THE EFFECTS OF PROLONGED VISUAL DEPRIVATION UPON CUTANEOUS SENSITIVITY

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ABSTRACT

Several studies have reported the presence of cutaneous supersensitivity in subjects exposed to prolonged periods of sensory and perceptual deprivation. The purpose of this study is to determine whether visual deprivation alone can produce this phenomenon.

Sixteen male subjects, wearing black masks, were confined in pairs in a small room for a period of 7 days. Apart from exposure to constant darkness their sensory environment was normal. Various measures of cutaneous sensitivity were taken before and after the week of darkness as well as at intervals of 1, 2, 5 and 7 days following visual deprivation. Thirty male control subjects were tested at the same time intervals but were in no way restricted.

The tactual acuity of the palm as measured by the two-point limen technique, and that of the index fingers and forearms as determined by a "fusion" method, were found to have increased significantly following the week of darkness. The skin of the forearm was also found to be significantly more sensitive to heat and pain. This cutaneous supersensitivity, which was shown by all experimental subjects, was still present several days after the termination of visual deprivation.

It is suggested that "sensitization" of certain areas of the central nervous system may result from reduced visual input and may be responsible for the increased cutaneous sensitivity observed in this experiment.

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CHAPTER I

INTRODUCTION AND HISTORICAL BACKGROUND

I Statement of the Problem

Exposure of human subjects to a severe reduction in the level of visual, auditory, tactual-kinesthetic and social stimulation can result in a variety of behavioral and physiological changes. One of the most unusual of these is an increase in tactual acuity and in pain sensitivity. This increase in cutaneous sensitivity, which represents the only clear instance of supersensitivity following sensory isolation, is quite pronounced. Furthermore, it seems to occur in all, or almost all experimental subjects. The purpose of this thesis is to demonstrate that a severe reduction in stimulation from several modalities is not essential for the appearance of this phenomenon. It can occur following visual deprivation alone.

II Introduction

A relatively recent development in experimental psychology has been the study of the effects upon human behavior of a severe reduction in the level and variability of sensory and perceptual stimulation. The attempts to achieve such a reduction in environmental stimulation are often referred to by such terms as sensory isolation, stimulus deprivation, sensory deprivation or perceptual deprivation. Although a variety of procedures have been used to reduce sensory stimulation they fall, in general, into two main categories. In the first, efforts are made to reduce sensory stimulation to as low a level as possible. This is usually accomplished by the use of a dark, sound-proofed room in which the subject, wearing gauntlet-like gloves, is instructed to lie quietly on a cot or mattress. Earplugs or earmuffs may be used to reduce further the level of sensory stimulation. Communication between subject and experimenter is kept to a minimum, thus reducing social stimulation. In the second general procedure, an attempt is made to reduce the patterning and organization of sensory stimulation while maintaining its level near normal. In this method, the subject typically lies on a cot in a cubicle and wears gloves and translucent goggles which permit diffuse light to enter the eyes, but eliminate all pattern vision. A masking sound, usually the hum of a fan or white noise, is directed into both ears. The intensity of light and noise is maintained at a constant level. Deprivation periods of up to 14 days may be employed.

Regardless of the type of deprivation condition which is used, a variety of behavioral impairments may be produced, e.g., disturbances in perception, thinking, emotions, motivation and, occasionally the appearance of hallucinatory-like phenomena (see reviews of the literature by Kubzansky, 1961; Fiske, 1961; Zubek, 1964). On the other hand, a few behavioral functions appear to be facilitated, e.g., certain types of verbal learning and immediate memory. Perhaps the most notable example, however, is a pronounced increase in tactual acuity and in pain sensitivity. Furthermore, this cutaneous supersensitivity seems to occur in all, or almost all, experimental subjects. Although little is known about the mechanisms underlying this unusual cutaneous phenomenon, an essential condition for its appearance is believed to be an overall reduction in the level of visual, auditory, and tactual-kinesthetic stimulation. This belief, however, may not be true. There are, for example, scattered reports in the literature suggesting that the blind sometimes exhibit improved cutaneous sensitivity. It is possible, therefore, that this cutaneous phenomenon, reported on several occasions in the isolation literature, may have resulted solely from visual deprivation. The purpose of this thesis is to explore this possibility.

III Historical Background

This review of the literature will begin with a survey of the sensory isolation studies in which measures of cutaneous sensitivity were obtained. This will be followed by a review of the relevant literature on the blind. Finally, some attention will be devoted to studies on sensory interaction or intermodal stimulation. These are relevant to this thesis topic since they indicate that stimulation of one sense modality may affect the functional level of other modalities.

Sensory Isolation Studies

Although a variety of sensory and perceptual functions have been investigated, only a handful of studies have concerned themselves with possible post-isolation changes in cutaneous sensitivity.

The earliest study was reported by Doane, Mahatoo, Heron and Scott (1959) in which five subjects were confined to a small lighted cubicle for a period of 4 days. Patterned vision was prevented by the use of translucent goggles, and cuffs and gloves reduced tactual stimulation. Auditory perception was severely limited by a masking noise. Lowered two-point thresholds, as compared to normal, unrestricted subjects, were obtained for the forehead, upper arm and forearm after periods of 48 and 72 hours of isolation. No change occurred on the tip of the index finger.

Recently, Zubek (1964) reported essentially similar results. A group of 12 subjects were exposed to 7 days of unpatterned light and white noise, a condition similar to that of Doane et al. However, only half the subjects wore heavy leather gloves. Tactual acuity thresholds for the index finger and fore arm were determined before and after isolation, using a "fusion" technique. All 12 experimental subjects showed a significant increase in forearm acuity, and 11 of 12 subjects showed increased finger acuity on the second threshold determination, a week later. On the other hand, the control subjects showed a chance distribution of increases and decreases in acuity. The discrepancy between the acuity of the index finger as reported by Zubek, and that reported by Doane et al, may be due to the different measuring techniques employed. It is possible that the two-point limen technique is not sufficiently sensitive for use on this area of the skin. It is also interesting to note that Zubek reports no differences between subjects who wore gloves and those who did not. This supports the contention that the same results may be obtained, even though fewer sense modalities are deprived.

Not only tactual acuity, but also pain sensitivity may increase after prolonged deprivation. Vernon and McGill (1961) found evidence of increased pain sensitivity following 4 days of darkness and silence. Deprivation consisted of confinement to a small light-proof, sound-proof cubicle. A modified method of limits was used to establish thresholds for a 1000 cy/sec. electric current which was conducted through dry electrodes clamped to either side of the right ear lobe. Following the 96 hour deprivation period, all 9 experimental subjects showed increased pain sensitivity. Vernon and McGill explain this phenomenon of supersensitivity in terms of the reticular activating system of the brain stem. They suggest that under normal conditions neural impulses from sensory stimuli encounter blocking in the descending tracts of the reticular formation. This blocking is the result of cortical excitation aroused by any sensory stimulation. Therefore, they hypothesize that under conditions of sensory deprivation this opposition is absent and pain impulses of lesser intensities are capable of registering.

This theory is quite similar to that put forth by Doane et al to explain their results. These authors suggest that "the lack of varied input results in an inactivity of the pathways of some higher levels of the central nervous system". Therefore, the increased acuity may result from stimulation of these inactive pathways.

Although pain sensitivity is increased after exposure to darkness and silence, Zubek et all (1962) have observed a decrease in pain sensitivity after exposure to unpatterned light and white noise. This decrease in sensitivity, however, is probably due to the action of the white noise in view of the analgesic properties claimed for this type of auditory stimulation (Gardiner and Licklider, 1959). Further evidence for the inhibitory action of acoustic stimuli on pain sensitivity is provided by Mountcastle (1961) who has found cells "both in the posterior group nuclei and in the cerebral cortex, which respond to nociceptive stimulation and whose responses are supressed by acoustic stimulation".

In conclusion, it would appear that an increase in both tactual acuity and in pain sensitivity can occur following certain conditions of reduced sensory stimulation.

Studies on the Blind

The notion that when an individual loses the use of one of his senses, the remaining senses function vicariously to compensate for the loss, is an old one. The literature is full of reports which both confirm and refute this concept of sensory compensation, particularly with reference to the blind. In reviewing the literature on the tactual sensitivity of the blind, a distinction will be made between basic acuity, and more complex tactual functioning. The former, in terms of its measurement by the two-point limen technique, will be presented first.

Results of early studies on tactual acuity have proved contradictory. Griesbach (1899) determined thresholds for 37 blind and 56 sighted subjects using a spring operated esthesiometer of his own design. He reported that the blind exhibited poorer tactual acuity than the sighted on the forehead, cheekbone, nose, lips, thumb and fingers. Furthermore, the reading finger of the blind proved less sensitive than their other fingers. Griesbach atrributed this effect to a thickening of the skin and the formation of callouses on the reading finger.

While Seashore and Ling (1918) do not support these findings of poorer sensitivity in the blind, neither do they support the notion of sensory compensation. In a study employing 16 blind and 15 sighted persons, they report no significant difference in tactual acuity for the tip of the index finger and the inner forearm, 5 cms. above the wrist. Plata (1941) using a sample of 5000 subjects, also obtained no evidence of a compensatory increase in touch or kinesthesis in the blind. However, Axelrod (1959) who reanalysed Plata's data, observed an interesting sex difference. Differences in tactual acuity among blind boys, sighted boys and sighted girls were negligible. However, blind girls proved significantly more sensitive than sighted girls.

In a study of his own on the early-blind, Axelrod (1959) also found a sex difference but in the opposite direction. Using Von Frey filaments, he found early-blind girls to have poorer light-touch thresholds than sighted girls on the left and right index fingers, and on the ring finger of the preferred hand. However, early-blind boys displayed better light-touch sensitivity than sighted boys on all three fingers. He hypothesizes that differential callous formation characteristic of the manual activities of the two sexes may be responsible for these results. Measurements of tactual acuity for these same skin areas were also recorded using the two-point threshold technique. The early-blind exhibited lower thresholds than the sighted for the right index finger. However, no differences were found between the two groups for the left index finger and the ring finger of the preferred hand. Therefore, this study offers only limited support to the concept of sensory compensation.

On the other hand, Wilson, Wilson and Swinyard (1962) attribute to the blind higher two-point thresholds for the forearm, than to either normal subjects or amputees. This the authors explain in terms of the dulling effect of increased afferent input to the cortex as a result of observed hyperactivity in the hands of the blind.

A survey of the literature reveals that claims regarding the tactual acuity of the blind have often been based on data from a few or even from one blind individual. Both Helen Keller and Laura Bridgman are famous examples of this. However, even here results are at variance. Miss Keller's sensitivity for a wide range of skin areas from the fingers to the tip of the tongue proved no greater than normal. Laura Bridgman, on the other hand, is credited as having tactual acuity two to three times greater than normal on her fingers. This supersensitivity is attributed by Hall (cited by Tilney, 1929) to her training in needlework. In the light of such contradictory evidence, it is difficult to arrive at any conclusions regarding the basic tactual acuity of the blind.

A number of investigators have reported on the comparative ability of the blind and the sighted to perform a variety of complex tactual tasks. A brief summary of these studies follows. Hayes (1934) found the blind less able than the sighted to identify various common objects by shaking them in a box. In discriminating between lifted weights the blind were again less accurate than the sighted (Seashore and Ling, 1918). However, Plata (1942) found the blind superior to the sighted in complex tactual tasks.

Contradictory results are reported regarding the ability of the blind to deal with raised or embossed surfaces. Merry (1932) and Merry and Merry (1933) found that blind children are deficient in their ability to recognise embossed pictures or simple designs tactually. However, this ability, they claim, can be somewhat improved through training. Seashore and Ling (1918) also reported that the blind are less able than the sighted in perceiving a copper wire through layers of tissue by stroking the area with the fingers. Since this task requires somewhat the same abilities as braille reading, these results are surprising. On the other hand, Brown and Stratton (1925) found the blind more sensitive than the sighted in an unconventional discrimination task in which they were required to indicate whether one or two points were felt, by moving the fingers over single and double rows of steel points set in a board. The similarity between this task and braille reading is obvious.

Neither Worchel (1951) nor Ewart and Carp (1963) found any difference between the blind and sighted in tactual recognition of simple geometric forms. Worchel (1951) however, found the blind poorer at describing and reproducing these forms than the sighted. Ewart and Carp (1963) report a difference based on intelligence. The blind registering high IQ's were more able to recognise the forms than the sighted or the less intelligent blind. It is interesting to note that Plata (1941) considered intelligence and training to be the important variables influencing the variance in the tactual sensitivity of the blind.

Data on the tactile perception of curved and straight surfaces by the blind is also contradictory. W. Hunter (1962) found the blind less able to manipulate a curved surface into a flat one. I.M. Hunter (1954) however, attributes finer and more consistent judgements of curved and straight lines to the blind.

It is evident from these studies that conclusions regarding the abilities of the blind to perform complex tactual tasks are no clearer than those regarding their basic sensitivity.

In reviewing and evaluating this contradictory literature, several considerations must be kept in mind. Primary among these is the degree of blindness possessed by the subjects. Unfortunately, this has not always been specified in some studies. Obviously, the greater the residual vision, the less importance must be attached to the sensory accomplishments of the "blind". A case in point is that of Wiletta Huggins, a girl probably more affected by hysteria than deaf-blindness, who claimed to "hear by touch and see by smell" (Hayes, 1934). Her ability to tell the denomination of bills by manipulation and the colour of fabrics by smell was subsequently traced to residual vision. Even when complete blindness is established, several considerations remain which must be taken into account. The cause of blindness is important, particularly in regard to negative reports of sensory compensation. If blindness arises through disease or accident, it is conceivable that other areas of the cerebrum may also be affected and the senses associated with these areas impaired. According to Axelrod (1959) retinal damage at an early age may in fact be symptomatic of more extensive damage to the central nervous system.

The age of onset of blindness is another important factor.

Various studies have shown that the early and late-blind perform differentially on complex tactual tasks. Axelrod (1959) reports the late-blind to be superior to the early-blind, and comparable to the sighted in performing a tactual matching task. Similarly, Worchel (1951) found the late-blind superior to the early-blind when required to draw and describe simple palpated forms. Also, late-blinded individuals perform better than the early-blind when required to replace pegs in a straight line in a board which has been rotated 180° (Drever, 1955). Steinberg (cited by Hayes, 1934) explains this difference in performance between the early and late-blind as being due to the ability of the late-blind to visualize tactile impressions just as the sighted do.

Finally, Hatwell (1959) observed that the late-blind are superior to the congenitally blind and the sighted on a task requiring the tactile recognition of two sizes of geometric figures and complex patterns. They were also superior in ability to reproduce these figures.

Due to the contradictory nature of the results reported in this review of the tactual sensitivity of the blind, it is difficult to arrive at a clear picture of the relationship between the loss of vision and skin sensitivity. Greater and lesser cutaneous sensitivity in the blind as compared to the sighted has been reported, as well as instances of no difference between the two. These contradictory results may be due to various confounding factors such as age, sex, I.Q., age of onset, degree of blindness and inadequate experimental techniques.

Studies of Sensory Interaction

Since the early 1930's the general area of sensory interaction or intersensory effects has been the object of considerable attention by researchers, particularly in the Soviet Union. This work has generally involved the study of modifications of response in one sense organ under direct stimulation, where another sense organ has been, or is subject to its own characteristic stimulus.

A summary of the Russian studies in this area is presented by London (1954). With the exception of some work on thermal sensitivity, very little is reported regarding the cutaneous senses. Stimulation of cold receptors in the skin is held to facilitate dark adaptation and to lower peripheral vision thresholds. Thermal stimulation is also reported to effect the CFF producing initially a decrease and subsequently an increase. An interaction between vision and touch, therefore, seems to be indicated.

Auditory sensitivity can also be affected by stimulation of other sense modalities. For example, it is reported to increase upon exposure to white light and to decrease in the absence of visual stimulation. Furthermore, various wave-lengths of light can produce differential effects. Gustatory stimulation also heightens auditory reception of low but not of high tones.

Olfactory and gustatory stimulation is reported to effect peripheral vision in an equally complex and specific manner. For example, sweet, sour and acid tastes as well as the odours of bergamot and spirits of hartshorn are facilitating. However, the taste of quinine and the odour of pyridine raise peripheral vision thresholds.

Since these effects have been shown to vary with particular auxiliary stimuli and with specific experimental procedures, it is difficult to generalize regarding the underlying parameters of sensory interaction. Further, most North Americans have been sceptical of this Soviet Research because of its often conflicting nature, inadequate methodology and almost primitive statistical treatment of data. It is also felt that the results reported could be attributed to changes in "attention" since momentary stimulation of one sense modality might serve to make the subject more alert to the presentation of a stimulus in another modality.

Recently, however, some of the Russian results have been verified by North American investigators. For example, Ryan (1940) reported an interaction between vision and touch. In his study, a tactual card-sorting task was facilitated by exposure to unpatterned visual stimulation. Other investigators such as Maier et al (1961) and Ogilvie (1956) have also reported intersensory effects. Moreover, their results were of such a nature that they could not be accounted for by changes in "attention". Although certain intersensory effects have been demonstrated in North American laboratories, the phenomena are often minute. For example, Ogilvie (1956) reported that the presence of auditory flutter increases the CFF by only half a cycle. It is not surprising, therefore, that conflicting results should characterize this area of research.

From this brief survey of the literature, it is clear that a variety of intersensory effects, often of a very complex nature, are possible. In the light of these results, therefore, it would not be surprising if visual deprivation alone had an effect on tactual acuity and pain sensitivity.

CHAPTER II

EXPERIMENTAL METHOD

I The Problem

The preceding chapter has shown that exposure of subjects to prolonged periods of sensory isolation can result in an increase in tactual acuity and pain sensitivity. Furthermore, some instances of increased cutaneous sensitivity in the blind have been reported. A wide variety of intersensory effects, including an interaction between vision and touch have also been demonstrated by the technique of simultaneous stimulation of one sense modality and observation of the functional level of another modality. This suggests, therefore, that this unusual isolation phenomenon may have resulted from visual deprivation alone, rather than from an overall reduction in sensory input from a number of modalities. This hypothesis will be tested in the present study.

II Subjects

The subjects were male university students drawn almost exclusively from the faculty of Arts and Science of the University of Manitoba. The sample consisted of 16 experimental subjects and 30 control subjects, ranging in age from 18 to 26 years. All subjects received financial remuneration for participation in the experiment.

III Deprivation Procedure

The 16 experimental subjects, each wearing a black mask, were placed in pairs in a room 10 ft. x 15 ft., which was equipped with two spring-filled mattresses, a table and a radio. A 40 watt red bulb dimly illuminated the room and enabled the subjects to be kept under constant visual surveillance. The black masks were never removed during the prescribed seven day period. Furthermore, the subjects were instructed to report any light "leaks" immediately. Apart from the exposure to constant darkness, the environment was quite normal. No gloves were worn and no restrictions were placed on motor activity or on conversation with one another or with the experimenters. The radio was frequently in use. There were no failures. All 16 subjects successfully endured the week of darkness.

IV Cutaneous Measures

Measures of tactual acuity were taken from the palm, index finger, and forearm before and after the week of darkness as well as at intervals of 1, 2, 5 and 7 days after termination of visual deprivation.

The sensitivity of the palm was determined by the two-point threshold technique. Four two-point thresholds were established for the transverse axis of the left and then the right palm. Ten second intervals were interspersed between presentations of the stimuli. The method of limits was used with descending and ascending series being presented alternately. One stimulation in every five was a "check test" employing only one point of the esthesiometer.

The sensitivity of the index finger and forearm were measured by the fusion or "flicker" technique described by Shewchuk and Zubek (1960a). These authors (1960a) have indicated agreement in the rank order of body area sensitivity as obtained by the two-point limen and fusion techniques. The results of these tests, therefore, should prove complimentary and mutually confirming. The fusion method involves the production of an interrupted stream of air at a specific pressure, whose frequency can be systematically increased until the subject reports a constant sensation of pressure on the skin. The frequency of air bursts at which the constant sensation occurs is referred to as the critical frequency of percussion (CFP).

Four measurements separated by 10 second intervals were taken from each index finger and forearm. All stimuli were presented in an ascending order and at a tank pressure of 30 lbs. Measurements were taken on the volar surface of each forearm, approximately 8 cms. below the elbow, and on the distal phalanges of both index fingers. A sequence of right arm, left finger, right finger, left arm was followed to minimize the effects of fatigue and discomfort in any one limb. Stands were provided to steady the arm or finger during testing and to maintain it at a constant distance of 0.50 cm. from the air nozzle. The subject was fitted with NRC type earmuffs through which a low level of "white noise" was generated, and a screen was placed so as to shield the arm or finger from his view. Discriminations were thus restricted to the cutaneous sense modality.

In addition to tactual acuity, measures of heat and pain sensitivity were taken from the forearm before and after the week of visual deprivation. Thresholds were determined using the Hardy, Wolff and Goodell dolorimeter (model ER 2-ES2, Williamson Development Co.). This apparatus consists of an incandescent lamp whose rays can be focused onto a blackened area of the skin. A heat setting dial on the control box makes regulation of the radiant heat output possible. This dial is calibrated from 50 to 500 m. ca./cm^2/sec. in units of 10 millicalories.

After the skin had been blackened with dolorimeter ink, four heat and pain readings separated by one minute intervals were obtained for each arm. The basal setting of the dolorimeter was 100 m. cal./$cm.^2$/sec. for a skin temperature of 34°C. Skin temperature was determined by a clinical thermometer prior to each testing session. A correction of $Hs = 100 + 20\ (34^{o}\ C - Ts)$ (where Hs is the final dolorimeter setting and Ts is the skin temperature) was applied to the basal setting in cases of variation from the normal skin temperature. The thresholds for heat and pain sensitivity were measured in terms of the latency of response. The subjects were instructed to indicate the first trace of warmth by pressing a microswitch which stopped a Hunter Klockounter. Subsequently, they were instructed to respond at the first indication of pricking pain so that the stimulus and a high speed timer could be stopped.

In order to acquaint them with the test procedures, the subjects were given practice trials for the various cutaneous measures a day prior to visual occlusion. This practice session also served as a screening device to identify and exclude from the sample, those subjects who proved unstable or whose scores deviated too markedly from previously determined norms.

A group of 30 control subjects were given the same cutaneous measures and at the same time intervals as the experimentals but they were never visually occluded.

CHAPTER III

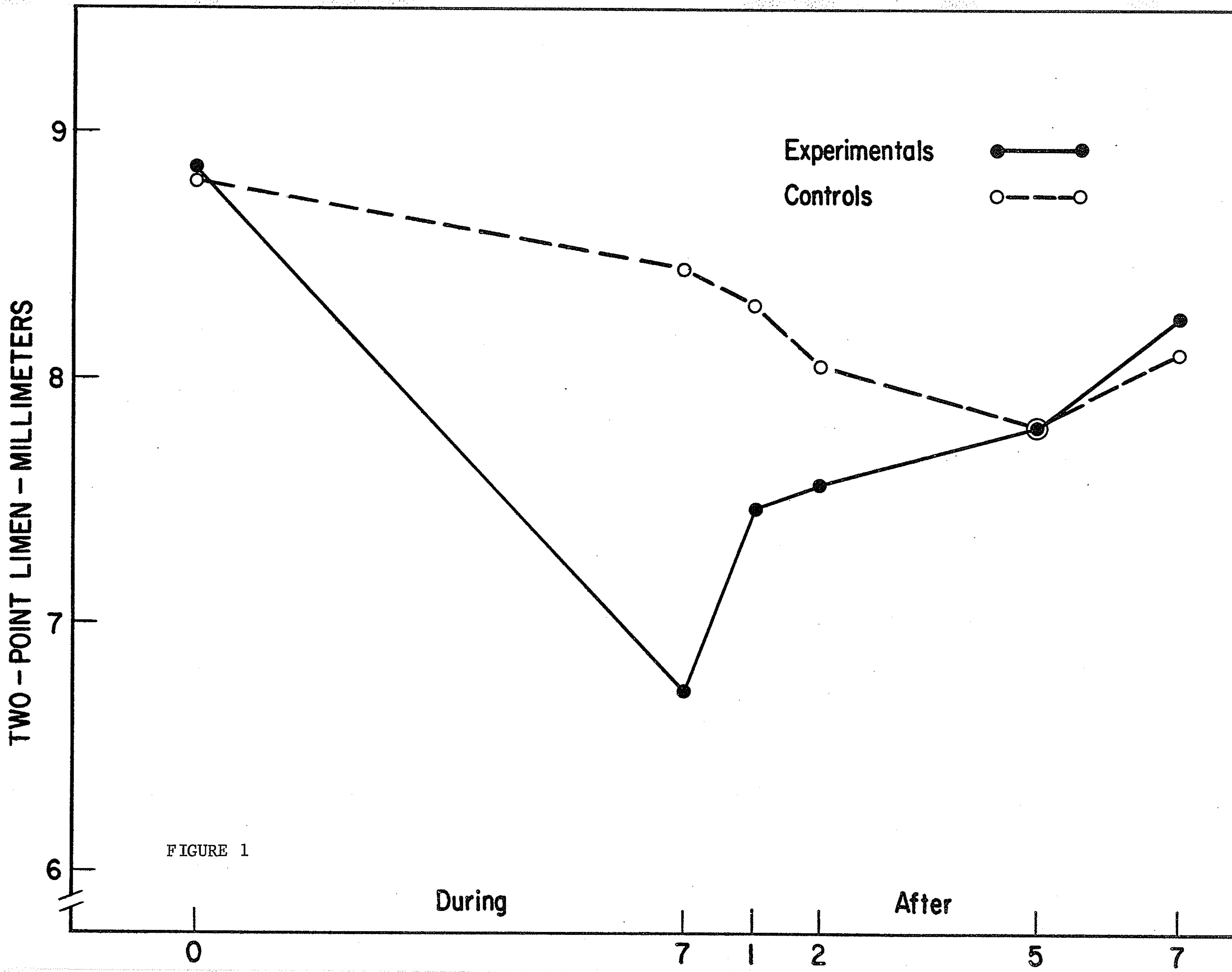
EXPERIMENTAL FINDINGS AND DISCUSSION OF RESULTS

I Results

For purposes of statistical analysis, the pre-darkness scores of the 16 experimental subjects, on the various cutaneous measures, were matched subject by subject with the initial scores of 16 of the 30 controls. This sample of controls was found to be sufficiently large to produce a good matching with the smaller experimental group. Two-tailed *t* tests for correlated measures were used in the statistical analysis.

Figure 1 indicates that the experimental subjects, after a week of darkness, show a pronounced increase in tactual acuity of the palm in relation to that of the matched controls ($p < .001$). Furthermore, there are suggestions that this effect is still present two days after termination of visual deprivation. However, only the "post day 1" difference between conditions is significant ($p < .05$). Figure 2 indicates that the tactual acuity of the index finger and forearm is also increased following a week of darkness (p's $< .001$). Again, the after-effects seem to persist for a number of days. However, for the finger only the "post day 1 and 2" differences between conditions are significant (p's $< .01$); for the forearm the "post day 7" difference is still significant ($p < .05$). In the latter case, however, the unusually long after-effect may partly be due to a change in standard of judgement. Finally, Figure 3 shows that not only is tactual acuity increased but also sensitivity to heat and pain (p's $< .01$). Furthermore, the hypersensitivity still persists on "post day 2" for pain ($p < .05$) and "post day 1" for heat ($p < .05$).

An examination of the individual performances of the 16 experimental subjects revealed that the effect of visual deprivation was uniform. The hypersensitivity was shown by all subjects, on all skin areas, and on all cutaneous measures. On the other hand, the control subjects exhibited a chance distribution of increases and decreases in sensitivity.



TWO - POINT LIMEN - MILLIMETERS
9
8
7
6
Experimentals
Controls
During
After
0
7
1
2
5
7

FIGURE 1

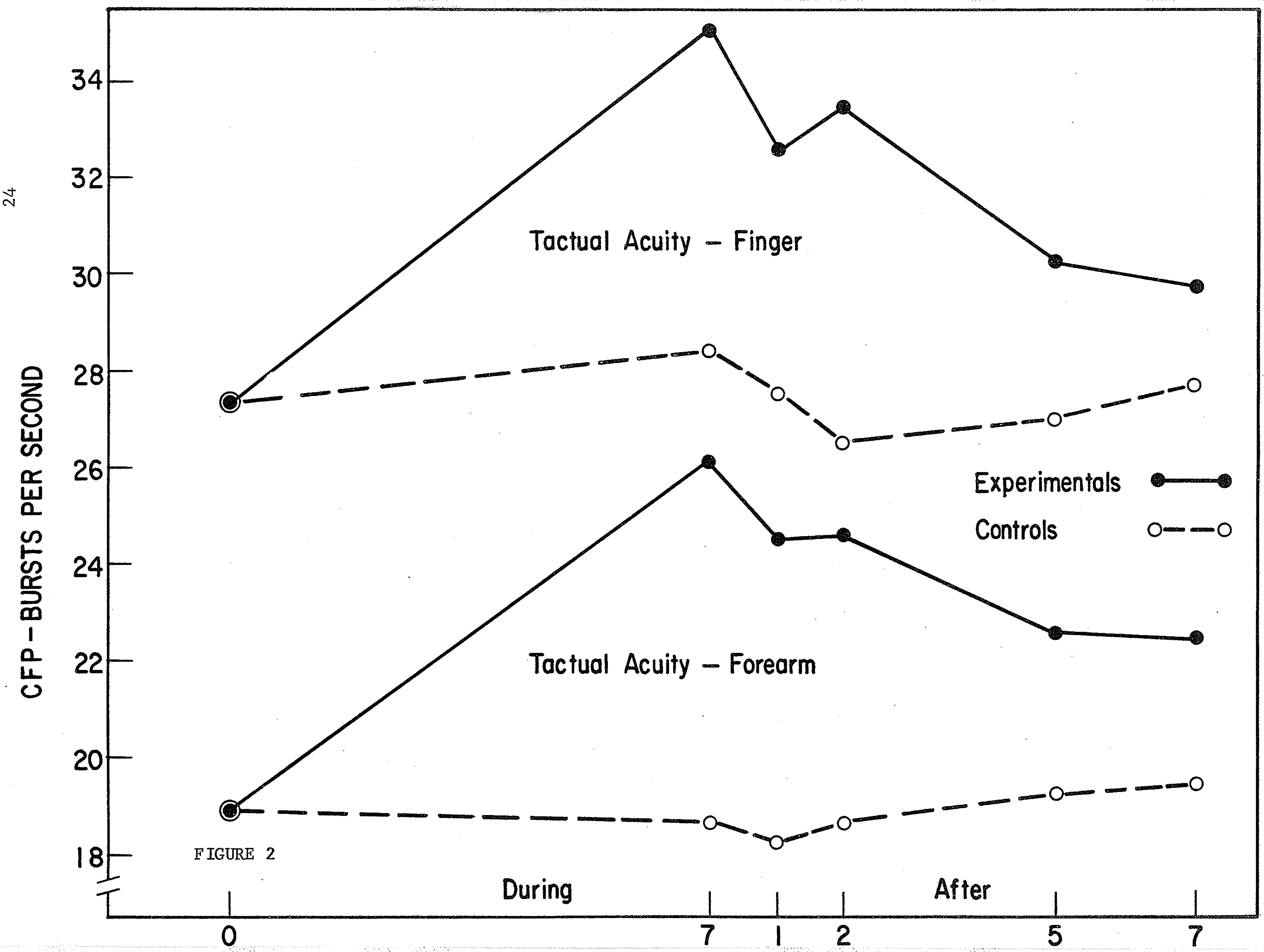
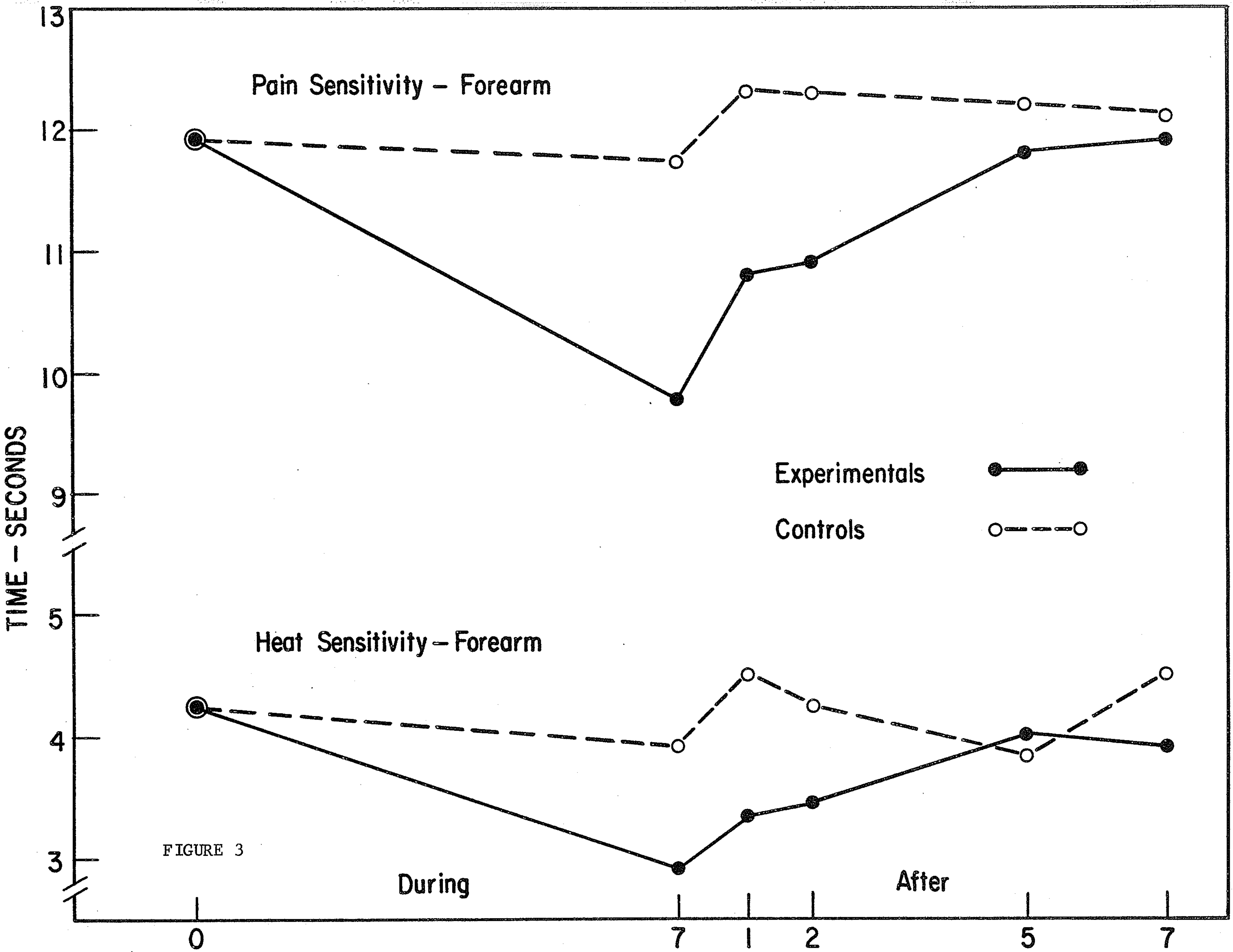

CFP - BURSTS PER SECOND
34
32
30
28
26
24
22
20
18
Tactual Acuity - Finger
Tactual Acuity - Forearm
Experimentals
Controls
During
After
0
7
1
2
5
7

FIGURE 2



TIME – SECONDS
13
12
11
10
9
5
4
3
Pain Sensitivity – Forearm
Heat Sensitivity – Forearm
Experimentals
Controls
During
After
0
7
1
2
5
7

FIGURE 3

II Discussion of Results

The results of this experiment indicate that an overall reduction in visual, auditory, tactual-kinesthetic, and social stimulation is not essential for the appearance of cutaneous supersensitivity. It can occur following visual deprivation alone.

Some spontaneous observations made by subjects during and after isolation support this finding. Among these are reports of supersensitivity on the arms and soles of the feet and of ticklishness in individuals not usually so affected. There were also instances of auditory and olfactory hyperacuity. Several subjects reported, on their return home, that the radio was unusually loud, and that its volume had to be reduced well below its usual level. Other subjects reported being acutely aware of the smell of food and cigarette smoke. It is possible, therefore, that a general enhancement of sensory functioning may occur following visual deprivation. Furthermore, the possibility that these effects might be observed with deprivation of a sense modality other than vision, for example hearing, must not be overlooked. In this regard, it is interesting to note that diminished proprioceptive stimulation alone can produce many of the classical deprivation effects. (Zubek and Wilgosh, 1963).

These results also seem to indicate that a deprivation procedure might prove to be a better method for studying the interrelationships existing among various sense modalities than the classical Russian method of stimulating one modality for a short period and testing the sensitivity of another. The more clear-cut results of deprivation studies may be due to the longer experimental conditions employed. Should this be the case, comparable results might be obtained with the Russian method by using longer periods of stimulation.

Since the cutaneous effects obtained in this experiment were so pronounced and long lasting, it seems worthwhile to consider the possible physiological mechanisms underlying these changes. It is hypothesized that one of the effects of the functional deafferentation produced by the visual deprivation technique may be to "sensitize" certain areas of the central nervous system. Some support for this contention is offered by Grey Walter (1963) who reported that in some congenitally blind children the nonspecific cortical responses evoked by tactile and auditory stimuli are unusually large in relation to those of sighted children of the same age. Krech, Rozenzweig, and Bennett (1963) have also demonstrated that rats, subjected to peripheral blinding at the time of weaning subsequently show an increase in the weight and cholinesterase activity of the somesthetic cortex. Furthermore, Krech (1964) in an unpublished study, observed similar somatosensory changes in sighted rats reared in darkness. They reasoned that the greater reliance of blind animals on somesthetic and kinesthetic information in dealing with their environment led to greater neural activity of the somesthetic cortex and therefore to both a growth of structure and increased cholinergic synaptic transmission. This explanation, however, is not applicable to the present results. In this study, the subjects, during the week of darkness, had less occasion to use their hands than would usually be the case in their roles as university students, taking notes, turning pages etc. Furthermore, even if they were more active during darkness, this would not account for the increase in heat and pain sensitivity. Thus it is unlikely that changes in the level of tactile-kinesthetic stimulation can account for the present results.

Krech's report of an increase in the weight of the somesthetic cortex following visual deprivation seems to be supported by an autopsy study on the brain of Laura Bridgman. This deaf and blind girl had a poor sense of taste and smell but a keen sense of touch (cited by Tilney, 1929). The autopsy revealed that the areas of the brain on which little demand was made, for example the inferior and superior colliculi and the temporal lobes, were poorly developed. However, the parietal lobe in which the somesthetic area is located, was highly developed. Thus the physiological studies on blind organisms suggest that visual deprivation alone can produce cortical changes of a type which could result in cutaneous supersensitivity. Whether the cortical changes in man, however, are similar to those reported by Krech is open to speculation, particularly in the light of the short deprivation period employed in this experiment.

Finally, since the present study deals with experimentally produced "blindness", its results should have implications with regard to the sensory capacities of the blind. In view of the pronounced post-darkness increases in cutaneous sensitivity, similar or even greater increases in sensitivity might be expected in blind human subjects. This, however, does not appear to be the case. What literature is available is contradictory in nature with both increases and decreases in sensitivity being reported. Although the reasons for this discrepancy in results are not known, two suggestions may be offered. First, it is possible that cutaneous supersensitivity in the blind may only occur shortly after their affliction when they are expected to be the most reliant on the sense of touch in dealing with their environment. It may not be present later when they have adjusted to their blindness. Unfortunately, no research data is available to support this hypothesis. Second, it is possible that cutaneous supersensitivity only occurs in the totally blind and not in those with some degree of brightness vision. Some support for this view is offered by a recent unpublished study by Zubek (1964) in which subjects were exposed to a week of unpatterned light instead of darkness. Although cutaneous supersensitivity was again observed, the phenomena was much less pronounced. Furthermore, the tactual hyperacuity could only be demonstrated by the "fusion" technique. In the present study, however, the effect was shown by both the fusion and the two-point limen techniques. In the light of this discussion, perhaps a "new look" at the centuries old controversy over sensory compensation in the blind may be justified.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Several isolation studies have shown increased cutaneous sensitivity following an overall reduction of visual, auditory, tactual-kinesthetic, and social stimulation. However, the present study indicates that visual deprivation alone may be sufficient to induce cutaneous supersensitivity.

In this study 16 male university students were housed in pairs in a small room for a period of 7 days. Black masks were worn throughout the prescribed period. No other restrictions, either of an auditory, tactual-kinesthetic or social nature were imposed. Various cutaneous measures were taken before and after the week of darkness, as well as at periods of 1, 2, 5 and 7 days after termination of visual deprivation. The same measures were taken at the same intervals for 30 control subjects who were otherwise unrestricted.

A significant improvement in two-point thresholds for the palms of both hands was observed following visual deprivation. Similarly, the tactual acuity of the index fingers and the volar surface of the forearms, as measured by the "fusion" technique, also showed an increase. In addition, a heightened sensitivity to heat and pain was observed. These effects were shown by all experimental subjects and were still in evidence several days after termination of visual deprivation.

Several conclusions may be drawn from these results. First, since the spontaneous remarks of the experimental subjects both support the findings of cutaneous-supersensitivity, and also suggest that other modalities, for example, hearing, may show increased sensitivity, it is possible that visual occlusion results in a general sensory enhancement. Secondly, these results suggest that the method of prolonged deprivation of one modality may prove fruitful in the study of intersensory relationships. Finally, the pronounced cutaneous changes observed in the "experimentally" blind should have implications with respect to the centuries old controversy over sensory compensation in the blind.

It is postulated that this cutaneous supersensitivity may have resulted from a "sensitization" of certain cortical areas as a consequence of the reduction in afferent visual input. This central interpretation is supported by some physiological studies showing cortical changes in congenitally blind children, ennucleated rats, and rats reared in darkness.

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