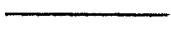


THE EFFECT OF SHORT-TERM DEPRIVATION ON THE TACHISTOSCOPIC
RECOGNITION THRESHOLD



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Stephen L. Milstein
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ABSTRACT

The Effect of Short-Term Deprivation on the Tachistoscopic Recognition Threshold

by

Stephen L. Milstein

In two short-duration studies it has been reported that either a 5 or a 50 minute period of sensory restriction, involving a reduction in visual, auditory, and kinesthetic stimulation, can result in a lowering of the tachistoscopic recognition threshold. The purpose of this thesis is to determine whether a similar facilitatory effect can occur after the deprivation of only one modality.

Ninety male subjects were divided into six groups, each containing 15 subjects. Two of the groups were control subjects while the remaining four were exposed to 5 minutes of either perceptual deprivation, visual deprivation, auditory deprivation, or kinesthetic deprivation.

The visual recognition threshold for each subject was determined immediately before, and two minutes after the five minute deprivation or control period by presenting, one at a time, eight randomly constructed five-digit numbers, composed of the integers 1, 4, 6, 7, and 9.

An analysis of the pre-post difference scores indicated that none of the resulting increases in sensitivity in the four experimental groups were significantly different relative to the two control groups. The discrepancy between the results of this study and those reported in the literature are explainable in terms of the procedural improvements made in this study.

CHAPTER I

THE PROBLEM, INTRODUCTION, AND HISTORICAL BACKGROUND

I. Statement of the Problem

Two short-duration studies (Friel & Derogatis, 1965; Rosenbaum, Dobie, & Cohen, 1959) have demonstrated that either a 5 or a 50 minute period of sensory restriction, involving a reduction in visual, auditory, and kinesthetic stimulation, can result in a lowering of the tachistoscopic recognition threshold. The purpose of this thesis is to determine whether a similar facilitatory phenomenon can occur after the deprivation of only one modality. Such an effect might be expected since it has been shown that many of the facilitatory changes reported after long durations of sensory restriction can occur after visual deprivation alone.

II. Introduction

The first experimental work on sensory restriction was initiated at McGill University in the early 1950's (Bexton, Heron, & Scott, 1954). Since this pioneer research, considerable interest has been shown by investigators from various disciplines in the psychological and physiological effects of a reduction in the level and variability of sensory stimulation. Furthermore, many different procedures have been employed to reduce sensory input. These procedures are customarily divided into two main categories: sensory deprivation and perceptual deprivation, a two-fold classification first advocated by Kubzansky (1961).

In sensory deprivation, an attempt is made to reduce the level of sensory input to as low a degree as possible, this condition being achieved by requiring the subject to lie or sit quietly in a dark and

silent environment. Perceptual deprivation, on the other hand, involves a reduction in the patterning and meaningfulness of sensory stimulation while maintaining the level of input near normal. This is accomplished by providing a constant masking sound (white noise or hum of a fan), covering the eyes with translucent goggles or a white mask which permits diffuse light but eliminates pattern vision, and requiring a minimum of movement from the subject. In the studies employing these two general approaches, the duration of sensory restriction has ranged from 5 minutes to 14 days, the most common periods being either 8 hours or 1, 3, and 7 days.

Since the early McGill studies, research on the effects of sensory and perceptual deprivation has involved the measurement of a wide range of physiological and behavioral processes (see reviews of Schultz, 1965; Zubek, 1964b). The physiological studies have included measures of EEG activity, skin resistance, muscle potential, respiration, blood pressure, basal metabolic rate, and urinary excretion of adrenaline and noradrenaline. The results have indicated a progressive slowing of EEG activity and a decrease in skin resistance (greater arousal) with increasing durations of sensory restriction. In contrast to these positive findings, none of the other physiological measures appear to be affected.

In the study of behavioral changes, a variety of cognitive abilities have been appraised. The measurements largely involve subtests of standard I.Q. tests or tests of primary mental abilities. These have yielded a differential pattern of results e.g., space relations, number facility, and abstract reasoning are impaired whereas digit span, rote learning, recall, and verbal reasoning are unaffected by sensory restriction. An even more complex pattern of results has been revealed in studies employing measures of various sensory and perceptual-motor processes. These

investigations have shown that such performance tasks as depth perception, the constancies, brightness discrimination, and c.f.f. are unaffected by deprivation while color perception, different types of illusions, and reaction time are considerably impaired. Certain other measures, surprisingly, have shown a facilitatory effect or improvement after prolonged periods of sensory restriction e.g., tactual acuity, pain sensitivity, taste sensitivity, auditory vigilance, and tachistoscopic acuity.

Although no satisfactory explanation of these perplexing facilitatory phenomena is available, it has been suggested that an essential condition for their appearance is a severe reduction in sensory stimulation from several modalities. Recently, however, a series of studies from the University of Manitoba has demonstrated that similar effects can be produced by visual deprivation alone. Employing a one week period of darkness, significant increases in cutaneous sensitivity, taste sensitivity, and auditory discrimination were observed. Furthermore, these changes persisted for several days after restoration of normal visual stimulation. Unfortunately, no other single modalities were studied to determine whether they would be equally as effective as visual deprivation.

Although facilitatory effects have been demonstrated most clearly after prolonged periods of sensory and perceptual deprivation (1 to 7 days), a handful of short-term studies, employing durations under one hour, have also reported an improvement in performance: a lowered tachistoscopic recognition threshold for words and digits and an increase in pain and auditory sensitivity. However, since no attempts have been made to determine whether these short-term effects can also result from single modality deprivation, further research appears to be warranted. In view of this, the present study was designed to investigate changes in

recognition thresholds before and after a brief duration of not only perceptual deprivation but also of visual, auditory, and kinesthetic deprivation alone.

III. Historical Background

Since a voluminous literature exists on the behavioral and physiological effects of sensory restriction (see review of Schultz, 1965; Zubek, 1964b), this historical review will be restricted largely to sensory and perceptual studies reporting facilitatory changes after both multi and single modality deprivation. For organizational purposes, the review will be presented in two sections: the first describing long-duration studies of one day or longer and the second, short-duration studies employing periods of less than a day. In describing the various experiments, a differentiation will be made between sensory and perceptual deprivation as defined in the introduction.

Long-Duration Studies

Multi-modality deprivation. The earliest demonstration of a sensory improvement was made in one of the McGill experiments (Doane et al., 1959) in which two-point threshold determinations were taken from five subjects before, and at intervals of two and three days of perceptual deprivation. A group of 20 controls was used for comparative purposes. The results revealed an increase in tactual acuity of the forehead and upper arm at both time intervals, an effect which was significantly greater relative to that of the controls. Furthermore, these facilitatory effects were greater after two days than after three days. No significant changes in acuity were seen on the finger and forearm. Although these two negative results might be attributed to the smallness of the experimental

sample, another possibility, at least for the finger, is that the two-point limen technique is not sufficiently accurate to demonstrate increased sensitivity in an area of the skin which normally is highly sensitive.

Using a more sensitive measure of tactual acuity (tactual fusion) Zubek (1964a) reported a significant increase in acuity of both the index finger and forearm after a week of perceptual deprivation. All 12 experimental subjects showed increased forearm acuity, and 11 of the 12 subjects an increased finger acuity on the second threshold determination. In comparison, the controls exhibited a chance distribution of increases and decreases. Similar results have also been demonstrated at a Japanese laboratory after two days of perceptual deprivation. Nagatsuka and Maruyama (1963) reported a significant increase in the tactual acuity of the back of the hand (two-point limen). It is interesting to note that eight of the nine experimental subjects showed the effect. Experimental verification of this phenomenon was provided in a subsequent replication (Nagatsuka & Suzuki, 1964).

An increased sensitivity to pain can also occur but apparently only under conditions of sensory deprivation. Vernon and McGill (1961), measuring the absolute threshold of electrical pain of the earlobe, reported a 42 per cent increase in pain sensitivity after four days of sensory deprivation in contrast to an increase of only 5 per cent in a group of controls. Of the nine experimental subjects, all but one showed this change. In discussing these results in a subsequent publication, Vernon (1963) raised two intriguing questions. First, since a 42 per cent increase was obtained after four days, would one day yield a 10 per cent change? Second, would longer periods lead to an even greater increase

in sensitivity? Although a linear increase in pain sensitivity may occur with increasing durations, a more likely possibility is that the greatest increase will occur early in the deprivation period and subsequently diminish with time. Some support for this hypothesis has been provided by Doane et al. (1959), who observed a greater increase in tactual acuity after two days than after three.

Contrary results on pain sensitivity were reported by Zubek et al. (1962), who, using a one week period of perceptual deprivation and a radiant heat technique for eliciting pricking pain, reported a significant decrease in sensitivity. Although this discrepancy might be attributed to the use of a seven-day rather than a four-day period, this appears unlikely since in two subsequent studies at the Manitoba laboratory, using seven days of visual deprivation alone, a significant increase in pain sensitivity was observed (Zubek, Flye, & Aftanas, 1964; Zubek, Flye, & Willows, 1964). A more likely possibility is that this decrease, occurring after perceptual deprivation, resulted from the constant exposure to white noise. Both Gardner and Licklider (1959) and Carlin et al. (1962) have reported that white noise has certain analgesic properties. Furthermore, Licklider (1961) has stated that "Mountcastle has found cells, both in the posterior group nuclei and in the cerebral cortex, which respond to nociceptive stimulation and whose responses are suppressed by acoustic stimulation" (p. 70). It would appear, therefore, that the presence or absence of white noise may be the critical factor. Furthermore, these findings suggest that qualitatively different results may be produced by sensory and perceptual deprivation.

Since significant improvements on various cutaneous measures of performance have been reported, one might expect similar facilitatory

effects in other sensory modalities. This appears to be the case. In a study on gustatory sensitivity, the Japanese investigator Nagatsuka (1965) reported a 36 per cent increase in sensitivity to both sweet (sucrose) and bitter (quinine) after one day of perceptual deprivation in contrast to no change in a group of controls. Measures of sensitivity to sour and salty substances, unfortunately, were not taken.

A suggestion of an improvement in visual functioning has also been reported. Doane et al. (1959) appraised visual acuity by means of a horizontal row of 14 vertical black lines (the "lines" test), with each line in the series possessing a small gap of progressively decreasing width. The lines were presented at a distance of 10 feet and the subject was required to indicate where the gap was in each line. The experimental subjects showed an increase in visual acuity after three days of perceptual deprivation in contrast to no change in controls who also received the same test three days apart. Although the results only bordered on statistical significance, the investigators attached considerable weight to this finding in view of a significant increase in tactual acuity present in the same subjects.

In this same study, an appraisal was also made of tachistoscopic perception of a series of black nonsense forms (outlines) presented one at a time on a white screen for approximately 50 msec. A recognition method of testing was used. No significant changes were observed. The failure of Doane et al. (1959) to demonstrate a significant improvement on either the "lines" test or on nonsense forms, after three days of perceptual deprivation, is puzzling since Suzuki, Ueno, and Tada (1966) recently reported a significant lowering of the tachistoscopic threshold for the Landolt ring after only one day of perceptual deprivation. One possible

explanation of this discrepancy is that a significant lowering of the threshold may have occurred in the Doane et al. study if their two measures had been administered after one day rather than after three days when most of the effects may have dissipated.

Finally, an improvement in auditory functioning has also been reported. Smith, Myers, and Murphy (1967) observed a superior performance on an auditory vigilance task after three days of sensory deprivation. Similar results were obtained in a replication study. In these two studies a total of 59 experimental and 76 control subjects were used, a sample much larger than is customarily employed in sensory restriction experiments. In the only other study on auditory vigilance, Zubek et al. (1961) reported no significant changes on this measure after a week of sensory deprivation. This apparent discrepancy in results probably can be attributed to the difference in duration. Various studies (e.g., Doane et al., 1959; Vernon et al., 1961) have indicated that performance on various perceptual measures is often affected more by short than by prolonged durations of deprivation, suggesting a recovery of function with time.

Single-modality deprivation. In the preceding section it has been shown that prolonged durations of sensory and perceptual deprivation can produce a significant improvement in cutaneous, gustatory, visual, and auditory functioning. Recently, five experiments from the Manitoba laboratory have indicated that many of these facilitatory effects can result from visual deprivation alone. An overall reduction in sensory stimulation from several modalities is not essential.

In the first study (Zubek, Flye, & Aftanas, 1964) 16 male subjects

were placed, in groups of two, in total darkness for a prescribed period of one week. Apart from the exposure to constant darkness, their environment was quite normal i.e., no gloves were worn and no restrictions were placed on their motor activity or on talking. A radio was available in the room at all times. Measures of tactual acuity were taken from the index finger, palm, and forearm before and immediately after the week of darkness, and subsequently at follow-up intervals of 1, 2, 5, and 7 days. The measures consisted of the two-point threshold and tactual fusion (interrupted bursts of air whose frequency can be increased until a constant sensation of pressure is reported). In addition to these measures, heat and pain thresholds were taken by means of the Hardy, Wolff, and Goodell dolorimeter. A group of control subjects received the same tests and at the same time intervals. The results showed a significant increase in cutaneous sensitivity relative to the control subjects. This increase was shown on all measures, on all skin areas tested, and by all 16 experimental subjects. Furthermore, this increased sensitivity was still present several days after the termination of darkness.

The purpose of the second experiment (Zubek, Flye, & Willows, 1964) was to determine whether effects, similar to those resulting from darkness, will result from prolonged exposure to non-varying homogeneous illumination. The previous procedure, therefore, was repeated with a new group of subjects, but instead of being exposed to darkness, each subject wore a pair of translucent goggles which permitted diffuse light but eliminated all pattern vision. The results revealed an essentially similar picture: an increase in pain and heat sensitivity and in tactual acuity as measured by the tactual fusion method. These results appear to suggest that it is the absence of pattern vision or of changes in visual input rather

than an absence of visual stimulation per se which is responsible for the increased cutaneous sensitivity.

During the course of these visual deprivation studies, several subjects reported spontaneously that their sense of hearing seemed to be much better. In view of these remarks, two types of auditory tests were used in the third study (Duda & Zubek, 1965). These were administered to a group of 15 subjects before and after a week of darkness. The first involved the measurement of auditory discrimination using an auditory flutter technique (interrupted white noise at a 0.90 on-off ratio). The second consisted in the determination of the threshold of hearing for five different frequencies: 100, 300, 1,000, 5,000, and 9,000 cps. The results revealed an increase in auditory discrimination with the after-effects persisting for one day. All subjects but one showed this effect. On the other hand, the absolute threshold of hearing for the five frequencies was not affected. Furthermore, no trends were evident.

In view of these differential results on auditory functioning, a fourth study (Phelps, 1967) was conducted whose purpose was to determine how general or specific these intersensory facilitatory effects may be. Two other auditory measures were taken, absolute and differential auditory localization, and two cutaneous measures, tactual localization and absolute pressure sensitivity of the finger, palm, forearm, neck, and leg. The results revealed no significant changes on the two auditory measures or on tactual localization, a finding which Phelps states may be related to the strong role that learning and practice plays in these performance tasks. However, a significant increase in absolute pressure sensitivity of the various skin areas did occur.

The purpose of the fifth experiment (Schutte & Zubek, 1967) was to

determine whether a week of visual deprivation can produce an increase in gustatory and olfactory sensitivity. If this should occur, it will suggest that prolonged visual deprivation may produce a general enhancement of sensory functioning. Olfactory sensitivity (recognition threshold for benzene) was measured by a power-operated, syringe-type olfactometer. In the determination of gustatory sensitivity, the test stimuli consisted of 21 different concentrations of sucrose (sweet), 20 for NaCl (salt), 22 for Hcl (sour), and 23 concentrations for quinine sulphate (bitter). The results indicated a significant increase in olfactory sensitivity, while gustatory sensitivity showed a differential pattern of results. Sensitivity to salty and sweet substances was increased significantly; a strong trend, though not significant, was observed for sour (11 of the 12 experimentals showed an improvement); and no change occurred for bitter. The failure to demonstrate even a trend toward increased sensitivity to bitter after a week of visual deprivation is puzzling since Nagatsuka (1965) reported that subjects exposed to one day of visual and auditory deprivation showed a 36 per cent increase in sensitivity to bitter (quinine) and sweet (sucrose). One possible explanation of this apparent discrepancy may be that increased sensitivity to bitter only occurs after combined visual and auditory deprivation and not after visual deprivation alone. It is also possible that the difference in the durations of the two experiments may be the critical factor; the effect on bitter sensitivity, though present at one day may have dissipated by the end of one week.

The results of these five Manitoba experiments are significant in two respects. First, they suggest that some of the other facilitatory effects e.g., the improvement in tachistoscopic visual acuity, may also

occur after visual deprivation alone. Second, these results are of considerable theoretical importance since they provide experimental support for the sensoristatic model of the nervous system recently formulated by Schultz (1965). According to Schultz, sensoristasis is a condition in which the organism strives to maintain an optimal range of sensory variation, a range which is capable of shifting to some degree as a function of several variables. The monitor serving to maintain the sensoristatic balance is the reticular activating system which Lindsley (1961) conceives of as serving as a sort of "homeostat" or regulator adjusting "input-output" relations. One of the predictions which Schultz derives from his model is that "when stimulus variation is restricted, central regulation of threshold sensitivities will function to lower sensory thresholds. Thus, the organism becomes increasingly sensitized to stimulation in an attempt to restore the balance" (p. 32). The demonstration of an increase in olfactory, gustatory, cutaneous, and auditory sensitivity, following prolonged visual deprivation, appears to support this theoretical prediction. Schultz's model would also predict that auditory, cutaneous, and kinesthetic deprivation, alone, should likewise produce lower thresholds in the non-deprived modalities. Unfortunately, no relevant studies depriving these other modalities of stimulation are as yet available.

Short-Duration Studies

Facilitatory effects have also been demonstrated in several studies employing a short period of sensory restriction. For example, Ormiston (1958) demonstrated that 30 subjects exposed to 30 minutes of unpatterned light and silence showed a greater readiness to perceive apparent motion than did either control subjects or a group receiving 30

minutes of sensory "bombardment". Using an even shorter duration, Glazer and Zenhausern (1966) measured the auditory and pain sensitivity of 32 subjects before and immediately after five minutes of sensory deprivation and subsequently at one minute intervals for four minutes. The results revealed an initial lowering of auditory and pain thresholds (increased sensitivity) immediately after deprivation, an "overswing" to raised thresholds two minutes later, and then a return to the normal pre-deprivation levels at the end of four minutes. The presence of these oscillatory changes was interpreted as indicating a temporary disturbance of some homeostatic regulatory mechanism such as the reticular activating system. These results, although intriguing in nature, are questionable since no control group, tested at the same time intervals as the experimental subjects, was employed.

Finally, two studies directly relevant to this thesis, have demonstrated that a short period of sensory and perceptual deprivation can produce a lowering of the tachistoscopic recognition threshold. In the first study, Friel and Derogatis (1965) determined the visual recognition thresholds for four-letter nouns immediately after the termination of a 50 minute period of perceptual deprivation and motor restriction. A list of 25 different nouns was projected tachistoscopically on a screen six feet from the subject at exposure rates of 1, 3, 6, 10, and 17 msec. Five nouns were presented at each exposure rate. The results indicated that the 18 perceptually isolated subjects recognized significantly more words and at a faster exposure time than did a group of 18 non-deprived subjects.

In the second study, Rosenbaum, Dobie, and Cohen (1959) obtained recognition thresholds for 13, five-digit numbers after deprivation

periods of 0, 5, 15, and 30 minutes. Two groups of 16 subjects were used, one exposed to sensory deprivation and the other to perceptual deprivation. The 16 subjects in each group were arranged in a diagonal 4 x 4 Latin square with four replications on each subject, the visual efficiency of each being tested on four separate days after either 0, 5, 15, or 30 minutes of deprivation. A different list of 13, five-digit numbers was employed at each test session. Several minutes after the termination of deprivation, the threshold was obtained by presenting each number at a 10 msec. duration in a prelighted exposure area, with a cross for a fixation point, and increasing the exposure duration in successive steps of 10 msec. until the number was recognized. The results indicated that both experimental conditions produced an improvement in visual efficiency but that the effect only occurred after the five minute deprivation period. The absence of an improvement with the longer durations is attributed, by the authors, to an "increased boredom and emotional interference accompanying lengthened isolation".

Although this review of the literature has indicated that a facilitatory performance can occur after brief durations of sensory and perceptual deprivation, no attempt, in contrast to the long-duration studies, has been made to determine whether a similar effect can also be obtained after the deprivation of only one modality. The purpose of this thesis is two-fold: (a) to investigate the effect of five minutes of perceptual deprivation on the tachistoscopic recognition threshold for digits and (b) to determine whether the facilitatory effect, if it does occur, can be demonstrated after either visual, auditory, or kinesthetic deprivation.

CHAPTER II
EXPERIMENTAL METHOD AND RESULTS

I. Subjects

The subjects were male university students, with normal vision, who were required to participate in departmental experiments in satisfaction of a course requirement. The sample consisted of 90 subjects randomly divided into six groups, each containing 15 subjects. Two of the groups were control subjects while the remaining four were exposed to perceptual deprivation, visual deprivation, auditory deprivation, and kinesthetic deprivation, separately. Each subject served in one condition only.

II. Deprivation Procedure

Prior to participation each subject was informed that this was an experiment designed to investigate the effect of various forms of relaxation on visual acuity and that all that was required of him was to relax and follow instructions (see Appendix A for detailed instructions). During the five-minute deprivation period the subject reclined in a comfortable chair with his feet on a cushioned stool, in a room illuminated with an overhead light and decorated with colorful travel posters. The perceptually deprived subjects (PD group) wore a white mask which permitted light but eliminated pattern vision, earphones through which they heard white noise, somewhat above the threshold of hearing, had their arms, legs, and torso strapped to restrict movement, and were instructed to move as little as possible; visually deprived subjects (VD group) wore a white mask and received normal auditory stimulation; auditorally deprived subjects (AD group) wore earphones through which they heard

white noise and were provided with magazines as additional visual stimulation; kinesthetically deprived subjects (KD group) had their arms, legs, and torso strapped to the chair and were provided with normal visual and auditory stimulation.

In addition, two control groups were employed. The non-deprived reclining group (RC group) was placed for a five-minute period in the same chair as the deprived subjects and provided with magazines and normal auditory stimulation while the non-deprived ambulatory group (AC group) was escorted to a waiting room and provided with reading material.

III. Testing Visual Efficiency

The visual recognition threshold for each subject was determined immediately before, and two minutes after the five minute deprivation or control period by presenting, one at a time, eight randomly constructed five-digit numbers, composed of the integers 1, 4, 6, 7, and 9 in which no number appeared more than once. These five integers, 3 mm. in height, were selected on the basis of a pilot study in which it was shown that these integers were similar in difficulty of recognition. The two-minute interval between the end of the deprivation period and the post-test allowed for visual adaptation in the PD and VD groups. The ascending method of limits was used. Beginning with a tachistoscopic exposure of one msec., a different five-digit number was successively presented, at increasing durations of one msec., until the number was correctly identified. In order to minimize the effect of practice, two lists of numbers were employed, one prior and the other after the five-minute experimental period.

The order of presentation of the five-digit numbers in each list was randomly determined using a table of random numbers. A black dot