the occipital area of the cortex are systematically related to the luminance-duration product and therefore to the apparent brightness of the eliciting flashes. In addition, the latency of the response to the flashes appears to be related to the luminance of the flash independently of its duration.

J. D. WICKE
E. DONCHIN
D. B. LINDSLEY
Department of Psychology,
University of California, Los Angeles

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Nystagmus as a Criterion of Hypnotically Induced Visual Hallucinations

Abstract. *Hypnotized subjects who report hallucinating a visual situation which would ordinarily elicit optokinetic nystagmus demonstrate nystagmus under these conditions. They and control subjects are unable to feign nystagmus in the waking state, either by imagining the situation or by direct efforts to simulate the eye movements. Thus an objective criterion is provided for the presence of visual hallucinations.*

Many hypnotized subjects report visual hallucinations on appropriate suggestion (for example, seeing a bowl of fruit on a table when none is actually present). However, there are obvious limitations in relying on the subject's verbal report alone as evidence that he has indeed experienced such an hallucination. For this reason there have been many efforts, dating back to at least 1888 (*1*), to develop objective criteria to determine the genuineness of hypnotically induced perceptual changes. However, as pointed out recently (*2*), none of these procedures has offered conclusive evidence that hypnotic visual "hallucinations" are more real than "imagining" in the waking state.

Optokinetic nystagmus (rhythmical oscillations of the eyes with a slow and fast component) can be elicited in normal individuals by having them gaze steadily at a rotating drum which contains alternate, vertical, black and white stripes (optokinetic drum). It is considered an involuntary reaction to an appropriate visual stimulus (*3*). In human beings the presence of the striate cortex is necessary for its elicitation, and lesions of many areas of the cortex affect its characteristics (*4*). If hypnotized subjects are made to hallucinate such a situation, and their perceptions are similar to those that result from viewing the actual drum, they might be expected to demonstrate optokinetic nystagmus during such an hallucinatory experience.

From a large pool of volunteers, five subjects were selected who reported visual hallucinations on appropriate hypnotic suggestion and who ascribed a realness to their hallucinatory experiences that approached or equaled the realness of perceptions which result from viewing actual objects. Eye movements were recorded on these subjects under the following conditions. (i) The subject was instructed to watch the rotating drum for 1 minute. (ii) Hypnosis was induced and the subject was instructed to watch the rotating drum for another minute. (iii) The subject was instructed to close his eyes and was told that on reopening them, 30 seconds later, he would be able to see the rotating drum again. However, the drum was actually removed while his eyes were closed. Movements were recorded for 1 minute after he reopened his eyes. (iv) Finally the trance was terminated and eye movements were recorded for 5 minutes while the subject attempted to feign nystagmus in various ways. This included having the subject imagine the rotating drum with his eyes opened and closed. The subject was also instructed on the nature of the eye movements of nystagmus and he was permitted to observe nystagmus in a laboratory assistant who was watching the rotating drum. After this he made a direct effort to feign nystagmus.

Figure 1 shows samples of the electrooculogram of one subject (*5*). The top record is a random sample of the subject's eye movements in condition (i)—that is, watching the rotating drum. Clear nystagmus is seen during the entire 8-second sample, regular oscillation occurring with alternating slow and fast components. Condition (ii), watching the drum after the induction of hypnosis, gave the same result. The middle record is a random sample of the tracing during condition (iii), while hallucinating the rotating drum. Unmistakable nystagmus is present during 80 percent of the sample. The frequency of the nystagmus is similar to that obtained in condition (i) (three per second) but the average amplitude of the eye excursions is smaller and there is a reversal in the direction of the slow and fast components (the hallucinated drum seemed farther away and moved in the opposite direction to the actual drum). The bottom tracing, condition (iv), represents an effort of the subject to feign nystagmus in the waking state. Many different patterns of eye movements were seen in various attempts of the subject to simulate nystagmus (such as imagining the rotating drum, or imitating the eye movements). However, as in Fig. 1, nystagmus was seen in none of these tracings.

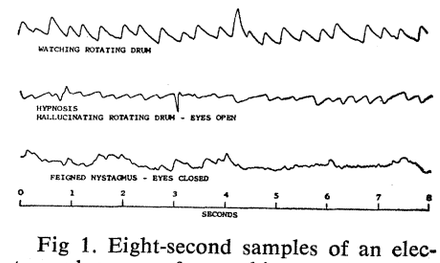

Fig 1. Eight-second samples of an electrooculogram of a subject under three different conditions.

The records of the other four subjects were similar, showing continuous nystagmus in conditions (i) and (ii), nystagmus during 50 to 90 percent of the tracings in condition (iii), and no nystagmus during condition (iv).

It is well known that volunteer subjects in hypnosis studies are highly motivated to meet the experimental expectations of the investigator (*6*), and additional control procedures were therefore required before valid inferences could be drawn from these experiments. For this reason 30 additional subjects were obtained who were unaware that experiments to demonstrate hypnotically induced hallucinations were in progress. These subjects were asked to feign nystagmus under various conditions to ascertain that the response was not obtainable in the waking state. None of the subjects showed nystagmus in the absence of the actual rotating drum. It was later found that 16 of these subjects could be hypnotized. The three subjects who reported seeing the rotating drum when it was suggested to them developed nystagmus under this condition. All remained unable to do so in the waking state.

The findings of these experiments have several implications. First, they demonstrate that an external visual stimulus is not necessary for eliciting optokinetic nystagmus. Second, they offer evidence that hypnotically induced visual hallucinations are "real" in the sense that they are capable of eliciting an involuntary reaction. Third, they suggest a means of studying hallucinatory phenomena, since a means is provided for verifying a subject's report that he is experiencing a visual hallucination.

JOHN PAUL BRADY
Department of Psychiatry,
University of Pennsylvania
School of Medicine, Philadelphia
EUGENE E. LEVITT
Department of Psychiatry,
University of Indiana
School of Medicine, Indianapolis

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Polonium-210 in Cigarette Smokers

Radford and Hunt's report [*Science* **143**, 247 (1964)] considered the bronchial epithelium as the critical organ in calculating the minimum dose from inhaled Po^{210} contained on particles of cigarette smoke. The mathematical model and assumptions used to make this calculation were not entirely evident in the report. The minimum dose estimate of 36 rem to bronchial epithelium as a result of smoking two packs of cigarettes per day over a period of 25 years far exceeds the dose of 1.1 rem to the entire lung as calculated from their data and the recommendations of the International Council for Radiation Protection [*Health Physics* **3**, 1 (1960)]. Because of the large difference in the minimum dose estimates, a comparison between Radford's assumptions and mathematical model and those of the ICRP is warranted.

Reference 16 of Radford and Hunt's report reads, "Dose [was] calculated on the basis of retention of 3.3×10^4 pc of Po^{210} in 25 years, a volume of the bronchial epithelium of 3 ml, and a mean transit time of the mucus sheet of 36 hours." This statement is confusing. Personal communication with Radford revealed that "retention" refers to the total quantity of Po^{210} deposited in the lung and not to the total quantity present at steady state. The value of 3.3×10^4 pc can be calculated from the product of the Po^{210} concentration in the main stream smoke, the number of cigarettes smoked in 25 years, and 75 percent deposition, with no correction for decay or biological elimination. The smoke particles are assumed to be deposited on the alveolar epithelium, from which they are phagocytosed and carried up the bronchial tree. In Radford and Hunt's calculation the bronchial epithelium is considered a single uniform sheet over which all the Po^{210} deposited in the alveoli passes with a mean residence time of 36 hours. However portions of the bronchial epithelium would in fact receive only that Po^{210} originating from alveoli connected to them. Mean exposure times and total quantity of Po^{210} passing over different segments of bronchial epithelium will be quite different and difficult, if not impossible, to calculate.

The ICRP recommends relative distributions of insoluble particles in the lung quite different from Radford and Hunt's. It is assumed that only 12½ percent of the total number of particles inhaled are removed from the lower respiratory passages in a short period of time. The ICRP recommendations indicate, therefore, that Radford and Hunt's dose estimate to bronchial epithelium might be too high by a factor of 8. The facts that a considerable quantity of smoke is exhaled and that many particles deposited in the alveoli remain there for a long period of time, as evidenced by the considerable amount of dust and soot found in the lung parenchyma of adults compared to the lungs of a new born child, indicate that Radford and Hunt's assumptions tend to overestimate the total quantity of Po^{210} passing over the bronchial epithelium, and hence to overestimate the dose. In reality probably neither Radford and Hunt's model and assumptions nor those of the ICRP actually describe the situation in the lung. However, it is important that present standards, such as those proposed by the ICRP, reflect not only our present state of knowledge but also safety factors where knowledge is lacking. Radford and Hunt's report indicates that there is Po^{210} in cigarette smoke and that there could be a harmful effect.

The report also implies that the recommendations of the ICRP with regard to distribution and fate of insoluble particles need revision. It is hoped that additional studies will be conducted to clarify this and many other points, so that the recommendations of the ICRP can be continued to be made on the basis of best knowledge available.

KENNETH W. SKRABLE
FRANCIS J. HAUGHEY
EDWARD L. ALEXANDER
Radiation Science Center,
Rutgers University,
New Brunswick, New Jersey

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