Modification of thermoregulatory responses to cold by hypnosis[1]

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KISSEN, ABBOTT T., CLIFFORD B. REIFLER, AND VICTOR H.
THALER. *Modification of thermoregulatory response to cold by hypnosis.*
J. Appl. Physiol. 19(6): 1043–1050. 1964.—The effects of
hypnosis on thermoregulatory responses were studied in non-
acclimatized acutely cold-exposed men. Forty exposures (4.5–
5.0 C) were conducted in an environmental chamber under
both hypnosis and nonhypnosis conditions. Five subjects, wear-
ing 1 clo insulation, were cold exposed for 1 hr, four times for
each condition, and each subject served as his own control.
Variables monitored included mean skin and rectal tempera-
tures, heart and shivering rates, basal skin resistance, and vigi-
lance task performance. In hypnosis, shivering was suppressed,
heart rate lowered, and vigilance task performance improved.
Basal skin resistance differed in terms of pattern and level, being
generally higher under hypnotic conditions. Rectal tempera-
tures were lower despite maintaining skin temperature at the
same level as during nonhypnosis conditions. These findings in-
dicate that with the thermal stress imposed and levels of trance
achieved, there is a general amelioration of the psychophysio-
logical effects of the stress. The mechanism responsible for this
form of "adaptation" remains speculative but is consistent with
generalized suppression of sympathetic activity.

thermoregulation   cold exposure   adaptation
sympathetic nerve activity   shivering   basal skin
resistance   vigilance task performance

PHYSIOLOGICAL ACTIVITIES which serve to maintain
body temperature within its normal range have been
noted to occur in response to stimuli generated by both
central and peripheral control mechanisms. Shivering,
as one example, has been observed to be associated with
alterations of rectal temperature (37); the implication
being that brain (specifically hypothalamic) temperature
exercises a "central" control over shivering. Other studies
(17, 20) have demonstrated that it is alterations in skin
temperature which are responsible for the initiation of

shivering. The predominant role of the peripheral mecha-
nism in the initiation of shivering has been stressed by
Lim (27). Helmendach and Meehan (16) noted that the
thermoregulatory responses of dogs were affected by al-
terations of peripheral sensitivity wherein depression of
peripheral thermosensitivity increased the amount of
skin cooling required to initiate shivering. A crucial factor
in such homeostatic control of thermoregulatory mecha-
nisms is apparently vasomotor activity.

Psychogenic influence of peripheral vasomotor activity
is frequently observed in most instances of facial blushing
and pallor. There is evidence of similar responsivity of
the peripheral vasomotor mechanism to hypnotic sug-
gestion (7). Reactivity of other aspects of the vasomotor
mechanism, such as thermal and tactile receptors, may
also be effected by hypnotic suggestions.

In view of the interrelationship of the peripheral vascu-
lar mechanism and thermoregulation, and the possibility
of influencing these by hypnosis, it seemed probable that
the utilization of hypnosis in a biothermal stress study
would provide both a novel and productive approach to
the study of thermoregulation. The following is a report
on the modification of shivering, temperature, and re-
lated responses in human subjects exposed to whole-body
cold stress in the hypnotic state.

PROCEDURE

Forty experiments were conducted on five healthy non-
acclimatized male subjects whose physical characteristics
are shown in Table 1. The sitting-resting subjects, wear-
ing 1.0 clo body insulation, were exposed to an ambient
air temperature of 4 ± 0.5 C for 60 min. Preceding each
exposure the subjects were thermally equilibrated at
room temperature (25–27 C) for 1 hr. Control recordings
were obtained during the last 5 min of this pre-exposure
period. In experimental exposures, the trance induction
was begun after 30 min of equilibration and continued
for the remainder of the control period. Each subject
completed eight tests, four of which were nonhypnotized
exposures, the remainder, in an induced trance. There
was no insulation on head or hands, and leather shoes and
light cotton socks were worn. Air-wall temperatures were

TABLE 1. *Subject characteristics*

Subj	Age, yr.	Occupation	Height cm	Weight kg	Surface Area m²
S	23	Airman	175.5	66.3	1.82
H	21	Student	177.5	77.7	1.95
D	20	Student	168.9	57.8	1.66
K	19	Student	163.0	52.6	1.55
A	20	Student	190.0	78.5	2.05

equivalent and maintained within ±0.5 C during the experimental period. Air motion around the subject (7–10 m/min) was turbulent in type. Heart rate, rectal, and 17 skin temperatures were recorded. The weighted mean skin and body temperatures were determined by the partitional calorimetry method of Burton (6). Body heat loss was assessed using the same equation prescribed for calculation of body heat storage (Q_s). This value, rendered in calories per square meter per hour, is symbolized here as $(-Q_s)$. The reader is referred to papers by Gold (12) and Hall (13) for a detailed description of this calculation.

The subject was seated on a precision, knife-edge, platform balance to which was attached a linear accelerometer. Signals generated by movement of this device were transmitted to a Sanborn 150 polygraph recorder where the continuous tracing of the shivering response was differentiated and integrated for each 20-sec period. The unit of measurement was millimeters deflection.

In an attempt to assess performance potentialities and alertness during the experimental situation an automatic scoring visual task projector was employed. This apparatus presented pairs of patterns to subjects at the rate of approximately one per sec. The subject's task was to recognize and respond to randomly displayed matched pairs by depressing a microswitch lever within the 1-sec interval. Automatic recordings were made at 10-min intervals of correct responses as well as of errors of omission and commission.

Basal skin resistance (BSR) was measured and recorded continuously by means of a locally designed BSR meter and polygraph. Electrodes used were of the dry plantar type, approximately 7 × 10 cm, made of silver conductive cloth (31) over a sponge rubber pad. These were secured to the feet by two-way stretch bands with Velcro closures. The slow write-out technique, previously described (24–26), permits monitoring of the state of consciousness throughout the stress exposure of the subject and provides a relative measure of alertness, drowsiness, or sleep. There is also some evidence that BSR level correlates with hypnotic depth and may be used as a monitor for such (36).

Each subject was seen for approximately 1 hr in six to eight pre-experimental sessions and was trained to enter into hypnosis. All subjects were able to enter into at least a deep-medium trance within the time requirements of the experiment. Although all were able to enter into autohypnosis when not under stress, the operator used

progressive relaxation as an induction procedure just before each subject entered the thermal chamber in an attempt to maximize the hypnotic state. Trance fluctuations were perhaps more variable than they would have been without stress; but, in general, the trance depth was fairly well maintained during the hour of exposure. In debriefing, all subjects were interviewed before and after arousal from the trance. They were asked to estimate their trance depth and fluctuations and to describe their subjective feelings. All subjects had been taught to utilize the phenomena of dissociation and time distortion and were able to employ these phenomena of hypnosis either the greater part of the time or the entire time in which they were subjected to the stress. No direct suggestions were given pertaining to feelings of comfort or physiological changes to be studied. Indirect suggestions were given by discussing feelings of comfort and enjoyment while dissociated and the ability of the unconscious mind to modify and control the physiological processes. Techniques which might aid the subject in achieving a state of greater comfort were discussed, e.g., the hallucination of wearing gloves during the cold exposure.

Analysis of variance was the major statistical technique employed. Because of the controversial nature of the effects of hypnosis (cf. Barber (2) among others) it was decided to accept as significant only those F ratios which had a probability of .01 or less of being due to chance.

RESULTS

Of the data generated in this study the most striking pertains to an apparent relationship of the hypnotic state to suppression of the shivering response. There develops a seeming paradox where significant inhibition of shivering is coincidental with falling colonic and mean skin temperatures, as well as increasing total body heat loss. In view of the number and variety of parameters recorded, the results of this investigation are presented in categorical fashion.

Shivering response. Under nonhypnotized conditions, onset of subject shivering was variable, usually beginning as gross tremors within the first 5 min of cold exposure. There were, however, marked shivering responses in all nonhypnotized conditions prior to 30 min of exposure. Once begun, shivering continued, phasically, for the remainder of the test period with increasing frequency and peak amplitude. In addition to the gross shivering response, the subjects displayed behavior responses indicative of extreme discomfort. These included grimacing, exertive sounds, and deliberative, gross body movements. All subjects when under nonhypnotized conditions expressed immense relief upon cessation of the experiment and invariably registered complaints of discomfort, particularly of finger pain.

The same subjects exposed to the same environmental manipulation but in a hypnotized state responded quite differently ($P < .001$; Fig. 1). By the end of the experiment shivering was reduced to less than one-third of the nonhypnotized values. In some subjects there was

absolute absence of tremor throughout the entire hypnotized exposure period. Shivering, when evident, was markedly delayed, occurring, generally, within the last 10 min of the experiment. Facial expressions were markedly impassive and breathing was relatively regular and shallow. Upon return to room temperature and arousal from trance, the subjects, with rare exception, reported a subjective shortening of exposure time and definite lack of difficulty in tolerating the conditions. While there were isolated references to finger discomfort, these remarks were never spontaneous, but rather in response to specific requests for recall.

Vigilance task. Vigilance performance scores registered by subjects under both hypnotized and nonhypnotized states were tested for statistical significance. These scores reflected three aspects of vigilance performance: correct responses, errors of omission, and errors of commission (Fig. 2). Despite large individual variations, significant improvement ($P < .01$) in the accomplishment of this task was demonstrated by subjects under hypnotized conditions during the last half of the exposure time. This improvement was manifested in terms of both increased correct responses and decreased errors of omission. There was no difference in scores relating to errors of commission.

Basal skin resistance. There is a consistent and significant difference in the BSR responses elicited by subjects under nonhypnotized as compared to hypnotized conditions (Fig. 3). Regardless of initial relationships, after 15 min of exposure the mean BSR values of subjects measured
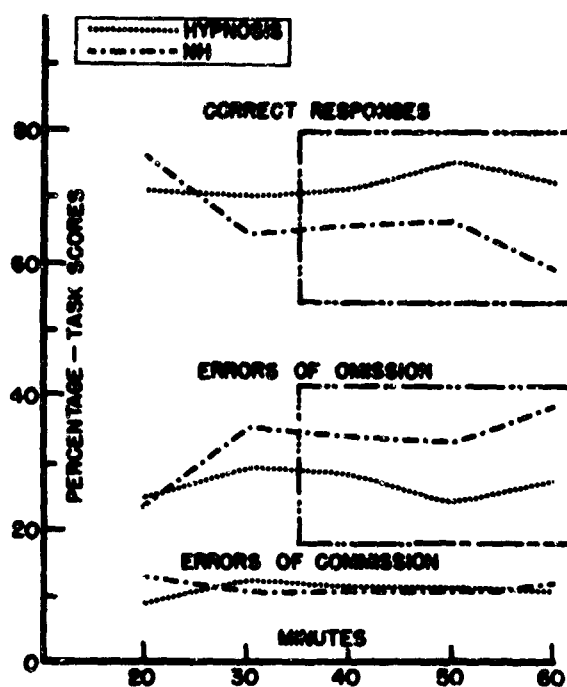
FIG. 2. Mean vigilance task scores by 10-min intervals. Areas enclosed in rectangle represent data showing significant difference between conditions ($P < .01$).

under hypnotized conditions were higher than those of nonhypnotized exposures. This difference progressively increased for the remainder of the exposure period with a terminal mean difference of almost 18,000 ohms.

Heart rate. In four of the five subjects, a relatively lower heart-rate trend was established during hypnotized conditions at or before 15 min of exposure time. This trend was consistent throughout the exposure period and the difference was intensified progressively (Fig. 4). Statistical treatment of the data for all subjects indicates a significantly reduced heart rate under hypnotized conditions ($P < .01$). Both the relative decrease and the absolute values for heart rate at the conclusion of the experimental exposure show significant differences ($P < .01$) between conditions (Table 2).

Heat loss ($-Q_s$). Heat loss, expressed as caloric loss per square meter per hour is shown in Fig. 5. All hypnotized condition exposures elicited higher heat loss rates throughout the experiment as compared to their nonhypnotized controls. The mean $-Q_s$ for all hypnotized runs at the termination of the exposure was 103 Cal/m² representing an increased heat-loss rate of approximately 15 Cal/m² per hour.

Skin temperature. With the exception of the scapular area, none of the 17 individual thermistor placements showed significant skin temperature differences between hypnotized and nonhypnotized conditions. There was some tendency for the "weighted mean skin temperatures" of the two groups to diverge, with maximum disparity occurring at the conclusion of the exposure period. Terminally this amounted to a 0.28 C difference, with the hypnotized condition being lower. Statistical analysis of this however fails to demonstrate significance (Table 3).
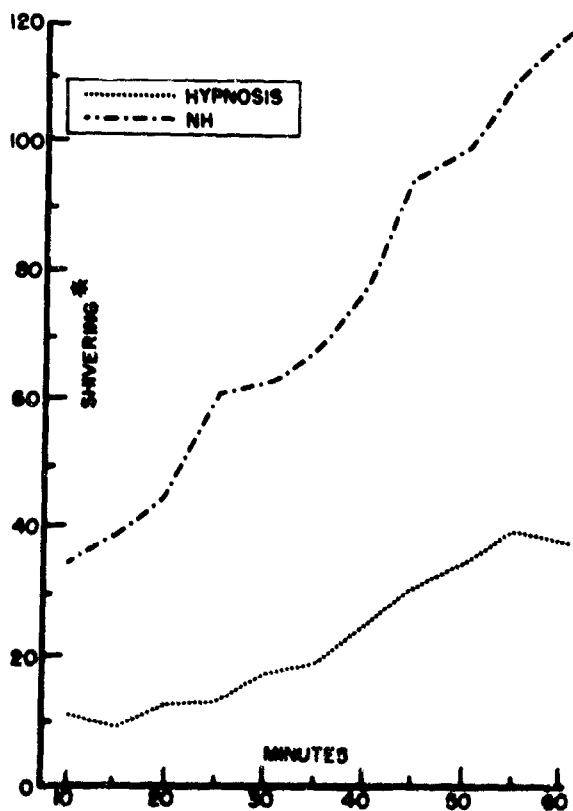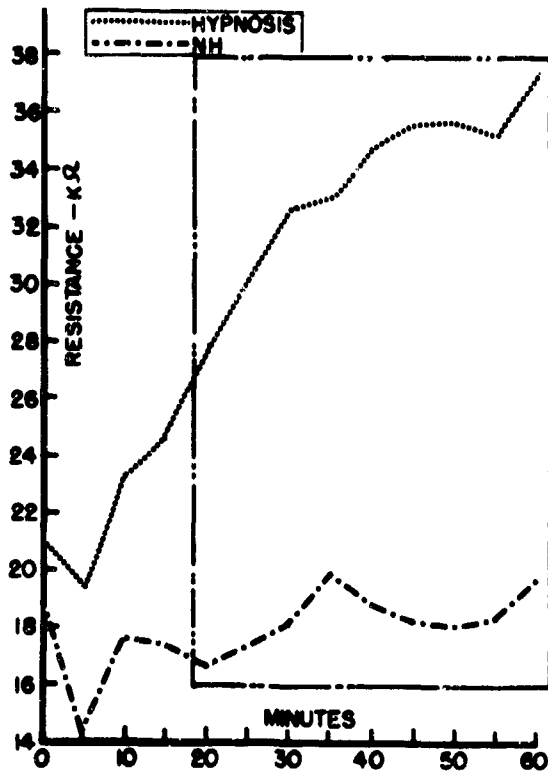
FIG. 1. Shivering response for all subjects over time. Analysis of variance shows significant differences ($P < .001$) with respect to condition only. *Shivering units are expressed in millimeters of deflection of recording pen.

FIG. 3. Mean basal skin resistance. Areas enclosed in rectangle represent data showing significant difference between conditions $(P < .01)$.

Rectal temperature. The pattern of rectal temperature response of subjects while under nonhypnotized conditions exhibited less consistency than did the pattern under hypnotized conditions. During nonhypnotized runs two subjects showed modest, but consistent, mean increases in rectal temperature (0.11 and 0.33 C). Rectal temperatures for the remaining subjects tended to fall during nonhypnotized exposures, the decrease ranging from 0.22 to 0.39 C. Rectal temperature responses in the hypnotized exposure were more uniform in that all subjects experienced a decrease (0.17 to 0.78 C) with a mean fall of 0.56 C for the group. Comparisons of these temperatures across time show a consistent trend of increasing difference between mean hypnotized and nonhypnotized values. At the last :·· 5-min intervals, these differences are significant beyond the 1 % level of confidence (Fig. 6).

DISCUSSION

There is an accumulation of evidence supporting the concept that the well-regulated central temperature of the cold-exposed, nonacclimatized man is, largely, a function of integrated sensory input. In a study designed to delineate the roles of central and peripheral control mechanisms in thermoregulation, Helmendach and Meehan (16) demonstrated the prepotent effect of the peripheral mechanism. They topically anesthetized a large surface area of dogs subsequently exposed to cold. Their findings indicate that it was necessary to produce significantly lower skin temperatures in dogs so treated before shivering was initiated. Hardy (14) observed that

upon abrupt exposure to cold, the skin and mean body temperatures of human subjects began to fall at once (in spite of, and perhaps causing, the rise in core temperature). The subjects evidenced vasoconstriction and shivering. It was concluded that the regulatory system was operating under a strong drive from the skin receptors and in an opposite direction from that which the increased core temperature would have driven it. Lim (27) demonstrated the existence of "peripheral" in addition to "pure central" shivering produced by local cooling of the hypothalamus. This study also emphasized the predominant role of the peripheral mechanism in the initiation of shivering and the conclusion was drawn that thermal stimuli originating at the cutaneous thermoreceptor level are at least as effective and probably more potent than central or core temperature.

Hardy (14) has said, "It has not been possible in animal or man to obtain data on a subject devoid of cutaneous sense of warmth or cold. Were it possible to find a man so deficient, headway could be made in closing an important gap in our knowledge." Acceptance of the concept of the major role of cutaneous sensory input in thermoregulation leads one to interesting speculations regarding the alteration of normal thermoregulatory responses by modification of the peripheral mechanism. It is our feeling that in a sense and, to at least a limited extent, we are dealing with such a modification in the hypnotized subject.

Discussion of the involvement of hypnosis in thermoregulatory investigation should be prefaced by an
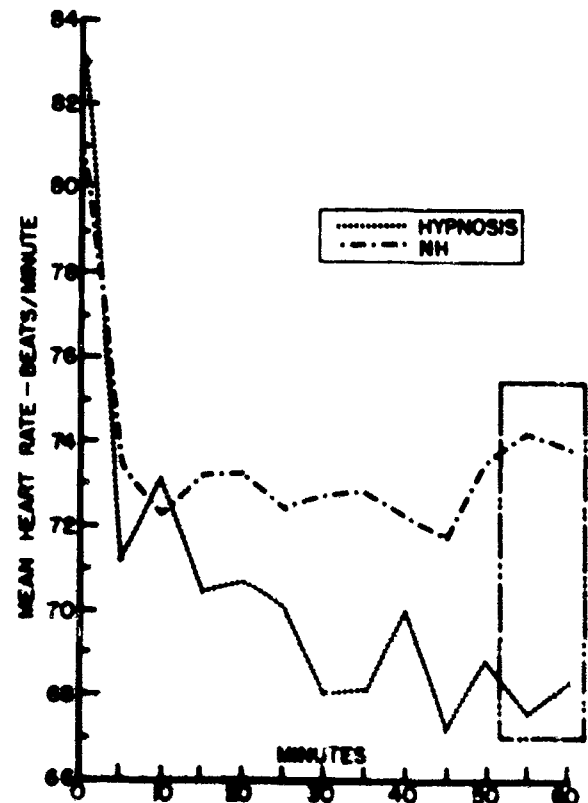

FIG. 4. Mean heart rate—absolute values. Areas enclosed in rectangle represent data showing significant difference between conditions $(P < .01)$.

acknowledgment of its limitations. Any study which utilizes hypnosis as a research tool is, at the outset, hampered by the difficulties of quantitating characteristics of the trance phenomenon. Despite numerous attempts, there is widespread disagreement as to the reliability and validity of any one system (LeCron (23), Hatfield (15), Witzenhoffer and Hilgard (40), Shor (35), Barber and Calverley (3), see also Jenness (19)). Other difficulties appear in relation to comparing effects of hypnosis on a particular parameter without specifying the over-all conditions which apply. We feel it is important to study the effect of hypnosis upon a functioning system rather than upon an isolated response. In this way hypnotic effect can be studied as an intervening condition which is expected to modify a pattern of response produced by a primary alteration of normal biological mechanisms. In this case, the pattern of response elicited by cold exposure is relatively constant and is related to basic physiological homeostatic mechanisms of the organism. How the organism will respond to the imposed stress can be quantified. How this ongoing homeostatic response is altered by the experimental interjection of hypnosis can then be compared to the original dynamic alteration.

This was an exploratory study, however, to determine the effectiveness of hypnosis as a research tool in thermoregulatory investigation. We are, therefore, not at this time concerned as much with the nature of the hypnotic alteration as we are in determining whether such an alteration can be achieved. For this purpose we maximized the intensity of those techniques usually characterized as "hypnotic" in an attempt to determine feasibility of the approach. On the basis of our data, we propose that hypnosis is effective in modifying the normal thermoregulatory response pattern of the non-acclimatized man, at least when acutely exposed to the level of cold stress specified in this study.

With the exception of von Eiff's study (38) on the influence of hypnosis on temperature sensation and heat control, we have been unable to uncover any other reports pertinent to the unique conditions of this investigation. Von Eiff studied three females and two males at 12 C and a different group of four males and one female at o C. Subjects had varying levels of hypnotic training, were exposed once to the cold while under hypnosis and a variable number of times under the nonhypnotized conditions. Length of the exposure to 12 C was 45 min for males and 25 min for females; for the o C condition the exposure was 20 min and 15 min, respectively. Additional

TABLE 2. *Change in heart rate*

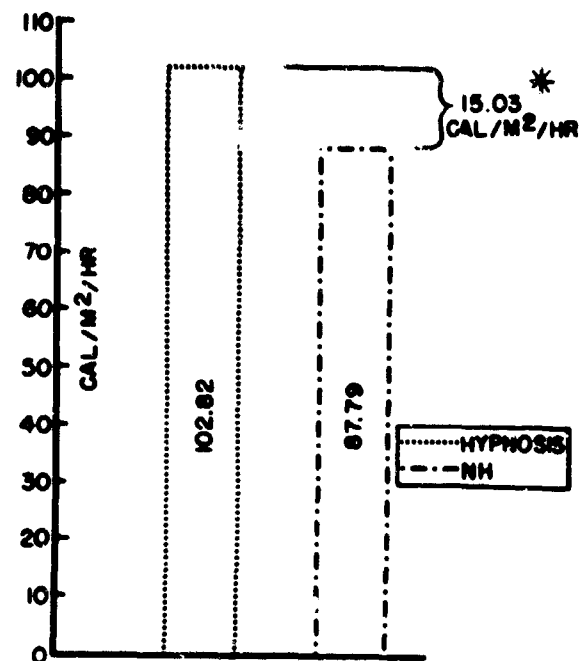|	x	m	diff	Signif of diff
Pre-exposure	83.04	80.92	2.12	ns
Final 5 min	68.35	73.90	5.55	p < .01
decrease	14.69	7.02	7.67	p < .01
Sig.	p < .01			

FIG. 5. Mean heat loss $(-Q_s)$. *The mean heat loss rate differential of 15.03 Cal/m² per hour is statistically significant $(P < .01)$.

major differences in experimental procedure were that von Eiff's subjects wore virtually o-clo insulation (bathing suits) and apparently were given direct suggestions of warmth, opposite to the prevailing environmental conditions, rather than permissive or indirect suggestions of comfort. Von Eiff also had his subjects "under four blankets for one-half hour" prior to exposure for the purpose of obtaining control values for O_2 consumption and temperature. The O_2 consumption did not appear significantly altered by hypnosis in the 12 C exposure; in the o C exposure the increase in O_2 consumption occurring under nonhypnotized conditions was significantly reduced to the point of being nonexistent under hypnotized conditions.

Despite these differences—particularly the amount of insulation worn and the length of exposure, which may serve to compensate for each other's opposite effects—our findings with respect to skin and rectal temperature changes under hypnotized and nonhypnotized conditions are in essential agreement with those of von Eiff. The rectal temperatures of subjects in hypnotized were lower than those of the same subjects under nonhypnotized conditions (von Eiff gives data on this only for his o C exposure). We were both unable to detect significantly different skin surface temperatures between the hypnotized and nonhypnotized conditions. Finally, we are in agreement that, at least on the basis of subjective reporting, hypnosis is capable of amelioration and even suppression of the general sensation of cold. We believe that the authenticity of these subjective responses is supported by other objective findings to be discussed.

In addition to the performance variable, quantitative measures of heat loss, heart rate, and shivering give added dimension and explanation to von Eiff's finding of decreased oxygen consumption under the more severe

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TABLE 3. *Skin temperatures; initial and terminal values*

Position	Initial NH(°C)	Initial H(°C)	Diff (°C)	Terminal NH(°C)	Terminal H(°C)	Diff (°C)
Forehead	34.82	35.16	0.34	25.38	26.33	-0.95
Neck	34.81	35.02	0.21	29.49	29.82	-0.33
Scapula	34.76	35.13	0.37	27.52	26.38	0.14
Kidney	32.85	32.89	0.04	26.58	25.94	0.64
Nipple	34.49	34.74	0.25	30.16	29.41	0.75
Abdomen	34.87	35.17	0.30	29.68	29.43	0.25
Rump	31.30	31.60	0.30	22.87	21.91	0.96
Upper Arm, Right	33.87	34.22	0.35	25.58	25.30	0.28
Lower Arm, Left	33.95	34.28	0.33	24.97	25.77	-0.80
Hand, Right	35.04	35.63	0.59	11.13	11.20	-0.07
Hand, Left	35.16	35.53	0.37	11.34	10.79	0.55
Ant. Thigh, Right	33.38	34.03	0.65*	25.99	25.90	0.09
Post. Thigh, Left	32.72	33.22	0.50	25.23	25.00	0.23
Skin, Right	32.36	32.68	0.32	25.13	24.53	0.60
Calf, Left	32.77	32.95	0.18	25.59	25.19	0.40
R. Foot	32.88	32.66	-0.22	20.07	19.46	0.61
L. Foot	32.89	33.02	0.13	19.60	19.42	0.18
Weighted Mean Skin	33.45	33.79	0.34	24.93	24.63	0.30

* Statistically significant temperature difference ($P < .01$).

of his two conditions. In this study the inhibition of shivering, evident in all subjects under hypnotized conditions, is the most striking observation. Meehan (30) has presented some empirical findings on the effects of hypnosis with local and whole-body cooling. They indicate that in hypnosis, shivering is intensely responsive to alterations of the psychic state.

Additional evidence which supports our premise that hypnotized subjects demonstrate altered responses to the thermal stress described is found in analysis of the BSR and heart rate changes. (Two additional subjects not otherwise discussed here were exposed to similar conditions with direct suggestion and exhortation substituted for hypnotized conditions. While subjective responses were the same, there was no tendency for any physiological alterations as described in this paper.) The observation of elevated BSR in subjects while under hypnotized conditions indicative of decreased general activation, is compatible with those of shivering inhibition and lowered heart rate. It has been shown by Malmo (28) for one that the state of decreased activation, concomitant with increase in BSR, involves not only physical relaxation but mental calmness as well. That this calmness exists is attested to not only by the subjective reports of the subjects but also by their performance on the vigilance task test administered in both the hypnotized and nonhypnotized conditions. Our initial reasons for the inclusion of the vigilance task test in the experimental protocol was twofold; not only did we wish to provide a barrier between the trance state

and physiological sleep, but also to provide a constant monitor of the subject's psychic state in terms of his ability to maintain contact with his environment. The interesting result of this measure is that not only was there no decrement (and assumed loss of awareness and ability to function adequately), but rather subjects were improved in their performance under conditions of hypnosis.

It is tempting to relate this effect to a dissociation of the effects of the cold from the task at hand. The possibility also exists, however, that the improved performance is due to the removal of mechanical interference because of severe shivering. It is unfortunate that no data are available concerning the performance under nonstress conditions (i.e., room temperature) to indicate whether this is a relative or absolute improvement. However, the lever was attached to a microswitch which required minimal pressure to operate; and, in general, the improvement also occurs in a period of time when severe shivering is not generally present.

In attempting to arrive at an over-all appraisal of the data we are impressed by the remarkable similarity in the response of our hypnotized subjects, acutely exposed to cold stress, with those reported for naturally and artificially cold-acclimatized men. Davis and Joy (8) have observed that shivering was virtually abolished in both seasonal and chamber cold-acclimatized men. They also add that not the least striking manifestation of acclimatization was the observed change from marked subjective discomfort of the subject early in the study to rather complete tolerance of, and indifference to, the cold at the end of the study. Irving et al. (18) found that Arctic Indians manifest significantly lowered rectal temperature during cold exposure. In this sense they duplicate the rectal temperature decline of nomadic Lapps (1) and the Australian aborigines (34) observed under similar environmental conditions. With the exception of the Arctic Indians the other native groups shivered less than Caucasian controls, or not at all. All of the native groups demonstrated greater tolerance to the exposure by sleeping longer and resting more comfortably than nonacclimatized subjects. Meehan (29) has presented similar findings in comparative exposures of Eskimos and Caucasians to cold. The relatively lower rectal, body, and trunk temperatures of the Eskimos are comparable in direction and magnitude to the related temperatures of our hypnotized subjects. The increased shivering response and greater conservation of body heat demonstrated by Meehan's native subjects is not, however, reproduced by our hypnosis group.

We are convinced that the subjects described in this study, when hypnotized, respond to cold exposure in a manner significantly different from their response to the same exposure in the nonhypnotized condition. They demonstrate at least a type of adaptation in the generic sense. Eagan (11) has presented a schema which attempts to categorize the effects on organisms of changes in thermal environments. Of the various subdivisions of adaptation suggested, habituation, specifically, cold

habituation, seems to describe most satisfactorily the response of hypnotized subjects. Eagan further categorizes cold habituation as being specific or general. Of these, we identify our results with the latter category. Eagan defines general cold habituation as "a change in the psychological set of the organism relevant to the repeated stimulus and the conditions incidental to its application (resulting in) a diminution in a physiological effect or response to the stimulus." The essential difference still remaining between the habituation described above and our results is of a temporal nature. The altered thermoregulatory response of hypnotized subjects is evident in the first acute exposure and the change in psychological "set" is not dependent upon the repetition of stimuli over an unspecified period of time. It is as if cold habituation had been accomplished instantly.

This "instant habituation" which our subjects evidenced while under hypnotized conditions is also reminiscent of the pharmacological effects of several drugs with psychoactive properties—particularly chlorpromazine (Thorazine) (39). The immediate but transient effect of our hypnotized conditions can be likened to the effect which might be elicited from such such drug administration. The subjective responses of the subjects (as well as the physiological measures) all indicate an effect of "tranquilization" consistent with the action of this particular drug, including the adrenolytic effect and suppression of shivering (10).

An explanation of the mechanism operative in hypnosis which is capable of altering the usual pattern of thermoregulatory responses cannot be completely generated from this study. Thermal regulation in man (5) can be ascribed, essentially, to two methods of control. Changes in heat production constitute what has been called "chemical" control and is so designated in view of the fact that all the heat produced in the body has its primary origin in chemical processes that occur in the tissues. On the other hand, bodily changes that alter the exchange of heat between the body and the environment are properly referred to as "physical" methods of control. Unfortunately, metabolic rate and plethysmographic measurements, so highly relevant in delineating these factors, were not performed in this study. In addition, efforts to explain the results obtained here are hampered by the insufficiency of information concerning the mode of operation of hypnosis in such a physiological alteration. Some of the questions which remain unanswered are as follows: To what extent, if any, is the central nervous system, particularly the cortical area, involved under these conditions? Delgado and Livingston (9) have shown in the monkey that bilateral removal of the posterior orbital gyrus leads to marked cutaneous vasodilatation and a reduced reaction to cold. Curiously, mechanical and electrical stimulation of this area or application of cold had the same effects as its removal (4). This might suggest an inhibitory function for the area. Are we to suppose that hypnotic suggestions of comfort are capable of so modifying integrative appreciation of
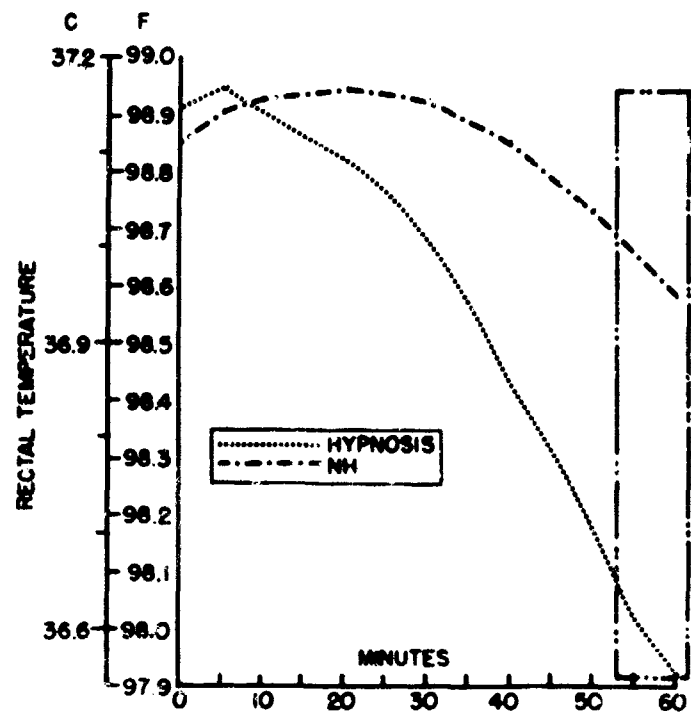
afferent inputs at the higher central nervous system levels? Further, is it possible that this modification is manifest in altered neural and neurohumoral outflow to peripheral target sites in the response pattern to cold? The data suggest the possibility of some such generalized mechanism. Decreased heart rate, elevated PSR, and diminished shivering are not completely independent variables but rather can be viewed as interdependent peripheral effects of autonomic nervous system alteration, most probably central in origin. The data also show that despite a fall in heat producetion (due partly at least to decreased shivering) and despite a loss of body heat $(-Q_s)$ the temperature of the skin remained essentially the same as when normal thermoregulatory mechanisms were unaltered (nonhypnotized condition). This maintenance of skin temperature we can explain on no other basis than that of altered vasomotor activity. Despite the lack of any direct evidence we must infer increased blood flow and heat transport to the periphery, without regard to any alteration in chemical heat production. Such an increased flow can only be accounted for on the basis of less vasoconstriction due to decreased sympathetic activity, there being no evidence for parasympathetic control of this phenomenon.

While the data are such that the hypothesis of decreased sympathetic "gain" due to hypnotic influence cannot be directly demonstrated, parsimony dictates primary consideration of this hypothesis as accounting for all the observed changes while under hypnosis, including the behavioral (4, 21, 22, 32, 33)

In summary, the results of this study are preliminary and do not warrant the use of hypnosis in current operational problems of thermoregulation. Our hypo-

thesis that hypnosis can alter thermoregulatory response in an objectively quantifiable way has been supported. While the mechanisms are unclear, our data suggest that an instant habituation is produced, similar to the pharmacological effect of chlorpromazine; and, like chlorpromazine, many of the effects of this alteration can be accounted for by decreased sympathetic gain. While we may not have simulated Hardy's thermally insensitive man, we feel that the data presented here indicate not only an approach to such a condition but also an explanation for the anticipated results.

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author)	2a REPORT SECURITY CLASSIFICATION
Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio	UNCLASSIFIED
	2b GROUP N/A

3 REPORT TITLE

MODIFICATION OF THERMOREGULATORY RESPONSES TO COLD BY HYPNOSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report, September 1962 - April 1963

5. AUTHOR(S) (Last name, first name, initial)

Kissen, Abbott T., PhD
Reifler, Clifford B., MD
Thaler, Victor H., Major, USAF

6. REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
November 1964	8	40

8a. CONTRACT OR GRANT NO	9a ORIGINATOR'S REPORT NUMBER(S)
b PROJECT NO 7164	AMRL-TR-65-21
c Task No. 716409	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d	

10. AVAILABILITY/LIMITATION NOTICES

Qualified requesters may obtain copies of this report from DDC.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Published in Journal of Applied Physiology, Vol. 19, No. 6, November 1964.	Aerospace Medical Research Laboratories, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson AFB, Ohio

13 ABSTRACT The effects of hypnosis on thermoregulatory responses were studied in non-acclimatized acutely cold-exposed men. Forty exposures (4.5 - 5.0C) were conducted in an environmental chamber under both hypnosis and nonhypnosis conditions. Five subjects, wearing 1 clo insulation, were cold exposed for 1 hr, four times for each condition, and each subject served as his own control. Variables monitored included mean skin and rectal temperatures, heart and shivering rates, basal skin resistance, and vigilance task performance. In hypnosis, shivering was suppressed, heart rate lowered, and vigilance task performance improved. Basal skin resistance differed in terms of pattern and level, being generally higher under hypnotic conditions. Rectal temperatures were lower despite maintaining skin temperature at the same level as during nonhypnosis conditions. These findings indicate that with the thermal stress imposed and levels of trance achieved, there is a general amelioration of the psycho-physiological effects of the stress. The mechanism responsible for this form of "adaptation" remains speculative but is consistent with generalized suppression of sympathetic activity.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Thermoregulation Cold exposure Adaptation Sympathetic nerve activity Shivering Basal skin resistance Vigilance task performance						

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