SENSORY DEPRIVATION

By

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EXPLORATORY experimental work into the effects of sensory deprivation on human subjects has developed rapidly during the past decade and many reports have been published. It would appear to be necessary, however, to pause for a moment and to review the work which has so far been executed with a view to facilitating the systematic investigation of this phenomenon.

The general importance of sensory deprivation can hardly be over-emphasized in view of the devastating psychological/psychiatric effects of its application, from which many believe we may obtain clues concerning the development of both normal and abnormal mental states. Clarke and Clarke, for instance (4) argues that extreme isolation (and consequent sensory deprivation) can, and usually does result in permanent severe intellectual impairment. Bruner (3) makes reference to the "need for variable sensory stimulation as a condition for maintaining a functioning organism" and also to "a need for continuing social contact and stimulation". Harris (10) argues that the exposure of schizophrenic patients to sensory deprivation will shed light on the nature of this illness. These, and other writings (Solomon *et al.*, 21) present cases and examples which testify to the potential value of deprivation studies in general.

Experimental studies of sensory deprivation have used three main experimental techniques. The first, initiated by Hebb and his associates (II) employed the technique which has come to be known as "The Reduction in Patterning". In this type of investigation the subject is restricted to an environment in which variations in sensory stimuli are reduced as far as possible. Thus the subject may be required to lie on a couch or bed in a specially prepared room which may be soundproof and lightproof. He may wear translucent goggles, permitting the entry of light but allowing no pattern vision, and his ears may be plugged with cotton wool. His arms and hands may be enclosed in a cardboard tube. In this way variations in the auditory, visual, or tactual spheres are minimized.

The second deprivation technique owes its existence to Lilly (13) and has been named the "Reduction of Absolute Intensity". It aims at reducing the absolute intensity of all ingoing stimuli. In a typical experiment in this category, a subject will be placed in a tank of water which is slightly below body temperature. He is enabled to breathe by wearing a lightproof mask through which air is pumped. By use of this technique the majority of ingoing sensations are reduced to a minimum.

The third technique has been named "The Structuring of Stimuli" and makes use of the tank type of respirator used for patients with poliomyelitis (Mendelson, 14). Subjects who are undergoing this experience have their arms and legs encased in cardboard cylinders and lie on a specially-built mattress placed inside the respirator. The motor of the respirator produces a dull repetitive auditory stimulus and the subject's area of vision is considerably reduced.

It should be noted in passing that these three techniques are not mutually exclusive, and the distinctions between them are far from clear. For instance, in reducing the absolute intensity of all ingoing stimuli we are, *ipso facto*, reducing

the patterning of these stimuli. Also, in some instances, there seems to be very little difference between the "Structuring of Stimuli" technique and that of reducing patterning. These three techniques would appear to represent three ingenious attempts to deprive subjects of their normal sensory experiences rather than three logical and complementary attempts to manipulate subjects' environments in such a way as to produce maximal information.

All investigators, using any of these three techniques, have invariably reported that their subjects found the experience to be quite a devastating one. Solomon's review (21) presents a fairly general account of this experience as reported by a large number of volunteers.

The present review attempts to systematize the experimental findings, to point out some of the shortcomings, and to make constructive suggestions regarding future experimentation. With at least three techniques at present at our disposal, with a growing number of experimentalists, and with a diversity of interests it is only too easy to see how the field could develop unsystematically over the next ten years, producing very few more facts than we have at present.

I—Work With Normal Subjects

(i) *Studies of Cognitive Changes*

The first study is that by Bexton, Heron and Scott (2) at McGill University. In this study 22 male college students experienced the Reduction of Patterning type of deprivation for two to three days. Intelligence test results given before, during and after the deprivation experience showed inferiority of performance during the isolation period when compared with a control group. This impairment was found to disappear soon after the termination of the experience.

Vernon and Hoffman (23) studied the effect of sensory deprivation on learning rate in human beings. They used essentially a Reduction of Patterning technique although not identical with that of Bexton, Heron and Scott. Using experimental and control subjects (college students) and word lists as criteria of learning, they demonstrated that the ability to learn these lists improved with continued sensory deprivation. This improvement declined to normal levels by 48 hours after confinement. Vernon and Hoffman point out that the discrepancy between this result and those reported by other workers may be due to differences in confinement conditions between the studies. Also the number of subjects used by Vernon was only four.

Wexler *et al.* (27) using a Structuring of Stimuli technique placed 17 males in a tank type respirator for periods up to 36 hours. They concluded that their subjects showed distortions in judgment of the time spent in the respirator, the amount of distortion being proportional to how soon the volunteers asked to be removed from the isolation experience. It is difficult to accept this conclusion in the absence of control data, particularly as the subjects were told beforehand that the experiment would last up to 36 hours. From their table, the five subjects who were able to remain in the respirator for the agreed 36 hours were remarkably accurate in judging how long they had been in!

Scott, Bexton, Heron and Doane (19) carried out a further study explicitly designed to investigate the cognitive effects of perceptual isolation, using a similar technique to that employed earlier. They used two batteries of tests, one given during the isolation period, and one afterwards. The first set of tests (the cubicle battery) had two parts: A, five types of problems from a variety of intelligence tests, and B, association learning, digit span, and analogies. The tests in part A were given before, during, and after the isolation experience,

and those in part B were given shortly before the subject left isolation. The tests in the cubicle battery were given orally. The tests in the "post cubicle" battery comprised Koh's blocks, digit symbol, Thurstone-Gottschaldt figures, transcribing a passage of unfamiliar technical material, the McGill picture anomaly test and a further block design test. Twenty-nine college students served as subjects, and 27 students acted as controls. The results indicated that the experimental conditions produced some deterioration in performance on tests of cognitive ability while the subjects were in isolation and after they emerged. However, the difference between the groups did not increase as time went on. The authors suggest that this absence of progressive deterioration might have been due to the experimental design.

To conclude this section on cognitive changes, there is some evidence that cognition is impaired under some conditions of deprivation. It is not possible to formulate these conditions explicitly, although Vernon puts forward the suggestion that in the Bexton, Heron and Scott study the subjects developed hallucinations which may have been in part responsible for their impaired mental performance. It could equally well be due to the perceptual changes. It would appear to be relatively easy to sort out the relation between deprivation conditions and cognitive functioning particularly as the latter has been adequately systematized. Such sorting out is not likely to be achieved, however, if a miscellany of tests are given to a miscellany of subjects in a miscellaneous manner at the whim of the experimenter.

(ii) *Perceptual Changes*

In this section we will deal with those perceptual phenomena which have been investigated, excluding hallucinatory experiences which will be dealt with separately.

The study by Bexton, Heron and Scott reported a variety of perceptual changes immediately following deprivation experience. Subjects reported an inability to focus, inability to perceive their environment in three dimensions, and supersaturation of colours.

In a more detailed study by Doane *et al.* (5), thirteen tests of visual perception were administered to 13 students after four days of perceptual isolation. They also included further tests of somaesthetic perception and spatial orientation. A further group of subjects experienced visual isolation but were not restricted in any other way. Twenty normal controls were used, and all subjects were tested before and immediately after the isolation experience. The main findings were that tests of Figural After Effects, of size constancy, of acuity, autokinetic, colour adaptation, shape constancy, and after-movement were significantly affected. The tests not affected were those of Critical Flicker Frequency, Phi Phenomenon, Brightness Contrast effects, Brightness constancy, Necker Cube reversals, and Tachistoscopic perception. In respect of the tests of somaesthesis and spatial orientation, there was a statistically significant improvement in the two point limen, deterioration in the Tactual form discrimination test, and impairment in spatial orientation. In summarizing these results the authors conclude that "the results from the visual tests indicate that the most prominent effects are a decrease in the constancies, and an increase in the after-effects of stimulation. . . . Size constancy is markedly reduced, and shape constancy probably reduced". Although this study is probably the most comprehensive one into the effects of sensory deprivation on perceptual processes it suffers from a number of defects resulting

from the apparent desire on the part of the investigators to obtain as much information as is humanly possible. The usual result from such a study is that the conclusions are, at best, indicators for further research. In this study, as the authors themselves admit, as the test battery took about an hour to administer, the tests which were placed at the end of the battery may have suffered less from the effects of sensory deprivation than the tests appearing earlier, although it is not possible to test this hypothesis from the data derived in this study as no control of test sequences was made.

Vernon and McGill (25) determined thresholds for electrically induced pain in eighteen male subjects, nine of whom were then exposed to four days of sensory deprivation, while nine acted as controls. They found that the pain threshold for the confined group decreased significantly after deprivation. The threshold for the non-confined group did not drop significantly over the same period. They thus concluded that sensory deprivation produced a significant lowering of thresholds for electrically induced pain.

(iii) *Hallucinations*

Although most investigators have reported that subjects undergoing deprivation experience hallucinations of one sort or another, these reports generate more problems than they have solved.

In one of the earlier investigations by Bexton, Heron and Scott (2), all subjects experienced hallucinations, which were predominantly visual or auditory. Vernon and Hoffman (23) in their preliminary study were unable to reproduce these findings and suggested that the differences in the confinement conditions were in part responsible for the divergent results. They pointed out that in the former study the subjects were experiencing amorphous visual stimuli (through translucent goggles) together with a repetitious masking noise. The subjects in the Vernon study on the other hand received very little visual and auditory stimulation. The hallucinations might therefore have been *generated* by the amorphous stimuli in the McGill study.

A more thorough investigation into visual hallucinations during perceptual isolation was carried out by Vernon, McGill and Schiffman (24). They classified hallucinations into Type I (flashes of light, flickering light, etc., which lacked shape), Type II (geometrical hallucinations—squares, circles, etc.) and Type III (highly structured integrated scenes). Two types of confinement were used, Phase I being of minimum severity, Phase II of maximum severity. The incidence of hallucinations was determined in a post-confinement interview. Their results indicated that Phase I conditions produced many more hallucinations than did Phase II, i.e. the confinement which permitted more sensory stimulation produced more hallucinations. There was also a relationship between length of confinement and number of hallucinations, with a slight increase in hallucinations as the length of confinement increased. There were no hallucinations of Type III reported in this study. In comparing these results with those reported from McGill in which Type III hallucinations were obtained, Vernon *et al.* attributed this to differences in the confinement conditions, i.e. in the McGill work the subjects were confined for longer periods and wore translucent goggles in an illuminated room. They conclude that confinement which allows no visual stimulation produces a minimum of hallucinations. Confinement permitting a slight amount of light stimulation may produce Type I and Type II hallucinations, while confinement permitting a great deal of visual stimulation but not pattern vision produces the greatest number and the

greatest variety of hallucinations, and that the longer the confinement the greater the probability of hallucinations regardless of confinement conditions.

Doane *et al.* (5) in their investigation of perceptual function above, report an incidental aspect of their study. Of the eleven subjects who wore a translucent mask, eight developed hallucinations. Of the two who wore opaque masks one developed hallucinations, but when they were given the translucent mask both had vivid hallucinations. This result suggested that exposure to diffuse light may have been responsible for the hallucinations. Subsequently five subjects who were persistent hallucinators when wearing the translucent mask were put in complete darkness. Within two hours there was a decrease in hallucinations, which returned on re-exposure to diffuse light, thus supporting the findings of Vernon *et al.*

(iv) *Suggestibility and Susceptibility to Propaganda*

Increases in suggestibility following sensory deprivation were reported by Bexton, Heron and Scott (2).

In a later publication, Scott, Bexton, Heron and Doane (19) assessed the effects of deprivation on susceptibility to propaganda. A group of normal subjects were subjected to perceptual isolation and a recording was played. These subjects proved to be more susceptible to propaganda than did a control group of subjects who did not have the perceptual isolation. This result could have been due, as the authors point out, to the fact that whilst only four of the 35 controls wanted to hear the record more than once, 16 of the 24 experimental subjects asked for repetitions. They argue, however, that this in itself could be attributed to experimental isolation, i.e. the isolated subject would like to hear the record more than would the control subject. It would be of interest to determine precisely how much of the increase in susceptibility to propaganda was due to the larger number of presentations of the record and how much to isolation *per se*.

(v) *Physiological Changes*

Physiological changes have been assessed by a few investigators.

Shurley (20) using a Reduction of Patterning technique reported a general tendency for pulse, respiratory rate, and blood pressure to drop moderately, and for body temperature to increase slightly, following deprivation, although exceptions were noted.

Doane *et al.* (5) attached EEG leads to their experimental subjects throughout their deprivation experience and reported significant EEG changes accompanying the experience. No detail, however, is given.

(vi) *Deprivation Tolerance*

The relation between a subject's ability to tolerate deprivation and other variables has been studied by Petrie *et al.* (15). These investigators employ the concept of "satiability" in which perceptual intensity diminishes after prolonged stimulation with a stronger stimulus. Satiability has been shown to be a general trait independent of the sense modality used, and individual differences in satiability have been shown to exist (Wertheimer (26)). There is also some evidence that susceptibility to satiation may be related to introversion-extraversion (Eysenck and Nichols (6)). Petrie suggests that pain tolerance is related to susceptibility to satiation and inversely to sensory deprivation tolerance. The results of her experiment support this suggestion.

In a further experiment (16) the same authors report further evidence that pain tolerance is related positively to satiation and negatively to deprivation tolerance and point out that satiation may be responsible for these findings.

In a third paper (17), concerned with psychological aspects of pain, Petrie presents her general findings in the following manner, using satiability as her central concept. Briefly, there is a tendency for some people to reduce the intensity of a perception subjectively after they have been stimulated further. This type of person she calls the Reducer. The Augmenters on the other hand, when stimulated by objects will have their perceptions enlarged. The Reducer's ability to tolerate pain, however, becomes a handicap in a situation in which environmental stimulation is minimal. In this case the Reducers can be expected, and have in fact been shown, to render them intolerant of confinement and sensory deprivation.

As a result of probable sex differences in the satiability of women relative to men, in which women have been shown to reduce less than men, Petrie in the same paper, makes the predictions that women will tolerate deprivation better than men, and that hallucinations and other effects of confinement will be less pronounced in women. These predictions await experimental testing, and this work would appear to have important implications for all investigators into the sensory deprivation field.

II—Work with Abnormal Subjects

There is, as yet, comparatively little work done in this field.

Azima and Cramer (1) subjected fourteen psychiatric patients of mixed diagnoses to a reduction of patterning technique specifically to gain some information about the therapeutic value of the disorganization-reorganization sequence of the psychic events and about the problem of depersonalization and body scheme. Two sets of changes occurred, disorganization and reorganization. Azima and Cramer suggest that the disorganization state can be therapeutically manipulated in such a way as to lead to reorganization according to planned patterns.

Harris (10) concluded that his group of twelve schizophrenic subjects who underwent a Reduction of Patterning deprivation technique tolerated the experience remarkably well and showed reduction in the intensity of their hallucinations.

Gibby *et al.* (9) subjected thirty psychiatric patients of mixed diagnoses to sensory deprivation, and employed a symptom rating scale. The main aim of this study was to produce beneficial changes in these patients. They concluded that positive changes for the whole group considerably outnumbered the negative changes although a wide range of individual differences was found, and that the results strongly suggested previously unsuspected psychotherapeutic possibilities of sensory deprivation methods. A control group, which would appear to be of prime importance to a study such as this, was not included.

Studies of the therapeutic efficiency of deprivation techniques cannot be expected to produce definitive results unless control groups are included in the design. In reviewing published drug trials Foulds (7) revealed that therapeutic success was claimed in 85 per cent. of studies not using control groups but in only 25 per cent. of those using control groups.

III—Discussion

It would appear, from the above, that much work has been done, and comparatively little achieved. The fact of the existence of three separate

deprivation techniques suggests that the aim is to produce deprivation effects at all costs rather than to investigate systematically the conditions under which deprivation effects appear, and those under which they disappear. It is perhaps worth noting that the excellent work of Vernon derived from the "accidental" finding that his subjects did not show the deprivation effects which had previously been produced by Bexton, Heron and Scott earlier.

Before the results of deprivation experiments can profitably be used either to throw light in normal brain function or abnormal mental states it would appear to be vital to investigate systematically and scientifically, the variables relevant to deprivation effects. These variables are both numerous and diverse, and, in the hope that future research may benefit, some of them can be listed as follows:

(i) *The Selection of Subjects*

Whether subjects are normal or abnormal, whether male or female, whether young or old and whether volunteers or conscripts and so on are variables which cannot be overlooked. Although the effects of these variables may be only slight in some cases, it is not possible to ignore them as if they had no relevance. We have already noted Petrie's prediction of a sex difference, and no doubt many more differences will eventually come to light. Also stemming from Petrie's work is the suggestion that extraverts will tolerate deprivation less and be more disturbed by it than will introverts. Whether the effects so far reported will apply to other subjects whose motivation may differ has yet to be demonstrated.

(ii) *Pre-Deprivation Experience*

The subjects having been selected, what precisely are they told, or, what are they told before they volunteer? Do the subjects know why they are doing it, are they to be paid by the hour, do they know how long they will be in the apparatus, can they terminate the experience at will and so on. Experimenters cannot be blamed for briefing their subjects beforehand, nor can they be excused for presuming that how much their subjects are told will have little effect upon the results produced. It has become commonplace to relate experimental work of this kind to the experience of shipwrecked mariners, or Arctic explorers, but there is surely an enormous difference between being shipwrecked in the Atlantic with little hope of survival and volunteering for an experiment in a research institute.

(iii) *The Deprivation Experience*

Here the possibly relevant variables are innumerable.

(*a*) The type of deprivation experience. We have already noted three. No doubt more will follow. It should not be too difficult to work in terms of the senses which are to be manipulated and the amount of manipulation of each. We noted earlier the probable relation between amount of visual stimulation and presence or absence of visual hallucinations. The same could also apply to hallucinations in the other sense modalities.

(*b*) The duration of the experience has already been shown to be important in the production of visual hallucinations. It has also been shown not to be related to the degree of intellectual impairment. This variable would appear to require intensive investigation.

(*c*) It would appear to be likely that a terminable deprivation experience will produce effects differing from one which is not terminated at will. It is not impossible in this connection that panic attacks for example will be less frequently seen when the subject cannot escape the situation. Although this variable will create enormous difficulties for the investigator, its effects must be known.

(*d*) Many experiments permit short periods of thirty minutes or so every few hours so that the subject can attend to feeding and toilet needs, while in others the deprivation experience is continuous. There is no study reported so far in which the continuity-discontinuity of the deprivation experience has been adequately assessed. Testing during isolation, important as it is, also has the effect of rendering the experience discontinuous.

(*e*) Of tremendous potential importance is the accessibility of the experimenter during the subject's isolation. It must surely matter, as Shurley's subject remarked, to know that the experimenter is actively observing the subject throughout the experiment.

(iv) *Post-Deprivation*

All effects or findings in the post-deprivation period must be related to the length of this period. It is astonishing how few experimenters report at what time since the termination of the experience the tests were given. As most effects clear up within a few hours it is hardly sufficient to say that such and such tests were given after the subject came out. Of some importance here is the environment to which the subject returns. It is rare for this to be reported at all.

In general, the time would appear to have come when it is no longer necessary to devise new deprivation techniques, to subject people to them and to write up what they say afterwards. Such preliminary work must give way to systematic research designed to investigate specific problems which have already been thrown up. Until these problems are solved it is extremely unlikely that a satisfactory explanation of the phenomena will appear.

One important omission in all this work has been the failure to distinguish between *sensory* and *social* deprivation, deprivation of the sensory type has usually included social deprivation as well. As has been seen in Solomon's review, social isolation *per se* is capable of producing devastating effects such as hallucinations, delusions, depression, and anxiety. Freedman (8) goes as far as to suggest that in sensory deprivation experiments, hallucinations, delusions, depersonalization, and changes in body image are the results of social rather than sensory isolation, the latter being responsible for visual and perceptual effects. This distinction is clearly an important one requiring much further work, and may have particular relevance to psychiatry where social isolation can be expected to play some part in the development of mental illness.

Another important omission is the failure to distinguish between the effects of *sensory* deprivation and those resulting from *sleep* deprivation. What is perhaps worse is that the majority of investigators fail even to make reference in their reports to the question whether their subjects were awake or asleep during their continued deprivation. In view of the impaired performance of subjects who experience sleep loss (Williams *et al.* (28)) this distinction may be an important one.

A third major omission has been the failure to give adequate accounts of dietary factors. It seems not unreasonable to suggest that certain vitamin deficiencies, if present, could have been in part responsible for the perceptual disturbances reported.

IV—THEORIES

In spite of the comparative paucity of systematic investigation into sensory deprivation, some theorists have already attempted explanatory reports of the results of these investigations. Three main kinds of theory have been put forward.

(i) *Psychological*

Utilizing the tripartite division of psychology into cognitive, affective, and conative, Freedman (8) postulates a conative theory to account for the perceptual effects of sensory isolation. He states, "The organism strives or seeks continuously and automatically to find ordered relationships in the perceptual environment. When, in the experiment on sensory deprivation, the subject is presented with a disordered perceptual environment, his previously acquired spatial schema becomes useless. What is worse, it becomes impossible to modify the old schema, or to develop a new one since he cannot extract from the stimulus field the amount of information required to maintain any spatial schema at all. . . . We would postulate that it is this process of seeking orderly relationships when there are none, and of unconsciously striving to incorporate non-order into previously existing schemata which degrades the perceptual frame of reference . . . With the breakdown of the internalized frame of reference, it becomes increasingly more difficult to structure the environment, to impose constances and stabilities on the perceived visual world. As a result, contours fluctuate, objects seem to change their size and shape, subjective colours appear, and walls bulge in and out."

Vernon, attempting to explain his finding that his sensory deprived subjects showed a significant lowering of pain threshold, and linking this finding with that of Doane *et al.* who showed a significant lowering of the two-point limen and an increase in visual acuity after sensory deprivation, suggested that such increased sensitivity may be due to a contrast phenomenon produced by sensory deprivation. He also attempts a neurological explanation which we shall meet later.

(ii) *Psychiatric*

J. C. Lilly, in his report on the mental effects of reduction of physical stimuli on healthy human beings (13) suggests that under these conditions "the mind turns inward and projects outward its own contents and processes; the brain not only stays active despite the lowered levels of input and output, but accumulates surplus energy to extreme degrees. In terms of libido theory, the total *amount* of libido increases with time of deprivation. . . . If body-libido is not discharged somatically, discharge starts through fantasy; but apparently this is neither an adequate mode nor can it achieve an adequate rate of discharge in the presence of the rapidly rising level. At some point a new threshold appears for more definite phenomena of regression: hallucinations, delusions, oceanic bliss, etc. At this stage, given any opportunities for action or stimulation by external reality, the healthy ego seizes them and re-establishes more secondary process. Lacking such opportunities for a long enough interval of time, reorganization takes place, how reversibly and how permanently we do not yet know."

Lilly makes no suggestion as to how his theory can be tested empirically, nor is it easy to see how this could, in fact, be done. Further work will determine to what extent this conclusion is justified.

(iii) *Neurological*

There is no shortage of neurological explanations of sensory deprivation. Such explanations can be regarded as taking the psychiatric and psychological types of explanation back one step further by making use of the physiological and neurological properties of the central nervous system itself. In this sense, theories of this type are more fundamental than the other two. The problem remains, however, that psychiatrists and psychologists are at best only partially qualified to put forward such theories, or indeed to criticize them. These theories, at least, have the property of lending themselves to experimental verification.

Doane *et al.* (5), attempting to explain the perceptual dysfunction following sensory deprivation, hazard the guess that the functional de-afferentation of the isolation conditions may cause parts of the central nervous system to become hyperexcitable. They add that "the lack of varied input results in an inactivity of pathways at some higher levels of the central nervous system. If these pathways consequently become sensitized, it might account for increased figural after-effect, autokinetic movement, colour adaptation and so on. It would also fit in with the least expected feature of the present experiment, the apparent increase in sensory acuity, visual and somaesthetic. . . . Finally it is easy to see how hyperexcitability of parts of the visual system might be related to the occurrence of hallucinations."

Scott *et al.* (19) in their investigation of the cognitive effects of perceptual isolation attributed their results to "some general disorganization of brain function which is also involved in the hallucinatory activity, disturbances of visual function and abnormal EEGs" which occur under deprivation conditions.

Vernon's alternative explanation of the lowering of the pain thresholds he found in his subjects is formulated in terms of the action of the reticular formation of the brain stem. "Under normal circumstances neural inputs from sensory departments can be blocked or partially inhibited at the level of the reticular formation. The blocking is produced in the descending tracts under cortical excitation aroused by any sensory stimulation. Thus it may be that sensory deprivation, by drastically reducing the amount of sensory input, minimizes the activity in the descending tracts of the reticular formation. If there is less inhibition to overcome at that level, then perhaps sensitivity is accordingly increased. In the case of pain, the neural impulses resulting from the pain stimuli would encounter less opposition and would register at a lower level of intensity."

Held (12), attempting to explain the perceptual effects of sensory deprivation, suggests that "there is ample evidence that some neurons fire spontaneously in the absence of their triggering energy and that members of a group of such neurons will fire in a non-synchronized or random manner. In the absence of systematic external stimuli, an "alert" sensory-neural system may be dominated by such internally generated noise (the word *noise* is used in analogy to acoustic noise—sound having energy distribution over a large range of audible frequencies). Noise—and this is the core of the assumption—may constitute a source of ambiguities of the type our experiment imposed upon the visual-motor system by external means. . . . With the aid of this assumption we can predict that the mere absence of orderly visual stimulation can degrade visual-motor co-ordination. The apparently innocuous condition of deprivation is really lethal because it allows intrinsic disorder to disrupt the internal state or schema that is responsible for ordered co-ordination."

Teuber (22) in elaborating notes for a neurological theory of the perceptual

effects of sensory deprivation is inclined "to see this mechanism in the central activities by which incoming sensory signals are adjusted to emerging efferent activity. The decay in perceptual constancies during deprivation, I should think, is due to the free-wheeling of some active process, rather than to mere effects of some internal 'biological noise'." He adds that in their present form these notes are inadequate as an acceptable neurological theory of sensory deprivation although they do give some idea of the form such a theory would take.

We would conclude with Hebb (11) that a number of useful theoretical ideas have been put forward but that we are still in search of a theory of sensory deprivation. As was suggested earlier, it may well be the case that there are insufficient facts about the consequences of sensory deprivation. Any theory based upon insufficient data cannot be expected to stand the test of time without some degree of modification. Theories do, however, serve one useful purpose—that of facilitating systematic enquiry.

V—The Uses of Sensory Deprivation Research

(i) *Psychological*

Psychologists have made great use of the work on sensory deprivation by considering it in relation to the development and maintenance of perception.

With regard to the maintenance of perception, Held (12) points out that the degrading perceptual and co-ordination effects of sensory deprivation are similar to those following the technique of re-arrangement—the procedure associated with Stratton's experiment in which retinal images are inverted. Both techniques demonstrate the importance of exposure history in spatial co-ordination and perception and Held suggests a common neurological process to account for them.

Teuber (22) argues convincingly that the technique of sensory deprivation produces results in the field of perception which are concordant with the results produced by the other techniques of recombination and defect. Sensory deprivation is thus an important technique in the study of perception.

Riesen's work on the development of perception using sensory deprivation techniques on animal subjects led him to carry out two experiments, one with a monkey which was deprived of visual stimulation from the age of five to ten months, the other with a chimpanzee deprived of patterned light from ten to eighteen months of age (18). The effects of such deprivations were the inability to recognize familiar objects, inaccuracies of distance and direction, and some peculiarities of eye movements and binocular co-ordinations. Riesen compared these inco-ordinations with those seen in animals deprived from birth, although in the case of the latter the development of co-ordination took much longer.

It is clear that the sensory deprivation technique is a great asset to workers in the perceptual field. It should be noted that long before sensory deprivation technique became fashionable, it was being used as a standard technique in the study of perception. In fact it was the earlier work of Hebb and his associates at McGill University, in which the effects of early sensory deprivation on animals was under study, which gave rise to the concept of sensory deprivation in its popularized form.

Related to the usefulness of the sensory deprivation technique for students of perception is its usefulness for students of cognitive development. Hebb's work on animals suggested that an impoverished and homogeneous environment produced an adult organism with poor ability to discriminate, less tendency

to explore the environments, and with diminished problem solving ability. Similar conclusions were drawn by Clarke and Clarke (4).

(ii) *Psychiatric*

Psychiatrists have, in the main, concentrated upon the similarities between the effects of sensory deprivation on normal human beings, and those of psychiatric illness which have much in common—hallucinations, delusions, perceptual disturbances and so on. They have also noted the similarity between the effects of deprivation and those of the hallucinogenic drug preparations. Although such considerations may lead to a better understanding of mental illness it should be realized that these similar effects may have entirely different causes, and, therefore, that any comparisons must proceed with caution.

Sensory deprivation, as we saw earlier, has been used therapeutically with some apparent success. In all these studies, however, control groups were lacking and conclusions must therefore be treated with care. Above all there is still the need for an adequate rationale behind the application of deprivation techniques in a therapeutic setting.

(iii) *Miscellaneous*

The value of sensory deprivation techniques in relation to brain washing has been pointed out by Solomon *et al.* (21). It should be noted in this connection that social isolation plays at least as great a part as does sensory isolation. As we saw earlier, until the effects of these two phenomena have been separated, a clear understanding of the role of sensory deprivation *per se* cannot be achieved.

Sensory deprivation techniques may also throw light on the psychological effects of space flight. Here again, we would hold that some important aspects of sensory deprivation phenomena have not yet been worked out, in particular the motivation of the subjects in relation to the type of task they are undertaking. Individual differences in deprivation tolerance will also have to be taken into account, and further work along the lines of Petrie's investigations can be expected to yield valuable results.

VI—Summary and Conclusions

The literature on the production, the effects, the explanations, and the uses of sensory deprivation techniques has been reviewed.

Attention has been drawn to the lack of adequate rationale for the existence of the three main techniques, and to the shortcomings of the experimental investigations into the effects of deprivation. The paucity of factual data gives rise to a variety of theories to explain these effects. In the absence of more data it is impossible to decide between these theories. The results of deprivation studies will continue to have limited practical application until the field is more systematically investigated.

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VIII.—References

1. Azima, H., and Cramer, F. J., "Effects of partial perceptual isolation in mentally-disturbed individuals", *Dis. nerv. Syst.*, 1956, **17**, 3–8.
2. Bexton, W. H., Heron, W., and Scott, T. H., "Effects of decreased variation in the sensory environment", *Canad. J. Psychol.*, 1954, **8**, 70–76.

3. BRUNER, J. S., "The cognitive consequences of early sensory deprivation", *Psychosomat. med.*, 1959, **21**, 89.
4. CLARKE, A. D. B., and CLARKE, A., "Some recent advances in the study of early deprivation", *J. Child Psychol. Psychiat.*, 1960, **1**, 26–36.
5. DOANE, B. K., MAHATOO, W., HERON, W., and SCOTT, T. H., "Changes in perceptual function after isolation", *Canad. J. Psychol.*, 1959, **13**, 210–219.
6. EYSENCK, H. J., *The Dynamics of Anxiety and Hysteria*, 1957. London: Routledge and Kegan Paul.
7. FOULDS, G. A., "Clinical research in psychiatry", *J. Ment. Sci.*, 1958, **104**, 259–265.
8. FREEDMAN, S. J., "Perceptual changes in sensory deprivation: suggestions for a conative theory", *J. nerv. ment. Dis.*, 1961, **132**, 17–21.
9. GIBBY, R. G., ADAMS, H. B., and CARRERA, R. N., "Therapeutic changes in psychiatric patients following partial sensory deprivation", *A.M.A. Arch. Gen. Psychiat.*, 1960, **3**, 33–42.
10. HARRIS, A., "Sensory deprivation and schizophrenia", *J. ment. Sci.*, 1959, **105**, 235–237.
11. HEBB, D. O., Discussion of papers in "Sensory deprivation: facts in search of a theory", *J. nerv. ment. Dis.*, 1961, **132**, 40–43.
12. HELD, R., "Exposure history as a factor in maintaining stability of perception and coordination", *ibid.*, 1961, **132**, 26-32.
13. LILLY, J. C., "Mental effects of reduction of ordinary levels of physical stimuli on intact, healthy persons", *Psychiat. Res. Rep.*, 1956, **5**, 1–9.
14. MENDELSON, J., and FOLEY, J., "An abnormality of mental function affecting patients with poliomyelitis in a tank type respirator", *Tr. Amer. Neurol. Assoc.*, 1956.
15. PETRIE, A., COLLINS, W., and SOLOMON, P., "Pain sensitivity, sensory deprivation, and susceptibility to satiation", *Science*, 1958, **128**, 1431–1433.
16. *Iidem*, "The tolerance for pain and for sensory deprivation", *Amer. J. Psychol.*, 1960, **73**, 80–90.
17. *Idem*, "Some psychological aspects of pain and the relief of suffering", *Ann. N.Y. Acad. Sci.*, 1960, **86**, 13–27.
18. RIESEN, A. H., "Studying perceptual development using the technique of sensory deprivation", *J. nerv. ment. Dis.*, 1961, **132**, 21–25.
19. SCOTT, T. H., BEXTON, W. H., HERON, W., and DOANE, B. K., "Cognitive effects of perceptual isolation", *Canad. J. Psychol.*, 1959, **13**, 200–209.
20. SHURLEY, J. T., "Profound experimental sensory isolation", *Amer. J. Psychiat.*, 1960, **117**, 539–545.
21. SOLOMON, P., HERBERT, L., MENDELSON, J., and WEXLER, D., "Sensory deprivation: A review", *ibid.*, 1957, **114**, 357–363.
22. TEUBER, H. L., "Sensory deprivation, sensory suppression, and agnosia: notes for a neurologic theory", *J. nerv. ment. Dis.*, 1961, **132**, 32–40.
23. VERNON, J., and HOFFMAN, J., "Effect of sensory deprivation on learning rate in human beings", *Science*, 1956, **123**, 1074–1075.
24. *Idem*, MCGILL, T. E., and SCHIFFMAN, H., "Visual hallucinations during perceptual isolation", *Canad. J. Psychol.*, 1958, **12**, 31–34.
25. VERNON, J., and MCGILL, T. E., "Sensory deprivation and pain thresholds", *Science*, 1961, **133**, 330–331.
26. WERTHEIMER, M., "Figural after-effect as a measure of metabolic efficiency", *J. Pers.*, 1955, **24**, 56.
27. WEXLER, D., MENDELSON, J., and LEIDERMAN, P. H., "Sensory deprivation: A technique for studying psychiatric aspects of stress", *A.M.A. Arch. Neurol. Psychiat.*, 1958, **79**, 225–233.
28. WILLIAMS, H. L., LUBIN, A., and GOODNOW, J. J., "Impaired performance with acute sleep loss", *Psychol. Mon.* (*Gen. and App.*), 1959, **73**, No. 14.

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