of symbolic or metaphoric dream translation" (p. 829). While their findings must be considered in the psychoanalytic framework in which they are presented rather than in terms of the quantifiable data of most other studies, Witkin and Lewis' evidence suggests that the effects of visual stimuli on dreams are by no means limited to direct representations of film elements.

These researchers showed films of a birth experience and a subincision initiation rite to subjects with the expectation of generating feelings about physical injury and of sexual excitement. Their analysis of subsequent dream mentation seemed to indicate that film elements were incorporated according to Freud's rules of the dream work. Examples of displacement, distortion, condensation, and classic sexual symbolism were noted in the representations of the films in dreams. When subjects were shown a travelogue with bland, predictable content, incorporations took a different form. Peripheral, rather than prominent aspects of the film, were

represented without the characteristic transformations noted above. Witkin and Lewis (1965) also observed individual consistencies in the ways film experience was represented in subjects' dreams and a tendency towards the repression of dreams following the exciting movies--findings which have been corroborated by other studies.

Cartwright, Bernick, Borowitz and Kling (1969) studied the effects of an erotic movie on the dreams of 10 young men. While the experimental design included four post-film experimental nights which enabled longitudinal effects on dream content to be observed, a major methodological problem stemmed from the fact that there was a six hour delay between each showing of the film and sleep time, so that the impact of intervening variables on sleep mentation could not be controlled. Despite this methodological problem the findings seem to concur with the results of other studies of visual content on dreams.

Initial scoring based on ratings of direct representations of film content found little evidence of film elements in REM mentation. However, when an index of symbolic aspects of film content was derived, more references to the film content were noted than

would have been expected from norms of baseline mentation. The authors observed also that representations of aspects of the experimental situation were prominent in dream reports, as had Witkin and Lewis (1965) who included an exploration of this area in their research.

Effects of the Experimental Setting

The studies reviewed thus far have examined the effect of various pre-sleep or concurrent experiences on sleep mentation. This research has in common a backdrop of the laboratory, its scientific accoutrements, and a staff of experimenters performing the required procedures. The examination of the impact of these aspects of the experimental setting on dream content has been the object of study in its own right. Some of the early sleep studies seemed to demonstrate that dreams obtained in the laboratory reflected various elements of the experimental setting and thus could not be considered a "pure culture" of dreams as they might be recalled at home. Subsequent research has inquired about the magnitude of these laboratory effects and attempted to determine whether the impact of the experimental situation might be limited to first nights in the lab. Studies in this area have focused

on REM mentation. While Dement, Kahn and Roffwarg (1965) and Domhoff and Kamiya (1964a,b) report that NREM data were included in their research they do not provide the results of any NREM findings involving these variables.

Whitman, Pierce, Maas, and Baldrige (1962) contributed the first quantitative study examining the influence of the experimental setting on dreams. Utilizing five male and five female subjects the researchers studied dream reports obtained during four nights in the sleep laboratory. Discriminations about dream content reflecting the experiment directly, indirectly, or not at all were made by the senior author. Whitman et al.'s results suggest that the laboratory setting exerts an overwhelming influence on dream content. The research found that 68.5% of all dreams deal with the experimental situation (about 32.4% directly) and that the strong effects of the laboratory setting on dreams were not mitigated over the course of four nights. However, the possibility of experimenter bias cannot be ruled out. In addition, Dement et al. (1965) have pointed out that the lack of habituation effects found in this study could be due to the absence of data from subjects' first nights in the

laboratory. Furthermore, both Baekeland (1971) and Dement et al. have pointed out that the high proportion of dreams concerned with the experiment found by Whitman's group may reflect unique aspects of this study and not be typical of other sleep research. They suggest that Whitman's subjects may have been preoccupied with feelings about the experiment because of anxiety evoked by subjects' taking drugs, the hospital setting, and the impersonal behavior of the investigators. Another aspect of the experiment that may have skewed results was the recruitment of all subjects from one college class.

Domhoff and Kamiya (1964a) obtained a percentage of direct experimental references in dreams almost as high as Whitman et al. (1962). They found 30% of the REM dreams of their eight female subjects studied for 10 non-sequential nights contained at least one overt reference to the experiment. No habituation or time of night effects were revealed in their analysis of the data. Domhoff and Kamiya and Whitman et al., found separate constellations of psychological concern about the experiment for male and female subjects. Keith (1962) studied only three male subjects but found in each instance transference aspects of the experimenter-

subject relationship stimulated regressive fantasies in dreams. There is the indication from research in this area that the sex of the subject and experimenter has a strong influence on how the experiment is perceived and represented in dream content (Fox, Kramer, Baldrige, Whitman & Ornstein, 1968). Whether the subjects and experimenters are male or female, as well as the quality of interaction between them seems to affect the content of dream material.

Domhoff and Kamiya (1964b) have suggested that what is not represented in experimental dreams may also be significant. In their comparison of home and laboratory dreams of 12 male subjects they found laboratory dreams contained fewer instances of sexuality, aggression, and misfortune, but more bizarre elements than home dreams. The authors hypothesize that because the experimental setting poses some threat subjects may inhibit the expression of emotionally charged content. The appearance of bizarre elements of content in laboratory dreams, Domhoff and Kamiya believe, may reflect the symbolization of the material that is repressed. The results of Whitman et al. (1962) and Domhoff and Kamiya point to the powerful impact of the laboratory setting on dreams from the standpoints

of both quantitative and qualitative analysis. In another group of studies, the effects of the experimental setting have been found to be somewhat less pervasive and persistent.

Dement et al.'s (1965) research culled the results of 813 awakenings of 77 subjects who spent a combined 277 nights in three sleep laboratories. The authors address the methodological problems implicit in comparing subjects with different ranges of nights (from 1 to 22) spent in different laboratories. While there is some overlap between the scoring system employed by Dement et al. and Whitman et al. (1962) Dement's group partialized their scoring and established its reliability. Dement's classifications included a complete, partial, and inferential category, the latter to deal with more disguised representations of the experiment. They found that 21.9% of all REM dreams reflected complete or partial representations of the experiment while 15.9% seemed to fall in the inferential category. The experimenters noted strong habituation effects in this study with complete and partial incorporations for the first night in the laboratory amounting to 33.6% and dropping on all other nights to 18.7%. (An interesting pattern emerged in

that the highest incidence of experimental dreams occurred on the first night, was lowest on the second night, and then increased again reaching its maximum on the 4th to 7th laboratory night.) In addition, they found a time of night effect with dreams earlier in the night tending to represent the lab situation more completely--especially on the first night, a trend noted also by Offenkrantz and Rechtschaffen (1963) in their study of one subject over the course of 15 nights. Dement et al. arrived at what they call a "minimum plateau level" of experimental dreams, which they estimated at 10-15% when subjects who had spent the longest time in the laboratory and those who had special motivation for participating in the study were eliminated from the data analysis. This estimation of the frequency of laboratory dreams is less than half that suggested by Whitman et al. Data from Hall's (1967) study of laboratory dreams in which anxiety producing aspects of the experimental situation were minimized corroborates Dement et al.'s findings.

Baekeland, Resch, and Katz' (1968) study of pre-sleep mentation, cognitive style, and dreams included an examination of the occurrence of lab references in pre-sleep associational material as well as in dreams.

The investigators found laboratory references were the one area of content common to all subjects' free associations. Baekeland et al. utilized a scoring system which analyzed dream material in small units and classified incorporations as direct representations or as first or second degree transformations of the material. A separate category was included for laboratory references. The authors attempted to base their judgments on the dream elements' "semantic or logical" distance from the pre-sleep material rather than on more clinical or private associations (p. 302). Their obtained percentage of laboratory dreams for the 27 subjects who spent one night in the lab was 23%. In contrast to Dement et al.'s (1965) results, these experimenters found no time of night effects for the number of laboratory references in dreams.

Another study by Baekeland (1971) focused on the effects of different experimental procedures on dream content. This study compared the group of 27 subjects described above with 17 subjects who did not participate in the free association period and were free of its concomitant anxieties. The scoring utilized in this study rated material on the basis of direct or indirect references to the experiment without

the breakdown of dream material into the smaller elements noted above. The data analysis revealed that only 8% of the dreams of the low-anxiety group seemed related to the laboratory situation. Baekeland explains the contrast between this low frequency of laboratory dreams and the results of other researchers in terms of the greater familiarity and ease his subjects felt about participation in this study as opposed to the stress experienced by subjects who participated in the earlier research. Thus Baekeland interprets differences in percentages of laboratory dreams obtained in various experiments as a function of the relative stress involved in the experimental procedures. A related study by Cohen (1975) suggests that this aspect of the experiment may affect the type of references to the experimental situation subjects produce in their dreams. In this research subjects who participated in a negative laboratory experience tended to produce more indirect laboratory references in dreams while subjects who experienced a more benign experimental procedure tended to produce more direct references to the experiment. These results corroborate Breger, Hunter, and Lane's (1971) and Cartwright et al.'s (1969) findings that anxiety

producing material may result in more symbolic transformations in dreams.

Effects of Stress

Breger, Hunter, and Lane (1971) examined the effects of stress on dreams by studying two small groups of subjects after real life stressful situations. In separate studies, they examined the dreams of four persons who participated in emotionally arousing group therapy and four persons about to undergo surgery. While the small number of subjects limits the generalizability of these results, the combination of clinical and statistical analyses conducted on the dreams allowed the authors to discover interesting links between dream production and emotional state which merit further study. That stressful experience seems to enhance the number of indirect incorporations in dreams has been noted above. In addition, Breger, Hunter, and Lane found a strong congruence between defenses and symbolizations utilized by subjects during the day and those expressed in their

dreams.³ In the pre-surgery group particularly they found dream content was typically repetitious⁴ and constricted as compared to post-surgery mentation. The authors interpret these findings on the effects of stress on dreams as support for the view that dreaming assists in processes of adaptation and assimilation (Dewan, 1968; Greenberg, Pillard, & Pearlman, 1972; Piaget, 1951).

Effects of Needs and Wishes

Another category of stimulus incorporation studies involves the examination of internally generated stimuli and their effects on dreams. Bokert (1967)

³Other studies of presleep experience and dreams do not always show the congruent effects described here. Hauri's (1968) research on the impact of different evening activities on sleep showed compensatory effects. That is, subjects who studied hard before sleep produced fewer dreams which involved thinking and problem-solving while those who exercised vigorously produced fewer dreams with activity. Similarly, Wood (1962) examined the effects of social isolation on sleep and found an increase in social interactions described in dreams.

⁴Horowitz and Becker (1971) have studied the tendency to repeat stressful experiences in cognition and compare this phenomenon to the Zeigarnik effect. "Unlike the Zeigarnik effect, which refers to greater voluntary memory, we hypothesize that stressful perceptions will lead to involuntary repetitions in thought." (p. 419)

conducted a thorough review of research in this area and noted contradictory results, some of which stemmed from methodological differences in evaluating the experimental evidence. An early study by Sorokin (1942) investigated dreams in subjects in whom hunger had been experimentally induced and noted a preoccupation with themes of food and eating. Brozek, Guetzkow, and Baldwin (1951) found dreams of subjects with inadequate diets over 24 weeks did not show any increase in food content. The latter two studies predated the more precise examination of dream content in the sleep laboratory. When Dement and Wolpert (1958) analyzed the dreams of three fluid deprived subjects in the lab, they found no evidence of direct incorporations of thirst related content. This research has been faulted by Bokert for its small subject pool, lack of a control group, and overly stringent scoring. When more indirect references to thirst were included, one-third of the reports showed effects of the experimental condition.

Bokert (1967) designed an experiment to put to scientific test a personal phenomenon described by Freud in which a salty dinner of anchovies or olives gave rise to dreams gratifying the wish to drink (Freud, 1965, p. 156). Bokert studied the impact of

thirst on dreams by comparing the dreams of 18 female subjects in a thirst condition, thirst plus tantalizing auditory stimulus condition, and a sated condition. A spicy spaghetti dinner was the salty thirst inducing stimulus, combined in the auditory condition with the phrase "a cool delicious drink of water" played to subjects during REM sleep. In the sated condition, subjects were allowed to drink as much as desired after their dinner. To determine the frequency of appearance of thirst references in dreams, Bokert utilized a scoring system based on a wide range of associates which were coded by three independent judges. Results revealed that while both the thirst and auditory-thirst condition produced more fluid related content in dreams than the satisfied condition, the auditory stimulus did not increase the production of thirst content for the general sample. The auditory stimulus did spur the production of related dreams for one subset of subjects who tended also to incorporate aspects of the actual phrase "cool delicious drink of water" in their dreams. Bokert noted in the whole sample a trend towards representing thirst content in later REM dreams rather than earlier ones.

Bokert's (1967) research demonstrates the

motivating force of conscious wishes, in this instance, the desire for a drink, in shaping the dream. This role had been ascribed by Freud, somewhat ambiguously, to the unconscious (Bokert, p. 10). Cartwright (1974) attempted to investigate the influence of a conscious wish on dreams by utilizing personal material suggested by subjects' performance on a relevant test. After determining subjects' individual conflict areas, Cartwright instructed them as they fell asleep to focus on their desire for personal change in the form of a specific wish. An independent judge scored the obtained dreams for evidence of designated words and their opposites. Cartwright found that 15 of her 17 male and female subjects tended to incorporate the target or opposite words in dreams, while the incorporation of control words did not approach that level of significance. She concludes that dreaming is less involved with wish fulfillment than with the exploration in night life of the emotional implications of behavior (p. 392).

The methodological and conceptual problems of Cartwright's (1974) research indicate the need for replication of her findings in a more rigorous study. Cartwright discusses the limitations due to the

differing levels of specificity of the target words employed (p. 392) and concurrent difficulties in scoring their appearance in dreams. Other problems involve the failure to compare the obtained results to baseline levels of related content for her male and female subjects and the lack of consideration of the impact of the experimental setting in stimulating conflictual themes in dreams. Furthermore, although Cartwright instructed her subjects to think of change in a target area (a conscious wish), the interplay of ever-present unconscious wishes is not addressed in this research.

Subliminal Effects

An interesting group of studies approaches the question of the role of recent impressions on dream formation through the study of subliminal stimulation. Poetzl (1917), the pioneer researcher in this field, discovered that subjects utilized aspects of a picture not consciously perceived as material for their dreams. Freud recognized in this research confirmation of his hypotheses about the incorporation of day residue material into the manifest content of dreams and cites Poetzl's findings in the Interpretation of Dreams (1900/1965). Allers and Teler's (1924) related study

found that subliminal images may also become part of conscious imagery obtained from subjects' word associations and drawings (Luborsky & Shevrin, 1956).

Fisher (1954, 1956, 1957, 1960, 1965) and Fisher and Paul (1959) conducted a series of replications of the original Poetzl experiment and derived many examples of how recently perceived subliminal stimuli are woven into the fabric of the dream. In a typical experiment tachistoscopic stimuli were flashed on a screen to subjects whose subsequent drawings and dreams were analyzed for indications of the subliminal material. While some studies in this area used complicated pictures as stimuli, Fisher found less complex visual percepts such as numbers and simple words better suited for this research. Fisher's first replications of Poetzl's findings were considered exploratory in nature with subjects gathered from the researcher's circle of friends and colleagues. The presentation of experimental results was in the form of protocols, with interpretation provided by the researchers or the subjects themselves. In these studies Fisher discovered certain commonalities in the mode of representation utilized in dreams and waking imagery to depict tachistoscopically exposed

experimental stimuli. Condensation, displacement, fragmentation, spatial rotation, and symbolic transformation, the very mechanisms mentioned by Freud as characterizing the dream work, were all observed in the images obtained. While lacking in rigorous methodology, this exploratory research provided empirical proof that recent, subliminally perceived impressions may be utilized by the dream work as material for the manifest content of the dream. Fisher linked this evidence to the Freudian propositions about day residue material serving as a screen for the expression of unconscious impulses. He hypothesized that the powerful transference wishes evoked by the subject-experimenter relationship stimulated the unconscious wishes expressed in these dreams.

Fisher's later studies attempted to introduce more scientific rigor into this area of experimentation. To avoid biased results subjects who had no knowledge of the purpose of the experiment were recruited and control images were systematically introduced to provide baseline data. Instead of subjective analysis of the obtained images and dreams for evidence of the experimental stimuli by the researchers or subjects themselves, independent teams of judges evaluated the

data according to clearly defined objective scoring categories. The results of these studies seemed to indicate that while drawn images included representations of the experimental stimuli that could be recognized objectively, the appearance of the stimuli in dreams could be detected only by especially skilled judges. The analysis of dream material for evidence of the subliminal stimuli produced rather ambiguous results.

Luborsky and Shevrin (1956) and Shevrin and Luborsky (1958) also conducted replications of the Poetzl experiment. In their first study they projected a complicated picture with many different elements as their tachistoscopic stimulus with the rationale that the subsequent appearance of many aspects of the picture in dreams would help to demonstrate that such incorporation effects were not merely random. The experimental procedure included eliciting recollections of the stimulus picture, drawings, dreams, and "waking dreams" (or day dreams) from the 28 subjects involved. The results showed that the Poetzl phenomenon is not limited to the mentation of sleep: Aspects of the subliminal stimulus appeared in waking imagery as well as in dreams. The dream data revealed that of the 18

subjects who provided at least one dream, 16 reported dream material related to the experimental stimulus. The authors explain this high production of experimental dreams in terms of subjects' perception of an unspoken suggestion to utilize the subliminal stimuli in their dreams. They also comment on the mental set to recall parts of the experimental picture induced in subjects by the "lack of closure" involved in the tachistoscopic presentations (p. 142). Like Fisher they emphasize the impact of the subject-experimenter relationship on the production of these laboratory dreams. In another aspect of their research, the experimenters derived interesting predictions from aspects of their subjects' descriptions and drawings as to what elements from the stimulus picture would appear in subjects' dreams. These predictions constitute a useful example of how Freudian concepts about defense mechanisms can be operationalized in the study of dreams.

Shevrin and Luborsky (1958) in a more tightly designed study examined the recollection of subliminal images in intentional recall as well as in the dreams of 27 subjects. In addition to dream reports, they collected three reports over the course of a day of

what subjects recalled of the tachistoscopic stimulation. In the absence of control groups in this research the authors obtained baseline data from a catalogue used in the study of extrasensory perception, a novel approach to providing standards of comparison for measuring the occurrence of aspects of the experimental stimulus in mentation. Criteria of conceptual similarity were established to score content related to the subliminal picture and inter-judge reliability was established. Shevrin and Luborsky found that initially unreported aspects of the subliminal stimulation appeared in dreams, but also so did reported perceptions. They discovered that while each of the consecutive daytime reports retrieved additional aspects of the subliminal picture which had been unreported initially, dreams remained the more effective "vehicle" for such recall (p. 289). The researchers noted a significant relationship in dreams between the number of incorporated elements of the experimental stimulus and the representation of unpleasant affect. They suggest that such findings help answer questions about the "characteristics of

preconscious perceptions [that] make it possible for them to play a role in dreams and images" (p. 293). Fisher and Paul (1959) have addressed this issue and comment that some ambiguity in a percept may be conducive to the expression of instinctual content in dreams. The results of these studies support and elaborate upon Freud's views about the relationship between "indifferent impressions" and the manifest content of the dream.

Shevrin and Fisher (1966) expanded the scope of research in this area using subliminal stimuli as tracer elements to probe the differences between REM and NREM mentation. Theirs is the only study to include an examination of the incorporation of subliminal stimuli into the productions of NREM sleep. Underlying this research is the supposition already discussed that REM and NREM mentation can be distinguished according to the transformations wrought on stimuli as they enter into thought. It was expected that the experimental stimuli would undergo primary process transformations in REM sleep and secondary process transformations in NREM sleep. The specific subliminal stimulus utilized was a picture which lends itself to different types of association: rebus and

clang associations as in primary process thought and conceptual associations as in secondary process thought. The subliminal pictures consisted of images of a fountain, pen, knee, and cap developed by Shevrin and Luborsky (1961), the same stimuli that had been utilized in an auditory form in the research of Castaldo and Holzman (1967, 1969) and Castaldo and Shevrin (1970) described earlier. Here Shevrin and Fisher used 10 women as subjects for two experimental sessions, one of which was a control night. Drawings and free associations were obtained as well as mentation from REM and NREM periods. In order to objectify scoring, baseline norms of conceptual and rebus associates to the stimuli were compiled from the responses of 200 other subjects and comprehensive word lists were drawn up to facilitate the assessment of clang effects. Contrary to expectation, analysis by two independent judges was not able to differentiate the productions of REM and NREM sleep on the basis of rebus, clang, or conceptual transformations of the subliminal stimulus. However, free associations obtained after periods of REM and NREM sleep showed differences in the expected direction for the rebus and conceptual associates of the experimental stimulus.

The authors speculate that it was perhaps a deficiency in the collection of the data which accounts for their failure to demonstrate the predicted experimental results in REM and NREM mentation. Nevertheless, this research provides a useful paradigm for studying the latent thought processes involved in presleep experiences entering into mentation.

Johnson and Eriksen (1960) have criticized some studies of the Poetzl phenomenon for their lack of control data, biased judges, and skewed results stemming from the use in some studies of a "cohesive scene" as stimulus picture (p. 497). They point out the likelihood that objects that occur together in such a scene would also appear in conjunction with one another in common associations. Such associations, they caution, could easily be mistaken for the recollection of various aspects of a subliminal stimulus. Johnson and Eriksen conducted their own examination of the Poetzl phenomenon but did not include dreams in their analysis because of an insufficient number collected. The images they studied revealed no evidence of Poetzl effect. While Johnson and Eriksen's critique raises important issues relevant to some of the studies reviewed here, the preponderance

of evidence in this area points to the fact that the incorporation of subliminal stimuli in dreams and images is a demonstrable phenomenon. As Fisher and Paul (1959) have commented individual differences in defensive structure, cognitive style, and in the personal meanings attached to the experiment may account for some of the variations in results on subliminal registrations. It is very possible that such subject differences may hold the key to understanding the discrepancies in the frequency of the Poetzl effects found in these investigations and the range of results found more generally in the many studies of external stimulation and dreams.

This chapter has reviewed and assessed the data from a range of studies on the effects of recent experience on sleep mentation. The results of this research indicate that many provocative questions remain about the extent of the influence of pre-sleep and concurrent stimulation on sleep mentation, the impact on NREM as well as REM mentation, and the longevity or transience of these effects. The next chapter presents the methodology, rationale, and hypotheses underlying the current exploration of the effects of a math experience on REM and NREM mentation.

This research has been designed in response to some of the unanswered questions about the influence of recent experience on sleep mentation.

CHAPTER III

Methodology

Research Description and Rationale

The current study examines the effects of doing math computations on the sleep mentation produced by twenty young adult male subjects during several nights in the sleep laboratory. Data from two baseline nights, six experimental nights, and a recovery night are studied. A scoring system for detecting math references has been developed and is described below.

This research studies incorporation effects in REM and NREM mentation and considers differential effects due to when the experimental condition was experienced-- during the interruption of REM or NREM sleep. It was expected that qualitative differences in the mentation of Stage 1 REM and Stage 2 NREM sleep would be demonstrated by examining the frequency of representation of the math experience in mentation produced during these stages. Hypotheses about differential stimulus incorporation rates in REM and NREM mentation were based on previous findings about the relative impermeability of REM mentation as compared to NREM mentation (Dement & Kleitman, 1957; McDonald et al., 1975; Rechtschaffen, 1978; Williams et al., 1964)

and other characteristics of mentation from each of these sleep stages. REM mentation has been shown typically to incorporate unconscious contents (Rechtschaffen, 1978) while NREM mentation is more typically thought-like and resembles everyday conscious concerns (Foulkes 1962, 1966; Rechtschaffen, Verdone, & Wheaton, 1963). Because the math experience required conscious thought processes typical of simple problem solving it was expected that representations of the math condition would be more prevalent in NREM mentation than REM mentation. Predictions about different frequencies of incorporation due to when subjects experienced the math condition were based on findings by Fiss, Ellman, and Klein (1969) and Fiss, Klein, and Bokert (1966). Their research demonstrated that qualities of REM and NREM sleep persist in fantasy stories (TAT) elicited during the abrupt interruption of those sleep stages. If the qualities of REM and NREM sleep persist after awakening from these stages, the relative impermeability of REM sleep and the resemblance of NREM mentation to conscious ruminations should contribute to greater receptivity to math content during the interruption of NREM sleep as opposed to REM sleep in this experiment. Because of this a higher frequency of math reports was

expected when subjects did math during awakenings from NREM sleep rather than REM sleep.

This study predicted that variations in the tendency of subjects to incorporate math in mentation would be explicable in terms of relevant personality data. It was expected that individual differences in the frequency of incorporation of recent experience in sleep mentation would be accounted for by characteristic differences in the mode of integrating internal stimulation and external experience. The personality data studied include scores from the MMPI, the Rod and Frame test, and the Imaginal Processes Inventory (IPI) (Antrobus & Singer, 1972). Even when within the normal range, subjects with high MMPI Schizophrenia scores have demonstrated an absorption with internal fantasy and fluidity of associations (Cartwright, 1972). In addition, high MMPI Schizophrenia scores are part of a factor linked to math giftedness in high school students (Kennedy & Wallace, 1965) and creative math ability in women (Helson, 1971). These attributes seem to indicate that high MMPI Schizophrenia scores may differentiate subjects who are more prone to incorporate the math experience from others whose mentation is less

affected. Witkin's field independence, field dependence scores also provide a relevant measure in predicting how recent experience may be incorporated in mentation. (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin & Goodenough, 1981; Witkin et al., 1954). Utilizing the construct of psychological differentiation, Witkin and Lewis (1965) designed instruments, including the Rod and Frame test, to assess whether persons experience parts of a field as discrete elements (field independence) or "fused with background" (field dependence) (p. 823). Field dependent people are more bound by external and "interpersonal sources of information" while field independent people tend more towards intrapersonal analysis based on experience, memory, and knowledge (Singer, 1984, p. 14). Field dependent subjects incorporate more aspects of sleep experiments in their dreams (Witkin & Lewis, 1965) while field independent subjects produce richer dream content, with transformations of presleep thought extending into dreams throughout the night (Baekeland, Resch, & Katz, 1968). Based on these findings it was expected that subjects who are more field dependent would show a greater utilization of math content in their night-time

mentation than those who are more field independent and less affected by recent stimulus input.

Other personality dimensions for study were chosen from the IPI which assesses self-acknowledged trends in the way daytime fantasy is experienced and provides an interesting link to the study of incorporation style in sleep. Scales from this inventory have been used by Schwartz (1979) and Weinstein (1982) to study the interaction between self representation and aspects of sleep stage and mentation. In the current research the IPI scale for Achievement-Oriented Daydreams and scale for Fear of Failure Daydreams were utilized. It was predicted that subjects with high strivings for achievement and fears of failure in their daydreaming would be more likely to experience the demand qualities in the requirements of the math condition and be more prone to incorporate computations or numbers in their mentation.

As has been discussed in the literature on the impact of the experimental setting on mentation, there are powerful demand characteristics built into the experimenter-subject relationship in the sleep laboratory aside from the requirements of particular experimental manipulations. The experimental design of

the current experiment allows exploration of the issue of whether subjects who incorporate math in their dreams are the same subjects who incorporate other aspects of the experiment in their dreams. An adaptation of a scoring system devised by Dement, Kahn, and Roffwarg (1965) is well suited for identifying experimental references in mentation.

It was expected that the data analysis would provide a useful elaboration of earlier research in terms of understanding the effects of recent experience on mentation. It was hoped that this investigation would not only help illuminate the general study of experimental effects on mentation, but also show how the effects of particular experimental manipulations are experienced by subjects over time. Thus, this study included the examination of time of night and longitudinal effects. It was predicted that more math mentation reports would be generated in the early part of each night both because of the initial impact of the experimental condition and because of related research findings that contemporary events are represented in earlier dreams of the night. (Roffwarg, Herman, Bowe-Anders, & Tauber, 1978; Verdone, 1965). It was expected that the habituation effects found in studies

of the impact of the experimental situation on mentation would be found in this study of the math condition.

Hypotheses

Specific hypotheses are as follows:

1. Nights of REM and NREM math will produce a greater number of mentation reports with clear math content than baseline nights.
2. Nights of REM and NREM math will produce a greater number of mentation reports with math content than the recovery night.
3. NREM math nights will produce a greater number of mentation reports with math content than REM math nights.
4. NREM reports will show a greater number of math and numerical references than REM reports.
5. Math content will be incorporated to a greater extent in the early REM and NREM reports of the night.
6. Subjects will show a leveling off in the production of math and numerical references over the course of nights within the REM and NREM math series.
7. Subjects who tend to incorporate math content will be high on the MMPI Schizophrenia scale.

8. Subjects who tend to incorporate math content will be more field dependent than those who do not.

9. Subjects who tend to incorporate math content will show greater evidence of achievement orientation in their self ratings of daydreaming experience (IPI).

10. Subjects who tend to incorporate math content will show greater evidence of fear of failure in their self ratings of daydreaming experience (IPI).

11. Subjects who are more prone to incorporate math content will also incorporate other aspects of the experiment in their mentation.

Experimental Design

The data base utilized in the current study was provided by Arkin, Antrobus, and Ellman (1978). The experimental design and methodology employed have been previously described (Arkin, Antrobus, and Ellman). Twenty male college students who were light sleepers and good dream recallers were paid to participate in the experiment which ran fourteen nights. Prior to the start of the experimental series proper, subjects spent five to seven nights stabilizing their sleep cycles at home and then spent three adaptation nights in the lab. The formal study began with two initial baseline

nights, followed by three experimental math nights, and a recovery night. After a rest period of three to eight nights at home, the experiment continued with two middle baseline nights, followed by another three experimental math nights, and a final recovery night. The experiment ended with two terminal baseline nights for all subjects. The experimental math nights in each half of the experiment involved subjects being awakened three nights from REM sleep or three nights from NREM sleep to do math computations aloud before being able to return to sleep. (The math awakenings were originally designed to accomplish stage REM or NREM deprivation.)

The experimental paradigm was as follows (Arkin, Antrobus, & Ellman, 1978):

Nights 1, 2	Initial baseline
Nights 3, 4, 5	REM or NREM math nights
Night 6	Recovery
Three to eight night	rest period at home
Nights 7, 8	Middle baseline
Nights 9, 10, 11	NREM or REM math nights
Night 12	Recovery
Nights 13, 14	Terminal baseline

The twenty subjects were assigned randomly to one of two groups to determine in which order they experienced the experimental series. Ten subjects participated in the three REM math nights in the initial part of the experiment and the three NREM math nights in the latter part of the study. The other ten subjects were run in the reverse order. The number of REM and NREM awakenings during which subjects did computations were counterbalanced for each subject and were sufficient to insure interruptions of the respective sleep stages. The study was designed so that each subject could serve as his own control and normative data could be obtained from baseline nights.

The math nights involved subjects computing a series of arithmetic problems aloud step by step so that their thought processes could be followed. After two to five minutes of doing arithmetic problems in this manner, subjects were informed of any needed corrections and were able to return to sleep.

Data Collection

The procedures for collecting mentation were specified in protocols by Arkin, Antrobus, and Ellman (1978). On each of the fourteen laboratory nights,

nine mentation reports were obtained for each subject: a sleep onset report, two REM reports, and 6 NREM reports. Mentation reports were elicited through a series of questions starting with a neutral inquiry about what was going through the subjects' minds, followed by questions about the vividness, clarity, emotional content, and reality of the report. REM reports were obtained 2-4 minutes after REM onset and equal numbers were gathered close to and remote from REM bursts. NREM reports (Stage 2) were obtained a minimum of 15 minutes after a previous REM period and equal numbers were elicited close to and remote from phasic events. The mentation report schedule throughout each night was as follows:

Sleep onset report (Stage 1);

Seventy to ninety minutes of uninterrupted sleep;

One REM, three NREM reports (early half of night);

One REM, three NREM reports (late half of night).

The current investigation focused on data from the two baseline nights, three REM math nights, three NREM math nights, and the final recovery night. On each of these nights eight mentation reports--two REM and six NREM reports per subject--were studied. (Sleep onset reports were not included in this analysis.) The 1440

mentation reports (REM and NREM) from the pool of twenty subjects were equally distributed between the early and late parts of each night as described above. Subjects' answers to the experimenters' questions about what was going through their minds when awakened comprised the codeable mentation reports.

Scoring Instruments

The scoring instruments utilized have been developed after the analysis of a range of classification systems for scoring dream content (Winget & Kramer, 1979). The scale for rating math content was devised to tap references to calculations and the appearance of numbers in mentation in a clear and unambiguous manner. Preliminary study with a more inclusive scoring system revealed that more abstract and inferential references to numerical content in mentation could not be reliably identified by judges.

The Mathematical Content Scale is a dichotomous scale consisting of three items for scoring the presence or absence of numerical content. Category 3 includes mentation reports with numbers and calculations in the context of mathematical operations or ruminations about numbers. Category 2 includes

reports with numbers in other contexts. Category 1 is for reports with no numbers or mathematical operations. Each mentation report was scored for mathematical content (or the lack of it) described by these categories. If a particular mentation report had content in both Category 3 and Category 2, it received two scores. The Mathematical Content Scale follows:

Mathematical Content Scale

3. Reports of active engagement in calculating, mathematical operations, counting, tallying, etc., without regard to correctness. Reports of having calculated, thinking about, or planning to calculate with or without mention of numbers. Reports of thinking about or having thought about a number, numbers, math, or arithmetic problems. Include reports where the intrusion of numbers into the ongoing mentation reveals subjects' thinking about numbers. Include reports with statements such as "I was not thinking about numbers, counting, etc., this time."

2. Reports with mention of numbers from zero on up in any context or application other than calculations, mathematical operations, or ruminations about numbers.

1. Reports with no mathematical operations or numbers.

The scale used to assess the appearance of experimental references in mentation is based on scales with established reliability designed by Dement, Kahn, and Roffwarg (1965) and utilized by Arey (1966). Similar scoring was used by Wood (1962). The adaptation utilized here is a three part scale which designates one category for direct and relatively complete references to the experiment, another for partial references, and a third for no related experimental content. The items are considered mutually exclusive. Each mentation report was scored according to this scale. The Experimental References Scale follows:

Experimental References Scale

3. Reports which describe the experimental situation directly and clearly. In these reports, the subject is the dreamer involved in lying in bed with electrodes attached, providing dreams to the experimenters, being awakened regularly for experimental purposes, etc.

2. Reports which include the representation of some aspect of the sleep experiment. Include references to being a subject, the experimenters, being awakened,

providing dreams, electrodes, EEG machines, the awakening bell, microphone, handgrip, tape recorders, instructions, conditions (darkness, temperature, etc.) and setting of the laboratory.

1. Reports with no clear representation of the experimental situation.

Personality Data

Each subject was scored on the MMPI Schizophrenia scale and on the IPI scales for Achievement-Oriented Daydreams and Fear of Failure Daydreams. Sixteen of the twenty subjects were scored for field dependence/independence on the Witkin Rod and Frame apparatus.

Assessment

Two independent judges were trained to score mentation according to the dimensions delineated by the Mathematical Content Scale and Experimental References Scale. Of the 1440 mentation awakenings, 50 (3 REM and 47 NREM) produced no reports. Most of the missing reports were due to difficulty in achieving the awakening criteria designated for obtaining a particular mentation report. Generally when this occurred for a particular report, a counterbalanced

report was not taken to insure that subjects had equal numbers of awakenings for matched sleep stages. A few reports were not available due to technical problems with taping, microphones, etc. A total of 1390 reports (357 REM and 1033 NREM) were included in the data analysis.

Mentation reports were scored first according to the categories of the Mathematical Content Scale. Judges' ratings were coded as ones or zeroes for each category of the scale to indicate the presence or absence of content described by that category. Mentation was scored also on the Experimental References Scale. Judges' ratings were coded as three, two, or one, a composite score to indicate which category on that scale described the content of the report. Scores assigned by the two judges were averaged so that every report had one set of scores on the Mathematical Content Scale and one score on the Experimental References Scale for analysis.

To test the hypotheses proposed in this study, the average frequency of math and numerical references was computed for baseline nights, REM math nights, NREM math nights, and the final recovery night. Mean scores were also obtained for the occurrence of math content

in mentation reports from the early half of the night and in reports from the late half of the night. Mean scores for each category of mathematical content and an experimental references score were obtained for each subject so that the relationship between these measures could be examined. Statistical measures utilized included t tests for correlated samples, Pearson correlations, linear trend tests, and repeated measures analyses of variance. These procedures are described in detail in the next chapter.

In summary, the proposed research constitutes a controlled investigation of the incorporation of a recent math experience in the mentation of twenty subjects studied in the sleep laboratory for fourteen nights. REM and NREM mentation produced on nine of these nights is examined. In addition to providing insights about how experience is represented in dreams, this analysis should result in findings which deepen the understanding of REM/NREM differences, personality correlates, time of night and longitudinal effects of stimulus incorporation on mentational processes.

CHAPTER IV

Results

Data Analysis

Two independent judges scored the 1390 (357 REM, 1033 NREM) mentation reports in random order on the Mathematical Content Scale and Experimental References Scale described previously. The judges were blind to subject, night of experiment, stage of sleep, and time of night from which awakenings had occurred. Reliability scores for the two content scales were computed based on correlations of the two judges' scores on 50 random reports for each of the twenty subjects. Reliability scores were .95 for the Mathematical Content Scale and .92 for the Experimental References Scale. To establish means for mentation studied, the two judges' scores for each report were averaged.

While half of the 20 subjects experienced the REM math condition first and the other half experienced the NREM math condition first, comparisons of the two groups revealed only trivial differences so that the two orders were collapsed for subsequent analyses. The discussion below describes the results of the research

procedures for the total subject pool. Data shown in table form generally present scores on the Mathematical Content Scale in terms of a breakdown between Category 3, reports with actual calculations, mathematical operations, or ruminations about numbers, and Category 2, reports with mention of numbers in other contexts, so that differences in the patterning of mathematical and numerical content can emerge. Scores for REM and NREM mentation are shown separately and combined. The mean scores shown for the Mathematical Content Scale may also be interpreted in percentage terms.

Effects of Math Experience on Mentation

Comparison of Baseline Nights and

Experimental Math Nights

Hypothesis 1 predicted that nights of REM and NREM math would produce a greater number of mentation reports with math content than Baseline Nights. To assess the effects of doing math on mentation the production of mathematical and numerical content in the mentation of REM and NREM Math Nights during which subjects computed arithmetic problems out loud was compared to the amount of mathematical and numerical content produced on Baseline Nights when no

computations were done. Table 1 shows the means for the production of mathematical and numerical content for baseline and experimental math nights.

Table 1

Mean Scores for Mentation of Baseline and Math Nights on Mathematical Content Scale

Math Content Category	Mentation	Baseline Nights 1,2	REM Math Nights 1,2,3	NREM Math Nights 1,2,3
3	REM	.04	.11	.16***
	NREM	.04	.19****	.15****
	Total REM & NREM	.04	.17****	.15****
2	REM	.33	.40	.41
	NREM	.22	.27	.24
	Total REM & NREM	.25	.30*	.29

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

Analysis demonstrates that there is a significant increase in the amount of mathematical and numerical content in mentation from baseline to experimental math nights, particularly within Category 3. For REM and NREM reports combined there was significantly more content in this area on both REM Math Nights ($M = .17$), $t(19) = 4.83$, $p \leq .001$ and NREM Math Nights ($M = .15$), $t(19) = 4.34$, $p \leq .001$ than on Baseline Nights ($M = .04$). Separate breakdowns revealed that on REM Math Nights the increase was significant for NREM reports ($M = .19$), $t(19) = 5.15$, $p \leq .001$ while for REM reports the increase was just short of significance. On NREM Math Nights both REM mentation ($M = .16$), $t(19) = 2.96$, $p \leq .005$, and NREM mentation ($M = .15$), $t(19) = 3.94$, $p \leq .001$ showed significant increases over baseline levels of Category 3 content. For Category 2 content, only the combined sample of mentation on REM Math Nights ($M = .30$), $t(19) = 1.72$, $p \leq .05$ showed a significant increase compared to Baseline Nights ($M = .25$). All other comparisons involving Category 2 showed insignificant increases over baseline levels.

Comparison of REM Math Nights, NREM Math Nights, and Recovery Night

Hypothesis 2 predicted that nights of REM and NREM math would produce a greater number of mentation reports with math content than the Recovery Night. Table 2 shows the mean levels of math and numerical content on these nights.

The results reveal a greater amount of mathematical content in REM and NREM Math Nights than the Recovery Night primarily for Category 3 content. A significant decrease in mean scores for math content (Category 3) occurred from REM Math Nights and NREM Math Nights to the Recovery Night for the total sample of REM and NREM reports. The REM Math Nights mean of .17, $t = 3.09$, $p \leq .005$ for the combined reports decreased on the Recovery Night to a mean of .07. The mean of .15, $t = 2.61$, $p \leq .01$ for these reports on NREM Math Nights also showed a significant decrease on the Recovery Night. NREM reports account for the major portion of the difference in Category 3 means on REM Math Nights and the Recovery Night. Both REM and NREM reports showed significant decreases in the amount of this content from NREM Math Nights to the Recovery Night. For Category 2 content, there were insignificant

differences on all comparisons between math nights and the recovery condition.

Table 2

Mean Scores for Mentation of Math Nights and Recovery Night on Mathematical Content Scale

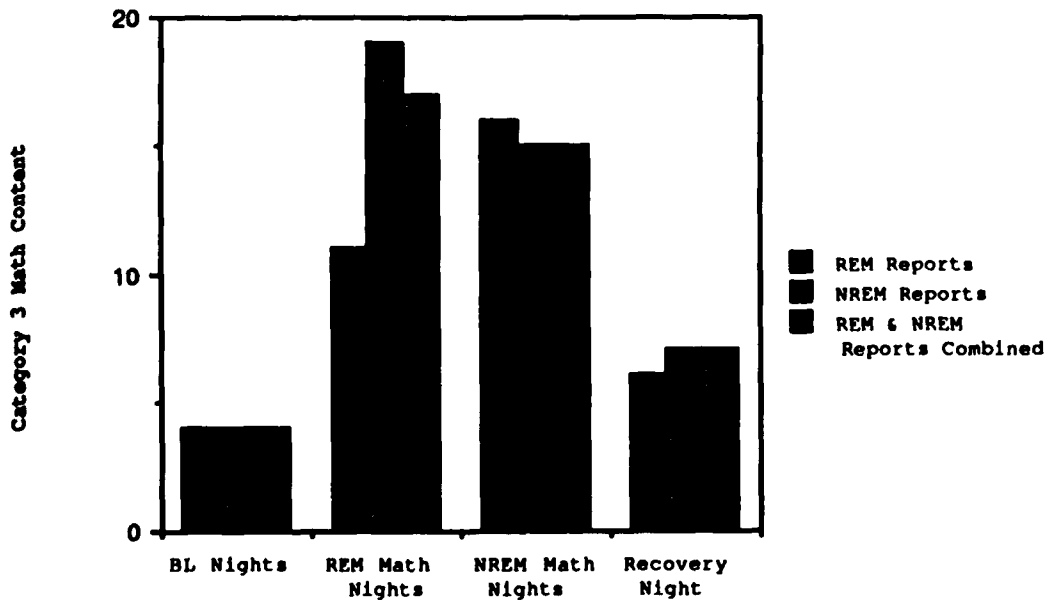
Math Content Category	Mentation	REM Math Nights 1,2,3	NREM Math Nights 1,2,3	Recovery Night
3	REM	.11	.16**	.06
	NREM	.19***	.15*	.07
	Total REM & NREM	.17***	.15**	.07
2	REM	.40	.41	.30
	NREM	.27	.24	.27
	Total REM & NREM	.30	.29	.28

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

Percentages of Incorporation Effects

The main incorporation effects can be seen clearly in percentage terms. Seventeen percent of the total reports on REM Math Nights and 15 percent on NREM Math Nights compared to 4 percent on baseline nights contained Category 3 math content. On the Recovery Night, 7% of the reports contained these references. Figure 1 demonstrates the distribution of reports with Category 3 math content on all nights of the experiment.

Figure 1. Percentages of Category 3 math content in mentation by nights.



Category 2 content showed significant effects of the mathematical experience only on REM Math Nights for the combined mentation sample. The percentage of reports with this content on these nights increased from a baseline level of 25% to 30%. No recovery effects were demonstrated.

Comparison of REM Math Nights
and NREM Math Nights

Hypothesis 3 predicted that on NREM Math Nights subjects would produce a greater number of mentation reports with math content than on REM Math Nights. Table 3 presents the means for the production of math content on REM and NREM Math Nights.

Results demonstrate that the differences between REM Math Nights and NREM Math Nights in the amount of mathematical and numerical content in mentation are insignificant. The largest difference shown in the mentation of the two series of nights was for REM reports with content in Category 3. The REM Math Nights mean for this mentation was .11 while the NREM Math Nights mean was .16, $t(19) = 1.51$, $p = .07$. This difference was in the predicted direction. Comparisons based on the appearance of Category 2 content in the

mentation of the two sets of math nights produced no significant findings.

Table 3

Mean Scores for Mentation of REM and NREM Math Nights on Mathematical Content Scale

Math Content Category	Mentation	REM Math Nights 1,2,3	NREM Math Nights 1,2,3	t (df = 19)
3	REM	.11	.16	1.51
	NREM	.19	.15	1.39
	Total REM & NREM	.17	.15	.58
2	REM	.40	.41	.08
	NREM	.27	.24	.88
	Total REM & NREM	.30	.29	.53

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

Comparison between REM and NREM Mentation

Hypothesis 4 predicted that NREM reports would show a greater number of math and numerical references

than REM reports. Table 4 presents the comparison of REM and NREM reports in terms of the appearance of this content.

Table 4

Mean Scores for REM and NREM Mentation on Mathematical Content Scale on Math Nights

Math Content Category	Math Nights Mentation		<i>t</i> (<i>df</i> = 19)
	REM	NREM	
3	.14	.17	1.05
2	.41	.25	3.82****

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

The results show that when the results of all six experimental math nights are considered together the difference in the amount of Category 3 content in REM and NREM mentation is insignificant. For reports with content in Category 2 there is a significant effect demonstrated in the opposite direction from the prediction. There is a greater representation of

Category 2 content in REM reports ($M = .41$) than NREM reports ($M = .25$), $t(19) = 3.82$, $p \leq .001$.

When the production of Category 3 math references are analyzed for REM Math Nights and NREM Math nights separately, the results seem to demonstrate some confirmation of Hypothesis 4. Table 5 shows the comparison in amount of this content for the two series of math nights.

Table 5

Mean Scores for Category 3 Content in Mentation of REM and NREM Math Nights

	Mentation		t (df = 19)
	REM	NREM	
REM Math Nights 1,2,3	.11	.19	2.28*
NREM Math Nights 1,2,3	.16	.15	.55

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

On REM Math Nights there are significantly more math references in NREM mentation than in REM

mentation. On NREM Math Nights, the difference between REM and NREM mentation in the production of Category 3 content is insignificant.

Comparison between Early and Late Reports

Hypothesis 5 predicted that math content will be incorporated to a greater extent in the early REM and NREM reports of each night. To test this hypothesis, the first REM report and first three NREM reports of each math night were designated early reports. The second REM report and last 3 NREM reports of each math night were designated late reports. Table 6 demonstrates the comparisons between categories of early and late reports.

Analysis of the mean scores for math content according to the time of night shows that for the combined sample of REM and NREM reports, as well as for NREM reports alone, there was a significant difference as predicted in the amount of Category 3 content in early and late reports. The mean for Category 3 content for the total sample of early reports was .19 while the mean for this content in the total sample of

Table 6

Mean Scores for Early and Late Reports on Mathematical
Content Scale

Math Content Category	Early	Late	<i>t</i> (<i>df</i> = 19)
	REM Report 1 NREM Reports 1,2,3	REM Report 2 NREM Reports 4,5,6	
3	.19	.13	3.02***
2	.30	.29	.39

Math Content Category	REM Report 1	REM Report 2	<i>t</i> (<i>df</i> = 19)
3	.14	.14	.07
2	.38	.44	.97

Math Content Category	NREM Reports 1,2,3	NREM Reports 4,5,6	<i>t</i> (<i>df</i> = 19)
3	.20	.13	3.03***
2	.27	.24	.71

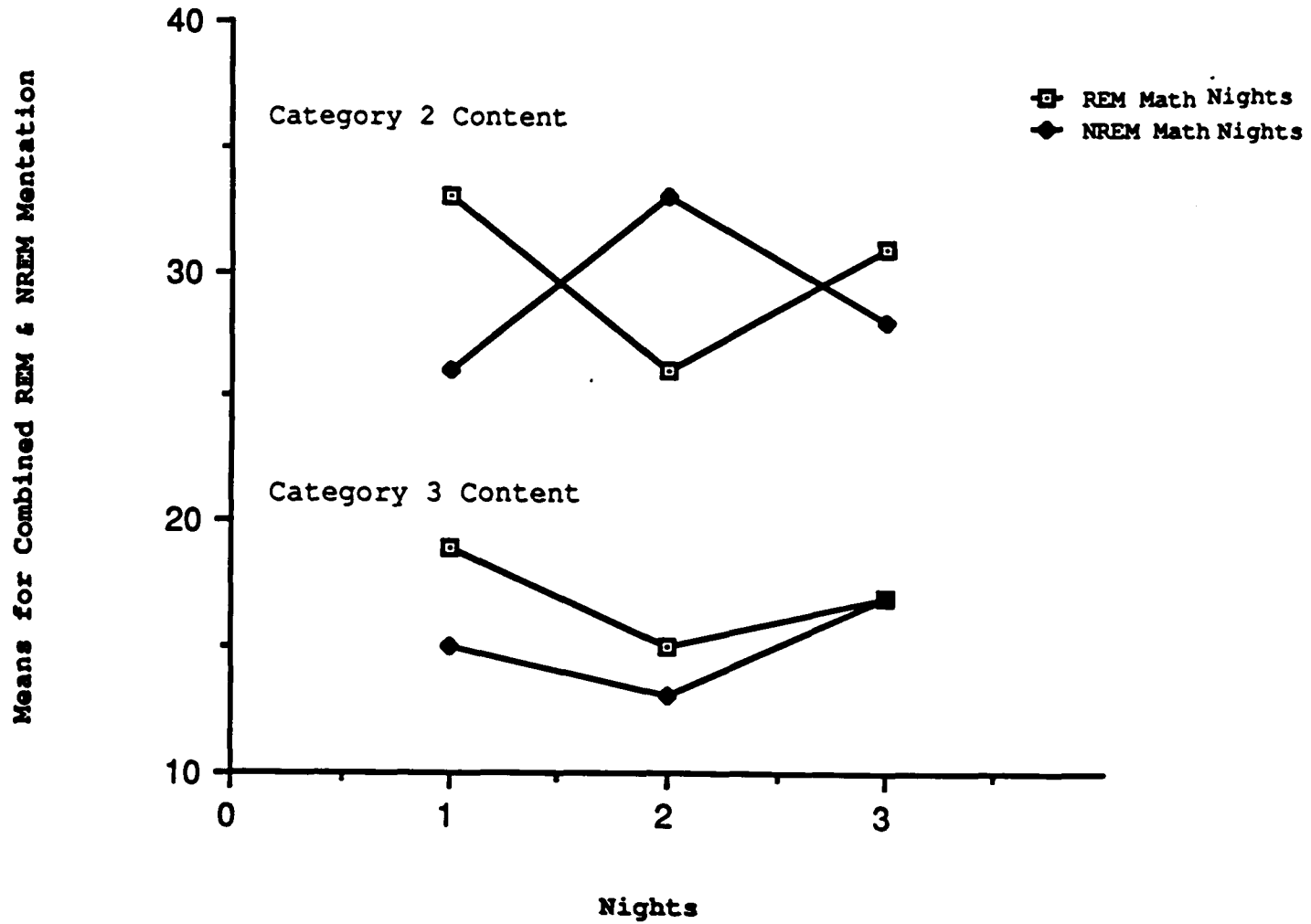
p* ≤ .05. *p* ≤ .01. ****p* ≤ .005. *****p* ≤ .001, one tailed test.

late reports was .13, $t(19) = 3.02$, ($p < .005$). The difference in means between early and late NREM reports accounts for this result. Early NREM reports had a mean of .20 while late NREM reports had a mean of .13, $t(19) = 3.03$, $p \leq .005$ for Category 3 content. No significant differences were found for the comparisons of early and late mentation with Category 2 content.

Inter-night Trends in Amount of Math Content

Hypothesis 6 predicted a leveling off in the production of math mentation as subjects went from Night 1 to Night 3 within each series of experimental math nights. To assess this prediction, repeated measures analyses of variance and linear trend tests were performed. There were no significant linear or quadratic trends noted in this data. The means for each series of three nights for the measures studied are not significantly different from one another. Figure 2 shows the mean scores for Category 3 and Category 2 content on REM Math Nights 1, 2, and 3 and NREM Math Nights 1, 2, and 3 for the total sample of mentation reports.

Figure 2. Means for math and numerical content on REM and NREM math nights.



Personality Correlates of Math Incorporators

Hypothesis 7 predicted subjects who tend to incorporate math content would be high on the MMPI Schizophrenia scale. Hypothesis 8 predicted that math incorporators would be more field dependent. Hypotheses 9 and 10 predicted they would be high in IPI scores for achievement-oriented and fear of failure daydreaming, respectively. Hypothesis 11 predicted incorporators of math and numerical references would also tend to represent other aspects of the experiment in mentation. Table 7 presents the correlations of math and numerical incorporations with these other dimensions.

The results reveal a relationship between the tendency to incorporate Category 2 numerical content in mentation and MMPI Schizophrenia scores. A low correlation $r(20) = .38$, $p = \leq .05$ was noted, while the relationship of MMPI Schizophrenia scores to the incorporation of Category 3 content fell just short of significance. There were no significant correlations between incorporation of math and numerical content and the other personality measures studied.

Table 7

Correlations of Math and Numerical Content with
Personality Measures and Other Experimental References

Mathematical Content	MMPI Schizo- phrenia	Field Depend- ence	IPI Achieve- ment	IPI Fear of Failure	Experimental References
Category 3	.35	.08	-.28	-.22	.44*
Category 2	.38*	.06	-.14	-.31	.45*

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .005$. **** $p \leq .001$, one tailed test.

Moderate correlations between the incorporation of math and numerical content and other experimental references were found. The incorporation of Category 3 math content $r(20) = .44$, $p \leq .05$ and of Category 2 content $r(20) = .45$, $p \leq .05$ on math nights was related to the production of other experimental references in mentation.

The following chapter assesses the implications of these results.

CHAPTER V

Discussion

Effects of the Math Experience on Mentation

The results of this study demonstrate that the mathematical experience of the experiment exerted a significant effect on the production of math content in mentation and that this effect occurs primarily in the appearance of Category 3 math content. The percentage of combined REM and NREM reports in this category was 17% on REM Math Nights and 15% on NREM Math Nights compared to a baseline level of 4%. These results indicate about a fourfold increase in math content on experimental math nights as compared to baseline nights. While no other study of stimulus incorporation involved an experience similar to the math experience which combined an auditory component and oral participation, it is interesting to see how the results described here compare to other findings on the impact of recent stimulation on mentation. The results of other investigations are confined to REM mentation unless otherwise noted.

The overall frequency of 16% for the relatively direct incorporation of the math experience in mentation falls in the lower third of the range of

results found in other studies. Dement and Wolpert (1958) reported percentages of 9%, 23%, and 42%, respectively for the incorporation of a tone, light flash, and water spray in mentation. Koulack (1969) reported a 56% incorporation rate for shocks to the wrist. Berger (1963) found a 54% incorporation rate when audio tapes of significant and neutral names were played to subjects while they slept. In contrast to some of these studies which indicate that more than half of the dreams examined showed evidence of the effects of recent stimulation, Rechtshaffen and Foulkes (1965) found no effects of a variety of visual stimuli in REM or NREM mentation. In looking at the impact of different films on mentation, the same authors, Foulkes and Rechtschaffen (1964) also found few instances of incorporation of film elements (5% overall) in the mentation of either sleep stage. On the other hand, Roffwarg, Herman, Bowe-Anders, and Tauber (1978) in examining the effects of sustained visual stimulation, red goggles worn five to eight days, found an increase of 3.5 over baseline levels in the number of REM reports affected by the visual condition. This increase was comparable to the increase found in the current study. Both studies, it should be noted, utilized repetitive exposure to the stimulus condition.

Methodological Issues in Assessment of Experimental Effects

As has been discussed previously, there are inherent limitations in comparing percentages of incorporation from studies which utilize different modalities, schedules of stimulation, and methods of scoring. Methodological problems with individual studies further limit the generalizability of some results. Two of the most common problems noted in the review of previous research were the failure to obtain baseline data and the inflation of results by over-inclusive scoring systems. The discussion below reinforces the importance of these methodological issues. For here too, had the percentages of Category 2 incorporations (that is, reports with references to numbers in any context) been added to the percentages of Category 3 incorporations on math nights without further consideration of the validity of these scores, the overall index of incorporation would obviously have been much higher. On REM Math Nights, 30% of the REM and NREM reports contained Category 2 content, which was significantly more than on Baseline Nights, and on NREM Math Nights, 29% of these reports contained Category 2 content, which fell just short of significance when compared to baseline levels.

Combining percentages of Category 3 and Category 2 references, even with a correction factor for reports with both types of content, would produce an index of incorporation towards the high end of the spectrum of results obtained in other studies. However, this combined percentage would be misleading without consideration of the high level of Category 2 numerical content found even on baseline nights. Analysis of the mentation of baseline nights shows that prior to the mathematical requirements of the experiment, a full 25% of the REM and NREM reports contained Category 2 content.

Effects of the Math Experience on the Mentation of Recovery Night

Examination of the production of math references on math nights and the recovery night reveals different trends in the occurrence of Category 3 and Category 2 content. Category 3 references to the math experience decline significantly on recovery nights, to a level of 7%, which is close to the baseline level of 4%. The return to low levels of incorporation on the recovery night suggests that the occurrence of math references in the mentation of math nights reflects the imminence of the experimental demand that math problems be

computed--the effects generally limited to the nights subjects were asked to calculate. When that demand ceased on the recovery night, the production of Category 3 math references dropped off.

The examination of the patterning of Category 2 content did not reveal a similar decline on the recovery night. In fact, similar levels of Category 2 content were produced on the recovery night and on experimental math nights. These percentages of incorporation were also quite close to the baseline level. The results demonstrated that 25% of the reports on baseline nights, 30% on math nights, and 28% on the recovery night contained Category 2 content. Since levels of Category 2 content on the recovery night were not significantly different from that obtained on other nights of the experiment, no conclusions can be drawn about Category 2 recovery effects. Category 3 mathematical content appears to be a more sensitive indicator of these effects.

Implications for Future Research on Recovery Effects

The possibility that the patterning of Category 3 and Category 2 content may indicate differences in the way the math experience affects mentation over the

course of experimental nights merits further exploration. Subsequent study might examine the hypothesis that Category 3 content is a more precise indicator of immediate effects of the math condition while Category 2 content registers more persistent effects. Perhaps more veridical representations of the math experience utilizing Category 3 content decline when the requirements of the math experience are withdrawn, but the transformations of the experience utilizing Category 2 content continue into the recovery condition.

Proposed Scoring Revisions for Assessment of
Incorporation Effects

The scoring parameters utilized in the current study to assess Category 2 content may have been too general to detect the full extent of change from baseline to math nights and the recovery night. The designation of Category 2 content was intended to identify references to the mathematical experience through the presence of numbers and numerical thinking in contexts other than mathematical operations in contrast to the direct representations of Category 3. A subsequent effort to tap indirect references to the mathematical experience might include mentation with

the mention of numbers above a certain numerical cut off point. It may be that low numbers are used frequently in typical dream description and are not indicative of the specific experimental effects of the math condition, while the utilization of higher digit numbers may represent these effects. In a redesigned scoring system, a stronger weight might be given also to mentation with repeated references to numbers as opposed to mentation with a single numerical reference. Figures of speech and the use of vocabulary that reflect a mathematical influence might also be considered evidence of the impact of the mathematical experience. In addition, a word count corrective would be useful in guarding against bias due to length of the verbal report. More precise analysis would result also from differentiating the no content and no recall reports from mentation with some item of content. These scoring refinements would seem to facilitate more accurate discrimination of incorporation effects.

REM/NREM Incorporation Effects

Another area of exploration in this research involved the testing of hypotheses based on differences in permeability to recent stimuli which were thought to characterize the stages of REM and NREM sleep. It was

predicted that more math and numerical content would appear in the mentation of NREM Math Nights than REM Math Nights. Contrary to expectation, the data analysis revealed no significant differences in the total percentages of math and numerical content produced on REM and NREM Math Nights. While the hypothesis that there would be more math and numerical content in mentation produced during the interruption of NREM sleep than REM sleep was based on differences in these sleep stages described by some authors (Dement & Kleitman, 1957; Rechtschaffen, 1978; Williams et al., 1964), reexamination of the literature reveals that the emphasis on the perceptual barriers of REM sleep and the relative openness to experience of NREM sleep represents an over-simplification of qualities of these sleep stages in terms of understanding the effects of recent experience.

The hypothesis that more NREM reports than REM reports would contain references to the math experiment was examined by an analysis of the data for all six nights, and for REM and NREM Math Nights separately. (The latter findings are discussed under the subsequent heading.) When the data for all six nights were reviewed, there was no significant difference in the production of Category 3 content in REM and NREM

mentation. It seemed the hypothesis about the likelihood of more math references in NREM than REM mentation was disconfirmed. In fact, for Category 2 content, a significant result was found in the opposite direction. More REM reports than NREM reports on both series of math nights contained numerical references.

It has been traditional in the literature to identify mentation obtained from REM periods by its more vivid, visual, and relatively bizarre content in contrast to mentation from NREM which has been likened to everyday concerns and conscious thought processes (Foulkes, 1962, 1966; Rechtschaffen, 1978; Rechtschaffen, Verdone, & Wheaton, 1963). Some authors have suggested a link between REM mentation and the Freudian concept of the primary process, and NREM mentation and the secondary process (Castaldo & Shevrin, 1970; Shevrin & Fisher, 1967). The "single mindedness and isolation" of the REM dream (Rechtschaffen, 1978) has been juxtaposed against the relative permeability of NREM mentation. However, the findings of this experiment and the data available from the few other studies in this area provide little evidence to support these descriptions of REM/NREM differences. REM sleep may not be as resistant to recent experience as a focus on its high arousal

thresholds and the involitional nature of its thought processes might suggest and NREM sleep may not be as permeable as has been described. Furthermore, the differences in these sleep stages in the modes of representation of recent experience may not be as clear-cut as believed. Foulkes and Rechtschaffen (1965) have reported that REM reports reflected qualitative aspects of an arousing film and showed more frequent incorporations of film elements than NREM reports. Roffwarg, Herman, Bowe-Anders, and Tauber (1978) noted significant effects of their red goggle experience on REM mentation and negligible effects on NREM mentation. Castaldo and Shevrin (1970) did find conceptual representations of an auditory stimulus in NREM mentation, but not the primary process transformations that had been expected in REM. Antrobus (1983) has demonstrated that many REM/NREM differences may be attributable simply to discrepancies in word count. He suggests that REM and NREM mentation may share qualitative aspects, and "differ only in quantity of recall" (p. 201). Greater cortical activation in REM than in Stage 2 NREM and increased capacity for memory and production of mental images may account for previously observed differences (Antrobus, 1983). Clearly, more evidence is needed to support the

views that have been proposed about differences in REM and NREM mentation based on permeability to stimulation and characteristic thought processes.

The predictions of this study that REM sleep would demonstrate greater resistance to recent input than NREM sleep and that NREM mentation would be characterized by more representations of the mathematical paradigm because of its link to secondary process thought were not supported by the total percentages of incorporation.

Category 3 Incorporation Effects
on REM vs. NREM Math Nights

When the results of the production of Category 3 math references were considered on REM and NREM Math Nights separately, an interesting finding emerged. On REM Math Nights, NREM reports contained significantly more math references than REM reports while on NREM Nights there was no significant difference in production of math references in the two forms of mentation. The question emerges why more of this content was observed in REM than NREM mentation on REM Math Nights, but not on NREM Math Nights.

The most cogent explanation seems to stem from the nature of the REM Math Nights. It is recalled that the

math experience on both the REM and NREM Math Nights involved considerable sleep stage deprivation. The literature on REM deprivation has been assessed in comprehensive reviews by Ellman, Spielman, Luck, Steiner, and Halperin (1978); Vogel (1975); and Weinstein (1982). Research has demonstrated that the effects of sleep stage deprivation are experienced more intensely by subjects on nights which involved REM deprivation rather than NREM deprivation (Agnew, Webb, & Williams, 1967; Dement, 1960; Kales, Hoedemaker, Jacobson, & Lichtenstein, 1964). Cartwright, Monroe and Palmer (1967) described the disruptive effects of REM deprivation on typical sleep records and have found that under deprivation conditions dream-like mentation may permeate NREM states. Subsequent research by Cartwright and Monroe (1968) produced data highly relevant to the findings of the current study. As in the investigation described here, Cartwright and Monroe utilized a numerical task, the digits-forward and digits-backwards subtests of the Wechsler Adult Intelligence Scale (WAIS), as their sleep-depriving condition. They discovered that performing the mathematical tasks on REM deprivation nights, but not NREM deprivation nights, produced a strong need for REM compensation. Furthermore, they noted that the "type

of mental activity required to do well on the digit task is antithetical to the REM state" (p. 73). Subjects with better performance on the mathematical tasks in the first half of the night produced higher REM compensation percentages in the subsequent part of the night. Other researchers have focused on qualitative effects of REM deprivation and described its disruptive effects on various behaviors, tests, and tasks (Clemes & Dement, 1967; Dement, 1960; Greenberg, Pillard, & Pearlman, 1972; Sampson, 1966). Pivik and Foulkes (1966a) found REM deprivation early in the night increased the intensity of REM reports obtained later on. Arkin, Antrobus, Ellman, and Farber (1978) did not find recovery night increases in dream-like fantasy of REM or NREM mentation after REM or NREM deprivation in their analysis of the data that provided the basis of this math study. However, Weinstein (1982) discovered subtle effects of REM deprivation on recovery night mentation in terms of Absorption in Mentation (AIM) (Weinstein, Schwartz, & Ellman, 1987, in press).

The findings of this experiment indicate that the REM deprivation of REM Math Nights exerted significant effects on the content of the obtained mentation in terms of the occurrence of Category 3 mathematical

references. It is contended that as a consequence of the disruptive effects of REM deprivation experienced on REM Math Nights subjects were unable to integrate and express the math experience in REM mentation in the direct manner typical of Category 3 incorporations. A spillover effect may have occurred, which caused more of this content to infiltrate NREM reports on these nights. These factors would account for the low occurrence of Category 3 math content in REM reports on REM Math Nights. The greater proportion of Category 3 math references in NREM mentation on these nights is seen as a consequence of the disruption of the normal REM processes on these nights, rather than as an indication of general differences in permeability to recent experience in REM and NREM mentation.

Category 2 Effects

The analysis of mentation in terms of Category 2 numerical references showed that over all six math nights significantly more REM reports than NREM reports contained this content. However, since baseline levels of Category 2 content also showed this discrepancy, this finding could not be attributed to differences in REM and NREM mentation in the representation of the effects of the mathematical experience. It had been

hoped that the data might indicate a tendency of REM dreams to abstract the numerical content involved in the mathematical requirements of the experiment into other dream contexts. However, this experimental effect was not demonstrated. Instead, this analysis revealed that REM reports generally seem to utilize more numerical content in the dream narrative than NREM reports. Perhaps this is due simply to the descriptive power of numbers in the articulation of the experiences of the REM dream.

Directions for Future Inquiry about REM/NREM Differences

It would be worthwhile to examine whether differences in the occurrence of numbers consistently distinguishes REM and NREM mentation. A review of other samples of REM and NREM reports could be conducted to study the appearance of numbers in mentation controlled for word count. There are no known analyses that provide information about the utilization of numbers in large samples of REM or NREM mentation. Hall and Van de Castle's (1966) study of 1000 dreams for the establishment of normative data on dream content included counts of the use of descriptive modifiers such as size, age, and references to time and

money in dreams. However, they did not include the actual appearance of numbers or mathematical content as categories in their analysis.

A replication of the current mathematical study would explore REM/NREM differences on experimental nights with the refinements for scoring mathematical and numerical content that have already been discussed. In addition, a redesigned experiment would include a sample of REM reports equal in size to the sample of NREM reports. This study obtained a sample of REM reports only one-third as large as the NREM sample, so that some differential effects may not have been detected. Perhaps most importantly, a follow-up study to examine incorporation of a math experience in REM and NREM mentation would utilize a salient mathematical experience without inducing serious sleep stage deprivation. Then the representation of this experience could be studied without the confounding effects of excessive sleep loss.

Time of Night and Longitudinal Effects

This study corroborated other findings that recent experience is more likely to affect the early mentation of the night (Verdone, 1965; Roffwarg et al., 1978). Trostman, Rechtschaffen, Offenkrantz, and Wolpert (1960)

observed that early dreams of the night tend to use more recently aroused information and that later dreams work this material over, utilizing early memories, solutions, and defenses. For the math experience a significant time of night effect was found on experimental math nights for Category 3 math content in the mentation sample as a whole. More of these references occurred in the early half of the night. No differences were found in the production of Category 2 content. The effect for Category 3 references was due essentially to the difference in the early/late patterning of math content in NREM reports as the production of this content in REM reports showed no time of night differences. It is possible that the small size of the REM sample, only one early REM report and one late REM report per subject, is responsible for the lack of significant findings.

In terms of the occurrence of this content over the course of experimental nights, no habituation effects were found for the production of mathematical and numerical content in mentation. The results demonstrate that the mathematical experience exerted persistent effects without significant increase or decrease during the three nights of the REM math and three nights of the NREM math conditions. The peak

effect found in some studies of the impact of the experimental situation on dreams for the first night in the laboratory and the decline in the production of laboratory references in dreams on subsequent nights (Dement, Kahn, & Roffwarg, 1965) were not replicated here. Nor was the longitudinal effect reported by Roffwarg et al. (1978) of greater penetration of the visual content of his experiment into later dreams of the night as the experiment progressed shown here. It should be noted, however, that the Roffwarg et al. experiment found the intrusion of the stimulus condition into later dreams occurred on the fourth of five to eight experimental nights. Here the data represent the combined results obtained for the two groups of subjects within the three nights of each math series. In subsequent analysis, the production of math references from the first math night to the sixth math night should be examined for all subjects combining the two orders of experimental conditions.

Personality Characteristics

of Math Incorporators

The attempt to predict the tendency to incorporate math and numerical content in sleep mentation according to subjects' scores on relevant personality measures

produced limited results. While subjects demonstrated a range in amount of math incorporation, these scores did not produce strong correlations with the personality measures studied. It is possible that the moderate characteristics of this subject pool of normal, young male, college students were of insufficient range to establish significant relationships.

Of the psychological data studied, only MMPI Schizophrenia scores demonstrated some relationship to incorporation effects, and the correlation was low and significant only for the production of Category 2 content. The relationship of Category 3 math references to MMPI Schizophrenia scores fell just short of significance. It had been thought that the problem schizophrenics have in separating internal perceptions and external reality would also characterize normal subjects with high schizophrenia scores (Weinstein, 1982). It was predicted that because of difficulty in processing internal and external experience, subjects high on this scale would incorporate more of the math experience in their dreams. This hypothesis was bolstered by evidence of a different kind: high MMPI Schizophrenia scores have been linked in other research to special math abilities

(Helson, 1971; Kennedy & Wallace, 1965). It seemed likely that math ability would also contribute to the tendency to utilize math references in mentation. The investigation of the relationship between schizophrenic traits and the incorporation of recent stimuli in sleep mentation, the influence of math aptitude, and even attitudes towards math merit further study. Future research might focus on stimulus incorporation in the mentation of subjects particularly chosen for high and low scores on these dimensions.

Field dependence scores were obtained for only 16 of the 20 subjects studied, but the inclusion of this data seemed important because of the strong relationship of these scores to cognitive style. It was thought that the way in which subjects organize perceptual stimulation in tasks such as the Rod and Frame test would be part of an enduring pattern of dealing with stimulus input even in dream. However, no significant correlation was found between math incorporation and the field dependence scores available. It is possible that other measures of perceptual responses might help detect patterns of responsiveness to stimulation in waking behavior and dreams. Starker (1973) based a study on a similar hypothesis, but did not find a link between a

perceptual measure--autokinesis--and cognitive style, daydreaming, and dream recall. Nonetheless, the examination of the relationship between perceptual measures and aspects of experience and dreaming remains an intriguing area of research. Knorrning, Jacobsson, Perris, and Perris (1980) have found correlations between subjects' reactions to stimulation and vulnerability to certain life events. They assessed a characteristic perceptual response, the tendency "to enlarge" or "diminish what is being perceived," by tests of visual average evoked potentials (p. 298). It would be interesting to include such a dimension in a follow-up study of the impact of recent experience on sleep mentation.

The other personality data examined for their relationship to production of math content were subjects' scores on the IPI Scales for Achievement-Oriented and Fear of Failure daydreaming. These scores based on subjects' own descriptions of their daydreaming content were not related to incorporation of math and numerical content in night time mentation. Whatever achievement wishes and fears of failure were stimulated by the experimental demand that subjects do math, these concerns were not connected with the production of more math and numerical content. In

fact, an opposite possibility is suggested by the negative direction of the results obtained. The wishes and fears evoked by the experimental demands of this study may have been so arousing that they mediated against incorporation effects for subjects high on these measures.

Incorporation of Other Aspects of Experiment

Analysis revealed that those who incorporate aspects of the math experience in sleep mentation are also likely to incorporate other aspects of the experiment in their dreams. While field dependence scores which have been linked in previous research to incorporation of aspects of the experiment in dreams (Baekeland, Resch, & Katz, 1965; Witkin & Lewis, 1965) did not correlate with incorporation of the math experience here, some of the other personality variables such as anxiety that have produced positive correlations with the production of experimental references in dreams (Baekeland, 1971; Breger, Hunter, & Lane, 1971; Cartwright, Bernick, Borowitz, & Kling, 1969; Cohen, 1975) might be examined in future study. Understanding more about the characteristics of subjects prone to incorporate particular experimental

stimuli in dreams would not only enlarge what is known about personality and dreaming, but would also have practical implications for the selection of subjects suited for the purposes of particular studies. Subjects less vulnerable to the effects of the experimental situation and particular stimulation might be chosen for studies where "pure cultures" of dreaming would be useful. Subjects apt to be more influenced by particular aspects of the experimental situation might be chosen for studies where a greater understanding of the representation, transformation, and symbolization of recent stimuli is desired.

Examples of Math and Numerical

Content in Mentation

A partial sample of the REM and NREM reports judged to contain mathematical and numerical content presents some interesting illustrations of the ways in which subjects represented aspects of the mathematical and numerical content of the experiment in sleep mentation. It is unfortunate that retrospective sessions were not scheduled to gather subjects' associations to aspects of the mathematical and numerical mentation, for in the absence of this material it is impossible to interpret the personal meanings of this content. Nonetheless, it

is still productive to examine how the mathematical and numerical content of the experiment filtered into the manifest content of the dream. The Category 3 reports reveal the integration into individual narratives of the concern with mathematics and various mathematical operations. The Category 2 reports are examples of reports judged to contain numerical content in contexts other than mathematics.

Category 3 Mathematical Content

1. Hmm . . . I was, eh, I was performing some type of mental exercise. It's kind of like a multiplication. Only it wasn't in my head, only it wasn't multiplication with numbers, it was like multiplication with concepts. I was taking concepts and putting them together and coming up with another concept. It was very abstract and, eh . . . and very nice (laugh). (Subject 17, REM Math Night 2, NREM Report.)
2. Mmm, (sigh) I was thinking about a mathematics text . . . textbook and the literal counterparts to, eh, some new kinds of thinking involved in basic operations. This time that subject came from thinking about, eh, from having an imaginative experience of of some American astronauts being up

and floating about and . . . coming in from all over etc., etc., etc. And having Walter Cronkite or somebody start explaining something that was going on with it. (Subject 9, NREM Math Night 2, REM Report.)

3. Everything that was going through my mind . . . (sigh) 699, 54, 199, 64, 160, . . . and 5 . . . eh hmmm . . . (sigh). [When asked about anything else going through his mind, subject continued.]
Everything that was going through my mind . . . I was . . . I was, eh, thinking about the, eh, paper that that's that was due last week for sociology and how I was working hard to get it done today and hand it in so I can get credits for the course. And I was really a hard time I had. (Subject 14, REM Math Night 3, NREM Report.)
4. I was playing mental games with numbers. Eh, not on a very sophisticated level I have to add but stuff like seeing numbers in highway signs, speed limits, interstate highway signs, eh, building numbers, eh, and room numbers, things like that. (Subject 9, REM Math Night 2, NREM Report.)
5. Um . . . I was with a friend of mine going to summer school and he's having trouble with physics and math in general and he, he has to, he has to write up

labs and he has to, should learn how to use the slide rule, he just won't practice, and he keeps forgetting how to use it. And I'm just too tired to just, I keep teaching him, he just doesn't practice . . . and so I'm gonna, I'm gonna try to get him to do, trying to learn something else. . . . (Subject 1, NREM Math Night 3, REM Report.)

6. Well I computed 32 times a, 6, I believe which came out to be 192, and what else did I do, I did another computation, I don't remember which one or the result was. Um, this is all I remember. [When asked about anything else going through his mind, subject continued.] No, no that's it, ah, ah, that's about it. Yes, I, I as a matter of fact, I'm in the middle of that. I thought that you asked me to do that computation 32 times 6 and I was about to ask you now I figured, gee, that's probably a dream since he's not bothering me about it, so I didn't tell you the result or anything like that. It was quite realistic as you see. Quite real. (Subject 13, NREM Math Night 3, NREM Report.)
7. I was thinking about numbers and realizing that I hate for them to take up any sort of majority space of time in my thinking. Especially from last night and tonight in the lab, numbers were beginning to go

through my mind too often. It puts me out a little bit. Ah . . . that was one thing and the other thing was an . . . I was thinking an . . . leaving, someone was leaving, maybe it went on a little while ago. It seemed to well, relieve a lot of tension I had felt today, and an maybe just the suggestion of a novel by ah . . . Hesse . . . seemed to smooth the day over a little bit. (Subject 18, REM Math Night 2, NREM Report.)

8. I was 23 and an 68, 68th, 92, 94, 96, 98, 98. Um hum, 92, 40, 42, 46, 48. (Subject 13, REM Math Night 2, NREM Report.)
9. Um, I didn't have any, um, dreams, so to speak, I had ah I was thinking about the stickiness that holds the wire to my hand, and ah ah you know also how you adjust for, um, how you, how you adjust for like a different food and different types of restaurants that as for rating restaurants 2, 3, 1 ah. (Subject 10, REM Math Night 3, REM Report.)

Category 2 Numerical Content

1. I was down at this swimming pool. I think it was the Columbia pool. And I was playing squash. Ah, my ball had just split in two and I was sort of pissed. I saw my neighbor coming up dressed in a bathing suit. He said, "Donald, surprise[d] to see you home. What are you doing here?" And I said "Oh I'm just practicing up for vacation." Then he asked me where the audio-visual resources room was. I said, "Yeah that's upstairs near the nursery. No it isn't. It's in the 3900 block of Henry Street." And, ah, we argued about this a little more and then put on our clothes and went off to look for the audio-visual room. (Subject 10, REM Math Night 1, REM Report.)
2. I would say it was a 50-50 split between reality and my creating a backdrop of reality. I would tend to fluctuate from one to another. No sooner start thinking about something really happening, when I would be drawn back towards the problem. Very guilty . . . social or a casual individual . . . [When asked about anything else going through his mind, subject continued.] Let's see. No, except that, eh . . . reporting an unreal most likely it was a 55, eh, old T-Ford coming into view so that

people on the avenue tend to have, eh . . . it's trying to, eh . . . the nature of this

(Subject 18, NREM Math Night 2, NREM Report.)

3. I was thinking about . . . I was thinking about, ah, I was thinking about later I have to go to work. I'm probably gonna um . . . probably gonna be a little late and ah . . . probably be getting out pretty early also . . . and like I have to kill like about three or four hours before I come back up here. I'm trying to figure out what I could do.

(Subject 1, REM Math Night 3, NREM Report.)

4. Yeah. I was trying to think . . . yeah, nothing was going through my mind. I was having a sort of, eh . . . Oh! I remember now. I was having, eh, eh . . . there was an image in my mind of two of my friends sitting in the living room discussing Catholic college, athletics. . . . I guess in a limited sense in my friends' room, I just got bored, and it kind of turned out in the living room watched television. . . .

(Subject 11, REM Math Night 3, REM Report.)

5. Um, um, I was really, uh, nothing really serious, I was reminiscing. Um, about my real childhood, like the ages of four or five to, uh, eight or nine or ten. (Subject 8, REM Math Night 1, NREM Report.)

6. Well, I was wondering at all these awakenings cause it seems like every, every, two minutes or something. Eh, and I was wondering that was, what was going on sort of. Eh, you know that is the main thing. I don't know if I had fallen back to sleep yet. I don't think so. I was sort of like still up now, and I was wondering why, why like, eh, you're coming in every two minutes or so. That's it. (Subject 3, Baseline Night 1, NREM Report.)

Historical Illustrations

It is of historical interest that Freud (1900/1965) presented fascinating accounts of the appearance of numbers and their meaning in dreams throughout his writings. He mentioned the superstitious belief in the link of numbers in dreams to predictions about the future¹ and the view of Mourly Vold (1896) about the relationship of dream production to the positioning of body parts, so that the appearance of numbers in dreams would be attributed to sensations in the fingers. He

¹A letter of Freud to Jung reveals Freud's own superstitious belief in the power of numbers. Around the time he wrote the Interpretation of Dreams he became obsessed with a newly assigned phone number, the digits of which he saw as prophetic of his life span. At age 43, he felt the phone number 14362 would indicate his death at 61 or 62. (Jung, 1965, p. 362)

discounted Stekel's assignment of "fixed symbolic meanings to numbers" in dreams because "these explanations seem neither sufficiently verified nor generally valid" despite their plausibility in "individual cases" (p. 393). Sharpe (1937) commented that numbers in dreams may be hard to analyze, but eliciting patients' "concrete associations" can help produce "valuable interpretations" about their meaning (p. 91). The number 180 in one dream she presented was interpreted as meaning "I ate nothing." In another dream, the number 4 was linked to a naked mother with four long braids (p. 92).

According to Freud the appearance of calculations, whether correct or incorrect, emanated from the dream thoughts, not the dream work. He believed "that the dream work does not in fact carry out any calculations at all, whether correctly or incorrectly; it merely throws into the form of a calculation numbers which are present in the dream thoughts and can serve as allusions" (p. 453). It is consistent with Freud's views to consider that in many of the mentation reports studied in this experiment the mathematical and numerical content entered subjects' dream thoughts as day, or more precisely, night residue material and

served as allusions for the personal material expressed.

Implications for Understanding Dream

Function and Formation

This research has demonstrated some of the ways in which the math and numerical content of this experiment filtered into sleep mentation. How does the evidence that a significant proportion of subjects' mentation reports on math nights represented aspects of this experience relate to an understanding of dream formation and function? The experiential aspects of the math requirements of the experiment, their representation in mentation, and alternative models of dream production must be examined.

It is assumed that the math experience, although seemingly neutral in itself, became stress-related for subjects as the experiment proceeded. While the initial anxiety generated by participation in the sleep experiment would tend to subside after several nights in the laboratory, the math requirements of the experiment repeated several times each night over six nights constituted a persistent demand for performance. It can be assumed that the math problems presented to subjects, while relatively simple in themselves, became

Herculean tasks as the experiment progressed--with new problems promptly presented on completion of the old and seemingly without end--as sleep deprivation and fatigue accumulated. For some subjects the arduous process of calculations seems to have become linked with a sense of powerlessness and helplessness about participating in the sleep experiment. Several reports demonstrated these concerns, along with the intrusion of mathematical content.

The production of these dreams can be understood in terms of a Freudian model of dream function. While some authors have been tempted to discard Freud's "safety valve" theory of the dream along with his "wish-fulfillment" theory, it has been demonstrated that many of Freud's views of the dream are consistent with and predictive of current physiological findings (Ellman & Weinstein, 1987, in press). It is consistent with a Freudian perspective to consider the mathematical content of this experiment the day, or night, residue material integrated into subjects' dreams both to express affective concerns and to allow some relatively undisturbed sleep.

The appearance in mentation of numerical content that seems to intrude upon the narrative of subjects' sleep reports can be understood in terms of findings

about the cognitive effects of stress. Horowitz and Becker (1971) have described a Zeigarnik effect for "involuntary repetitions" of stressful events in cognition (p. 419). Studies of people who have suffered the extremes of situational stress have documented the tendency towards persistent reliving of these traumatic events in REM and NREM sleep (Hefez, Metz, & Lavie, 1987). Other mentation reports which are comprised solely of calculations resembling those of the math awakenings may also be explained in terms of cognitive repetitions. The persistent performance of math computations when awakened may have served a rehearsal function in shaping the night's mentation.

Several authors have discussed the production of dreams in terms of the cognitive operations involved in information-processing (Dewan, 1968; Gaarder, 1966; Shapiro, 1967). According to these models, the mathematical content of this experiment would constitute wakeful input processed during sleep to aid processes of assimilation and adaptation. Thus, sleep reports in which the math and numerical content is embedded in the ongoing stream of cognition can be understood as attempts to both process the experience and facilitate adaptation to the experimental demands. Studies of the effects of REM deprivation (Greenberg &

Pearlman, 1974; Greenberg, Pearlman, Fingar, Kantrowitz, & Kawliche, 1970) have shown how in the absence of dreaming adaptation, defense, and learning are impaired. Breger's (1971) research presents evidence from a different perspective that dreaming is related to coping with stress. The results of learning experiments point to differences in the processing of emotional and neutral material during REM and NREM sleep. It has been shown that "REM sleep is important for memory of high association value and emotive material, whereas slow-wave sleep benefits retention of neutral material" (Grosvenor & Lack, 1984, p. 157). The expectation in the current experiment that consistent differences would be found in REM and NREM mentation in the occurrence of mathematical and numerical references on math nights was not confirmed. Such differences would have provided additional evidence of different modes of information-processing in these two stages of sleep.

Antrobus (1986) has applied another "computer-based model," Anderson's Active Control of Thought (1983), to the understanding of the cognitive processes involved in dream formation. As Antrobus describes it:

the cognitive system is continuously constructing events whether it has sensory input or not. If

the information in the sensory environment is sufficiently salient or has sufficient learned value to the individual, the processing resources of the cognitive system will be largely devoted to processing that sensory information. Otherwise the cognitive constructions may continue relatively independent of external sensory stimulation. (p. 199)

The notion of variations in salience or "value" of the math experience for individual subjects provides an alternative context for understanding why the intrusion of the mathematical experience occurred in the mentation of some subjects and not others. Freud's (1900/1965) hypothesis that recent experience would be incorporated in the dream narrative to the extent that it could become linked to unconscious excitations or wishes has not been subject to unequivocal proof. The attempt to predict the tendency to incorporate the math experience based on personality measures did not produce strong results in this study.

Analysis of the salience, value, and meaning of recent experiences as they are represented in dreams is a vital component of dream interpretation whether in the laboratory or clinician's office. The qualitative analysis of the mentation in this study has been

limited by the absence of information about subjects' associations to the math experience and particular elements of their dreams. The emphasis has of necessity been on the manifest content of the dream and the references to the math experience which recapitulate the mathematical and/or numerical paradigm of the experiment. While significant findings have been demonstrated involving concrete representations of the math experience, it is certain that the impact of this material extended deeper and further than the results indicate. The influence of recent experience on the dream is not confined merely to the reappearance in mentation of elements of recent activities or events (Berger, 1963; Cartwright, Bernick, Borowitz, & Kling, 1969; Castaldo & Holzman, 1967, 1969; Foulkes & Rechtschaffen, 1965; Koulack, 1969; Witkin & Lewis, 1965).

Several authors have attempted to enrich the analysis of sleep mentation gathered in the laboratory with clinical perceptions (Cartwright, 1974; Cartwright et al., 1969; Fisher, 1957, 1965; Offenkrantz & Rechtschaffen, 1963; Witkin & Lewis, 1965). Despite different perspectives, each of the major theories of human development includes a belief in the importance of dreams in dealing with psychological conflict or

disequilibrium. Some of these theoretical assumptions can now be assessed by using a psychological framework to design and interpret the results of stimulus incorporation studies.

Summary and Conclusions

This research has examined the effects of a recent mathematical experience on the mentation produced by twenty subjects during REM and NREM sleep over several nights in the sleep laboratory. After a series of adaptation nights, mentation produced on two baseline nights, three REM math nights, three NREM math nights, and a recovery night was evaluated. Incorporation of math and numerical content as well as representations of other aspects of the experiment in mentation were studied. The relationship of relevant dimensions of personality and cognitive style to the tendency to utilize math and numerical material in mentation was assessed. This investigation improved upon some of the methodological problems that have characterized previous work in terms of sample size, duration of observation, inclusion of normative data, and reliable measurement of incorporation effects.

The results indicated that a significant number of subjects' mentation reports were affected by the math

experience. The appearance of direct representations of the stimulus experience, that is, the actual use of mathematical content in mentation proved to be a more sensitive indicator of experimental effects than more indirect representations. Both the quantitative and qualitative analysis of the reports corroborated the impact of recent experience on the cognition of sleep. The design of this study enabled observations to be made about the penetration and persistence of incorporation effects on mentation. Within nights there was evidence to confirm that the influence of recent events is experienced to a greater extent in the early part of the night. Over the course of each series of math nights the experimental effects continued at about the same level. Only on the recovery night was there a significant decline in the expression of mathematical content in mentation.

Examination of subjects' reports revealed commonalities in the mode of representation of mathematical aspects of the experiment. It was found that subjects who incorporated mathematical content were also likely to incorporate other references to the experiment. The incorporation of this material was explained in terms of various models of dream function. This study did not demonstrate the differences in REM

and NREM mentation expected on the basis of differences in permeability and in the levels of thought of these two sleep stages; however, interesting dimensions for future investigation in this area were identified. While the personality data and cognitive measures included in the analysis did not produce strong correlations with the tendency to represent the math experience in mentation, recommendations were made for further assessment of the psychological characteristics involved in such effects.

During the last thirty years researchers have illuminated the neurophysiological bases of dreaming and have developed sophisticated cognitive models to explain dream process. The current study indicates the need for additional exploration involving the role of personality, the phenomenological aspects of experience, and the representational processes underlying the production of the dream. Only by integrating psychological analysis with contributions from the physiological and cognitive sciences can an understanding of the complex nature of the dream be achieved.

Bibliography

- Agnew, H. W., Webb, W. B., & Williams, R. L. (1967). Comparisons of stage four and 1-REM deprivation, 24, 851-858.
- Antrobus, J. S. (1977). The dream as metaphor: An information-processing and learning model. Journal of Mental Imagery, 2, 327-338.
- Antrobus, J. S. (1986). Dreaming: Cortical activation and perceptual thresholds. The Journal of Mind and Behavior, 7, 193-212.
- Antrobus, J. S., & Ehrlichman, H. (1981). The "dream" report: Attention, memory, functional hemispheric asymmetry, and memory organization. In W. Fishbein (Ed.), Sleep, Dreams, and Memory (pp. 135-144). New York: SP Medical & Scientific Books.
- Arey, L. B. (1966, March). First night dreams of normals, neurotics, and three groups of schizophrenics. Paper presented to APSS, Gainesville, FL (cited in Winget and Kramer, 1979).
- Arey, L. B. (1971, September). Dreams in reactive and process schizophrenics. Paper presented at APA Symposium on Process and Reactive Schizophrenia, Washington, D.C. (cited in Winget and Kramer, 1979).
- Arkin, A., & Antrobus, J. (1978). The effects of external stimuli applied prior to and during sleep on sleep experience. In A. Arkin, J. Antrobus, & S. Ellman (Eds.), The mind in sleep: Psychology and psychophysiology (pp. 459-484). New York: Lawrence Erlbaum Associates.
- Arkin, A., Antrobus, J., & Ellman, S. J. (Eds.), The mind in sleep: Psychology and psychophysiology. New York: Lawrence Erlbaum Associates.

- Arkin, A., Antrobus, J. S., Ellman, S. J., & Farber, J. (1978). Sleep mentation as affected by REMP deprivation. In A. Arkin, J. Antrobus, & S. J. Ellman (Eds.), The mind in sleep: Psychology and psychophysiology (pp. 351-391). New York: Lawrence Erlbaum Associates.
- Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye motility and concomitant phenomena during sleep. Science, 118, 273-274.
- Babcock, C. (1966). The manifest content of the dream. Journal of the American Psychoanalytic Association, 14, 154-171.
- Baekeland, F. (1971). Effects of pre-sleep procedures and cognitive style on dream content. Perceptual and Motor Skills, 32, 63-69.
- Baekeland, F., & Lasky, R. (1968). Effects of a stressful presleep experience on electroencephalograph-recorded sleep. Psychophysiology, 4, 367.
- Baekeland, F., & Lasky, R. (1968). The morning recall of rapid eye movement period reports given earlier in the night. Journal of Nervous and Mental Disease, 147, 570-579.
- Baekeland, F., Resch, R., & Katz, D. (1968). Pre-sleep mentation and dream reports. Archives of General Psychiatry, 19, 300-311.
- Baldrige, B. J. (1966). Physical concomitants of dreaming and the effect of stimulation on dreams. Ohio State Medical Journal, 62, 1271-9.
- Berger, R. J. (1963). Experimental modification of dream content by meaningful verbal stimuli. British Journal of Psychiatry, 109, 722-740.
- Bertini, M., Violani, C., Zoccolotti, P., Antonelli, A., & DiStefano, L. (1984). Right cerebral activation in REM sleep: Evidence from a unilateral tactile recognition test. Psychophysiology, 21, 418-423.

- Bokert, Ed. (1967). The effects of thirst and a related verbal stimulus on dream reports. Unpublished Doctoral Dissertation, New York University, New York.
- Bonime, W., & Bonime, F. (1962). The clinical use of dreams. New York: Basic Books.
- Bosinelli, M., Cicogna, P., Bianchi, A., & Reale, N. (1978). Experimental research on secondary revision process. Waking and Sleeping, 2, 195-199.
- Brojek, J., Guetzkow, H., & Baldwin, M. V. (1951). A quantitative study of perception and association in experimental semi-starvation. Journal of Personality, 19, 245-264.
- Breger, L., Hunter, I., & Lane, R. W. (1971). The effects of stress on dreams. Psychological Issues, 1, (3, Monograph 27).
- Brenman, M. (1954). Dreams and hypnosis. In R. B. Knight (Ed.). Psychoanalytic psychiatry and psychology: Clinical and theoretical papers (pp. 323-329). New York: International Universities Press.
- Bruner, J., & Postman, L. (1947). Emotional selectivity in perception and reaction. Journal of Personality, 16, 69-77.
- Byrne, D. (1961). The repression-sensitization scale: Rationale, reliability, and validity. Journal of Personality, 29, 334-347.
- Cartwright, R. D. (1974). The influence of a conscious wish on dreams: A methodological study of dream meaning and function. Journal of Abnormal Psychology, 83, 387-393.
- Cartwright, R. D. (1977). Night life: Explorations in dreaming. Englewood Cliffs: Prentice Hall.

- Cartwright, R. D. (1981). The contribution of research on memory and dreaming to a 24-hour model of cognitive behavior. In W. Fishbein (Ed.), Sleep, dreams and memory (pp. 239-247). New York: SP Medical and Scientific Books.
- Cartwright, R. D., Bernick, N., Borowitz, G., & Kling, A. (1969). Effect of an erotic movie on the sleep and dreams of young men. Archives of General Psychiatry, 20, 263-271.
- Cartwright, R. D., & Monroe, L. J. (1968). The effects of REM deprivation under two conditions. Journal of Personality and Social Psychology, 10, 69-74.
- Cartwright, R., Monroe, L. J., & Palmer, C. (1967). Individual differences in response to REM deprivation. Archives of General Psychiatry, 16, 297-303.
- Cartwright, R. D., & Ratzel, R. W. (1972) Effects of dream loss on waking behaviors. Archives of General Psychiatry, 27, 277-280.
- Castaldo, V., & Holzman, P. (1967). The effects of hearing one's own voice on sleep mentation. Journal of Nervous and Mental Disease, 144, 2-13.
- Castaldo, V., & Holzman, P. (1969). The effects of hearing one's own voice on dream content: A replication. Journal of Nervous and Mental Disease, 148, 74-82.
- Castaldo, V., & Shevrin, H. (1970). Different effect of an auditory stimulus as a function of rapid eye movement and non-rapid eye movement sleep. Journal of Nervous and Mental Disease, 150, 195-200.
- Cavallero, C., & Cicogna, P. (1983). Comparing reports of the same dream: Proposals for a structural analysis. Perceptual and Motor Skills, 57, 339-356.

- Cernovsky, Zack Z. (1984) Content of waking life events and of nightmare themes. Perceptual and Motor Skills, 58, 899-902.
- Chaves, J., & Barber, F. (1974). Cognitive strategies, experimenter modeling, and expectation in the attenuation of pain. Journal of Abnormal Psychology, 83, 356-363.
- Cicogna, P., Cavallero, C., & Bosinelli, M. (1982). Analyzing modifications across dream reports. Perceptual and Motor Skills, 55, 27-44.
- Cipolli, C., Dubois, D., & Salzarulo, P. (1975). In G. C. Lairy & P. Salzarulo (Eds.), The experimental study of human sleep (pp. 311-330). Amsterdam, New York: Elsevier Publishing Co.
- Clemes, S. R., & Dement, W. (1967). Effect of REM sleep deprivation on psychological functioning. Journal of Nervous and Mental Disease, 144, 488-491.
- Cipolli, C., & Salzarulo, P. (1975). Effect of a memory retrieval task on recall of verbal material obtained after awakening from sleep. Biological Psychology, 3, 321-326.
- Cohen, D. B. (1974). Presleep mood and dream recall. Journal of Abnormal Psychology, 83, 45-51.
- Cohen, D. B. (1974). Effect of personality and presleep mood on dream recall. Journal of Abnormal Psychology, 83, 151-156.
- Cohen, D. B. (1975). Neuroticism in the dream laboratory. Journal of Abnormal Psychology, 84, 93-108.
- De Koninck, J. M., & Koulack, D. (1975). Dream content and adaptation to a stressful situation. Journal of Abnormal Psychology, 84, 250-260.
- Dement, W. C. (1965). An essay on dreams: The role of physiology in understanding their nature. In F. Barron (Ed.), New directions in psychology, Vol. II (pp. 137-249). New York: Holt, Rinehart, & Winston.

- Dement, W. C. (1972). Some must watch while some must sleep. San Francisco: W. H. Freeman & Co.
- Dement, W. C., & Fisher, C. (1963). Experimental interference with the sleep cycle. Canadian Psychiatric Association, 8, 400-405.
- Dement, W. C., Kahn, E., & Roffwarg, H. P. (1965). The influence of the laboratory situation on the dreams of the experimental subject. Journal of Nervous and Mental Disease, 140, 119-131.
- Dement, W. C., & Kleitman, N. (1957). Cyclic variations in EEG during sleep and their relation to eye movements, body motility, and dreaming. Electroencephalography and Clinical Neurophysiology, 9, 673-690.
- Dement, W. C., & Wolpert, E. (1958). The relation of eye movements, body motility, and external stimuli to dream content. Journal of Experimental Psychology 55, 543-553.
- Dement, W., & Wolpert, E. (1958). Relationships in the manifest content of dreams occurring on the same night. Journal of Nervous and Mental Disease, 126, 568-578.
- Dewan, E. (1968). The p (programming) hypothesis for REMS. Psychophysiology, 4, 365.
- Domhoff, B., & Kamiya, J. (1964a). Problems in dream content study with objective indicators: I. A comparison of home and laboratory dream reports. Archives of General Psychiatry, 11, 519-524.
- Domhoff, B., & Kamiya, J. (1964b). Problems in dream content study with objective indicators: II. Appearance of experimental situation in laboratory dream narratives. Archives of General Psychiatry, 11, 525-529.

- Domhoff, B., & Kamiya, J. (1964c). Problems in dream content study with objective indicators: III. Changes in dream content throughout the night. Archives of General Psychiatry, 11, 529-532.
- Dorus, E., Dorus, W., & Rechtschaffen, A. (1971). The incidence of novelty in dreams. Archives of General Psychiatry, 25, 364-368.
- Ehrlichman, H., Antrobus, J., & Wiener, M. (1985). EEG asymmetry and sleep mentation during REM and NREM. Brain and Cognition, 4, 447-485.
- Ellman, S. J., Spielman, A. J., Luck, D., Steiner, S., & Halperin, R. (1978). REM deprivation: A review. In The mind in sleep: Psychology and psychophysiology (pp. 419-457). New Jersey: Lawrence Erlbaum Associates.
- Ellman, S. J., & Weinstein, L. (in press). REM sleep and dream formation: A theoretical integration. The mind in sleep: Psychology and psychophysiology. Volume II. New Jersey: Lawrence Erlbaum Associates.
- Erikson, E. H. (1954). The dream specimen of psychoanalysis. Journal of the American Psychoanalytic Association, 2, 5-55.
- Evans, F. J., Gustafson, L. A., O'Connell, D. N., Orne, M. T., & Shor, R. E. (1965). Verbally induced behavioral responses during sleep. Journal of Nervous and Mental Disease, 150, 171-187.
- Evans, F. J., Gustafson, L. A., O'Connell, D. N., Orne, M. T., & Shor, R. E. (1969). Sleep induced behavioral response: Relationship to susceptibility to hypnosis and laboratory sleep patterns. Journal of Nervous and Mental Disease, 148, 467-476.
- Fisher, C. (1957). A study of the preliminary stages of the construction of dreams and images. Journal of the American Psychoanalytic Association, 5, 5-60.
- Fisher, C. (1960). Subliminal and supraliminal influences on dreams. The American Journal of Psychiatry, 116, 1009-1017.

- Fisher, C. (1965). Psychoanalytic implications of recent research on sleep and dreaming. Part I: Empirical findings. Part II: Implications for psychoanalytic theory. Journal of the American Psychoanalytic Association, 13, 197-303.
- Fisher, C., & Paul, I. (1959). Subliminal visual stimulation and dreams. Journal of the American Psychoanalytic Association 7, 35-81.
- Fiss, H., Ellman, S. J., & Klein, G. A. (1969). Waking fantasies following interrupted and completed REM periods. Archives of General Psychiatry, 21, 230-239.
- Fiss, H., Klein, G. S., & Bokert, E. (1966). Waking fantasies following interruption of two types of sleep. Archives of General Psychiatry, 14, 543-551.
- Fliess, R. (1953). The revival of interest in the dream. New York: International Universities Press.
- Foulkes, D. (1962). Dream reports from different stages of sleep. Journal of Abnormal and Social Psychology, 65, 14-25.
- Foulkes, D. (1964). Theories of dream formation and recent studies of sleep consciousness. Psychological Bulletin, 62, 236-247.
- Foulkes, D. (1966). The psychology of sleep. New York: Charles Scribners & Sons.
- Foulkes, D. (1967). Dreams of the male child: Four case studies. Journal of Child Psychology and Psychiatry, 8, 81-97.
- Foulkes, D. (1982). A cognitive-psychological model of REM dream production. Sleep, 5, 169-187.
- Foulkes, D. (1985). Children's dreams, longitudinal studies. New York: John Wiley & Sons.

- Foulkes, D., & Rechtschaffen, A. (1964). Presleep determinants of dream content: Effect of two films. Perceptual and Motor Skills, 19, 983-1005.
- Foulkes, D., & Schmidt, M. (1983). Temporal sequence and unit composition in dream reports from different stages of sleep. Sleep, 6, 265-280.
- Foulkes, D., Spear, P. S., & Symonds, J. D. (1966). Individual differences in mental activity at sleep onset. Journal of Abnormal Psychology, 71, 280-286.
- Fox, R. P., Kramer, M., Baldrige, B. J., Whitman, R. M., & Ornstein, P. H. (1968). The experimenter variable in dream research. Psychophysiology, 4, 373.
- Frazier, R., McDonald, D. G., & Edwards, D. (1968). Discrimination between signal and non-signal stimuli during sleep. Psychophysiology, 4, 369.
- Freemon, F. R. (1972). Sleep research, a critical review. Springfield: Charles C. Thomas.
- Freud, S. (1900/1965). The interpretation of dreams. New York: Basic Books.
- Gaarder, K. (1966). A conceptual model of sleep. Archives of General Psychiatry, 14, 253-260.
- Gillin, J. C., Buchsbaum, M. S., Jacobs, L. S., Fram, D. H., Redford, B. W., Vaughan, T. B., Mellon, E., Snyder F., Wyatt, R. J. (1974). Partial REM sleep deprivation, schizophrenia and field articulation. Archives of General Psychiatry, 30, 653-662.
- Goodenough, D. R. (1963). Cyclical fluctuations in sleep-depth and eye-movement activity during the course of natural sleep. Canadian Psychiatric Association, 8, 406-408.
- Goodenough, D. R. (1967). Some recent studies of dream recall. In H. A. Witkin & H. B. Lewis (Eds.), Experimental studies of dreaming (pp. 129-147). New York: Random House.

- Goodenough, D. R., Lewis, H. B., Shapiro, A., Jaret, L., & Sleser, I. (1965). Dream reporting following abrupt and gradual awakenings from different types of sleep. Journal of Personality and Social Psychology, 21, 170-179.
- Goodenough, D. R., Lewis, H. B., Shapiro, A., & Sleser, I. (1965). Some correlates of dream reporting following laboratory awakenings. Journal of Nervous and Mental Disease, 140, 365-373.
- Goodenough, D. R., Witkin, H. A., Lewis, H. B., Koulack, D., & Cohen, H. (1974). Repression, interference, and field dependence as factors in dream forgetting. Journal of Abnormal Psychology, 83, 32-44.
- Greenberg, R., & Pearlman, C. (1974). Cutting the REM nerve: An approach to the adaptive role of REM sleep. Perspectives in Biology and Medicine, 17, 513-521.
- Greenberg, R., & Pearlman, C. (1975). REM sleep and the analytic process: A psychophysiological bridge. Psychoanalytic Quarterly, 44, 392-402.
- Greenberg, R., Pearlman, C., Fingar, R., Kantrowitz, J., & Kawliche, S. (1970). The effects of dream deprivation: Implications for a theory of the psychological function of dreaming. British Journal of Medical Psychology, 43, 1-11.
- Greenberg, R., Pillard, R., & Pearlman, C. (1972). The effect of dream (stage REM) deprivation on adaptation to stress. Psychosomatic Medicine, 34, 257-262.
- Grosvenor, A., & Lack. (1984). The effect of sleep before or after learning on memory. Sleep 7, 155-167.
- Hall, C. S. (1953). The meaning of dreams. New York: Harper and Bros.
- Hall, C. S. (1967). Representation of the laboratory setting in dreams. Journal of Nervous and Mental Disease, 144, 198-206.

- Hall, C. S. & Van de Castle, R. L. (1966). The content analysis of dreams. New York: Appleton-Century-Crofts.
- Hartmann, E. (1973). The functions of sleep. New Haven: Yale University Press.
- Hauri, P. (1968). Effects of evening activity on early night sleep. Psychophysiology 4, 267-277.
- Hauri, P. (1975), Categorization of sleep mental activity for psychophysiological studies. In G. C. Lairy & P. Salzarulo (Eds.), The experimental study of human sleep (pp. 271-307). Amsterdam, New York: Elsevier Publishing Co.
- Hawkins, D. R. (1966). A review of psychoanalytic dream theory in the light of recent psychophysiological studies of sleep and dreaming. British Journal of Medical Psychology, 39, 85-104.
- Hefez, A., Metz, L., & Lavie, P. (1987). Long-term effects of extreme situational stress on sleep and dreaming. American Journal of Psychiatry, 144, 344-347.
- Helson, R. (1971). Women mathematicians and the creative personality. Journal of Consulting and Clinical Psychology, 36, 210-220.
- Hobson, J. A., & McCarley, R. (1977). The brain as a dream state generator: An activation-synthesis hypothesis of the dream process. The American Journal of Psychiatry, 134, 1335-1348.
- Holzman, P. S., & Rousey, C. (1966). The voice as percept. Journal of Personality and Social Psychology, 4, 79-86.
- Holzman, P. S., Rousey, C., & Snyder, C. (1966). On listening to one's own voice: Effects on psychophysiological responses and free associations. Journal of Personality and Social Psychology, 4, 432-441.

- Horowitz, M. (1975), Intrusive and repetitive thoughts after experimental stress. Archives of General Psychiatry, 32, 1457-1463.
- Horowitz, M., & Becker, S. (1971). Cognitive response to stressful stimuli. Archives of General Psychiatry, 25, 419-428.
- Johnson, H., & Eriksen, C. W. (1960). Preconscious perception: A re-examination of the Poetzl phenomenon. Journal of Abnormal and Social Psychology, 58, 497-503.
- Jones, R. M. (1968). The psychoanalytic theory of dreaming. Journal of Nervous and Mental Disease, 147, 587-603.
- Jouvet, M. (1965). Paradoxical sleep: A study of its nature and mechanisms. Progress in Brain Research, 18, 20-57.
- Jung, C. G. (1965). Memories, dreams and reflections. New York: Vintage Books.
- Kales, A. (Ed.). (1969). Sleep. Physiology and pathology. Philadelphia: Lippincott.
- Kales, A., Hoedemaker, F. S., Jacobson, A., & Lichtenstein, E. L. (1964). Dream deprivation: An experimental reappraisal. Nature, 204, 1337-1338.
- Kennedy, W., & Walsh, J. (1965). A factor analysis of mathematical giftedness. Psychological Reports, 17, 115-119.
- Keith, C. (1962). Some aspects of transference in dream research. Bulletin of the Menninger Clinic, 26, 248-257.
- Knorrning, L. von, Jacobsson, L., Perris, C., & Perris, H. (1980). Reactivity to incoming stimuli and the experience of life-events. Neuropsychobiology, 6, 297-303.

- Koulack, D. (1969). Effects of somatosensory stimulation on dream content. Archives of General Psychiatry, 20, 718-725.
- Koulack, C. (1970). Effects of thirst on the sleep cycle. Journal of Nervous and Mental Disease, 151, 143-145.
- Kramer, M. (Ed.). (1969). Dream psychology and the new biology of dreaming. Springfield, IL: Charles Thomas.
- Kramer, M., Winget, C., & Whitman, R. M. (1971). A survey approach to normative dream content. American Journal of Psychiatry, 127, 86-92.
- Kubie, L. (1962). The concept of dream deprivation. A critical analysis. Psychosomatic Medicine, 24, 62-65.
- Labruzza, A. (1978). The activation-synthesis hypothesis of dreams: A theoretical note. American Journal of Psychiatry, 135, 1536-1538.
- Ladd, G. T. (1892). Contribution to the psychology of visual dreams. Mind, 1, 299-304.
- Lairy, G. C., & Salzaruolo, P. C. (Eds.). (1975). The experimental study of human sleep. Amsterdam, New York: Elsevier Publishing Co..
- Lasaga, J. I., & Lasaga, A. M. (1973). Sleep learning and progressive blurring of perception during sleep. Perceptual and Motor Skills, 37, 51-62.
- Lazarus, R. S., Eriksen, C. W., & Fonda, C. P. (1951). Personality dynamics and auditory perceptual recognition. Journal of Personality, 19, 471-482.
- Luborsky, L., & Shevrin, H. (1956). Dreams and day residues: A study of the Poetzl observation. Bulletin of the Menninger Clinic, 20, 135-148.
- Maier, N. R., & Ellen, P. (1959). The integrative value of concepts in frustration theory. Journal of Consulting Psychology, 23, 195-206.

- McCarley, R., & Hobson, J. A. (1977). The neurobiological origins of psychoanalytic dream theory. The American Journal of Psychiatry, 134, 1211-1221.
- McCarley, R., & Hoffman, E. (1981). REM sleep dreams and the activation-synthesis hypothesis. The American Journal of Psychiatry, 138, 904-912.
- McDonald, D. G., Schicht, W. W., Frazier, R. E., Shallenberger, H. D., & Edwards, D. J. (1975). Studies of information processing in sleep. Psychophysiology, 12, 624-629.
- Messick, S. (1967). Response styles and assessment of pathology. In D. N. Jackson (Ed.), Problems in human assessment (pp. 541-558). New York: McGraw Hill.
- Molinari, S., & Foulkes, D. (1969). Tonic and phasic events during sleep: Psychological correlates and implications. Perceptual and Motor Skills, 29, 343-368.
- Moss, C. S. (1967). The hypnotic investigation of dreams. New York: John Wiley & Sons, Inc.
- Moss, C. S. (1970). Dreams, images, and fantasy: A semantic differential casebook. Urbana: University of Illinois Press.
- Nakazawa, Y., Kotorii, M., Kotorii, T., Tachibana, H., & Nakano, T. (1975). Individual differences in compensatory rebound of REM sleep, with particular reference to their relationship to personality and behavioral characteristics. Journal of Nervous and Mental Disease, 161, 18-25.
- Offenkrantz, W., & Rechtschaffen, A. (1963). Clinical studies of sequential dreams. Archives of General Psychiatry, 8, 497-508.
- Orne, M. (1962). On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. American Psychologist, 17, 776-783.

- Oswald, I. (1962). Sleeping and waking. Amsterdam, New York: Elsevier Publishing Co.
- Oswald, I., Taylor, A. M., & Treisman, M. (1960). Discriminative responses to stimulation during human sleep. Brain, 83, 440-453.
- Palumbo, S. R. (1978). Dreaming and memory, a new information processing model. New York: Basic Books.
- Pearlman, C. A. (1970). Effect of stage REM deprivation upon latent learning. Psychophysiology, 70, 299.
- Pivik, T., & Foulkes, D. (1966a). "Dream deprivation": Effects on dream content. Science, 153, 1282-1284.
- Pivik, T., & Foulkes, D. (1966b). NREM mentation: Relation to personality, orientation time, and time of night. Journal of Consulting and Clinical Psychology, 37, 144-151.
- Rapaport, D. (Ed.). (1951). Organization and pathology of thought. New York: Columbia University Press.
- Rechtschaffen, A. (1978). The single-mindedness and isolation of dreams. Sleep, 1, 97-109.
- Rechtschaffen, A., & Foulkes, D. (1965). Effect of visual stimuli on dream content. Perceptual and Motor Skills, 20, 1149-1160.
- Rechtschaffen, A., Hauri, P., & Zeitlin, M. (1966). Auditory awakening thresholds in REM and NREM sleep stages. Perceptual and Motor Skills, 22, 927-942.
- Rechtschaffen, A., Verdone, P., & Wheaton, J. (1963). Reports of mental activity during sleep. Canadian Psychiatric Journal, 8, 409-414.
- Reding, G. R., Daniels, R. S., & Offenkrantz, W. (1968). A method for investigating the latent content of awakenings. Psychophysiology, 4, 387-388.

- Roffwarg, H., Bowe-Anders, C., & Tauber, E. (1978). The effects of sustained alterations of waking visual input on dream content. In A. Arkin, J. Antrobus, & S. J. Ellman (Eds.), The mind in sleep: Psychology and psychophysiology (pp.295-350). New York: Lawrence Erlbaum Associates.
- Salzarulo, P., & Cipolli, C. (1974). Spontaneously recalled verbal material and its linguistic organization in relation to different stages of sleep. Biological Psychology, 2, 47-57.
- Sampson, H. (1966). Psychological effects of deprivation of dreaming sleep. Journal of Nervous and Mental Disease, 143, 305-317.
- Sandler, J., Holder, A., & Dare, C. (1975). Frames of reference in psychoanalytic psychology. British Journal of Medical Psychology, 48, 161-174.
- Schonbar, R. A. (1959). Some manifest characteristics of recallers and nonrecallers of dreams. Journal of Consulting Psychology, 23, 414-418.
- Schonbar, R. A. (1965). Differential dream recall frequency as a component of "life style." Journal of Consulting Psychology, 29, 468-474.
- Schwartz, D. (1979). Reflective self representation, sleep, and dreams. Unpublished Doctoral Dissertation, City University of New York, New York.
- Shapiro, A. (1967). Dreaming and the physiology of sleep. Experimental Neurology, 19(Suppl. 4), 56-81.
- Shapiro, A., Goodenough, D. R., & Gryler, R. B. (1963). Dream recall as a function of method of awakening. Psychosomatic Medicine, 25, 174-180.
- Sharpe, E. F. (1937/1978). Dream Analysis. New York: Brunner/Mazel.

- Shevrin, H., & Fisher, C. (1967). Changes in the effects of a waking subliminal stimulus as a function of dreaming and non-dreaming sleep. Journal of Abnormal Psychology, 72, 362-368.
- Shevrin, H., & Luborsky, L. (1958). The measurement of preconscious perception in dreams and images: An investigation of the Poetzl phenomenon. Journal of Abnormal and Social Psychology, 56, 285-294.
- Shirley, A. W. (1970). The scientific status of psychoanalytic dream theory. British Journal of Medical Psychology, 43, 13-17.
- Singer, J. (1984). The private personality. Personality and Social Psychology Bulletin, 10, 7-30.
- Singer, D., & Antrobus, J. (1970). The Imaginal Process Inventory, City University of New York: New York.
- Snyder, F. (1963). The new biology of dreaming. Archives of General Psychiatry, 8, 381-391.
- Snyder, F. (1966). Toward an evolutionary theory of dreaming. American Journal of Psychiatry, 123, 121-142.
- Snyder, F., Karacan, I., Sharp, Van K., Jr. & Scott, J. (1968). Phenomenology of REMS dreaming. Psychophysiology, 4, 375.
- Sorokin, P. A. (1942). Man and society in calamity. New York: Dutton.
- Spear, N. E., & Gordon, W. C. (1981). Sleep, dreaming and the retrieval of memories. In W. Fishbein (Ed.), Sleep, dreams, and memory. New York: SP Medical & Scientific Books.
- Stark, S. (1966). Rorschach movement, fantastic daydreaming, and Freud's concept of primary process: Interpretive commentary. Perceptual and Motor Skills, 21, 523-532.

- Starker, S. (1973). Aspects of inner experience: Autokinesis, daydreaming, dream recall, and cognitive style. Perceptual and Motor Skills, 36, 663-673.
- Starker, S. (1974). Daydreaming styles and nocturnal dreaming. Journal of Abnormal Psychology, 83, 52-55.
- Starker, S., & Goodenough, D. (1970). Effects of sleep state and method of awakening upon thematic apperception test productions at arousal. Journal of Nervous and Mental Disease, 150, 188-194.
- Stross, L., & Shevrin, H. (1968). Thought organization in hypnosis and the waking state. Journal of Nervous and Mental Disease, 147, 272-288.
- Stoyva, J. M. (1965). Posthypnotically suggested dreams and the sleep cycle. Archives of General Psychiatry, 12, 287-294.
- Tart, C. T. (1965). Toward the experimental control of dreaming: A review of the literature. Psychological Bulletin, 64, 81-91.
- Trosman, H., Rechtschaffen, A., Offenkrantz, W., & Wolpert, E. (1960). Studies in the psychophysiology of dreams. IV. Relations among dreams in sequence. Archives of General Psychiatry, 3, 602-607.
- Tyson, P. D., Ogilvie, R. D., & Hunt, H. T. (1984). Lucid, prelucid, and nonlucid dreams related to the amount of EEG alpha activity during REM sleep. Psychophysiology, 21, 442-451.
- Ullman, M. (1958). Dreams and arousal. American Journal of Psychotherapy, 12, 222-244.
- Ullman, M. (1958). The dream process. American Journal of Psychotherapy, 12, 671-690.
- Verdone, P. (1965). Temporal reference of manifest dream content. Perceptual and Motor Skills, 20, 1253-1268.
- Vogel, G. (1975). A review of REM sleep deprivation. Archives of General Psychiatry, 32, 765-777.

- Vogel, G. (1978). An alternative view of the neurobiology of dreaming. American Journal of Psychiatry, 135, 1531-1535.
- Vogel, G, Foulkes, D., & Trosman, H. (1966). Ego functions and dreaming during sleep onset. Archives of General Psychiatry, 14, 238-248.
- Wallach, M. S. (1963). Dream report and some psychological concomitants. Journal of Consulting Psychology, 63, 549.
- Watson, R. & Rechtschaffen, A. (1969). Auditory awakening thresholds and dream recall in NREM sleep. Perceptual and Motor Skills, 29, 635-644.
- Weinstein, L. (1982). Individual differences in response to REM deprivation. Unpublished Doctoral Dissertation, City University of New York, New York.
- Weinstein, L., Schwartz, D., & Ellman, S. J. (in press). In J. Antrobus & S. J. Ellman (Eds.), The mind in sleep: Psychology and psychophysiology. Volume II New York: Lawrence Erlbaum Associates.
- Whitman, R. (1963). Drugs, dreams and the experimental subject. Canadian Psychiatric Association Journal, 8, 395-399.
- Whitman, R. M., Kramer, M., & Baldrige, A. B. (1963). Which dream does the patient tell? Archives of General Psychiatry, 8, 277-282.
- Whitman, R. M., Pierce, C. M., Maas, J. W., & Baldrige, B. J. (1962). The dreams of the experimental subject. Journal of Nervous and Mental Disease, 134, 431-439.
- Williams, H. L., Hammack, J. T., Daly, R. L., Dement, W. C., & Lubin, A. (1964). Responses to auditory stimulation, sleep loss, and the EEG stages of sleep. Electroencephalography and Clinical Neurophysiology, 16, 269-279.

- Willis, N., & Trinder, J. (1978). Influence of response criterion on the awakening thresholds of sleep stages. Waking and Sleeping, 2, 57-62.
- Winget, C. N., & Kramer, M. (1979). Dimensions of dreams. Gainesville: University Presses of Florida.
- Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., & Karp, S. A. (1962). Psychological differentiation. New York: Wiley.
- Witkin, H. A., & Lewis, H. B. (1965). The relation of experimentally induced presleep experiences to dreams: A report on method and preliminary findings. Journal of the American Psychoanalytic Association, 13, 819-849.
- Witkin, H. A., & Lewis, H. B. (1967). Presleep experiences and dreams. In H. A. Witkin & H. B. Lewis (Eds.), Experimental studies of dreaming (pp. 148-201). New York: Random House.
- Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Meisser, P. B., & Wapner, S. (1954). Personality through perception. New York: Harper & Row.
- Wood, P. B. (1962). Dreaming and social isolation. Unpublished Doctoral Dissertation, University of North Carolina, North Carolina (cited in Winget and Kramer, 1979).
- Zimmerman, J., Stoyva, J., & Metcalf, D. (1970). Distorted visual feedback and augmented REM sleep. Psychophysiology, 7, 298.
- Zimmerman, W. B. (1968). Psychological and physiological differences between "light" and "deep" sleepers. Psychophysiology, 4, 387.
- Zung, W. K., & Wilson, W. P. (1961). Response to auditory stimulation during sleep: Discrimination and arousal as studied with electroencephalography. Archives of General Psychiatry, 4, 548-552.