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SENSORY AND PERCEPTUAL DEPRIVATION:

STUDIES IN HUMAN ISOLATION

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PREFACE

This paper will be concerned with a discussion of the experiments conducted in the field of sensory and perceptual deprivation. It is a comparatively new area of study, and will be traced from its beginnings to its present status as a tool in neurophysiological and behavioral research.

I would like to express my thanks to Dr. M. L. Riedesel of the University of New Mexico for stimulating my original interest in this area, and also to the Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico, for the use of their fine Documents Library in Aerospace Medicine and Bioastronautics.

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CHAPTER I

INTRODUCTION

Desire for more information about man and his relation to his environment has prompted many experiments, but perhaps one of the most unique approaches to this problem has been sensory and perceptual deprivation. Here, an attempt has been made to completely separate man from his normal surroundings--indeed, from any outside stimuli at all. Public interest in this research has generally been high, for everyone finds himself wondering what his own reactions would be to this unusual situation. Assessments of man's reactions to complete and severe isolation have been as varied as they are interesting, and the results have offered some surprising insights into behavior and psychology, as well as physiology and neural activity.

The field is comparatively new, at least new enough to cover in a fairly comprehensive manner in a report of this size. An attempt will be made to give a summation of the various aspects of sensory and perceptual deprivation studies past and present, and to acquaint the reader with the current status of the field.

CHAPTER II

HISTORY OF RESEARCH

Actual experimental studies on the effects of reduction of environmental stimuli were begun some ten years ago. Many have thought that interest in this field of study is comparatively new, but actually some of the primary source material is fairly well known and many years old. The effects of extreme isolation were noted and recorded by naval personnel such as Byrd, Slocum, Burney, and Bombard in autobiographical reports. They discovered that the greatest threat to survival was not the hazard of the environment, but the loneliness and monotony of the surroundings. Though each had daily tasks to perform, lapses of attention were frequent and the boredom often seemed unbearable.

It has even been discovered (23) that the Eskimos of Western Greenland are familiar enough with isolation and sensory deprivation reactions to coin the term "kayak-angst" to indicate to a phobia to the severe disequilibrium resulting from prolonged immobility in the hunting boat. The familiarity of the situation evidently has no effect on the lowering of the level of consciousness induced by the absence of external reference points.

One of the most unexpected results of polar isolation was hallucinatory activity, recorded by several explorers. This was of interest to some workers and became general knowledge to many, but little intensive study was done on it at the time.

In a few years, however, increased demands were made for further inquiry into actual effects of isolation situations. Men returning from the war reported a sort of "psychological warfare" used by the enemy, which soon acquired the popular name of "brainwashing." It was found that a forced restrictive environment involving isolation and confinement of the subject was an integral part of this technique. Public arousal and scientific interest led to investigations of the possible reasons for the success of the practice. In 1951, Professor D. O. Hebb of McGill University began the first experimental work on "sensory deprivation." His rather sensational results (including subjects' hallucinations, delusions, and other psychological responses) caused a surge of interest in the scientific community.

Hebb's work implied a whole new line of approach--no longer were secondhand reports on possible stresses of isolation the only source of information, for now these stresses could be induced experimentally for study. Restricted environmental situations again became of vital concern with the advent of extensive training of men for work in submarines and spacecraft. The latter was of special significance because of the individual isolation involved, whereas the former was more a matter of group interaction in restrictive surroundings.

It came to be a well-known observation that solitude (in a comfortable but monotonous sensory environment) is a definitely "stressful" situation as compared to normal activity (38). This led to further applications of the work in the areas of monotony and boredom. Assembly line workers, truck drivers, locomotive engineers, and pilots had all been involved in unexplained accidents which might have resulted from the prolonged effects of monotonous stimulation. Government grants were available to find ways of eliminating this problem.

What happened to human behavior when the level of incoming stimuli to the visual, auditory and kinesthetic senses was lowered? Psychologists were interested in man's behavioral reaction to aloneness and the simultaneous reduction of this stimulus level. Physiologists, on the other hand, were more concerned with the functional effects of reduced sensory input. By depriving man of sensory stimulation, it might be possible to learn more about the activity of the brain. As John C. Lilly (31) asked, "Freed of normal efferent and afferent activities, does the brain soon become that of coma or sleep, or is there some inherent mechanism which keeps it going, a pacemaker of the awake type of activity?" To these two ends, psychological and physiological, experiments were designed to discover the effects of reduction of the absolute intensity of physical stimuli received by a human subject.

In one decade, the knowledge of sensory deprivation studies began and grew as more and more researchers published results of their work. Some began their studies with aerospace grants, others in the field of psychology, others sought strictly physiological data, and some were merely curious about all isolation effects. Each, however, seemed to experiment with only his own particular immediate problem in mind, and seldom, if ever, did one group try to duplicate the results of another. The methods of testing and measuring effects, the number and type of subjects, the duration of the experimental conditions--all these were dissimilar. Different laboratories devised slightly or even radically different setups and the results varied so widely that a similarity between workers was almost coincidental.

As the studies went on, attempts began to be made to correlate these various experimental data and arrive at a working hypothesis. The American Psychological Association even held a symposium (at the annual convention in Cincinnati in 1959) entitled "Sensory Deprivation: Facts in Search of a Theory." This need for a theory still, unfortunately, exists; but progress is made as similarities begin to be noticed and mentioned in the laboratory results, and a trend is begun to special experimentation repeating the work of others. Gaps are now slowly filling in and recent well-controlled experiments have initiated some new areas, while eliminating others and clarifying the field as a whole.

CHAPTER III

METHODS OF STUDY

The two main categories of deprivation studies are sensory deprivation and perceptual deprivation, as defined by P. E. Kubzansky (29). In the former, an attempt is made at "an absolute reduction in variety and intensity of sensory input." That is, the external world is excluded to the greatest possible extent by the use of a dark, soundproof room. The subject lies on a cot or mattress, with gloves and cardboard cuffs decreasing the possibility of tactile stimulation. Earplugs may also be used to further guarantee silence. The subject is sometimes allowed to speak, but communication with the experimenter is kept to as low a frequency as possible in an attempt to eliminate social stimulation. Lilly, and more recently, Shurley and Camberarc have employed a water bath technique demanding complete immersion of the body. In this situation, the subject wears a mask and is told to keep movements to a minimum. Although giving additional information on effects resulting from the elimination of tactile stimulation, this is perhaps the most severe method of all, for subjects can tolerate the conditions for only a few hours. It is also rather difficult to set up, which may account for its lack of popularity.

The category of perceptual deprivation refers to "reduced patterning, imposed structuring, and homogeneous stimulation" (29). This is the most common setup used in the well-known McGill studies. The intensity level of incoming auditory and visual stimuli is maintained at near normal, but translucent goggles (or halves of ping-pong balls taped over the eyes) and white noise eliminate stimulus organization or patterning. ("White noise" is often mentioned in the literature, and should be explained. It is the acoustical equivalent of white light (61) and is the transmission of all the various frequencies in the audible range, producing a constant hissing or humming of 40 to 70 decibels attenuation. Produced to the subject through earphones, it effectively masks outside auditory stimuli.) Physical stimulation in perceptual deprivation, as in sensory deprivation, is lacking. The subject may be confined in a chamber or, in some cases, a tank-type respirator (iron lung) with the vents opened. In the latter case, blank walls provide the reduction of sight stimuli while the humming of a motor keeps the auditory level constant.

In both sensory and perceptual deprivation studies, the lengths of confinement may vary. In the past, some have lasted only minutes, while others have extended for as long as two weeks. The trend more recently has been to these longer isolations, since experimenters have found them to give more accurate and indicative results. Tests of various motor functions, reasoning ability, and psychological processes are administered to the subject before, after, and sometimes during the isolation period.

Though the two deprivation categories do differ, the term "sensory deprivation" is commonly used in reports to indicate both types of study. It will be used here with this general meaning unless otherwise specified.

CHAPTER IV

HALLUCINATIONS

Hallucinatory activity (or imagery) has been one of the most argued and most interesting points in sensory deprivation studies. Any discussion of isolation studies without some mention of this phenomenon would indeed be imcomplete, for the two have been linked almost from the beginning. Ideas have changed considerably and many problems have arisen, but progress is gradually being made toward understanding in this area.

First, it should be mentioned that there have been noted some general affects on subjects undergoing isolation. J. L. Wheaton (57) has presented what he termed an "isolation syndrome." Although some workers deny the possibility of rigid definition of isolation responses, Wheaton's outline may serve to give a basic introductory idea of behavior seemingly common to the situations imposed by various experimenters.

a) An asymptomatic state when the subject thinks of various things simply for the purpose of passing time.

b) Sleep or somnolence with the loss of a desire to structure thought content.

c) Irritability, restlessness, and an attitude of hostility toward the experimenter when the lack of stimulation continues.

d) A conscious attempt to utilize fantasy material.

e) Regression to childlike emotional lability and behavioral patterns.

f) Replacement of fantasy material by vivid and repetitive visual, auditory, or kinesthetic hallucinations.

g) A feeling of "otherness", or what pilots have termed the "break-off phenomenon"--when one suddenly has a sensation of escape from reality under conditions of solitude and minimal activity (9).

h) A readjustment after the termination of isolation characterized by blank periods and difficulty in focusing the attention.

Zubek (62) observed subjects to have a poor ability to concentrate, jumbled thoughts or blankness, and a difficulty in thinking and reflection. He also found irritability and annoyance with trivial matters and depression, brooding, and dwelling on imaginary injustices. Subjects' dreams were exceptionally vivid and, as might be expected, were largely of an anxiety nature whose main theme concerned death or restricted spaces.

Basically, limiting the number of stimulus elements in an organism's environment can have two immediate consequences (8). First, there is a reduction in the number of primary responses directly cued by the stimulus element. Second, the number of associative (or S-S) responses that are indirectly cued by the stimulus element also decreases. With the passage of time, a third possible response to this limited environment can also occur; generally speaking, this response takes the form of illusory or hallucinatory experiences. The organism now becomes aware of certain less well-defined aspects of a particular stimulus (such as shadows, shading, or certain incongruities when they exist) and "reads into" the environment other stimuli that are not physically present. Furthermore, under particular circumstances, some individuals appear more likely to exhibit this behavior than others. Theoretically, these misperceptions may be positively rewarding to the subject in that they provide stimulus variability in an otherwise unchanging environment.

Guiraud, a French psychiatrist working in the early 1800's, formulated a set of rules for the identification of hallucinations to use in his work in diagnosis of the mentally ill. His criteria are still valid, and have been useful in sensory deprivation work. These rules were: (a) the feeling must be that of a real visual experience, that is, be a little "distant" from the subject; (b) it must be scannable, so it becomes possible to select certain parts of the "picture"; (c) it must appear without the subject's will; (d) the subject must not be able to terminate it; and (e) it must "fool" the subject or "observer." These rules were adopted by Vernon in his Princeton work (52), and have aided other investigators since.

Bliss and Clark (5) have stated that, to be classed as a vision, a response must originate from the eyes, optic radiations, visual integrating stations and centers in the temporal lobe and the occipital cortex--that is, within the visual system. They feel that "abnormal visual experiences" fall into three areas. First are those realistic experiences reported by "normal" individuals, which may be increased or intensified by decreasing internal and external stimulation, thus allowing the visual system to function autonomously. The second category includes dreams, visions during sleep deprivation and hypnagogic states. Third are those having a depressing action on the brain. These last visions are usually very strange and peculiar, and are associated with "widespread toxic neurophysiologic effects of the brain." Any of these types might be associated with sensory deprivation studies.

Vernon (52) has proposed three possible "intensities" of visual experiences classified as hallucinations. "Type 1 hallucination" is the simplest possible, consisting of flashes, flickering, and shimmering of lights in the peripheral field which cannot be fixed by the subject. "Type 2 hallucination" is geometric in nature, but can be fixed in the central field of vision and is more complex. "Type 3 hallucination" is classified as a fully integrated scene, possibly including motion, which cannot be reduced to simple geometric figures.

The early reports of experimental hallucinations (in the original studies conducted at McGill University) were most influential in giving these experiments the notice and recognition they soon received. Translucent goggles, gloves and cardboard cuffs extending from the elbow to beyond the fingertips were used, while the background noise of an air conditioner was assumed to effectively mask outside sounds, acting as "white noise." Almost all the McGill subjects described simple forms of hallucinations consisting of dots of light, lines, and simple geometric patterns (types 1 and 2). About 75 percent of these saw "wallpaper patterns" (simple designs repeated over and over). Fifty percent saw isolated figures or objects (a row of "little yellow men with black caps and their mouths open," a German helmet), and about 20 percent of these described type 3 integrated scenes (a procession of squirrels with sacks over their shoulders marching "purposefully" across a snow field and out of the "field of vision," or "prehistoric animals walking about in a jungle.") Some subjects could exercise "control" over the content, but this was minimal. In a few cases, auditory (voices, a music box), kinesthetic, and somesthetic phenomena were reported (4).

The water immersion studies confirmed the occurrence of hallucinations under deprivation conditions, but the time lapse between beginning the experiment and observation of resulting imagery was found to be a good deal shorter than in the McGill report.

Some hallucinations reported in other sensory deprivation experiments have appeared to fit Bliss and Clark's third category and have been compared to the visual effects of peyote, mescal intoxication and LSD drugs (47). Other studies have been more closely associated with their first category (realistic experiences of normal people intensified by a decrease in external stimuli) such as symptoms of mental aberrations observed in a clinical study of patients who had just had eye operations and were forced to wear patches over their eyes. As the duration of visual deprivation lengthened, the number of patients exhibiting the symptoms increased until all eventually showed some signs (16). Clinical observations like these paired with incoming reports of experimental sensory deprivation effects led some medical investigators to feel that perhaps they might have found a new approach to studies of some psychological conditions. Almost immediately, a wide variety of experiments began.

Reitman (42), for example, realizing the feeling of disorganization subjects normally seemed to experience in these studies, felt that perhaps schizophrenic patients might react differently. These disturbed individuals are confused and disorganized not by the <u>lack</u> of normal stimuli, but by its <u>presence</u>. He hypothesized a chance for <u>re</u>organization with the withdrawal of stimuli, in reversal of the normal situation. This idea was also suggested in a study (10) involving disturbed children. (The latter work also proposed, however, that the interpersonal relationships before and after the deprivation had a great effect on the outcome, and later work by Reitman (11) indicated no consistent changes in behavior or psychological test performance before or after sensory deprivation.)

Smith (44) studied not only schizophrenics and normal subjects, but volunteers receiving a psychosomatic drug as well. His findings indicated a slight improvement on psychological tests by the schizoid patients as well as an ability on their part to endure the isolation conditions very well. Most of his normal subjects, however, reacted in a rather fixed "chain of events"--sleep, then a period of tension and agitation followed by panic. Though this reaction has been observed in some studies, it is infrequent enough (especially for a high percentage of subjects) to cause some doubts about the efficiency of the methods he employed. A more valid discovery, perhaps, was that phencyclidine and lysergic acid, when combined with sensory deprivation, sharply decreased the psychological effects normally connected with these drugs. This suggests that a certain level of sensory input is necessary to develop the symptoms usually associated with these drugs.

Ziskind (58) hypothesized that sensory deprivation hallucinations are fragments of normal imagery, and not mental aberrations. He felt that the subjects' confusion from reduced patterning had concealed the origins and hence had given the impression of a different type of imagery. Freedman (17) has also mentioned the possibility of adaptation to a homogeneous field which might lead to domination of a system by spontaneous, random (non-patterned) discharge of the cells of the retinal ganglion. Using intensity variables, it was discovered (30) that some imagery relates to stimulus conditions--with low sound input and high visual input, there is a high frequency of auditory imagery and low visual imagery.

Another experiment (14) was designed to test the idea that it was not the absence of sensory stimulation *per se* producing the effects of sensory deprivation, but the absence of *meaningful* stimulation. It was again concluded that the alerting action of random visual stimulation during isolation is not sufficient (under the conditions of this study--a respirator tank for $10\frac{1}{2}$ hours) to prevent occurrence of mental aberrations. In other words, a continuous meaningful contact with the outside world was necessary to the individual.

Some direct experimentation was then begun on the conditions required to produce maximal hallucinatory activity, rather than observing the phenomenon as simply a "side effect" (53). These workers had assumed, as had others, that as the subject approached complete sensory deprivation, the hallucinations would increase. This would be quite logical, according to most of the theories advanced up to this time. Actually, they found that "as sensory impoverishment of confinement increases, the likelihood of hallucinations decreases." That is, the less the sensory input, the fewer the hallucinations. The most hallucinatory activity they reported was due to a faulty blindfold through which subjects could catch glimpses of the area as they were led to the bathroom (a frequently allowed procedure in many studies) or to meals. There were fewer hallucinations with sensory deprivation than with perceptual deprivation.

A comparable experiment (43) was set up to see which of four conditions would produce the most visual activity. The same instructions were used each time, but the subjects were under either normal conditions, hypnosis, sensory deprivation, or the administration of a placebo drug (described to the subject as a relaxant with hallucinogenic action). A questionnaire was presented at the end of the test, and asked whether the images (if present) occurred as the subjects expected they would under each particular condition. Four conclusions were drawn: (a) that there was more imagery under hypnosis than any other condition; (b) that there was no significant difference between normal and placebo drug conditions; (c) that the imagery reported during sensory deprivation was significantly less than the other conditions; and (d) the prediction of imagery and actual results showed no significant correlation.

Other studies showed that when subjects were questioned for previous conceptions of effects of sensory deprivation and then subsequently tested, there were definite associations with the subjects' expectations and imagery production (41). Those subjects feeling that sensory deprivation would cause pronounced effects and who were also told that it was a sign of intelligence and stability to experience unusual perceptual experiences actually did report more complex and numerous experiences. This same experiment showed that, using normal subjects, most sensory deprivation phenomena occurring after several hours or days in other work could be elicited in 40 minutes.

In a similar report (35) to check suggestion effects, groups of subjects were divided and half given a "positive" set of instructions that mentioned that it was "normal to have visual sensations" and the other half told that "psychiatric patients have visual sensations" (negative" set). It was found that the positive instruction groups reported more sensations than the negative groups. These sensations occurred after only ten minutes of isolation.

The rather surprising observation in both the previous studies, that visual imagery could be obtained in less than one hour of deprivation, has been upheld in other work. Volunteers lying quietly in an otherwise normal sensory input situation (68), or else left in 10 to 30 minutes of darkness, have often reported experiences of a visual or auditory nature which may sometimes be quite complex. This would seem to indicate the establishment of a possible "base line of visual sensations" under minimal deprivation conditions before attributing these effects completely to sustained sensory deprivation (35). In addition, the definition of this "base line" might diminish clinical experimentation as a means of producing "mental aberrations resembling those occurring in various pathological and psychotic states" (61). Measured against this "standard base," the complexity and frequency of sensory deprivation hallucinations would not be as close to these "states" as was previously believed.

A recent paper, however, has given some new evidence and a new approach to the connection of visual sensations with perceptual deprivation. Using 58 male undergraduates, it was found that prior expectations and knowledge had no effect on sensations reported, and that only the least patterned or meaningful increased with suggestion (69). These authors felt that the role of direct suggestion in perceptual isolation has been overestimated, and that a possible important factor is the continuous subject reporting method often employed during experiments. This method itself may be at fault for increasing the likelihood of erroneously perceived imagery. Once again, there is no certain answer as yet in this area.

Another vital factor in this research, as it is in so very many projects, involves the selection, as well as the instruction, of the subjects (39). Some interesting preliminary work was done on 20 introverts and 20 extraverts under effects of perceptual isolation (51). The experiment lasted four hours, but the introverts tended to terminate the experiment before this time period was up. They were also observed to follow instructions carefully, and keep thought processes stimulus-bound. The extraverts, on the other hand, had pleasant thoughts, slept, moved about when awake, and endured the isolation for the full period of time. They were not as careful of instructions, however. Though no hallucinations, delusions, or fantasy occurred in either type, it is obvious that simply the variables presented could radically influence results.

Leiderman (30) stressed the use of the same individual in various studies as a "self" control, to avoid discrepancies. He found that the occurrence of visual imagery in a subject appeared to be related to the individual personality, and not to the conditions of deprivation.

Although auditory hallucinations have been mentioned but briefly here, they have been known to occur; however, they do not receive as much attention as the visual experiences. In auditory hallucinations, the suggestion has been made that the investigator should be aware that complete auditory blocking is almost impossible, since the subject can hear noises emanating from his own body--his heartbeat, stomach rumblings, breathing noises, and sounds made by the muscles of the middle ear. Some subjects interpreting a sound as "a truck passing" or the "drone of an airplane" could very well have been misled by these body sounds. Another interesting observation during perceptual deprivation is that the abrupt silence caused by white noise cutoff as the subject is dropping off to sleep may prove to be quite disturbing. This effect may indicate that the sensory mechanism cease action just in advance of losing consciousness, as in sleep (52).

So this advice given in regard to psychiatric patients is valid for all--"the nature of a person's response to deprivation is largely determined by his characteristic ego defenses" (12). Some (41) have even gone so far as to say that all the reported phenomena are wholly explicable in terms of normal psychology--implying that the term "hallucination" has been used too loosely in previous studies.

This "tightening up" of the definition has been well summarized by Mendelson (33) in his six types of reported imagery.

a) Analogy: any experience reported with the preface, "it feels like" or "as if."

b) Daydream: any thought concerning events in the past of anticipated in the future.

c) Fantasy: mental phenomena reported as though actually occurring but with recognition of their unreality.

d) Illusion: a misinterpretation of a perceptual experience.

e) Pseudosomatic delusion: a change in perception of the body without basis in reality.

f) Hallucination: a sensory experience without basis in reality.

Completing the subject of hallucinations, several suggestions for explanations of discrepancies between early and more recent experiments have been offered. The establishment of more valid and specific criteria for determining differences between hallucinations, delusions, fantasies, etc. have undoubtedly been influential in decreasing the number of reports of hallucinatory phenomena in recent work. Suggestion has received a good deal of attention as a factor in reports of hallucinations, and has been found to be of some importance. Another aspect is the wide range of subject personality, which can greatly influence results in the degree of frequency and complexity of hallucinatory experiences. The publicity of sensory deprivation experimentation in the past several years must not be overlooked as a factor in subject response. It has become very difficult to find naive subjects who know absolutely nothing about the work, and the limited knowledge they often do possess can be detrimental to the experimental results. Zubek (61) feels that the original "dramatic results may have been produced by some unique interaction of procedural, personal, and motivational variables." This seems to be about the only conclusion that can be drawn to explain the wide gulf that separates the early work from the present status of thought on the subject of hallucinations.

CHAPTER V

PERCEPTUAL AND MOTOR CHANGES

Various sensory and perceptual processes have been found to be affected by prolonged isolation. Upon termination of the isolation period, many subjects have reported a feeling of being overwhelmed by the "bright and vivid" colors of objects about them (62). Sounds were loud and disturbing to them, and their speech was often slow and halting. The first McGill experiments reported extensive perceptual disturbances upon emerging from several days of isolation. These subjects mentioned not only vividness and brightness, but changes in the shape of objects, movement of the visual field, after-images, and distortions of human faces. These effects were usually gone after half an hour, but if the isolation had endured for six days or more, the after-effects might last in some cases for up to 24 hours.

Additional objective perceptual measurements administered to the subjects (in additional to their own subjective reports) showed that figural after-effects, size and shape constancy, color adaptation, movement after-effects, autokinetic effects, visual-motor coordination and tactual form discrimination were indeed impaired. Two-point tactual threshold, or successful discrimination between two points applied to the skin, showed increased sensitivity.

In somewhat later work utilizing eight-hour sensory and perceptual deprivation, simple pattern distortion was observed--e.g. the moving or bending of a straight line or a cross (18). But again, the more recent experiments lasting from two to fourteen days do not agree completely with the original work. None of these have demonstrated gross disturbances of the perceptual field--even after 14 days of perceptual deprivation, where these changes would be most likely to occur. In this area, as in the hallucination work, no explanations have been found as yet for the discrepancy in early and later reports.

Objective tests have shown a greater agreement, however, than the subjective reports. Handwriting, rotary pursuit, rail-walking, and mirror tracing (various aspects of visual-motor coordination) show impairments and seem to leave little doubt of decreased facility. Definite confirmation of color perception impairment has also been established. These later results, however, show no changes in size constancy and depth perception.

There seem to also be significant differences between behavioral impairments following perceptual deprivation and those occurring after sensory deprivation, especially after long periods of time in isolation. Visual but not auditory vigilance is diminished by sensory deprivation, while perceptual deprivation seems to cause impairment in both visual and auditory vigilance. Reversal of ambiguous figures is not significantly affected by sensory deprivation, but is definitely affected by perceptual deprivation. There are also reports of a greater incidence of distortion of simple patterns after perceptual deprivation than after sensory deprivation. This would seem to indicate that perceptual deprivation affects perceptual and motor skills, as well as hallucinatory activity, to a greater degree than sensory deprivation.

A study of reduced sensory stimulation approximating that to be found in future space vehicles has presented a reasonably valid point (25). It was concluded that sources of variance may be attributed to personality differences among subjects, and that certain response systems are more sensitive to deprivation than others. It appears that once again the individual subject may control results. However, perceptual and motor measures in other studies have proven to be more objective and less likely to vary from person to person than the hallucination "measurements," for example, and can therefore be assumed to give more indicative results.

Zubek (60), in his own work, came to the conclusion that the degree of motor activity permitted during isolation is perhaps one of the most important variables operating in sensory and perceptual deprivation experiments. In a one-week perceptual deprivation study demanding physical activity there were fewer impairments in 15 behavioral measures than when the subjects were not required to exercise during the same period. In another report (68) he also mentions that subjects in a normal and varied sensory environment who were immobilized for a week demonstrated perceptual and intellectual deficiencies very similar to those occurring after prolonged visual and auditory deprivation. A review of the experimental literature comparing restricted and free subjects and incidence of hallucinations supports this idea, and Leiderman (30) specifically mentioned that body movement was negatively related to the amount of imagery.

Freedman (20) also stated that human performance under conditions of reduced and abnormal sensory input related to restriction of bodily movement. He found that humans show a remarkable ability to adapt to conditions of sensory rearrangement and distortion, but that the subject is only able to adapt when allowed free movement of the whole body or of an appropriate limb. If restricted in movement, or passively moved, there is no comparable adaptation. With prolonged exposure to conditions not permitting a correlated feedback, the accuracy of performance is degraded. A Russian report (1), discussed in more detail later, also emphasized systematic specified physical exercises, in a rational work-rest regiment.

Another interesting discovery by Vernon and McGill (54) was that after four days of sensory deprivation, there was a significant lowering of pain thresholds, or an increase in sensitivity to electrically induced pain. (These studies employed two low frequency electrodes applied to the earlobes of the subjects.) This sensitivity was evidently not due to any changes in the skin, but was explained on the grounds that sensory deprivation is a "contrast phenomenon." Normally neural inputs from sensory departments can be blocked or partially inhibited at the level of the reticular formation. Sensory deprivation may minimize activity in the descending tracts of the reticular formation by drastically reducing the amount of sensory input. With less inhibition to overcome at that level, sensitivity may be accordingly high. Neural impulses relating to pain stimuli would not encounter the mild cortical blocking usually present and would register at a lower level of intensity, or to be specific, registration would occur with impulses of lower frequency.

An experiment (64) to determine conditions for an increase in tactual acuity and in sensitivity to heat and pain placed subjects in darkness for a week, but otherwise exposed them to a normal and varied sensory environment. It was shown that an overall reduction in the level of visual, auditory, tactual-proprioceptive, and social stimulation is not essential for the appearance of this phenomenon. It occurred after visual deprivation alone, and the cutaneous supersensitivity was still present several days after the termination of visual deprivation.

Of some interest was an observation (63) that after perceptual deprivation there may be a decrease in pain sensitivity. This effect was explained by the probable action of the white noise, in view of the "analgesic properties" claimed for this type of auditory stimulus (21). This finding would seem to warrant more investigation.

Vernon's subjects, groups of Princeton students, showed a great deal of concern over their ability to correctly perceive time while they were isolated. They found it inconvenient and disturbing not to know the time and tried to estimate it even though this was not asked of them (52). Although the presence of biological clocks in many organisms has been amply demonstrated, the same phenomenon is not found to any great extent in man. For short time intervals, over- and underestimates can be fairly well predicted--subjects tend to overestimate one second, estimate five seconds accurately, and underestimate ten seconds (34). Significant underestimations were made of six, 30, 60, and 120 minutes. (Confusion and sleep contributed to incorrect answers.) As everyone knows, judgements of time passage of longer intervals depend upon whether the interval is filled and in what manner it is filled. A filled interval is generally perceived as longer than an unfilled interval. It also seems to be the case that increased interest leads to decreased time estimation.

In an experiment specifically set up to determine time estimation, subjects were asked to press a button every 30 minutes for four days (52). Sleep was estimated by pressing the button once for every estimated 30 minutes lapse. Judging from the long, monotonous intervals afforded by sensory deprivation, it was assumed that subjects would significantly overestimate time intervals. This was not found to be true, however, for underestimations were observed in a majority of cases. These underestimations were frequently due to sleep for a longer period of time than the subjects intended, thus upsetting their schedule of time estimation. Other subjects used aids in judgement of time, such as growth of beard, rate of drying of washcloth, feeling of eyes upon waking, cooling of soup, hunger pangs, etc. These latter subjects showed a much more accurate estimation of time passage. (One of Vernon's subjects took the time estimation seriously, and ingeniously utilized a pendulum made from an apple and some wire to determine the time interval between his heartbeats, then counted his pulse during his isolation. This became almost automatic with him and he could engage in other thoughts at the same time. His estimation was only one-half hour off in four days, but obviously this is an unusual case. It is interesting to note how resourceful someone can be in a situation like this.)

The most obvious answer to time underestimation that presents itself is that the subjects were trying to protect themselves from depression as the experiment wore on. Vernon says that this is not true, for each of his subjects insisted that he estimated time to the best of his ability and tried only to be as accurate as possible.

A significant observation was that none of the subjects left isolation before the entire four-day period, which might seem to indicate that the task required of them, small though it was, gave them the relief from monotony that made the period of confinement more tolerable (52).

CHAPTER VI

COGNITIVE CHANGES

After the initial sleep period common upon entering sensory deprivation, most subjects found the first day to be a "period of sharpened thought" (52) when they could concentrate easily. However, many of the subjects found later confinement to be a different matter, and complained of uncontrollable daydreaming and a decrease in willful maintainance of thought. This supports Kubzansky's finding that subjects in most sensory deprivation studies have reported difficulty in concentrating and in maintaining and organizing connected trains of thought (29). Other experimenters (26) have also confirmed that after a few hours, the efficiency of logical thought decreases and there is a corresponding emergence of fantasy and dreamlike states of consciousness. Affective changes consistent with the cognitive effects also appear.

The type and degree of change in cognitive functioning is, it seems, related to the type of deprivation employed. Short-term exposure of only a few hours gives no proof of this, but when isolation time is sufficiently long, intellectual functioning will be disturbed. As in other areas, the disturbance appears to be greater with perceptual than with sensory deprivation.

Most test results show little change during isolation, but significant decrements were discovered in arithmetic problems, numerical reasoning, verbal fluency, visualization in two- and three-dimensional space and in abstract reasoning (61). When rote learning ability of subjects under conditions of sensory deprivation for 48 hours was compared with results for a control group (2), no significant facilitation or decrement in performance was noted and the performance of the two groups was essentially the same. Memory retention of a short verbal passage was also compared between sensorily deprived subjects and normal activity controls, and only the controls showed a significant decrease in retention between the immediate recall test and the terminal recall test (22).

An experiment (50) utilizing a verbal description of a TAT-like (Thematic Apperception Test) scene to induce subjects to make up stories to fit the "picture" was employed to evaluate cognitive impairment as a result of social isolation and severe sensory deprivation. No change in story length was observed in the controls, but non-deprived subjects showed significant increases in story length while sensorily deprived subjects demonstrated a significant decrease in length as well as a decrease in speech-rate. This shorter story length may be directly correlated with the decreased ability to concentrate.

Most of Vernon's (52) subjects who did not find themselves able to maintain organized thought expressed the wish for a "listener" of some sort. He believes that this is a function of the importance of social interaction in daily life. This has been verified by the observation that social contact (in the form of two tank-type respirators side by side) does not eliminate the effect of sensory deprivation, but it does lessen it to some degree (13).

All in all, the cognitive effects of prolonged deprivation do not seem to be particularly severe. Some abilities do show impairment, but many others do not; and it seems that some may actually improve after a period of deprivation.

In regard to learning, apparently some sensory stimulation in excess of that present in sensory deprivation is necessary for proper mental functioning. However, when the level of stimulation becomes excessive, as in normal situations, this functioning is not as good as it might otherwise be. Social isolation appears to be the best midpoint between these two and seems to give the best results in learning.

At McGill University, Hebb was the first to attempt to determine the extent of shifts in attitude during isolation (37). This work has rather obvious applications in the study of brainwashing techniques, and this was indeed its intent. Using subjects first neutral in attitude, recordings were played after 18 hours in perceptual isolation advocating a belief in psychic phenomena (ghosts, poltergeists, and ESP). Those subjects in perceptual isolation made more requests for these lectures and showed a greater attitude shift than the controls. In the same line, Suedfield at Princeton gave positive propaganda concerning the Turkish people to subjects undergoing 24 hours of dark and quiet and found a higher attitude change among these individuals than the normal activity controls (37).

More recently, a series of experiments was planned by Smith, Murphy, and Myers in an Army research program designed to assess the effects of sensory deprivation and social isolation on subjects' behavior when deliberate attempts were made to influence their judgements and attitudes. In testing conformity to a group norm (45) (in which the subject gives his answer to a question following the responses of fictitious subjects who may all answer wrong), it was found that the higher the intelligence, the lower the conformity; or that conformity was much easier to elicit from subjects with lower intelligence levels.

In another experiment in the same series (37), the subjects' prior attitude concerning Turkish people (a popular choice) was determined and three minute recordings opposing this view were made available in the cubicle. The subjects played the recording even though its content didn't agree with their own beliefs in an apparently greater desire to receive information than to have no stimulation at all. The attitude shift found was not as great as the McGill study reported, but this may have been due to a lack of explanation to the subjects.

In the third study, a conditioned stimulus word was paired with an unconditioned stimulus adjective (36). Again, the results showed greater ease of conditioning during isolation among subjects of lower intelligence. Set of attitude toward the test had a great effect on the direction of conditioning, however, and the best conditioning of cubicle subjects was found to be among those who did not correctly identify the purpose of the conditioning procedure. The subjects knowing about the conditioning attempt appeared to deliberately oppose the results.

At the present time, it seems that there are two hypotheses in regard to mental functioning in sensory deprivation. One view is that mental function is impaired, the other that it is facilitated. More research on this point is suggested (7) before a conclusion is reached, due to the extreme variation in reports. However, it seems that whatever the requirements of the human organism for varied external stimulation, mere reduction or increased patterning of input will not alone produce major disruptive or enhancing effects.

CHAPTER VII

PHYSIOLOGICAL EFFECTS

There are many ideas concerning physiological changes occurring during deprivation. One neurophysiological explanation of effects emphasized the function of the reticular activating system; for Heron, one of the early workers, felt that normal brain function depends on a continuing arousal reaction produced in the reticular formation which in turn depends on constantly varying sensory stimuli. When the variability of sensory input is reduced in constant dark and silence or diffuse light and noise, sensory stimuli lose the power of arousal. It is then that the activity of the brain may be impaired and disturbances of psychological processes may occur (65).

In a primarily psychological approach, Freedman and Greenblatt (19) have stated that, to a considerable extent, the brain is self-stimulating, providing inputs of its own. If the inactive brain were simply a biological motor idling in neutral, there would be no reason to expect changes with blackout conditions. Since disorganization occurs in both sensory and perceptual deprivation, they indicate that this is due to the absence of order and/or meaning rather than the specific nature of the stimulus field. They postulate an active automatic process in the waking state which seeks continuously to find ordered relationships in the perceptual environment. When sensory deprivation eliminates the internal frame of reference, structuring of the environment becomes practically impossible. Therefore, they feel that deprivation effects may be due to the release of primitive perceptual process tendencies normally held in check by the structuring and stabilizing of the visual field. The theory they advance is that perceptual distortions may be attributed to the organism's continuous, automatic search for order in a non-ordered environment.

Zubek and Welsh in Canada (66) devised an experiment to determine if behavioral differences between the two conditions of sensory and perceptual deprivation can cause disturbances of the electrical activity of the brain. They found that seven days exposure to perceptual deprivation produced a significantly greater decrease in mean occiptital lobe frequencies than the same period of sensory deprivation (1.21 to 0.85 cycles/second). They think this differential disturbance may be related to higher behavioral impairments occurring after prolonged perceptual deprivation. They mentioned, however, that since the electroencephalogram was taken <u>after</u> isolation, physiological effects of sensory deprivation may wear off more quickly, but they doubt that this is so.

In other work, Zubek (67) found a progressive decrease in frequencies in the alpha range during a 14-day exposure to perceptual deprivation. Alpha waves are characteristic of the normal quiet resting state of cerebration, and do not appear during sleep (24). Lilly (31) also found in the water bath studies that there was a decrease of alpha waves, and he also observed an increase of beta activity, indicating interference of normal cortical function. Beta waves are of two types, I and II, and the beta II waves inhibit the beta I waves during intense activation of the central nervous system or during tension (24). This is probably the case in the stressful water immersion experiments.

Smith (44) found widespread slowing in the electroencephalogram with conspicuous theta and delta rhythms up to one hour after a two day deprivation. The theta waves are often characteristic of disappointment and frustration stresses and can be used as a clinical manifestation of severe tension in adults (24). Excessive theta waves were also observed by Zubek (66), and he found their incidence was the same for sensory and perceptual deprivation. Delta waves, on the other hand, occur in deep sleep (24), and a comparison made between sensory deprivation and sleep (6) showed common neurophysiological features between the two. What relationship this may have to aftereffects of deprivation has yet to be ascertained. Another experiment (40) found that first the alpha amplitude increased, then began an alternation with low, slow, dysrhythmic activity in the theta and delta frequency. This was termed a typical "transition" pattern. Subjects reported the sensation of "sinking away and emerging again," and it appeared that the electroencephalogram showed the same number of "transition" runs between the stretches of normal alpha activity. From this information, it seems that there is a definite buildup of tension and stress during sensory deprivation as witnessed by changes in brain waves.

Ziskind (59) has investigated an approach which seems to be a rather meaningful one, since it brings out a possible point of reference for further research. He identified a "syndrome" of reduced consciousness which included "altered goal-directed behavior, dreamlike perceptual distortions associated with coordinated motor activity, increased sleep, confusion, anxiety, and restlessness." Diagnostically, he differentiated it from the acute brain syndrome by its brevity, the lesser number of sensory modalities involved, the absence of subcortical hyperkinesis, and a minor transient degree of amnesia. Sleep (including periods of reduced awareness in varying degrees) was emphasized as a major factor in sensory deprivation effects. He found reduction of conscious awareness to be a necessary condition, and felt that it may (with other psychological factors) constitute sufficient conditions for the "sensory deprivation" symptoms. He concluded that this "hypnoid syndrome" probably accounts for many symptoms reported in the sensory deprivation experiments lasting eight hours or longer, and possibly in some of the shorter tests.

Heron found progressively slower frequencies in the parieto-occipital tracings with increasing length of deprivation, and abnormal electroencephalograms three and one-half hours after the termination of four days of isolation (61). Smith's work (44) showed changes lasting one hour after two days of deprivation, and Zubek reported abnormal electroencephalograph records one full week after the 14-day deprivation. These progressive aftereffects seem to be rather significant. Interestingly enough, pronounced changes in the electroencephalogram also occur when subjects are simply immobilized without visual and auditory deprivation--that is, in a normal environment (68).

The temporal lobes may be involved in sensory deprivation effects, as evidenced by a study on chimpanzees undergoing bilateral removal of the temperal lobes prior to 13 days of sensory deprivation (3). In contrast to the controls, no perceptual, motor, or emotional disturbances were observed, and there was an immunity to the effects of lysergic acid diethylamide (mentioned earlier as having psychological effects leading to pronounced behavioral changes). This work indicates a possibility of temporal lobe involvement in human subjects as well.

A very comprehensive report of neurophysiological function during sensory deprivation concerned the attentive, affective, and adaptive behavior in the cat and was carried out by stereotaxically performed lesions in the brain stem with electrolytic currents (48). The major findings reported relate to the animals prepared with lesions of the lateral brain stem, involving the long lemniscal pathway. Lateral lesions produced surprisingly extensive defects and provided a unique opportunity to assess the contribution of the reticular formation to behavioral functions after severance of the lemnisci. These lesions provided effective sensory deprivation of the forebrain, and resulted in behavioral abnormalities characterized by three types of symptoms: changes in the sensory capacity, changes in affect or emotion, and changes in adaptive response.

This study suggests thst specific, patterned and localized sensory information, carried to the forebrain via the lemnisci, is essential to the normal behavior of an animal. It is actually one of the first studies performed on specific sensory pathways affecting deprivation. It appears that without a patterned afferent input to the forebrain via the lemnisci, the remaining portions of the central nervous system (which include a virtually intact reticular formation) seem incapable of elaborating a large part of the animal's repertoire of adaptive behavior.

A Russian study (1) of relative adynamia and isolation noted physiological changes presumed to be due to the reduced excitability of the central nervous system. The conditioned motor responses were affected and the heart rate was increased. The respiratory rate, arterial blood pressure, and oxygen saturation of the blood all decreased at first and were not restored until much later in the second part of the experiment. They also reported a decrease in the mental working capacity and the development of fatigue.

It has been found that the level of somatic activity increases for subjects with a specific task as compared with subjects who are simply told to relax for one hour (32). Sensory deprivation for a relatively brief period of time is conducive to relaxation and even sleep if no demands are made on the subject. Measures of electromyogram, electrocardiogram, galvanic skin response, and respiration show that the level of physiological activity is determined by the importance of the task (49); therefore, this should be taken into consideration when using these figures in assessing changes during deprivation. Different values will be obtained in resting and "working" subjects, as Zubek, Leiderman, and Freedman found with regard to motor activity.

An interesting approach to the study of stress involved the actual quantitative measure of hormonal responses, utilizing the catechol amines, epinephrine, and norepinephrine (33). Epinephrine is excreted primarily by the adrenal medulla, while norephinephrine is secreted by the peripheral sympathetic nerve endings and only secondarily by the adrenal medulla (55). Agressive emotional displays were found to be characterized by increased norepinephrine excretion, while tense, anxious emotional displays were related to increased epinephrine excretion (15). Along with the increased epinephrine values, the systolic blood pressure was found to decrease, as pointed out in the Russian findings. Anxiety accompanied by hostility, as might be expected, showed an increase in both epinephrine and norepinephrine output. Subjects under sensory deprivation were found to show this increase in catechol amine measures and also a decline following release from the experimental situation (33). The suggestion was made that epinephrine may be more closely associated with psychological stress, and norepinephrine with basal physiological processes.

The discoveries in this section have led investigators to class sensory deprivation with other stresses having measurable physiological effects.

CHAPTER VIII

TOLERANCE OF DEPRIVATION

So far, the main discussion has been of the subjects who have successfully completed the period of deprivation prescribed by each experiment, and little mention has been made of those who have found the conditions of isolation intolerable. It has been estimated that roughly one-third of all volunteers are not able, for one reason or another, to finish the period of sensory or perceptual deprivation. Vernon has reported that almost invariably these subjects terminate before 48 hours (52), and Zubek has found a mean of 45 hours in a four-year survey of his experimental work (61).

There was not, as one might think, a high percentage of real panic among these subjects--in fact, Vernon found no cases of panic or anything close to it. The subjects came out of isolation in a "quiet, calm, and completely collected manner" (52). Although individuals differed widely in their reasons for quitting, they all seemed to report the same general experiences before deciding to leave. First there was a period of indecision, thoughts of quitting, followed by the subject's being able to talk himself out of terminating the test. Then the need to leave again occupied the subject's mind, and he again put it away, almost like a cycle. Usually only two or three of these cycles were necessary to drive him out of the chamber, for the subject simply tired of talking himself out of the feeling.

The first assumption made in these cases was that personality differences might provide the answer. To determine if this was true, a battery of paper-and-pencil tests measuring 40 personality characteristics found no reliable differences in those who remained and those who terminated (27). This type of test, then, appears to be relatively useless for predicting tolerance, but work is being continued. So far, the most promising approach seems to be an inquiry into the motives and values of the volunteers. It has also been noted that the strangeness of the test situation may be a critical factor, and prior exposure can aid the subject immensely.

If it were possible to train people to endure confinement more easily, some suggestions (52) might be: (a) simple "games" to keep up the thinking process, (b) repetition of thoughts to improve the power of concentration, (c) provision of "checks" for the thinking process to minimize frustration, (d) an imaginary listener in order to keep motivation for thought control at a high level, (e) avoidance of the "easy way out" of daydreaming or fantasy, and (f) avoidance of fatigue by deliberately allowing <u>short</u> daydreaming periods.

CHAPTER IX

VARIABLES INFLUENCING RESULTS

As a brief review of the discussion thus far will reveal, there have been many reasons given for variations in results of different sensory deprivation experiments. There are a good number of variables which must be considered, and they are beginning to be more fully explored in recent work. Some very important factors already mentioned deal with the subject and his attitude toward the experiment, his expectations, motivations, and the type of instructions he receives (28). In addition to these, the experimental procedure itself may introduce many variables, such as the quantity, modality and pattern of sensory input, the duration of the experiment, the "aloneness" experienced by the subject, the degree of social interaction between the subject and the experimenter, the diet of the subject, the type of tests and the times they are administered, and the type of subjects, i.e. students or non-students, volunteers or assignees (61). Some of these have yet to be fully considered and explored in the experiments, but undoubtedly research will become more intensive with time.

CHAPTER X

THEORETICAL EXPLANATIONS

Vernon (52) has put the matter of a "theory of sensory deprivation" rather well when he observes that the sensory deprivation investigators have not asked too many questions, but rather that they have asked too great a variety of questions. The result has been a little knowledge about a great number of reactions to the situation. He also mentions the problem of a "reverse view" of the work--that is, thinking of it as a means of changing the personality rather than looking at the ways personalities react to sensory deprivation.

There are three general types of theories (61):

(A) The psychoanalytically orientated interpretations postulate changes in the relationship between the functioning of ego and id, or a weakening of the ego for reality testing.

(B) Theories of a psychological nature attribute the effects to the organism's continuous search for order and meaning in an unorganized perceptual environment, or deal with the relationship of the organism to the environment through a set of models or expectancies gradually acquired from birth. In the latter approach, sensory deprivation is a disruptive process since it halts progress in the monitoring and correcting of these "strategies" used in dealing with the environment.

(C) Finally, neurophysiological theories emphasize the function of the reticular activating system because of its importance in attention, perception, and motivation. The reticular formation has somewhat of a selective function in regard to the messages passing through the neurons, and it can inhibit some and enhance others. A decrease in the level and variability of sensory input coming into the reticular activating system (via collateral fibers from the sensory systems) may enhance the "importance" of any given set of stimuli. In other words, the mind may be able to content itself with ideas or thoughts that it would otherwise dismiss. If extreme conditions of sensory deprivation were imposed on the individual, a "stimulus hunger" would be generated in the existing void, producing both behavioral and psychological effects.

Vernon (52) feels that man is not equipped to endure homogeneous sensory situations, no matter what kind they may be. When man becomes almost totally dependent upon himself with little opportunity to change his circumstances, he can experience many difficulties. Only when some stimuli are offered can deprivation become tolerable, and then it makes no difference how slight or minimal these stimuli may be, for they provide the necessary change so vital to normal functioning of the human mind.

The neurophysiological theories seem to be the most promising, but, as Hebb has stated, we are still in search of an adequate theory of stimulus deprivation.

CHAPTER XI

CONCLUSION

The study of sensory and perceptual deprivation is a fascinating one, for through these experiments man is learning more about himself and his environment. The changes brought about by this situation are so uncommon as to open a new method and area of study for almost all the branches of science devoted to the study of man. Psychology, physiology, behavioral science and medicine have all benefitted from this work.

It should be noted, however, that one cannot make too many hasty conclusions from this data. It has been pointed out that these studies, though interesting and informative, cannot be directly extrapolated to real-life situations. The experimental setup is just that--experimental. As any other research, it should act as a guide, opening the way for new discoveries in specific areas. Though it should not be thought of as providing all the answers, sensory deprivation will undoubtedly continue to be instrumental in research, for it has only scratched the surface of its potential value to science.

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