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Sleep: Physiology, Biochemistry, Psychology, Pharmacology, Clinical Implications.

The Induction of a Quasi-Dreaming Mental State
by Means of Flickering Photic Stimulation

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This paper is based on the assumption that EEG a-rhythm is concomitant with divergent thinking. This assumption is suggested here as an alternative to the usual assumptions that a-rhythm represents a lack of visual perception and of visual imagination, or a lack of arousal state. The theoretical considerations for this new assumption will be discussed elsewhere, where it will be shown that it accounts for most of the known empirical facts about the relationship between the appearance and disappearance of

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a-waves in the EEG records and the simultaneous mental states [Lewin, in preparation]. Among other facts, the occurrence of a substantial proportion of a-waves during dreaming and hypnagogic experiences [Dement and Kleitman, 1957a, b; Foulkes and Vogel, 1965; Johnson et al., 1969; Kleitman, 1963; Rechtschaffen and Kales, 1968] which is contradictory to both the non-visual and the non-arousal interpretations of a-activity, is quite in accord with our assumption in regard to divergent thinking. The term divergent thinking is used here following Guilford’s suggestions [1959], but also in a way similar to Neisser’s idea of ‘multiple processing’ [Neisser, 1963, 1966]. In extreme situations of divergent thinking many mental processes, relatively independent of each other, take place simultaneously and successively; there is no main stream of mental activity, and dominance randomly and quickly shifts from one mental process to another. Divergent thinking, thus conceived, constitutes one of the major aspects of dreaming and of hypnagogic experiences, as well as of ‘wild’ waking imagination.

The Manipulation of Brain Waves

The usual strategy for research into the relationship between a-brain waves and mental activity has been to manipulate the latter while using electrical brain activity as the dependent variable. In contrast, we tried here to treat brain waves as the independent variable and to measure the accompanying mental states as the dependent variable. In order to manipulate brain waves, we used flickering photic stimulations. It has long been known that flickering photic stimulation may induce frequency of brain waves which roughly corresponds to the flicker frequency [Adrian, 1947; Adrian and Matthews, 1943; Barlow, 1960; Barlow and Estrin, 1971; Durup and Fessard, 1935; Jasper, 1937; Loomis et al., 1936; Montagu, 1967; Toman, 1941; Vogel et al, 1969; Walker et al., 1944; Walter, 1963; Walter and Walter, 1949]. In our laboratory we have found that the same holds true also when the flickering stimulation is applied to a sleeping subject, provided that the light stimulus of the flicker is of appropriate intensity (intense enough to change brain waves but not to awaken the subject).

It was hypothesized that induction of a-like brain waves by photic flickering will enhance non-sequential, rich imagery in the waking subject, and produce dream-like mental activity in the sleeping subject.
Experiment I, Enhancement of Imagination

The purpose of this experiment was to compare the effect of photic stimulation of 10 flickers/sec (FPS) with that of other flicker frequencies, on imagination in the waking subject. The hypothesis was that a frequency of 10 FPS induces a-like brain waves which, according to our basic assumption, are most appropriate to divergent thinking. Under this condition, subjects who are engaged in imaginative story-telling will increase the quality, in wealth and originality, of their imagination and fantasy. Three other FPS frequencies were chosen for comparison: (1) 2 FPS, which is close to the so-called 8 brain waves; (2) 4 FPS, so as to approach ^-frequency, and (3) 26 FPS, as an average ^-frequency.

Materials and Methods

24 undergraduate students from the Department of Psychology at Bar-Ilan University were randomly assigned to the four different experimental conditions, i.e. 6 to each condition. Each subject participated twice in the experiment, the second session taking place approximately one week after the first. During the experiment, the subject lay down on a sofa with his eyes closed. In one session, the source of light (stroboscope) was placed about 20 cm above his eyes, emitting 88,000 cd blue-white light with a flash duration of 15 /xsec. In the other session, the flickering light was not administered. Half of the subjects, chosen at random, were given the flickering stimulation during their first session, and the other half during the second session. Each subject was asked to tell an imaginative original story for 5 min. A condition precedent for the first session was that the stories be set in the prehistoric period, while the second session stories had to be set some 2,000 years into the future. All stories were tape-recorded, then typed on separate sheets with code numbers, and evaluated by two independent ‘blind’ judges. Three elements were evaluated: activity, surprise and general quality of imaginative wealth.

Results

The evaluation averages for the flickering and non-flickering conditions for each experimental group in the three aspects evaluated are given in table I. An analysis of variance (flicker-non-flicker x order X flicker frequency x past-future) showed the interaction of flicker-non-flicker x flicker frequency to be significant beyond p < 0.05; t-tests revealed high significance for the differences between flicker and non-flicker of all three
aspects in the 10 FPS group to be highly significant.

Table I. Average evaluation scores, comparing the flicker to non-flicker conditions in 2, 4, 10 and 26 fps frequencies

As may be seen in the 2, 4 and 26 FPS sessions, the stories told in general have less activity, surprise and imagination than their control non-flicker session, while the 10 FPS session has more activity, surprise and imagination than the control group.

It is evident that the frequency of 10 FPS enhances the three imaginative and fantasy aspects, while with all other frequencies flicker in general reduces these indices.

Experiment II, Flickering and Retroactive Inhibition

This experiment was designed mainly to test the hypothesis that 10 FPS will induce a quite different mental state than will 2 FPS. This was done by relating flickering effects to the area of recall and forgetting. One of the major factors in forgetting is retroactive inhibition. The law of retroactive inhibition states that there is an impairment in the retention of one task (A) caused by the subsequent performance of another task (B); the impairment is the greater the more similar A and B are [McGeoch and Iron, 1952]. As flickering at 10 and 2 FPS is supposed to induce different mental states, it was hypothesized that the amount of recall of imaginative stories told under flickering photic stimulation at 10 and 2 FPS (all other things being equal) would depend on the flickering frequency during the time interval between cessation of the story-telling and the attempted recall. It was expected that the amount of recall would be less when the flickering frequency would be the same during the story-telling and the intervening interval.

Material and Methods

The subjects were 23 undergraduates of the Department of Psychology at Bar-Ilan University, who were randomly assigned to four experimental groups.

The subjects had to tell original, extemporaneous imaginative stories for 5 min. During the following 5 min, subjects performed various tasks, which were designed to
keep them busy and to ensure their concentration, so as to prevent their reflecting upon the stories just told. After the elapse of these 5 min, subjects were asked to recall the stories they had told. The flickering apparatus used was the same as in experiment I. The subjects lay down, with their eyes closed.

The experimental session was thus divided into three parts: (1) the general instructions and the story-telling; (2) the 5-min interpolated tasks, and (3) the recall. All subjects throughout the first and second parts were given flickering photic stimulation while no stimulation was administered during the third part. The flickering photic stimulation was either 10 FPS (designated ‘A’, i.e. a-frequency), or 2 FPS (designated ‘D’, i.e. 8-frequency). The frequency was either the same for the first and second parts, or varied.

We thus had four experimental groups: A in parts 1 and 2 (A-A), A in part 1, and D in part 2 (A-D), D in part 1 and A in part 2 (D-A), D in both parts (D-D).

The recording and scoring procedures followed were the same as in experiment I.

Results

The average percentage recall for each experimental group is given in table II. 2 x 2 analysis of variance shows a significant effect for the inter-

Table II. Mean percentages of recall as a function of flicker frequency during storytelling and during interpolating tasks

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action of the flickering frequency during the interpolated task (F = 5.252; d.f. = 1, 19; p < 0.05). It is evident from these data that recall is poorest when the flickering frequency is the same for the task (imaginative storytelling) and the interpolated activity. This supports the hypothesis that frequencies of 2 and 10 FPS induce different mental states.

Experiment III; Flickering in a-FPS and Dreaming

This experiment was designed to test the hypothesis that when subjects change from EEG stage 3 to a-activity while continuing to sleep, this change will be concomitant with dream-like mental experience. As a control stimulation, the 26-FPS frequency was used. The hypothesis was that the mental experiences would be similar during a-flickering, REM sleep and during EEG stage 1 sleep, whereas it would be different during 26 FPS frequency stimulation and stage 3 sleep.

Subjects
A questionnaire was handed to 30 Bar-Ilan University undergraduates, aged 20-24 years. Subjects were excluded from this experiment if they were light sleepers (awakened easily), if they claimed that they seldom dreamed (less than once per month), if they did not generally remember their dreams, or if they had a tendency to faint. According to these criteria, 13 subjects were selected. Of these, one subject who was found to wake every time the stroboscope started to flicker, even in its lowest intensity, was also excluded. Another three subjects were excluded from our final analysis, as our EEG frequency analyzer showed no effect of the stroboscopic stimulation. The data from 9 subjects were thus used for our final analysis.

Procedure

Each subject slept for three consecutive nights in our laboratory, while his EEG, EMG and EOG were recorded continuously. Electrodes were placed, and records analyzed, as recommended by Rechtschaffen and Kales [1968]. In addition, the information from the two EEG channels was continuously passed through an EEG frequency-analyzer (Nihon Kohden Induction of a Quasi-Dreaming Mental State 409

Kohden Kogyo, Model MAF-5) and recorded after every 5 sec of accumulation. The first night, for each subject, served the purpose of becoming adapted to the laboratory situation. On the other two nights, the stroboscope was set to flicker for 5 min, twice each night, in the course of the subjects’ recurring EEG stage 3 sleep. Each night, the subject was exposed to two flickering frequencies, one of 26 FPS and the other of his own a-frequency. Each night (except the first), the subject was awakened 6 times with a standard procedure and immediately was asked to describe his preceding mental experiences; his responses were tape-recorded. The awakenings occurred from the following stages:
1. EEG stage 1: either (a) 8-10 min after turning off the light at the beginning of the night sleep, or (b) 8-10 min after returning to sleep from one of the other experimental awakenings.
2. EEG stage 3.
3. EEG stage 3, immediately after stopping the flickering of 26 FPS.
4. EEG stage 3, immediately after stopping the flickering of a-FPS.
5. REM period.

The recorded mental experiences were then typed, each on a separately coded sheet. These sheets were submitted to two experienced ‘blind’ judges. The judges had to decide whether the experience resembled a dream or a hypnagogic experience, or whether it did not. Remoteness from the
immediate, real surroundings and bizarre and grotesque elements were some of the defining characteristics of dream and hypnagogic experiences.

Results

The percentage of experiences judged as dream-like was as follows: (1) awakening from stage 1, 85.0%; (2) awakening after a-frequency flickering, 92.9%; (3) awakening from REM, 85.0%; (4) awakening after 26-FPS frequency, 16.7%, and (5) awakening from stage 3, 25.0%. It is evident that flickering in the a-frequency shifts the mental state towards dream-like experiences, while flickering of 26 FPS does not.

Conclusion and Summary

A new interpretation concerning the psychological meaning of EEG a-activity is put forward, namely that a is concomitant with divergent thinking. Experimental support for this assumption was gained by manipulating brain-wave activity with flickering photic stimulation. The three experiments reported here clearly denote that flickering in the frequency of a-brain-waves changes the subjects' waking mental state, as well as the mental state of sleeping subjects who manage to stay asleep and yet respond in their EEG to the flickering stimulation. The various experimental controls show that the mental state of remoteness from a real immediate situation, 'wild' imagination, flexible and bizarre dream-like and hypnagogic-like experiences, are all the result, not of flicker stimulation per se, but of the specific a-frequency thus induced.

References


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