References and Notes

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2. C. Blakemore and G. F. Cooper, *Nature (Lond.)* **228**, 447 (1970).
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4. In this article, we will not attempt to provide a comprehensive literature review, but rather will focus on what we think are the important examples illustrative of the points we are trying to emphasize. In so doing, we concentrate on physiological studies of the development of cortical neuronal receptive field organization and of the effects of abnormal visual experience on binocularity and orientation specificity. For more comprehensive reviews of the effects of abnormal visual experience on neuronal physiology, see J. D. Pettigrew, *Ann. N.Y. Acad. Sci.* **228**, 393 (1974); C. Blakemore, *Br. Med. Bull.* **30**, 152 (1974); P. Grobstein and K. L. Chow, in *Development of Neural and Behavioral Specificities*, G. Gottlieb, Ed. (Academic Press, New York, in press). For a review of the effects of abnormal visual experience on anatomy, see R. W. Guillery, in *Essays on the Nervous System*, R. Bellairs and E. G. Gray, Eds. (Clarendon, Oxford, 1974).
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11. D. H. Hubel and T. N. Wiesel, *J. Physiol. (Lond.)* **160**, 106 (1962).
12. For studies on the small region of rabbit cortex containing binocular neurons, see R. Van Sluyters and D. L. Stewart, *Exp. Brain Res.* **19**, 196 (1974).
13. In practice, we place neurons in one of nine categories depending on their responses to visual stimulation. Of these categories, seven are well-defined receptive field types: uniform, concentric, motion, directional, simple, complex, and oriented-directional. For detailed descriptions, see (*10*). "Oriented-directional" has replaced the earlier name "hypercomplex" [see (*6*)]. Of the seven receptive field types, the last three require properly oriented linear contours for maximal response; they are here collectively termed "oriented." The first three do not require oriented stimuli and are here collectively termed "nonoriented." These collective terms have been adopted as a result of our recent deprivation studies (*7*) and differ respectively from the "asymmetric" and "symmetric" supercategories used earlier (*6*) only in that the directional receptive field type has been excluded from the former and is treated independently. The two remaining categories are "nonresponsive," meaning unaffected by visual stimulation, and "indefinite," meaning responsive to visual stimulation but too unpredictable to identify as one of the seven receptive field types.
14. T. N. Wiesel and D. H. Hubel, *J. Comp. Neurol.* **158**, 307 (1974).
15. ———, *J. Neurophysiol.* **28**, 1029 (1965).
16. Our intention in this analysis of the effects of long-term deprivation is to call attention to the possibility that they may represent in part delayed development rather than degradation of previously developed behavior. We wish to explicitly note, however, that in addition to delaying development, continued deprivation may subsequently cause degradation. Separation of these two effects may require a well-resolved temporal analysis of the percentages of the cortical neuronal population exhibiting various behaviors in binocularly deprived animals.
17. L. Ganz, M. Fitch, J. A. Satterberg, *Exp. Neurol.* **22**, 614 (1968).
18. There are two somewhat distinct ways that retardation of development could yield the observed results of monocular deprivation, that is, the virtual domination of neurons by one eye. They differ with respect to the fate of the binocularly activated neurons present before eye-opening. One possible interpretation is that these neurons are unaffected by the deprivation but that the hypothesized large population of nonresponsive neurons all develop inputs only from the open eye. The observed result would then be largely a sampling effect and should not be interpreted as deterioration. The other is that the developmental retardation puts the deprived eye at a disadvantage even in maintaining functional inputs to neurons it was once capable of activating. Because of the sampling problem, these are not distinguishable interpretations at present.
19. D. H. Hubel and T. N. Wiesel, *J. Neurophysiol.* **28**, 1041 (1965).
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21. There is a second difference between prism-reared animals and those with strabismus produced surgically by cutting one extraocular muscle. In the latter the animal's ability to produce coordinate movement of the two eyes has been reduced. Experiments over a range of prism displacements are needed to verify that it is the magnitude of the displacement which accounts for the difference between prism-reared and strabismatic animals.
22. J. D. Pettigrew, C. Olson, H. V. B. Hirsch, *Brain Res.* **51**, 345 (1973); D. N. Spinelli, H. V. B. Hirsch, R. W. Phelps, J. Metzler, *Exp. Brain Res.* **15**, 289 (1972).
23. At the April 1975 meeting of the Association for Research in Vision and Ophthalmology, M. P. Stryker and H. Sherk reported that, using somewhat different techniques for sampling neurons, they were unable to detect the effect reported by Blakemore and Cooper (*2*). Other laboratories have, however, observed the effect [see (*24*)]. A resolution for these contradictory results may be forthcoming in the near future.
24. R. R. Mize and E. H. Murphy, *Science* **180**, 320 (1973). Whether this reflects a qualitative difference between cats and rabbits has been thrown into some question by the report of failure to obtain effects of tube rearing in cats (*23*).
25. C. Blakemore, in *The Neurosciences: Third Study Program*, F. O. Schmidt and F. G. Worden, Eds. (MIT Press, Cambridge, Mass., 1974), pp. 105–113.
26. ——— and R. C. Van Sluyters, *J. Physiol. (Lond.)* **237**, 195 (1974).
27. R. W. Guillery and J. H. Kaas, *J. Comp. Neurol.* **154**, 443 (1974); S. M. Sherman, K.-P. Hoffmann, J. Stone, *J. Neurophysiol.* **35**, 532 (1972).
28. Van Sluyters and Stewart (*12*) have reported that, in binocular areas of monocularly deprived rabbits, the distribution of direction selectivities of neurons driven by the deprived eye is different from the distribution of neurons driven by the experienced eye or that obtained in a normally experienced animal. Because of slightly differing terminologies, many of the neurons included in their samples probably would qualify as orientation-specific in our classification scheme. We are reevaluating whether, in monocular cortical areas, there is an abnormal distribution of directional or orientation specificities.

29. We thank E. H. Murphy, P. C. Fox, and W. B. Kristan, Jr., for helpful discussion. We thank C. Bailey for secretarial assistance. This article grew out of research done while P. G. was an NIH postdoctoral fellow at Stanford University. Supported by PHS grants NS 18512 and EY 00691 and NASA grant NGR-05-020-435 to K.L.C.

NEWS AND COMMENT

Sakharov: Scientists Welcome Award of Nobel Peace Prize

Soviet physicist Andrei D. Sakharov achieved a form of secular sainthood on 9 October when the Norwegian parliament announced that he had won this year's Nobel peace prize. Reportedly, the Norwegians passed over an Indian nun, the International Boy Scouts, and a number of prime ministers in favor of Sakharov. After helping to develop the Soviet hydrogen bomb in the 1950's, Sakharov began a one-man campaign against nuclear testing, against the Cold War arms race, and in favor of individual liberties, activities which have incurred him the hostility of the Soviet authorities.

American scientists, many of whom when in Moscow pilgrimage to see him as a way of maintaining contact, reacted jubilantly to the news. They said it would strengthen Sakharov's international stature and protect him from further indignities.

"This is a great man," said Philip Handler, the president of the National Academy of Sciences, "His voice has spoken for all people." At the height of détente, in late 1973, Handler led the NAS in protesting an official Soviet anti-Sakharov campaign, despite the fact that official U.S. policy was to downplay what had been happening (*Science*, 28 September 1973).

Victor F. Weisskopf, former chairman of the physics department at the Massachusetts Institute of Technology, reacted with enthusiasm to word of the award. "I think it's wonderful that he got it. He does something for peace, you know. His constant preaching of openness, that only openness in every respect will bring peace, is wonderful. Openness is the credo of the scientific world as well."

Also delighted was Marvin Goldberger, chairman of the physics department at Princeton, which has invited Sakharov for a sabbatical but received no reply. Goldberger, a former high-level government defense consultant, says, "Sakharov has been a forthright and fearless opponent of the Soviet military industrial complex. He has fought for arms control and international cooperation . . . in the face of extreme pressures from his government. One can only hope that, in similar circumstances, one would be as brave."

The presentation of the award will prove a test of Soviet sincerity about the Helsinki accords, signed last summer, which are widely interpreted as pledging the Soviets to show greater respect for human rights, including the right of travel. The Soviet government may allow Sakharov to go to

Oslo for the award ceremony on 10 December—but it may not permit him to return.

"He won't go if he thinks it will be a one-way trip," says one of his American friends. Sakharov has often said it is his "mission" to remain in the Soviet Union permanently. This choice—made despite many invitations to teach abroad at prominent Western institutions—has led one Harvard professor to describe him as "a Christ-like figure" who goes out into the wilderness while others remain behind.

The aegis of Sakharov's Nobel comes at a time when other forms of protection for Soviet scientists are crumbling. Last week the Soviet Academy of Sciences, whose members have traditionally enjoyed a certain degree of political autonomy, celebrated its 250th birthday. According to news reports, party ideology dominated the proceedings; Mstislav V. Keldysh, who as the academy's president had preserved

Andrei Sakharov

some of its trappings of autonomy, resigned; Mikhail Suslov, a top party ideologue with no scientific credentials, gave the keynote address and announced who the new, "elected" president of the academy would be, astronomer Vladimir Kotelnikov. (However the election of the new president is expected to take place, as always, by a secret ballot among the members.)

To some American scientists, the Nobel will only enhance the glow around a man to whom the word "saint" has been applied for some time. Apparently both his Soviet and his American colleagues use the term, among other things because of Sakharov's habits of self-denial and personal frugality. One American notes his physical bearing; "He has an other-worldly quality. He is the opposite of the prototypal, temperamental Easterner. He is a slight person. He walks slowly. He is balding. . . .

"Considering some of the things he says he's very unexpressive with his voice and gestures. . . . And his general proposals sometimes seem to relate to the world after this."—DEBORAH SHAPLEY

Lie Detectors: PSE Gains Audience Despite Critics' Doubts

Ultimately, the PSE could affect human communication the way the development of the atomic bomb affected warfare.—International Moneyline, a newsletter.

The above agitated observation reflects the fascination felt in some quarters over a recently developed instrument called the psychological stress evaluator, or PSE. The PSE has become the first competition of the polygraph (or lie detector) since the latter was developed in the 1920's. Whereas a polygraph tests a subject's psychophysiological responses to questioning by measuring his or her respiration, blood pressure, and skin conductivity, the PSE registers stress by measuring certain inaudible modulations in the voice. Because it can be operated simply with the tape recording of a voice, "it is the first lie detector that can be used on a dead man," notes its inventor, Allan D. Bell.

The PSE has been the object of considerable attention and controversy and the subject of articles in *Playboy* and *Penthouse*, as well as publications aimed at law enforcement and security personnel. Its reliability as an aid to lie detection has come under attack—notably in a study commissioned in 1973 by the Army—and its versatility and simplicity have aroused ethical concerns because they give it a real edge over the polygraph when it comes to invading privacy.

The PSE was introduced a few years ago by Dektor Counterintelligence and Security, an adventurous little electronics company run by ex-Army sleuths who believe a man's reach should exceed his grasp. (Dektor was in the news last year, it may be recalled, for coming up with an ingenious counterexplanation for the 18½-minute gap in Rose Mary Woods' tape. See *Science*, 22 February 1974 and 21 June 1974.) The PSE was born in Allan Bell's basement. Bell, a retired Army intelligence officer who quit 5 years ago to form Dektor, says the search for a new way to measure stress was triggered by a market research assignment to come up with a way to measure the emotionality with which people answer questions by pollsters. Bell and the PSE's coinventors, Charles McQuiston and Bill Ford, set out to seek "identifiable emissions from the human body." Odors and voice were the best prospects, but odors are so numerous and easily dispelled or adulterated that they settled on the voice. They discovered that all muscles, including those controlling the vocal cords, vibrate slightly when in use, a phenomenon that is believed to be an involuntary function of the central nervous system. This is called the muscle microtremor and had already been identified, although the inventors didn't know it at the time—"we reinvented the wheel," says Bell. What was not known was that this tremor, which is transmitted to vocal cords, is suppressed by activity of the autonomic nervous system when the speaker is under stress. It is analogous, and may be directly related, to the suppression of the brain's alpha waves (which are associated with a relaxed waking state) when a person is making a conscious effort to think.

The PSE is more versatile than the polygraph because the subject is not required to be hooked up, immobile, to a machine, and, in fact, doesn't even need to be present; the analysis is made from a tape recording, and can be done on a tape made from a telephone conversation or a broadcast. In a lie detection situation the subject is asked the same carefully designed set of questions (innocuous "control" questions interspersed with significant ones) that are asked in a polygraph exam. The tape is then played back through the PSE—a portable affair ensconced in an inconspicuous black suitcase—at a speed four times slower than that at which it was recorded, and a needle on a moving graph chart plots the stress. If the waveform travels up and down erratically, the frequency modulation of the