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## Electroencephalographic Changes during and after 14 Days of Perceptual Deprivation

Abstract. *A progressive decrease in frequencies in the alpha range was observed during 14-day exposure to unpatterned light and white noise. The electroencephalographic records were still abnormal 1 week later, and long-lasting motivational losses were observed.*

For several years researchers at the University of Manitoba have been studying the behavioral effects of 7-day periods of perceptual deprivation (*1*). Recently it was decided to extend the period to 2 weeks. It was considered important to obtain, first, some data on the electrical activity of the brain during isolation, particularly in the second week, as well as data for some days after termination of the period of isolation. Our report covers electroencephalographic changes in three individuals subjected to perceptual deprivation for this prolonged period.

Although there is a voluminous literature on the effects of sensory and perceptual deprivation, data on the electroencephalographic changes are almost nonexistent (*2*). In one of the McGill studies (*3*), electroencephalographic tracings for six subjects who were isolated from 3 to 6 days showed a progressive decrease in frequencies for the occipital lobe. Tracings taken 3½ hours after isolation still showed some signs of abnormality. Electroencephalographic records taken in the Manitoba studies also revealed a decrease in frequencies for the occipital lobe after 7 days of perceptual deprivation. These records showed that frequencies had not returned to normal 3 to 4 hours later (*4*). Finally, we have data on one subject isolated for 10 days. In this case the electroencephalographic activity was still abnormal 1 week after the end of isolation. It is of interest to note that this subject experienced a severe and long-lasting motivational loss (*1*). In the light of these meager but provocative findings, further research seemed warranted.

Three male subjects—two senior undergraduate students 21 and 22 years old, respectively, and a university professor 36 years old (subject C in Table 1)—were placed at different times in a dome-shaped isolation chamber for a period of 14 days. Toilet facilities, a food chamber, and an air-conditioning unit were provided within the chamber, making it unnecessary for the subject to leave for any reason during the isolation period. The only piece of furniture was an air mattress. Entrance to the chamber was through a double trapdoor in the floor, which also served as a food chamber. The behavior of the subjects was monitored at all times by means of an intercommunication and closed-circuit television system. The subject, wearing polo pajamas, lay on a mattress. He wore a pair of translucent goggles which reduced the level of ambient illumination from 90 to 20 ft-ca (under the goggles). He also wore a pair of special gloves to minimize tactual stimulation, and a set of earmuffs through which white noise, somewhat above the threshold of hearing, was constantly presented. He was not permitted to sing, hum, or engage in any other vocal activity. He was allowed to move about but not to exercise. Conversation over the intercommunication system was kept to a bare minimum; it occurred on the rare occasion when the subject did not adhere to certain restrictions, such as those against singing or humming. No psychological tests of any type were administered during the period of isolation. Each student was paid $300 for participating in the experiment. The professor was not paid. His incentive was scientific curiosity. There were no failures: the first three candidates selected successfully endured the prolonged isolation.

Electroencephalographic tracings were taken by an Offner type T, eight-channel machine. Records were taken before isolation and then during isolation at 7, 10, 12, and 14 days. At these specified times the electroencephalographer entered the chamber and attached a set of needle electrodes to the subject's skull. The entire intrusion lasted approximately 30 minutes. During this interval the white noise was shut off, but the subject continued to wear the goggles. Follow-up records were taken at 3 hours and at 1, 2, and 7 days after the end of the isolation period. In order to obtain a quantitative measure of the electroencephalographic changes, two types of analyses were

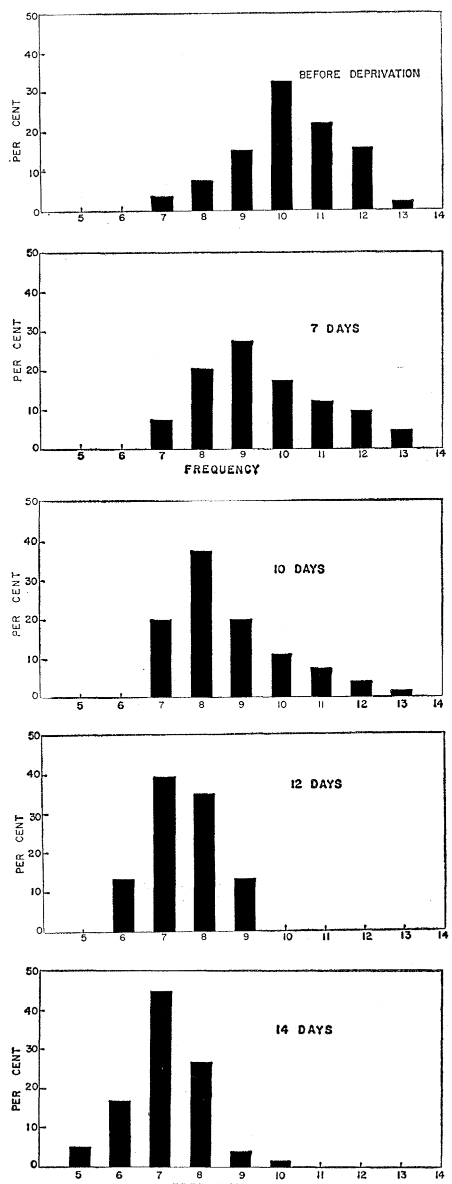


Fig. 1. Frequency spectrum for subject A before perceptual deprivation and at 7, 10, 12, and 14 days after the beginning of deprivation. The ordinate shows the percentage of time that waves of various frequencies appear in the occipital lobe tracings during a 300-second period.

made. In the first, the mean frequency for the occipital lobe was determined. This involved calculating the number of waves occurring in each of 300 1-second samples of artifact-free occipital lobe tracings. The second method involved a frequency spectrum analysis of the type suggested by Engel *et al.* (*5*). This consists of determining the percentage of time that a particular frequency (for example, 8, 9, or 10, waves per second) appears in the occipital lobe tracings during the total 300-second period.

Table 1 shows the mean occipital frequency for the subjects at various times during and after isolation. The picture is remarkably consistent for the three subjects. There is a progressive decrease in mean frequency during the course of isolation. This decrease, however, appears to have been more than twice as great during the second week as during the first. The postisolation records for the three subjects are also similar. They show a progressive increase in mean frequency during the first week after isolation. After 7 days the frequencies had still not returned to the pre-isolation levels; in all three cases they were within half a cycle of these levels. Figure 1 shows the changes in the frequency spectrum for subject A at various times during isolation. It can be seen that there is a progressive shift in the spectrum toward the lower end of the frequency scale. After isolation, as Fig. 2 indicates, this spectrum gradually shifts back to the higher frequencies. However, at the end of 7 days the frequency pattern is still unlike that for the pre-isolation period. The spectra for the other two subjects showed similar changes both during and after isolation.

Since subjects that have experienced isolation for 14 days are rare, some mention should be made of their subjective reactions. Data on these were obtained after isolation by means of a questionnaire, an interview, and diaries. Various precautions were taken to minimize the factor of suggestion. All three subjects reported intellectual deficits during isolation—inability to concentrate, difficulty in organizing their thoughts, and reduced motivation for thinking and reasoning. These deficits, contrary to what the electroencephalographic results suggest, did not appear to be accentuated during the second week. This discrepancy, however, may be due to the unreliability of the retrospective reports. Hallucinatory phenomena were almost totally lacking.

Table 1. Mean frequencies (waves per second) for the occipital lobe for three subjects at various times during and after 14 days of perceptual deprivation.

| Subject | During deprivation | | | | | After deprivation | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Day 0 | Day 7 | Day 10 | Day 12 | Day 14 | Hour 3 | Day 1 | Day 2 | Day 7 |
| A | 10.10 | 9.16 | 8.60 | 7.48 | 7.15 | 7.50 | 7.89 | 8.62 | 9.57 |
| B | 13.03 | 12.65 | 11.40 | 10.94 | 10.44 | 10.80 | 11.04 | 11.34 | 12.50 |
| C* | 11.56 | | 10.14 | 8.84 | 8.00 | 9.00 | 10.21 | | 11.01 |

*No encephalographic records were taken for this subject during day 7 of deprivation or on day 2 after deprivation.

One subject reported two instances of a "black dot racing across [his] field of vision." Another reported the occasional presence of "flickering pinpoints of light lasting from 10 to 15 seconds." All these occurred toward the end of the experimental period. Frequent references were made to repetitive auditory events noted throughout the entire 14-day period—birds chirping or singing, waves splashing, water dripping, and so on. These experiences, however, are believed to have been auditory illusions rather than hallucinations, since the subjects were not convinced of their reality and regarded them merely as distortions of the continually present white noise.

Upon emerging from isolation, none of the subjects reported any "profound and prolonged disturbances of visual perception" of the type mentioned in one of the McGill 6-day studies (*6*) (for example, warping and curving of lines, walls moving in and out, and gross changes in the size and shape of objects—effects which in some instances were present 24 hours later, as reported in the McGill study). Various objects were seen as much brighter and more vivid in color than usual, but they did not seem changed in size, shape, or movement. Although this absence of hallucinations and perceptual distortions is at variance with the McGill findings, the results are in agreement with those of the more recent 7-day deprivation experiments. In our earlier studies (*1*) and in studies of Ruff and Levy (*7*), hallucinations and postisolation perceptual distortions were rare. Furthermore, Cameron *et al.* (*8*) recently reported similar negative results in an individual subjected to perceptual deprivation for 16 days.

Certain dramatic and prolonged behavioral changes were observed, but they were of a motivational rather than a perceptual nature. After isolation, two of the subjects reported (in their diaries) severe motivational losses, which they described as "an inability to get started doing anything," a "loathing to do any work requiring even the slightest degree of physical or mental exertion," and "a don't-give-a-darn attitude toward everything." In one of the two subjects these symptoms lasted for 8 days; in the other, for 6 days. The third subject reported similar motivational losses but felt that he had completely recovered by the third day. It is interesting to note that the postisolation electroencephalographic record for this subject (C) was characterized by a greater initial degree of recovery than the records for the other two (see Table 1).

This study is based on a small

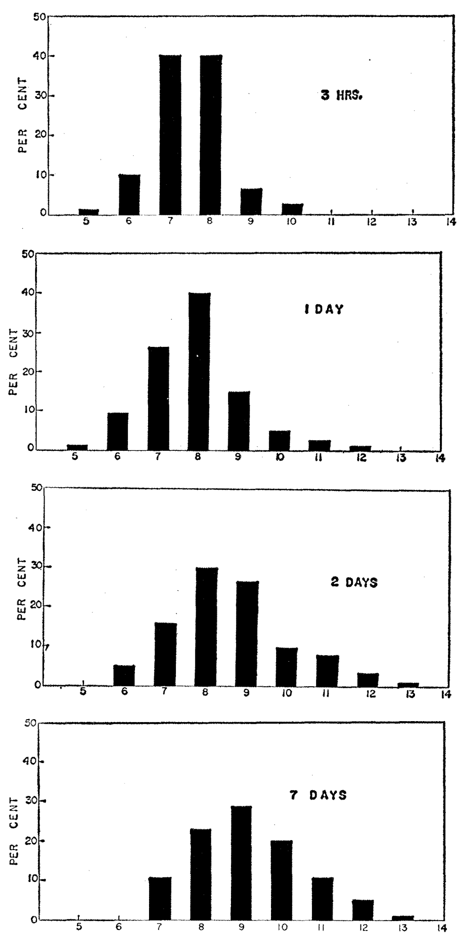


Fig. 2. Frequency spectrum for subject A at 3 hours and at 1, 2, and 7 days after the completion of 2 weeks of perceptual deprivation.

sample, it is true, but the results are remarkably consistent. They indicate that prolonged periods of perceptual deprivation can produce a considerable degree of disorganization of brain activity, with effects still discernible a week later. In the light of these results one can only wonder about the possible physiological and psychological state of prisoners of war and others who, in the past, have been isolated for months or even years (*9*).

JOHN P. ZUBEK
G. WELCH
M. G. SAUNDERS
*Department of Psychology* and *Faculty of Medicine, University of Manitoba, Winnipeg, Canada*

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## Anoxia: Tolerance in Reptiles

Abstract. *Measurements of the lengths of time various reptiles can continue to breathe in atmospheres of nitrogen have shown that turtles are several times more tolerant of these conditions than are other reptiles. The major correlate of this tolerance is taxonomic, rather than ecological.*

Turtles (species not stated) breathing pure nitrogen are able to survive for 27 hours at 20°C (*1*). The loggerhead musk turtle, *Sternothaerus minor*, can tolerate complete anoxia for over 12 hours at 22°C; in order to do so it must use anaerobic glycolysis (*2*). If adult mammals of the several species which have been tested breathe pure nitrogen, they die after about 5 minutes; newborn altricial mammals survive up to 50 minutes of this treatment (*3*). Hibernating hedgehogs (*Erinaceus*) tolerate 1 to 2 hours of anoxia, while active hedgehogs are killed in 3 to 5 minutes (*4*). Similar resistance has been noted in other hibernating mammals, and is probably related to their relatively low metabolic rate. Data on the ability of other amniotes to survive anaerobically are not available. It would be interesting to know the systematic and ecological distribution of this neglected physiological parameter, as well as its biochemical basis. Accordingly, I have been systematically cataloging the lengths of time various reptiles can tolerate anoxia, and to date have made measurements on about 400 individuals representing 17 families, 45 genera, and 70 species.

Each animal is kept in the laboratory at 22 ± 3°C and starved for at least 7 days before being used in an experiment. The photoperiod is approximately 15 hours. Each measurement is made in the following manner. The animal is sealed in a gas-tight chamber made of glass; this is then completely filled with oxygen-free water. The water in the chamber is immediately displaced with nitrogen (containing less than 0.001 percent oxygen), which is then passed through the chamber and exhausted at the rate of 250 $cm^3$/min for the remainder of the experiment. After an animal weighing more than 40 g has breathed nitrogen for about 2 minutes, the chamber is again flushed with water in order to expel exhaled oxygen. By means of a water bath, the temperature of the chamber and the animal contained therein is maintained at 22 ± 0.5°C. Under these conditions, all reptiles tested breathe the nitrogen freely, and in this manner all molecular oxygen is washed from their lungs, circulatory systems, and tissues. In control experiments in which air replaced nitrogen, none of the reptiles tested appeared to suffer any ill effects from the 90-second immersion in water. Each animal is observed visually during its exposure to nitrogen. When it has failed to breathe for a period more than five times the duration of the period between the preceding two breaths, it is removed from the chamber and can then usually be resuscitated by means of pulmonary inflation with oxygen. Tolerance time is defined as the period between the first and last breaths of nitrogen.

Results of these measurements are presented in Table 1. The most significant feature of these data is the presence of two distinct groups: one with a minimum tolerance time of more than 4.5 hours (usually about 12 hours), the other with a maximum tolerance time of less than 2.5 hours (usually about 45 minutes). The first group includes all the chelonians tested except the sea turtles, and the second group includes snakes, lizards, and crocodilians. The sea turtles (Cheloniidae) tested appear to be intermediate between these two groups. Thus, the major correlate of this trait is taxonomic, rather than ecological. Speculation concerning variation between the families within each of these two groups is unprofitable at this time because many families are as yet represented by only two or three individual measurements; intraspecific variation is great, so that some apparent differences may disappear when more data are collected. Two families, the Testudinidae and the Colubridae, are represented by samples containing a sufficient number of genera, species, and individuals to make an examination of the variation in and between the taxa within families worth while. Variation between genera appears to be no greater than variation between the species of a given genus. Intrafamilial variation between species shows no obvious correlation with habitat or ecology; tropical and boreal species show no consistent differences, nor do burrowing and diving species always appear to tolerate anoxia better than do terrestrial and arboreal ones. Within species, tolerance time exhibits a rough proportionality with the logarithm of body mass, seems unrelated to sex, and can be affected by the experimental animal's nutritive condition; animals starved for more than 2 months at 22°C tend to have smaller tolerance times than controls. Quiet individuals usually continue to breathe longer than excited ones. In contrast to newborn mammals,

Table 1. Tolerance times of various families of reptiles.

| Family | No. of species tested | Mean and range of species means (min) |
|---|---|---|
| | *Turtles* | |
| Kinosternidae | 5 | 876 (480–1140) |
| Chelydridae | 1 | 1050 |
| Testudinidae | 14 | 945 (495–1980) |
| Cheloniidae | 2 | 120 (114–126) |
| Trionychidae | 1 | 546 |
| Pelomedusidae | 2 | 980 (738–1218) |
| Chelidae | 2 | 465 (360–570) |
| | *Lizards* | |
| Iguanidae | 6 | 57 (22–79) |
| Gekkonidae | 1 | 31 |
| Teiidae | 1 | 22 |
| Scincidae | 4 | 25 (20–30) |
| Anguidae | 1 | 29 |
| | *Snakes* | |
| Boidae | 3 | 59 (41–61) |
| Colubridae | 22 | 42 (25–84) |
| Viperidae | 3 | 95 (64–118) |
| Elapidae | 1 | 33 |
| | *Crocodilians* | |
| Crocodylidae | 1 | 33 |