gram showed a single peak. The prominent peaks at 464 (M), 446 ($M-H_2O$), 431 ($M-H_2O-CH_3$), 428 ($M-2H_2O$), 348 ($M-C_6H_{12}O_2$), and 330 ($348-H_2O$) coincided with those of α-ecdysone.
11. α-Ecdysone from the peak in Fig. 1A, part c, was further purified by HPLC (*9*) and the radioactivity associated with the α-ecdysone fraction was determined. Identification was carried out by the methods described above (*10*).
12. The labeled unknown steroid was prepared by incubating prothoracic glands with [4- ^{14}C] cholesterol emulsified with Tween 80 in Wyatt's medium.
13. 3β-Hydroxy-5α-cholestan-6-one was synthesized by the method of E. A. Constantine and L. F. Fieser [*J. Am. Chem. Soc.* **76**, 532 (1954)]. The 5β isomer was prepared by treating the 5α isomer with 5 percent KOH in methanol for 1 hour. The 5β isomer was purified by use of a silicic acid column after several recrystallizations to remove the 5α isomer. The yield was less than 2 percent. The nuclear magnetic resonance spectrum ($CDCl_3$) showed the following shifts (parts per million): 0.64 [(C-18)H_3], 0.84 [doublet, J 5 hertz, (C-26/27)H_6], 0.89 [(C-19)H_3], 4.10 [multiplet, (C-3)H]. The retention times in GLC (1.5 percent OV-1, 180 cm by 4 mm inner diameter, 270°C) were 10.3 minutes for the 5β isomer and 11.8 minutes for the 5α isomer. Partial isomerization of the configuration at the C-5 position occurred in both isomers during GLC.
14. Thin-layer chromatograms were developed in three solvent systems: hexane and ethyl acetate (2:1), benzene and acetone (5:1), and chloroform and methanol (15:1). The R_F values of the 5α and 5β isomers were 0.16 and 0.21, 0.29 and 0.38, and 0.51 and 0.63, respectively.
15. The labeled unknown sterol was cochromatographed in HPLC with the 5α and 5β isomers and fractionated at each 0.5 minute. The conditions were as described above (*9*) except that the solvent system was CH_2Cl_2 and CH_3OH (99:1). Each fraction was analyzed by GLC to determine the amount of the 6-one, and the remaining part of each fraction was counted for radioactivity. The 5α isomer was eluted at 9.5 to 10.0 minutes and the 5β isomer at 8.0 to 8.5 minutes.
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17. α-Ecdysone was extracted and partially purified by TLC (*3*). The α-ecdysone region from TLC was submitted to HPLC (*9*) and fractionated at 1-minute intervals to determine the radioactivity.
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13 June 1977

Visual Association Cortex and Vision in Man: Pattern-Evoked Occipital Potentials in a Blind Boy

Abstract. *In a 6-year-old child who had been blind since the age of 2 years, occipital potentials of normal amplitude and waveform could be evoked not only by diffuse light flashes but also by alternating checkerboard and sinusoidal grating patterns of low spatial frequency. Computerized tomography demonstrated destruction of the occipital lobes except of the primary visual projection area. Thus, in man, destruction of visual association cortices may result in loss of vision with partial preservation of pattern-evoked occipital potentials.*

The mammalian visual cortex is divided into anatomically distinct primary and associative areas (*1*). In primates, the striate cortex (area 17) is the primary receiving area of the geniculo-cortical visual pathways (*2*). Prestriate "association" cortices (areas 18 and 19) are supposed to have cognitive functions (*3*). When, in the monkey, areas 18 and 19 are ablated while area 17 is spared, visual acuity and the ability to sort objects is preserved (*4*). Thus, in the subhuman primate, some aspects of vision may be mediated by area 17 independently of the association cortices. Whether this is true for the human is unknown.

It is believed that the evoked potentials (EP's) that result in humans from repetitive stimulation with grating or checkerboard patterns originate from the occipital cortex (*5*). Grating patterns have been used extensively in physiological studies of elementary aspects of information processing in the human and subhuman visual systems (*6*). These patterns are optimal stimuli for width and orientation-selective neurons of both primary and association areas of the visual cortex (*7*). The variation of EP's with parameters of grating stimuli parallels their psychophysically determined visual detectability in normals and many patients with cerebral lesions (*8*). Whether pattern-evoked potentials can validly be used for assessing the competence of all areas of the visual cortex of man, or only the functions of area 17, is unknown. An unusual combination of circumstances provided a rare opportunity to explore these questions concerning (i) vision in a human without the association cortices and (ii) the diagnostic use of EP's when the association cortices are damaged.

A boy was left deaf and blind after an acute febrile illness when he was 2 years old. When he was examined at the age of 6 years, hearing and motor coordination had apparently returned to normal, but vision had not: observation revealed a child depending entirely upon auditory, tactile, and kinesthetic cues in coping with and moving around in the environment. When walking in a fully lit room, the patient did not avoid any obstacles. In a dark room he did not localize bright light. There was no blink reflex to light or threatening movements. These findings were in marked contrast to the behavior of patients with cerebral blindness, who often say they cannot see, but nevertheless are able to avoid obstacles and sometimes detect the presence of an object if it is in motion (*9*). Reexamination 6 months later showed no change (*10*). He is blind.

Neuro-ophthalmologic evaluation revealed that his eyes moved conjugatedly in all directions of gaze. Reliable optokinetic nystagmus (OKN) could not be elicited (*11*). Convergence was noted when his own finger was moved in front of him by the examiner; no convergence was noted when any other object was shown to him. His fundi were normal. Electroretinography and occipital EP tests with flash stimuli (Fig. 1A) yielded essentially normal results (*12*). The electroencephalogram (EEG) showed alpha-range activity in the usual distribution during eye closure. Furthermore, and quite unexpectedly, EP's of normal amplitude and waveshape were obtained when he was placed in front of alternating coarse checkerboard (*13*) or alternating vertical grating patterns (*14*) (Fig. 1B). The responses were no longer seen when he turned his eyes away from the screen or closed his eyes. Evoked potentials were also unrecordable when the patterns were made finer (that is, higher in spatial frequency).

Computerized tomography (CT scan) of the brain demonstrated that the occipital lobes had been almost entirely destroyed. Some tissue had been spared medially, mainly or entirely to the left of the midline; this preserved tissue corresponded to part of the optic radiation and area 17, or striate cortex (*15*) (Fig. 2). Destruction of areas 18 and 19 appeared complete on the right, whereas on the left there was some tissue preserved. No lesions were demonstrable anterior to the occipital lobes.

The almost complete absence of areas 18 and 19 suggests that the pattern-evoked potentials that were recordable over the scalp originated from area 17 (*16*). However, the spared striate cortex that was apparently sufficient to generate recordable electrical signals was not sufficient for vision (*17*). This dissociation between physiological and psychological functions (*18*) may be consistent with the classical concept that the visual association cortices are essential for seeing in the human (*3*). It is not consistent with most animal data, including that from primates. In adult monkeys, complete ablation of areas 18 and 19 does not lead to complete blindness, although it does prevent learning to discriminate between visual patterns, apparently because the pathway from the primary visual projection cortex to the inferotemporal cortex is interrupted (*19*). One conclusion from the incompatibility of this case of complete blindness in a human with data from primates may be that there exists a crucial difference between species. However, another possible explanation should not be overlooked. It may be that in this boy damage of the association cortices occurred in a critical period (*20*), while in the monkey experiments this was not the case. Mishkin (*19*) suggests that the integrity of prestriate cortex, because it is the relay from striate to inferotemporal cortex, may be essential for "the acts of noticing and remembering an object's qualities"; also, via links with superior colliculus, pulvinar, or posterior parietal cortex (or all) it is essential for "perception of spatial relations." It is thus possible that our patient's complete inability to make any use of visual information resulted, not from an incomplete disruption of processes by which the spatial and temporal patterns of images are initially filtered by visual cortex, but rather from complete interruption in the sensitive period of efferent pathways essential for the subsequent processes by which any visual stimulus takes on meaning. The sensitive period for depriving the inferotemporal cortex of input is not known in any species. Our case suggests that relevant experiments could be performed by severing connections between the striate and inferotemporal cortex in young subhuman primates.

In conclusion, two inferences about human vision may be drawn from the present case: (i) in the absence of cortical areas 18 and 19, pattern-evoked potentials may be generated when area 17 is preserved and (ii) complete blindness may, nevertheless, result from the early destruction of areas 18 and 19, even when part of area 17 is preserved.

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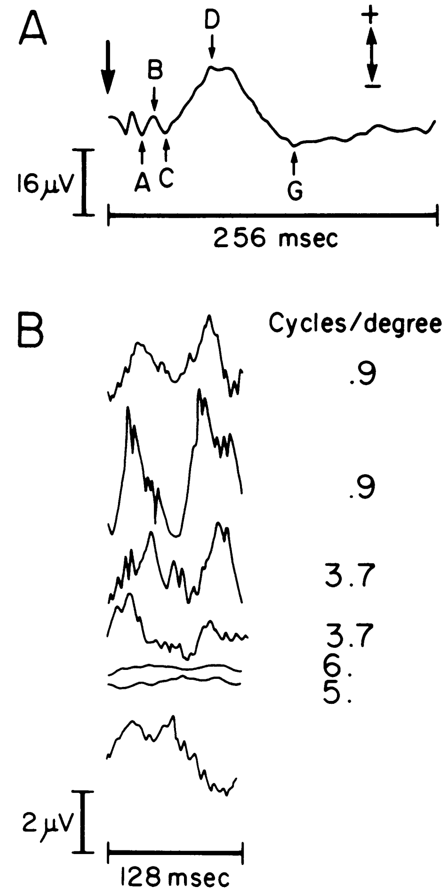

Fig. 1. Visual EP's recorded from a midline occipital scalp electrode placed 1 cm above the inion, referred to mastoid (earlobe) electrodes. (A) Response to single diffuse light flashes presented at the rate of 1 per second. The large arrow (upper left) indicates the time of flash. Flashes were presented to both eyes. Responses were amplified and monitored with a Grass P-7 polygraph, and averaged with a Nicolet 1070 computer. Upward deflection is positive. By the method of Rhodes *et al.* (*12*), successive peaks were labeled *A* to *G*. Amplitudes were: *A* to *B*, 5 μv (2 μv); *B* to *C*, 4 μv (16 μv). Latencies were: *A*, 60 msec (38 msec); *B*, 75 msec (52 msec); *C*, 90 msec (67 msec); *D*, 140 msec (105 msec); figures in parentheses are normal mean values (*12*). Thus, amplitudes were similar to those reported by Rhodes *et al.* (*12*) for older children, but latencies were greater. (B) Responses to high-contrast gratings, phase-alternated at 8 hertz [counterphase presentation, see (*14*)], at constant mean luminance. This steady state stimulus typically evokes a 16-hertz quasi-sinusoidal EP waveform—that is, two response cycles per cycle of stimulation. The 128-msec trace is the duration of one cycle of stimulation, and the typical response therefore appears as a "double hump." The patient was stimulated with gratings having the spatial frequencies indicated to the right of each trace. The first four traces show clear responses to spatial frequencies of 0.9 and 3.7 cycles per degree. (The uppermost trace is at half the gain of the others.) There were no detectable responses to gratings with spatial frequencies of 5 and 6 cycles per degree. The unlabeled bottom trace is the averaged waveform obtained while the patient was either looking away from the display or closing his eyes; this control waveform has a frequency apparently unrelated to that of the stimulus.

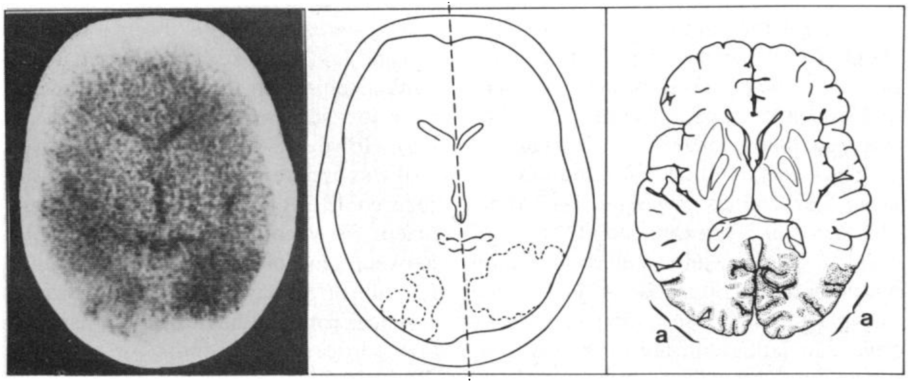

Fig. 2. A horizontal section through the patient's cerebral hemispheres, viewed by computerized tomography (CT scan), is shown on the left of the figure. The occipital lobes are at the bottom. Regions which absorb less x-radiation appear darker. Thus, dark areas represent tissue destruction. These areas are dotted in the center panel, which is a schematic representation of the CT section. The tissue near the midline (where most of area 17 is located) appears to have been relatively spared. At the right is a horizontal section following a standard neuroanatomy textbook (*15*), showing a level of the normal brain corresponding to that of the CT scan on the left of the figure. The primary and associative visual cortices are stippled. The braces labeled *a* indicate the approximate location and extent of the association cortices (areas 18 and 19) on the lateral surface of the hemispheres. The rest of the stippled region is primary visual cortex (area 17), located medially.

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9. See, for instance, I. Bodis-Wollner, *Electroencephalogr. Clin. Neurophysiol.* **42**, 178 (1977).
10. Recently placed in a training school for blind children, his learning of new motor and sensory skills has been rapid.
11. For OKN testing he was placed within a large drum. One observer reported a transient occurrence of three or four nystagmoid eye move-

ments at the onset of sustained drum rotation, but others were unable to detect any optokinetic response.

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15. CT scan was performed with an Ohio Nuclear scanner (256 by 256 element matrix). The normal brain section (horizontal section through midlevel of diencephalon) shown for reference on the right in Fig. 2 is redrawn after M. Roberts and J. Hanaway [*Atlas of the Human Brain in Section* (Lea & Febiger, Philadelphia, 1970), p. 49]. An approximation of the boundary between primary and secondary visual cortices was based on figures 289, 290, 293, 294, 296, 300, and 301 in S. Polyak, *The Vertebrate Visual System*, (Univ. of Chicago Press, Chicago, 1957). There is interindividual variability in the location of this boundary [see also G. S. Brindley, *J. Physiol. (London)* **225**, 1P (1972)].
16. It may be logically argued that pattern-evoked potentials in the present case were generated not in area 17 but in nonvisual (cortical or subcortical) areas. There is no experimental support for this supposition [see (*7*)]. The fact that only broadly striped patterns could elicit these potentials, not finer ones, is consistent with the concept of a nontopographically determined specific vulnerability of high spatial frequency channels in cerebral lesions. Cortical neurons with high spatial frequency optima may belong to a class functionally different from those with low spatial frequency optima [H. Ikeda and M. J. Wright, *Exp. Brain Res.* **22**, 363 (1975)]. Those with high spatial frequency optima might be especially vulnerable to hypoxia [I. Bodis-Wollner, *Nature (London)* **261**, 309 (1976)]. Another possible explanation is that the patient's high frequency loss was the result of a partial inclusion of the foveal projection of area 17 in the destroyed cortex.
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21. We thank Dr. A. M. Aron for making the neurological and behavioral evaluation, Dr. H. Nakagawa for interpretation of the CT scans, and H. Morgan and C. D. Morgan of Friendship Ambassadors, Inc., New York, for making these studies possible. Supported in part by NIH grants EY 01867 and EY 01708, and by the Clinical Center for Research in Parkinson's and Allied Disorders, NIH grant NS 11631-03.

24 May 1977; revised 26 August 1977

Fifty Centuries of Right-Handedness: The Historical Record

Abstract. *A survey of more than 5000 years of art works, encompassing 1180 scorable instances of unimanual tool or weapon usage, revealed no systematic trends in hand usage. The right hand was used in an average of 93 percent of the cases, regardless of which historical era or geographic region was assessed.*

It is common knowledge that contemporary man prefers to use his right hand when performing unimanual tasks; however, little evidence exists as to whether this has always been so. To embark on such an investigation is theoretically important because it could possibly elucidate the adequacy of competing explanations of the etiology of hand preference. Basically, there are two types of theories that attempt to explain the development of handedness in man. The first maintains that there are physiological predispositions, possibly heritable in nature, which lead to the favoring of one hand over the other (*1*). This position is supported by reports of familial similarities in handedness patterns (*2*). The second type of theory suggests that social or environmental pressures (or both) lead to the high incidence of dextrality in man. This position is supported by human and animal work that has attempted to alter limb preference through behavioral manipulations (*3*). The social pressure position is summarized by Wile (*4*) who stated: "There arose, not so much a decline in the hereditary presence of left-handedness but rather a suppression of it under the demand for adaptation to changing principles of social organization, preservation and advancement."

Given these different viewpoints, one might be led to different predictions about the distribution of handedness if it were measured at different points along the historical continuum. The social pressure theory would predict an increase in the percentage of human dextrality coincident with the development of more formalized societies with more complex patterns of tool use. In contrast, the physiological theory, which views handedness as being independent of these influences, should presume a relatively constant distribution of manual preference regardless of historical period measured. Unfortunately, these predictions are difficult to test since written references to the distribution of lateral preferences are rare. Perhaps the earliest quantitative account of handedness appears in the Bible, Judges **20** : 15-16, where 700 left-handed or ambidextrous men were counted against 26,000 right-handed individuals. Thus, this biblical population was 97 percent dextral. However, unhappily, such written reports are too rare to be useful in systematic investigations of the history of handedness. There are, however, other archival sources which can be used to assess historical trends in the distribution of manual preference. Nearly all cultures have art forms that depict human beings engaged in various activities. To the extent that such artistic efforts are an attempt to describe reality, one might expect that such drawings and paintings would mimic the distribution of hand use which the artist actually observed. If so, then manifestations of lateral preference in works of art could serve as a record of the handedness pattern within the culture which produced them. Although this has been suggested before (*5*), no systematic studies of handedness over the broad range of eras and cultures using this data base have as yet been attempted.

Table 1. Historical distribution of handedness as manifested by works of art.

Time	Sample size	Right-handed (%)
Pre 3000 B.C.	39	90
2000 B.C.	51	86
1000 B.C.	99	90
500 B.C.	142	94
~0 B.C.	134	97
A.D. 500	42	93
A.D. 1000	64	89
A.D. 1200	41	98
A.D. 1400	50	88
A.D. 1500	68	93
A.D. 1600	72	94
A.D. 1700	71	93
A.D. 1800	101	94
A.D. 1850	39	97
A.D. 1900	77	92
A.D. 1950	90	89
Summary	1,180	92.6

The history of manual preference was assessed from works of art from various cultures and times. More than 12,000 photographs and reproductions of drawings, paintings, and sculpture were examined. The earliest sample included was dated at approximately 15,000 B.C., the latest in A.D. 1950. Items were drawn from European, Asian, African, and American sources. Each plate or reproduction was examined for figures displaying a clear hand preference. Only unambiguous instances of unimanual tool or weapon use were scored. Instances of mirror image symmetry (such as are common in some urn patterns) were excluded from the sample. For