OBSERVATIONS ON HUMAN BEHAVIOR IN EXPERIMENTAL SEMISTARVATION AND REHABILITATION*

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INTRODUCTION

The primary purpose of the starvation-rehabilitation experiment carried out at the Laboratory of Physiological Hygiene, University of Minnesota, was to investigate under strictly controlled conditions the relative effectiveness of different types of diets in bringing about recovery from prolonged inanition. The starvation which preceded rehabilitation provided a unique opportunity for the assessment of the physiological and psychological concomitants and effects of severe undernutrition. In accordance with the interdisciplinary character of research at the Laboratory (3), the methods and techniques of physiology, biochemistry, medicine, psychology, and psychiatry were employed in parallel. Preliminary findings were reported for the use of research workers and Allied governmental and military authorities concerned with the problems of nutritional rehabilitation (8, 9, 10), and the salient aspects were briefly summarized for general use(7). Numerous journalistic reports, some of relatively high quality, have appeared (16). A general summary, prepared specifically for relief workers, has been published(6). The present paper is a detailed descriptive report on behavior in the Minnesota Experiment.

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EXPERIMENTAL DESIGN

Thirty-six "normal" young men between the ages of 20 and 33 (mean age 25.5 years, S. D. 3.5 years) served as volunteer subjects. The body build, physical performance capacity, and personality of these men varied within broad limits.

Excluding the follow-up studies, the experiment lasted for approximately a year. Control data were obtained during three months of standardization (November, 1944 to February, 1945) in which the subjects were maintained on a "good" diet providing a daily average of 3,492 Calories per man. Six months of semistarvation followed (February to July, 1945) when the actual daily average intake was reduced to 1,570 Calories. The diet was planned to simulate in quality and quantity the food available in western and central Europe under the conditions of severe food shortages during the Second World War. The semistarvation period was followed by three months of controlled rehabilitation ending in October, 1945. As we are concerned in this

paper primarily with the descriptive, "qualitative" aspects of behavior, there is no need to go into the details of the complex design of the rehabilitation phase of the experiment(2).

Results: Semistarvation Phase

Physical Changes and Energy Output. Striking changes occurred in the size and weight of the subjects, the average loss of gross body weight at the end of semistarvation representing twenty-four per cent of the control value. Both the face and the body showed a marked emaciation. Gradual wasting of muscle and subcutaneous adipose tissues made sitting on hard surfaces increasingly uncomfortable and sometimes painful. For the same reason shoes were too large and clothes loose and poorly fitting. By the twelfth week of semistarvation, edema became common and was especially noticeable in the knees, ankles, and face. The subjects reported that their nails grew more slowly and that their hair was falling out in large amounts. Shaving became necessary less frequently. The men noted, particularly in shaving, that cuts and wounds bled less than normally and were slower to heal. Physical ability to laugh heartily, sneeze, and blush was reduced or absent during the later stages of semistarvation. Muscle cramps and muscle soreness were reported. Jarring of knee joints, especially when walking on hard pavements, was an annoyance to some. Pigmentation, thinning, and roughening of the skin occurred; however, changes in the sensitivity of the skin, paresthesic and hypesthesic in character, were observed only rarely. There were many complaints that the extremities "went to sleep." Tolerance to heat was greatly increased, *e.g.* subjects could hold extremely hot plates without discomfort; and they required their food, coffee, and tea served unusually hot. Conversely, cold temperatures were poorly tolerated. Complaints of being cold or of having cold hands and feet were frequent and persistent. In hot summer weather many of the subjects slept under heavy blankets and wore "extra" clothing during the day. Vertigo, giddiness, and momentary blackouts were experienced on rising from lying or sitting positions by almost all during the first months and by some subjects throughout the semistarvation period. Actual fainting, however, occurred on only one occasion. Polyuria and, particularly, nocturia became a common problem.

Objective tests revealed no impairment of visual acuity, but many subjects complained of transient visual disturbances such as inability to focus, eye aches, and "spots" before their eyes. Standard measurements of hearing showed a slight but consistent increase in auditory acuity during the period of semistarvation. It is difficult to determine whether the complaints, that ordinary sounds and noises were disturbing and annoying, had a direct physiological basis in the "improved" auditory sensitivity or were primarily signs of general increase in the irritability of the subjects. Sensations of fullness and ringing were reported by some. Except for hunger pains and some decrease in the frequency of bowel movements, gastro-intestinal symptoms were rare. In several cases periods of transient nausea were experienced.

A marked decrease in pulse rate and in basal metabolism may be regarded as critical indicators of bodily adjustment to reduced food intake, involving a lowering of the speed of the auto-

nomic functions of the body. The overt movements also became noticeably slower, and voluntary energy output was in general markedly reduced. However, overall energy expenditure was maintained on a relatively high level by scheduled physical activity (walking to and from the mess hall, hiking about twenty miles per week, etc.) in order to simulate conditions of natural starvation.

The attitude of the men to physical exertion was ambivalent. It made them tired and as a rule was avoided. On the other hand, occasionally some men exercised deliberately. Thus certain subjects attempted to lose weight by driving themselves through periods of excessive expenditure of energy with the object of either obtaining increased bread rations (when weight loss exceeded the prescribed rate) or avoiding reduction in rations (when weight loss lagged). Fatigue, weakness, and hunger were outstanding complaints. The marked reduction in strength and endurance was paralleled by a curtailment of spontaneous activity. The subjects moved slowly and cautiously; they climbed stairs one at a time. Coordination was affected, and the men sometimes tripped over curbstones and bumped into objects which they intended to sidestep.

In general, fewer and fewer things were capable of stimulating overt action. The subjects described their increasing weakness, loss of ambition, narrowing of interests, depression, irritability, and loss of *libido* as a pattern of experience characteristic of "growing old." Even though a defined amount of physical work (principally walking) was required by the experimental regimen, fluctuations in spontaneous activity accounted for large variations in daily energy output. All had periods of well-being when they expended much energy in working, exercise, and occasionally even in sports.

The subjects were not apprehensive about their health. None evidenced anxiety over the possibility of chronic or permanent effects of the stress. They were confident that they would not only receive prompt and adequate care if they became ill but also that they would be removed from the experiment if serious consequences were thought likely to develop from their continued participation in it.

Hunger and Appetite. In speaking of "hunger" the subjects referred to sensations vaguely localized in the abdominal region which varied from mild discomfort to intense pain. In total starvation the sensation of hunger rapidly disappears. This is not true in semi-starvation. There was no diminution of the desire for food as the starvation progressed. While some subjects suffered relatively little from the distress of hunger, others complained of being hungry all of the time. Frequently the men complained of hunger immediately after eating a bulky meal. The most bulky was the most popular menu of the three to which the men were limited.* The desire for variety in diet

* The chief items on the three menus (repeated in rotation) were as follows:

Menu No. 1. Morning meal—farina, fried potatoes, jello, bread, jam, milk, sugar. Evening meal—fish chowder, spaghetti, meat ball, potatoes, peas and carrots, cabbage salad.

Menu No. 2. Morning meal—oatmeal, potatoes, gingerbread, bread, jam, milk, sugar. Evening meal—bean and pea soup, macaroni, cheese, rutabagas, potatoes, lettuce salad.

Menu No. 3. Morning meal—pancake, syrup, applesauce, corn bread, bread, jam. Evening meal—potato soup, stew, potatoes.

It should be noted that such items as milk and meat were served only in token amounts.

became very strong at times but was always subordinated to the craving for greater quantity.

Eating Habits. Anticipation of eating heightened the craving for food. Consequently, the men dreaded waiting in line while their meals were measured and weighed, each man defensively guarding his place in line. They tended to become irritated when the serving was slow or those who served the food gave any evidence of not taking their business "seriously." The food had to be very hot to be satisfying. This was universally held to be very important. It was as though the starving individual "borrowed" heat from the food ingested as a means of conserving energy.

The subjects exhibited a possessive attitude toward their food. At the table some hovered closely over their trays with their arms placed so as to protect their ration. In eating they were, for the most part, silent, deliberate, and gave total attention to the food and its consumption. Many ingenious devices were used for making food appear to go further and to provide the illusion of variety. As the starvation progressed, the number of men who "toyed" with their food increased. They made what under normal conditions would be weird and distasteful concoctions. There was a marked increase in the use of spices and salt. The subjects were often caught between conflicting desires to gulp food down ravenously or to consume it slowly so that the taste and odor of each morsel would be fully appreciated. Toward the end of starvation some of the men would dawdle for almost two hours over a meal which previously they would have consumed in a matter of minutes.

In order to maximize the pleasure of eating, there was much planning done by the men as to how they would handle their day's allotment of food. Since the subjects went to the dining room only twice a day during the starvation phase of the experiment, many of them saved out part of their meals for later consumption. All food was consumed to the last crumb. The men were cultured and refined, yet they routinely licked their dishes in order to obtain every vestige of food. They quickly became intolerant of food waste and were visibly upset when they noticed others discarding food. There were many bitter comments that any spoilage or wastage of food was prodigal and criminal in a starving world.

Individual food dislikes for such diet items as rutabagas and fish disappeared in the early part of the semistarvation period. Although the subjects were restricted to three rather monotonous menus, the taste appeal of the diet increased rather than diminished throughout the six months of semistarvation.

Food Substitution Habits. Various techniques were developed to approximate or substitute for satisfactions normally derived from eating. Prominent among these were gum chewing and smoking. It was often reported that vivid vicarious pleasure was derived from watching other persons eat or from just smelling food. Large quantities of water were consumed with and between meals, and the subjects increased the bulk of their food by "souping." For example, a man would drink the fluid from his soup, then fill the bowl with hot water, salt it heavily, drink the fluid off again, and repeat this process before eating the solid part of the soup. Satisfaction was also obtained from consumption of coffee and tea

(without cream or sugar but with a limited amount of saccharin), both of which were used in large quantities, presumably for their pharmacological as well as their filling and warming effects. It was generally reported that coffee and tea provided a "lift." Because some of the men increased their consumption to fifteen or more cups daily, it became necessary to limit all subjects to a maximum of nine cups per day. A few occasionally violated the spirit of this restriction by brewing nine cups of the strongest possible tea or coffee and then diluting further with hot water. About a half dozen subjects who never drank coffee or tea before the experiment became habitual users of both. For experimental purposes, the subjects were occasionally placed for three-day periods on severely reduced fluid intake; when thus deprived of their beverages, a few complained of headache and greater-than-usual lassitude.

During the early part of the experiment the use of chewing-gum was not limited; however, in time this became excessive. "Heavy gum chewers" would take two or three sticks at a time, chew until the sweet taste was gone, discard them, and then replace with fresh sticks in chain fashion. Finally, some chewed up to forty packages of gum per day. One of the subjects chewed so continuously that he developed a sore mouth. Thereafter, the use of gum was restricted to two packages a day. Several men who had not used tobacco prior to participation in the experiment acquired the habit of smoking during semistarvation because it afforded some degree of relief from hunger.

Preoccupation with Food. Food in all of its ramifications became the principal topic of the subjects' conversations, reading, and day dreams. More dreams about food were reported as the stress continued. When subjects read books and attended movies, they were deeply impressed by the frequency with which food and eating were mentioned. Cook books, menus, and information bulletins on food production became intensely interesting reading matter to many of the subjects who previously had little or no interest in dietetics or agriculture. Some men went so far as to re-plan their lives according to their newly-acquired respect for food. For example, one man became impressed by the importance of developing efficient methods of food raising and decided to go into agriculture as a vocation. A few planned to become cooks. In some men there appeared, particularly toward the end of the experiment, a reaction against this "tyranny" of food; they became annoyed by discussions of food and related subjects. One man expressed disgust at this "animal attitude;" another referred to such engrossment as "nutritional masturbation."

Adherence to Diet. The subjects were thoroughly aware of the importance of the experiment, and each man felt that his participation in the experimental program would result in a definite contribution to the body of scientific knowledge in an important area. They were convinced that the findings would aid in the relief and rehabilitation of the starving people of the world. Many of the subjects hoped to be able to go to Europe as members of nutritional relief teams, and they felt that they would be much more able to understand and to minister to famine sufferers by virtue of their first-hand starvation

experiences. These factors provided strong incentives to adhere strictly to the diet.

Although some temptation to break the diet was present at times, voluntary commitment to complete the experiment as planned was, with few exceptions, greater than the tantalizing craving for food. This is attested by attainment of the required weight loss (an average of twenty-four per cent). Some men maintained that eating other food than that provided by the diet simply never occurred to them. Direct or indirect evidence of non-adherence to diet was obtained in four out of thirty-six subjects; these men were released from the experiment.

In the beginning of the semistarvation period the subjects were allowed to go about alone but later were required to be accompanied always by a "buddy." If invited out or to a friend's home for a meal, a subject could take a part of his own food (likely a cold maraconi sandwich or a plain slice of bread). Under such conditions the men disclaimed any conscious temptations and even reported annoyance when hosts or others tried to persuade them to take just a little extra food.

The use of subjects on food-handling jobs was discontinued at their request because the temptations under these circumstances became too great; they had found themselves inadvertently licking gravy off their fingers or picking up crumbs.

Emotions and Attitudes. The cumulative effects of the stress were definitely associated with emotional instability. The men experienced transitory and sometimes protracted periods of depression. They became discouraged because of their relative ineffectiveness in daily living. Inability to sustain mental or physical effort contributed much to this feeling of inefficiency. The persistent clamor of hunger distracted the subjects when they attempted to continue their cultural interests, hobby activities, and studies. The discrepancy between what the men wanted to do and what they were able to do resulted in frustration.

During the advanced stages of semistarvation there was a marked lowering of the threshold to depressive reactions. Although clinically, depression reached frankly pathological proportions only on rare occasions and in only a few individuals, the men were always more serious and obviously less happy than during the control period. Unexpected spells of elation, sometimes bordering on ecstasy, occurred. Feeling "high" was sometimes attributed by the men to a "quickening" effect of starvation or to success in adjusting to the semistarvation diet. Feelings of well-being and exhilaration lasted from a few hours to several days but were inevitably followed by ensuing "low" periods. Just as the subjects were unduly depressed by untoward events, their spirits were markedly boosted by such things as fine weather, anticipation of an outing, a profitable "bull session," and other variations in daily routine capable of arousing enough interest or enthusiasm to take them "out" of themselves.

Frequently, both subjects and observers remarked that the group was apathetic. Apathy grew out of repeated failure, with accompanying frustrations, to carry on "normally" during the stress. Things which would arouse their interest tended more and more to fall within the complex of "guinea-pig" life; loss of body weight, hunger, and

food. In discussing these, the men would often become animated.

The smooth-temperedness, patience, and tolerance evidenced during the control period gave way under stress to the converse. Irritability increased to the point where it became an individual and group problem. Although the men were aware of their hyper-irritability, they were not altogether able to control their emotionally charged responses. Thus, outbursts of temper and periods of sulking and pique were not uncommon, and a few had strong urges to violence but these were not carried out.

The men exhibiting a large degree of personal and social deterioration easily became objects of aggression for the rest of the group. In particular, one of these subjects, who dramatized himself and his semistarvation role, served as a scapegoat and a ready reference point for favorable self-comparison. The men rated themselves in comparison with their normal condition as lacking in self-discipline and self control, subject to indecisiveness, restless, sensitive to noise, unable to concentrate, and markedly "nervous."

It is likely that the widespread use of coffee, tea, and chewing gum represented attempts to allay nervous tension besides serving as substitutes for food. Similarly, the occurrence of nail-biting (not present during standardization) and the acquisition of or increase in smoking habits were related to increased "nervousness." Personal appearance and care began to deteriorate as the stress progressed. The men often neglected to shave, brush their teeth, and comb their hair. Even those who had been careful or even particular in their grooming now dressed carelessly and presented a slovenly appearance. It should be noted, however, that bathing was not neglected. It was a source of pleasure as it provided means of getting warm as well as a form of hydrotherapy; it was reported to have relieved aches, pains, and fatigue.

Social initiative, and sociability in general, underwent remarkable change. Their earlier interest in having a voice in the making of policies and rules for the conduct of the non-scientific aspects of the experiment dwindled. The men became indecisive, unable to make personal plans, and unwilling to participate in group activities. The subjects spent more and more time alone. It became "too much trouble" or "too tiring" to have to contend with other people. With the decline in the interests which had previously been held in common with others and with the growth of feelings of social inadequacy the men became self-centered. The egocentricity and associated heightened irritability, of which the subjects were well aware, required at times a real effort to maintain socially acceptable behavior. Too often, attempts to keep the interpersonal relationships tolerable, if not gracious, produced an uncomfortable and emotionally charged atmosphere in which politeness was artificial and social interaction stilted. Humor and high morale, which had been an outstanding characteristic of the group during standardization, gradually disappeared. Humor "dried up" and the tone of the group became sober and serious. What humor remained at the end of semistarvation was mainly of the ironic and sarcastic variety.

The men devoted much time and energy to the collection of recipes, studying of cookbooks, and contemplation of menus. The acquisition of coffee pots, hot plates, kitchen utensils, and the like on shopping "sprees" appeared

reasonable. Much less so was the buying of old books, unnecessary secondhand clothes, knick-knacks, and other items which came to be known as "junk." Often after making such purchases, which could be afforded only with sacrifice, the men would be puzzled as to why they had bought such more or less useless articles. This acquisitive behavior may be interpreted as a mechanism compensating for the deprivation of food. Several subjects insisted that they had grown unusually anxious to save money for a "rainy day" and attributed this to the insecurity they felt in the experimental situation.

In the later part of semistarvation, housekeeping chores were neglected and non-experimental Laboratory duties were carried out less and less effectively. The educational program, designed to prepare the men for foreign relief work and followed at the start with enthusiasm, in time quietly but decisively collapsed. As the distinction between the men and their non-starved associates became more pronounced, the subjects became strangely and somewhat defensively aware of belonging to a "group." The men exhibited heightened sympathy for an identification with the starving and suffering people throughout the world.

Sex. Sexual feeling and expression declined to the point where at the end of the semistarvation period it was virtually extinguished in all but a few subjects. The decline of sex drive was so dramatic that the subjects were struck by the change and used colorful language to describe it. As one of them put it, "I have no more sexual feeling than a sick oyster." The number of "dates" dropped drastically. Those who continued to "date" found their relationships strained. Some of the men were surprised to find that this was also true in even those cases where their female contacts had appeared to be based on intellectual, social, and group interests. Such situations probably stemmed from decline in sociability as well as loss of sex impulses. Masturbation and nocturnal emissions were reported as absent or greatly reduced. Moreover, sex fantasies and sex dreams were reduced in number and when present were severely attenuated.

Intelligence. Complaints of inability to concentrate for any period of time and of difficulty in developing thoughts became numerous. By the end of the semistarvation period a large proportion of the men felt that their judgment had been impaired. They reported, further, that their alertness and comprehension had declined. Clinically, we had the impression that the intellective capacity was essentially unchanged; this impression was supported by objective test evidence. Memory disturbances and decrease of expressive power were only rarely encountered and did not go beyond the range of normality. Throughout the stress the subjects thought clearly and talked intelligently, and the self-estimates of loss of intellective abilities may be regarded as a function of physical disability and emotional factors. It was the narrowing of their interests, apathy, and lack of initiative in carrying on conversation and study which led the men to conclude that they had suffered actual decline of intellective powers.

Results: Rehabilitation Phase

The purpose of the rehabilitation phase of the experiment was to measure the relative efficiency of several levels

of refeeding in order to secure the most efficient, practical, and economic regimen for dietary rehabilitation. There was little change in the composition of diet, simply more of it. The average caloric intake was 2,448 Calories during the first six weeks, 3,257 Calories from the seventh to the tenth week, and 3,518 Calories during the eleventh and the twelfth week of controlled rehabilitation. Within the context of this report it is not possible to discuss the differential effects of the experimentally varied levels of caloric, protein, and vitamin intake. We shall, therefore, limit ourselves to a qualitative description of behavior during the rehabilitation phase of the experiment.

The process of recovery was slow. It should be emphasized that the psychobiological stress of semistarvation actually continued to a greater or lesser degree (depending upon the level of refeeding) throughout the entire twelve weeks of controlled rehabilitation.

Physical Changes. At the end of twelve weeks of controlled rehabilitation the subjects in the highest caloric group, which received 1200 Calories more than the lowest group, had regained less than sixty per cent of the weight lost. Those in the lowest group gained no weight during the first six weeks and by the end of the twelfth week had regained only twenty per cent of the weight lost in the semistarvation phase. Energy and physical well-being increased roughly in proportion to caloric intake.

Recovery from dizziness, apathy, and lethargy was most rapid. Tiredness, loss of sex drive, and weakness were slow to improve. Although visible edema tended to disappear, in some men there was little change and even an increase in edema. Cramps, vague aches and pains, and paresthesias were unrelieved for some time. Some of the men had new complaints such as flatus, distension, belching, and stomach ache. Those subjects who gained the most weight became concerned about their increasing sluggishness, general flabbiness, and the tendency of fat to accumulate in the abdomen and buttocks.

At the end of three months of rehabilitation even in those subjects who were maintained on the highest caloric intake, the overall physical condition was considerably inferior to the prestarvation status. Later reports from the subjects indicated that it was not until an additional three months of "normal" living and super-normal eating, beyond the twelve weeks of controlled rehabilitation, that their physical capacity approached pre-experimental levels.

Food. During the twelve weeks of rehabilitation there was relatively little change in the subjects' eating habits and attitudes toward food. The men continued to want more than they received. Even when those on the highest caloric intake were physically full, they wanted more—their appetites were insatiable. The men continued to be concerned with food and their rations above all else. Food substitution habits persisted with only minor alterations. Heavy use of coffee, tea, "souping" of food, and generally high fluid intake continued to be characteristic for most of the rehabilitation period. Keeping foods hot, "formalities" of serving, and creation of mixtures and "concoctions" continued. About half a dozen of the men were more deteriorated in their eating habits and table manners during the first six weeks of the rehabilitation

period than during semistarvation. There was little flagging in food interests and culinary matters, although the filing of recipes and the reading of cook books gradually declined.

Emotions and Attitudes. For six months the men had looked forward to the last day of semistarvation as the day which would mark the end of their ordeal. They had anticipated that rehabilitation would bring about early alleviation of their symptoms and distress. This belief was a sustaining motivation during the semistarvation period. The expected "new lease on life" did not materialize. As already stated, weight gains were small or non-existent (a few men even lost weight due to loss of edematous fluid). Weakness, tiredness, pains, and myriad other discomforts continued to contribute to their suffering. Hunger and appetite were not appeased. As one subject expressed himself, "Now I go away from meals hungry three times a day instead of two."

Some men actually became more depressed and irritable than in semistarvation. Many grew argumentative and negativistic. Others professed grave doubts as to the value of the entire project or questioned the motives and competence of the experimenters. Several subjects confessed that their humanitarian concern for the welfare of mankind had become elusive and difficult to maintain. Impatience, tenseness, and a feeling of a "let down" pervaded the group. After the first few encouraging days of the rehabilitation regimen there was a pronounced and decided slump in morale.

However, the discontent and aggressiveness, as distinguished from the apathy and acquiescence of semistarvation, was an indirect evidence of an increase in energy. It foreran the gradual reappearance of physical, social, and cultural interests which had gone "underground" for the duration of semistarvation. No longer were the men willing to accept without question the formation of policy by those responsible for conducting the experiment. They insisted that the rules and regulations make "good sense" to them. The men became increasingly impatient with the "buddy system" which was maintained until the sixth week of rehabilitation when it was finally removed in the face of imminent wholesale violation. General unrest was reflected in the failure to re-establish efficient non-experimental laboratory and work assignments.

It was difficult for the men to abandon or modify attitudes and habits which they had acquired during semistarvation. In readapting to pre-experimental interests and activities, the subjects were often frustrated by lack of supporting strength and endurance. The circumstances of normal living were appealing to the subjects long before they were able to cope with them successfully. This added to the restlessness and complicated the morale problem. In the latter part of rehabilitation the cumulative effects of increased food intake and the nearing prospect of the end of the experiment brought about a noticeable improvement in morale.

Humor, enthusiasm, and sociability progressively reappeared; and irritability and nervousness diminished. The strong sense of group identity was dissipated as the men once again looked forward to developing their own plans for the future and took up interests not immediately related to their participation in the experimental program. The

distinction between the "in-group" and the "out-group" (*i.e.* the starved and well-fed) disappeared.

Sex. The sexual impulses, needs, and interests were very slow in regaining their pre-experimental intensity.

Intelligence. There was a pronounced decline in the number of complaints about the lack of alertness, inability to concentrate, poor comprehension, impaired judgment, and deterioration of memory. However, the inefficiency and poor habits of study persisted. It was apparent that the men by and large did not resume their academic studies and intellectual pursuits with the application and vigor that was characteristic of their efforts during the control period.

Results: Post-Experimental Phase

On October 20, 1945 (the end of the twelfth week of controlled rehabilitation and the forty-eighth week of the experimental regimen) twenty of the thirty-two subjects were released altogether from dietary and experimental restrictions. The twelve men selected to remain at the Laboratory for further study were relieved of all dietary restraints over week-ends. Thus on the weekend of October 20, the whole group was at long last free to satisfy their personal food cravings and, most importantly, to eat as much as they wanted. The men gorged prodigious quantities of food which approximated six to seven thousand calories per day. Many ate more or less continuously throughout the two-day period. Some reported eating as many as three consecutive lunches. In many cases the men were not content to eat "normal" menus but persevered in their habits of making "concoctions" and combinations which could only be described as fantastic. The free choice of ingredients, moreover, stimulated "creative" and "experimental" messing with food. Licking of plates and neglect of table manners persisted. Attempts to avoid wasting even a particle continued in the face of unlimited supplies of immediately available food. An irrational fear that food would not be available or that the opportunity to eat would somehow be taken away from them was present in some of the men. This may have motivated their eating as much as they could hold at any given time.

Generally, the men ate more food than they were prepared to cope with. This gluttony resulted in a high incidence of headaches, constipation or diarrhea, intestinal distension, belching, flatus, and unusual sleepiness. Several men had spells of nausea and vomiting; one became acutely ill and required hospitalization for a week. Follow-up studies made at thirty-three and fifty-five weeks after the end of semistarvation showed that the men had returned, by and large, to their pre-experimental "normal" status except that a number of men exceeded their pre-starvation weight.

Discussion

Methodological comment. This paper presents clinical observations, impressions, and generalizations derived from formal and informal contacts with the subjects and from descriptive protocols including diaries and interviews. The subjects were observed under such varied conditions as individual and group testing sessions, personal interviews, clerical and technical laboratory work, participation in group meetings, at times when the authors ate with the men, etc. Test results and ratings were

mentioned only occasionally and were used as evidence supporting and/or supplementing qualitative clinical judgment. The parallel use of the clinical approach and standardized testing techniques facilitates interpretation of the data and has the advantage of providing for cross-validation of the findings.

Magnitude of the semistarvation changes. The fact that it was possible to complete successfully the experiment indicates that neither the physical nor mental health of the group was affected to a pathological degree. At no time was it necessary to omit a test or an interview because of lack of cooperation or incapacity of the subjects which was due to semistarvation alone. Many of the physical and psychological alterations may be considered as adaptive and protective. For example, reduction of basal metabolism conserved energy; likewise, reduction in social participation resulted in decreasing demands upon the energy of the organism. Other changes were frankly deteriorative, such as development of edema, loss of muscle tissue, lack of endurance, reduction in concentration and self-discipline. The character and magnitude of these changes were such as to render the men increasingly inefficient in their daily living. However, persons who came into superficial contact with the subjects did not notice anything strikingly abnormal about their behavior even though it was drastically altered from their pre-starvation norm.

Similarity between experimental and non-experimental semistarvation and rehabilitation. Sorokin(14) criticized experimental studies on starvation in man as lacking in realism. In spite of this criticism the picture of semistarvaton as seen in the Minnesota Experiment resembled in all essential points the effects of famine as presented by Sorokin in his monograph. For a direct comparison with the changes observed in the Minnesota Experiment, digests of a few representative field reports on war-time semistarvation will be presented.

The severely undernourished persons seen in 1942 in internment camps in southern France(13) universally exhibited weakness, exhaustion, and apathy. Their body temperature was lowered, and they were sensitive to cold; the onset of warmer weather was reflected in an improved sense of well-being. The facial expression was painful ("facies dolorosa"), sometimes mask-like. There was an acute desire for food in large amounts and frequently individuals had to be torn away from refuse cans. Schwarz noted that the increase in the desire to eat (hyperorexia) tended to last long after the patients became well. Even in the treatment of edematous cases the food had to be mixed with large amounts of liquid in order to make up the quantity desired by the patients. The daily bread rations had to be divided into three portions and given out separately, otherwise all the bread would be eaten as soon as it was received. Polyuria and nocturia were universal. Marked neurological changes were observed rarely and then only in the terminal stages of starvation.

Similar findings were obtained in Leningrad in 1941-42(15). Because of the German blockade the supply of food to the city decreased rapidly and the progress of starvation approximated the rate of weight loss present in the Minnesota Experiment. The first clinical symptoms of ill-being began to appear in the population about four weeks

following drastic reduction in food supply. Emaciation and decrease in strength became noticeable. Numerous cases of generalized weakness and occasional fainting came to the attention of the Leningrad First Aid Service. The effects of the blockade on the health of the population were complex. There were cases of simple semistarvation uncomplicated by symptoms of hypovitaminosis, but frequently there were added the effects of qualitative malnutrition and of intercurrent infectious diseases. In a sample of forty-eight semistarvation patients all but one complained of increased fatigability. All had lost weight, the most frequent loss being between twenty and twenty-five per cent of the prestarvation level with a range of between ten and thirty-three per cent. Polyuria, sensitivity to cold, dryness of the skin and hair, aches and pains in the extremities, and amenorrhea were frequent. No important visual disturbances were reported. Psychologically, various degrees of personality deterioration were observed: apathy, dulling of the emotions, lowering of the moral level, and narrowing down of intellectual interests(4). Psychotic involvements were rare.

Psychological investigation by means of interviews was carried out(12) on a group of internees who lived through the starvation at the Belsen concentration camp in Germany. The author's main task was to examine patients who needed psychiatric attention and who were referred to him by other physicians. In addition, he examined some sixty cases in the hospital and convalescent areas selected at random to represent a cross-section of the camp population. Unfortunately, in his description the information from these two sources is not clearly differentiated. The nutrition was extremely poor; nine ounces of bread and two pints of turnip soup were given as the daily ration. At the time of liberation, the camp was estimated to contain about 50,000 people with some 10,000 lying dead in the huts and around the camp. In the semistarved inmates of the camp there was a marked reduction in activity, reaching in some cases the form of complete immobility. Many internees did not have enough strength to walk. A common reaction was the loss of appreciation of social ties, each individual living entirely for himself; family had little meaning. Responsiveness to death, cruelty, and humiliation was blunted, and the individuals became apathetic to incidents in the camp. Many showed discouragement, seclusion, introversion, and depression. Only a minority exhibited aggressive reactions. Impairment of memory appeared common. Carelessness in appearance, particularly in men, tended to persist even after liberation. In women the sense of modesty was dull or lacking. Interests were severely narrowed down to matters of food. The inmates were continually hungry, and it was reported that in the last stages of the camp before liberation cases of cannibalism had occurred. Even after the danger of starvation ceased and anxiety about food was objectively without grounds, the semistarvation reactions such as stealing, hiding, and "saving" food persisted. As nutritional rehabilitation progressed, the pattern of complaints changed. Whereas before the patients complained wearily and hopelessly, later the complaints became fierce, bitter, and resentful. Cases with frank psychopathology were few in view of the harrowing experiences, the physical suffering, and the fear of hunger, torture,

and death to which the internees were exposed. There were cases of conversion hysteria, expressed in the inability to hear or see. Delusions were rare. A few patients exhibited maniacal outbursts.

There are many similarities between our experimental findings and the conditions described in the above reports. The loss of weight and the physiological changes were essentially typical of those encountered in non-experimental semistarvation. This was confirmed by Major Marvin Corlette, M.C., who made extensive observations on malnutrition in northwestern Europe at the time of liberation and who visited the Laboratory in July, 1945, at the end of the semistarvation period. He stated:

> ". . . . the salient clinical features of the picture we saw at Minneapolis . . . . very closely simulated the picture of semistarvation seen in western Holland as well as in some of the German concentration camps in the early spring of 1945. Except for the absence of filth and secondary skin infections in the experimental subjects, it appears that the fundamental clinical pattern of partial starvation as we observed it in Europe has been duplicated."(5)

The intrinsic psychological effects of semistarvation are also practically identical under both conditions: intense hunger, preoccupation with thoughts of food, marked emotional changes (*e.g.* depression, apathy, irritability), loss of sex drive, and overall suffering. The somewhat inimical social climate in which the men as conscientious objectors had moved prior to participating in the experiment and the unavoidable regimentation of their lives as subjects may be considered to have engendered psychological stresses analogous in some degree to the personal and social insecurity usually experienced by famine victims.

The behavior of the subjects during nutritional rehabilitation in the Minnesota Experiment had its counterpart in patients who suffered from natural semistarvation and were later placed on hospital diets. In this context reference may be made to the released Indian prisoners of war who lost on the average about twenty-five per cent of their body weight during their internment by the Japanese(11). After admission to the 47th British General Hospital, Singapore, they were served four meals daily. Between the main meals the men were given milk drinks with biscuits, sweets, or chocolates. The light hospital diet provided an estimated 3,384 Calories; the ordinary hospital diet 4,260. As a rule the men had very large appetites which were not satisfied by these diets. Overeating was often followed by flatulence and abdominal distension. Sometimes diarrhea was present. Gastrointestinal discomfort lasted from a few hours to a few days. In severely debilitated persons overeating had serious results including sudden collapse, low blood pressure, a rapid feeble pulse, cold extremities, and stupor. In our group there was only one man who needed hospitalization because of gastrointestinal and cardiac symptoms resulting from overeating although minor distress was experienced by a considerable number of our subjects when they were released from all dietary restrictions.

Factors specific to the Minnesota experiment. In spite of the many similarities between the picture of experimental and "natural" semistarvation, we do not wish to minimize the specific

factors present in the Minnesota Experiment. The subjects were specially selected and constituted a group which was neither a random nor a cross-sectional sample of the population. Certain aspects of the experiment tended to mitigate the severity of the stress as compared with non-experimental semistarvation. The men had clean, healthful living accommodations with adequate sanitary facilities, including soap, hot water, and other comforts. They had sufficient clothing and adequate medical supervision and care. All food was skillfully prepared and served. Since the subjects were not permitted to eat off-diet, the danger of ingesting contaminated food or harmful substitutes was eliminated. Neither did they get the opportunity to gorge from time to time. The men had strong intellectual, religious, humanitarian, and ethical values which played an important role in the maintenance of morale and in keeping the men from getting into "trouble." Unquestionably, the subjects possessed a rare capacity for continuous denial of the demands of intensive hunger.

Certain sources of insecurity present in conditions of "natural" famine were absent in this experiment. The subjects knew that the stress would come to an end at a predetermined date and that rehabilitation would follow. They knew when and what food would be served and that it would be available without fail. There was no competition as to who got what to eat and, therefore, no question of fending for it. The men were protected in other ways. When they were too weak or ill, arrangements were made so that their work and "guinea-pig" duties were postponed or re-scheduled. More importantly, they were free from political turmoil and oppression, bombing, threat of sudden death or injury, destruction and loss of property. Furthermore, crime, theft, depravity, exploitation, and other socially disruptive concomitants of non-experimental semistarvation were not present.

On the other hand, some of the provisions and restrictions imposed by the experimental regimen increased its severity as compared with non-experimental situations. The subjects starved in the midst of plenty. The drastic limitations of personal freedom required by the experimental program itself was a hardship. Being volunteers, they could have withdrawn from the experiment; for this reason conflicts and tensions were generated which made the experimental semistarvation more difficult to endure. In the experimental situation the subjects were unable to improve their nutritional condition through ingenuity and individual effort as is often possible in "natural" semistarvation.

It is worthwhile to examine the hypothesis that the necessary controls and grueling regimen of the experiment, aside from diet, heightened significantly the psycho-biological stress and contributed to the behavioral changes. On this point we have only indirect but relevant evidence; twelve subjects serving in another nutritional experiment, who lived in the same quarters as the semistarvation subjects and under similarly controlled experimental conditions but on an adequate diet, gave no evidence of the behavior changes characteristic of semistarvation. It is believed in view of this fact that the rigorous experimental regimen as such did not distort for the group as a whole the personality changes induced by starvation.

Comparison of the Minnesota experiment with other experimental investigations. The psychological effects of semistarvation have been studied in the past primarily during acute and, as a rule, short-term starvation. Since these situations differ radically from prolonged semistarvation, there is no need to review this material.

There is only one experiment, carried out in 1918, which is somewhat similar to the present investigation(1). The effects of semistarvation on the well-being and personality of our subjects closely paralleled the changes observed by Benedict and his collaborators in their study on prolonged undernutrition. However, in the Minnesota Experiment, the alterations were much more marked. This is understandable because the period of reduced food intake in the present study was one-third longer and the average weight-loss was twenty-four per cent as compared with a decrement of 10.5 per cent in the case of the twelve subjects observed by Benedict. It may be expected that the strain of semistarvation bears an exponential rather than a linear relationship to the loss of body weight.

Use of conscientious objectors as subjects. Because conscientious objectors are members of a small minority group and, as such, known to relatively few people except in a stereotyped and superficial way, some comments on the subjects as persons rather than as "guinea-pigs" may be pertinent. Moreover, descriptive and identifying information may serve to forestall unwarranted criticisms of the experimental findings based on the status of the subjects as conscientious objectors.

Before the men were transferred to Minneapolis to serve as experimental subjects, they had been engaged in a variety of jobs classified as "civilian work of national importance," principally manual labor in work camps but also in special projects where they served as orderlies and attendants in mental hospitals, etc. Over a hundred men responded to the call for volunteers as "human guinea-pigs" in the starvation-rehabilitation experiment. Those candidates whose applications were approved after careful screening were physically examined and interviewed by Laboratory personnel before final selection. The men finally accepted were chosen according to these criteria:

Freedom from history of disabling diseases including mental illness.
Absence of physical disabilities or handicaps.
Ability to cooperate and get along well with others.
Willingness to subordinate personal interests, activities, and welfare to the requirements of the experimental program.
Active interest in problems of nutritional relief and rehabilitation.
Freedom from marital or familial responsibilities.

The individuals selected were healthy, intelligent, young, white males representing a wide range of body type, physical endurance, personality characteristics, and socio-economic background. According to clinical evaluation as well as the results of objective measures of personality, only their pacifist convictions set these men apart from other men of similar age, health, intelligence, education, and background. The immature and neurotic personality traits evidenced in a few men prior to the experiment were either sub-clinical or mild. The men were highly regarded, both as subjects and as persons, by

those with whom they worked and associated. It seems safe to assume that any sample-bias present in the experimental findings errs on the conservative side. The psycho-biological "stamina" of the subjects was unquestionably superior to that likely to be found in any random or more generally representative population sample. It is unlikely that such a sample of subjects could be kept to the grueling regimen for the necessary duration of such an experiment. It should be remembered that the subjects could eat nothing but what the Laboratory prescribed and provided for almost a year. Moreover, for many, at the levels of refeeding used, rehabilitation was, for weeks, little more than a painful continuation of the six months of semistarvation stress.

Summary

Observations are reported on behavioral changes which occurred in 36 volunteer subjects during a semistarvation-rehabilitation experiment.

Six months of semistarvation produced marked deteriorative and adaptive changes in all subjects. The men lost twenty-four per cent of their initial gross body weight. The physiological responses to undernutrition included such changes as decrease in the pulse and basal metabolic rate. A large number of men suffered from edema. The subjects complained of weakness, fatigability, sensitivity to cold, giddiness on arising, polyuria, distressing sensations of hunger, and other aches and pains.

The personality changes were "psychoneurotic" in type and although not grossly pathological, rendered the subjects increasingly ineffective in their daily living. The men exhibited symptoms of depression, irritability, "nervousness," and general emotional instability. Social withdrawal, narrowing of interests, obliteration of sexual drive, and difficulty in concentration were prominent. Food and eating became their dominant concern.

Marked individual differences were present in both the degree of overall deterioration shown in starvation and in the rate of recovery. During the period of rehabilitation, return to "normal" was unexpectedly slow and in general paralleled the levels of caloric intake. Feeling of well being, range of interests, emotional stability, and sociability were regained more rapidly than strength, endurance, normal eating habits, and sexual drive.

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References

1. Benedict, F. G., Miles, W. R., Roth, P., and Smith, H. M. *Human vitality and efficiency under prolonged restricted diet.* Carnegie Inst. Wash. Publ. No. 280, 1919.
2. Brozek, J., Alexander, H., and Keys, A. Analysis of variance in an experiment on nutritional rehabilitation in man (in press).
3. Brozek, J., and Keys, A. General aspects of interdisciplinary research in experimental human biology. *Science,* 1944, *100,* 507-512.
4. Chernorutskii, M. V. Problem of alimentary dystrophy. *Studies Leningrad Physi-*

cians during War (in Russian), 1943, *3*, 3-13.
5. CORLETTE, M. (Personal communication), 1945.
6. GUETZKOW, H. S., and BOWMAN, P. H. *Men and Hunger: A psychological manual for relief workers.* Elgin, Ill.: Brethren Publishing House, 1946.
7. KEYS, A. Human starvation and its consequences. *J. Amer. Diet. Assoc.*, 1946, *22*, 582-587.
8. KEYS, A., BROZEK, J., HENSCHEL, A., MICKELSEN, O., and TAYLOR, H. L. *Experimental starvation in man.* Publ. Lab. Physiol. Hyg., Univ. Minn., 1945.
9. KEYS, A., MICKELSEN, O., HENSCHEL, A., BROZEK, J., and TAYLOR, H. L. *Later stages of rehabilitation following experimental starvation in man. Publ. Lab. Physiol. Hyg.*, Univ. Minn., 1946.
10. KEYS, A., TAYLOR, H. L., MICKELSEN, O., HENSCHEL, A., and BROZEK, J. *Rehabilitation following experimental starvation in man.* Publ. Lab. Physiol. Hyg., Univ. Minn., 1946.
11. MITCHELL, J. B., and BLACK, J. A. Malnutrition in released prisoners of war and internees at Singapore. *Lancet*, 1946, *2*, 855-862.
12. NIREMBERSKI, M. Psychological investigations of a group of internees at Belsen camp. *J. Ment. Sci.*, 1946, *92*, 60-74.
13. SCHWARZ, O. Beobachtungen und Erfahrungen bei der Hungerkrankheit im Lager von Gurs (Südfrankreich). *Schweiz. med. Wchnschr.*, 1945, *75*, 1136-1137.
14. SOROKIN, P. O. *Man and society in calamity.* New York: Dutton & Co., 1942.
15. TUSHINSKII, M. D., ALESHINA, F. J., and ZEITS, Z. R. Clinical observations on patients with alimentary dystrophy in quantitative and qualitative malnutrition. *Studies Leningrad Physicians during War* (in Russian), 1943, *3*, 14-24.
16. ZIM, H. S. What happens when people starve. *Liberty*, Feb. 17, 1946, 16-17, 75-77.

A PRELIMINARY INVESTIGATION OF THE SARGENT TEST[1]

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PROBLEM

Sargent has recently made an attempt to incorporate the principles of projective methods into a group paper-and-pencil personality test, thus combining the administrative advantages of a written test with the diagnostic value of a projective technique(1). The theory and principles which lie behind this Test of Insight into Human Motives are reviewed and summarized in her more recent article(2). Further investigation of this test has formed the basis of the present study. The test comprises situations, briefly described, in which the major conflict areas of personality are emphasized, followed in each case by the questions, "What did he (or she) do and why?" and "How did he (or she) feel?" The subjects are instructed to write answers to the situation-question items, called armatures, in any order they like and as many as they like. The replies are scored by the classification of feeling and cognitive expressions, types of conflict solution, maladjustment indicators, and various counts and ratios of these. Sargent considers her test to be sufficiently promising to warrant further experimentation, and has made a number of suggestions for further research.

Sargent used alternative forms to determine the reliability of the test and concludes that there is "at least a sus-

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