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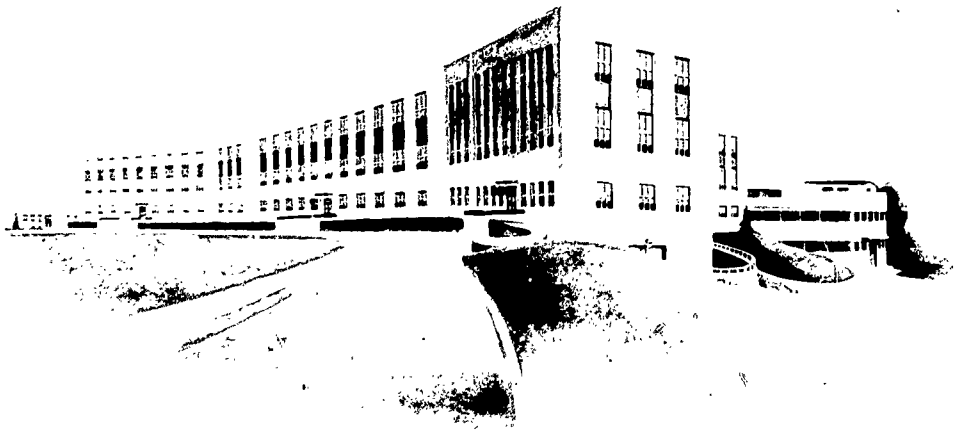

PSYCHOLOGIC DISCOMFORTS IN 1962 PROTECTIVE SHELTER TESTS

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Psychologic Discomforts in 1962 Navy Protective Shelter Tests[1]

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UNDER THE sponsorship of the Navy Bureau of Yards and Docks, two major habitability studies have been conducted using a prototype protective shelter located on the grounds of the National Naval Medical Center, Bethesda, Maryland. This shelter was designed and constructed as part of the Navy's effort to develop a standardized protective shelter for shore installations. The Naval Research Laboratory in Washington, D. C., was assigned primary responsibility for the research project, which was carried out in collaboration with the Naval Medical Research Institute.

Investigations of atmospheric characteristics and temperature within the shelter were made by the Naval Research Laboratory. Physiologic, nutritional, bacteriologic, dental, and psychologic studies were conducted by the Medical Research Institute. This paper will be confined to a general overview of the research efforts and of psychologic discomfort factors, with a more detailed consideration of the place of food in shelter living. A full presentation of the nutritional findings has been made by Van Reen (1).

The Bureau of Yards and Docks was primarily concerned with engineering habitability. More specifically, the objective of the research was to determine if the shelter, as designed and constructed, will sustain life and insure an adequate degree of post-shelter physical fitness for one hundred inhabitants over a two-week period, under varying external extremes of temperature and humidity. No attempt was made to undertake extensive studies of psychologic adjustment problems which might be encountered in the actual use of protective shelters. However, because of the obvious relationship between environmental variables and psychologic response, periodic measures were obtained on a number of psychologic discomfort indices.

The research was divided into two phases. The first, concerned with testing the shelter under winter conditions, was carried out in the two-week period beginning 17 February 1962. Outside temperatures ranged from 16° to 55°F. during that test. The second phase took place from 1 to 15 August 1962, during which time outside temperatures ranged from 73.5° to 92°F.

Medical and behavioral problems were intentionally minimized by choosing a highly select population as subjects. Failure to utilize a random cross-section of either the military or civilian population introduced certain limitations on the degree to which findings may be generalized. On the other hand, the homogeneity of the subjects does permit one to obtain somewhat more definitive information regarding the variables studied.

Although an artifact intentionally was introduced in selecting subjects, an effort also was made to add realism to the tests. Two conditions were introduced which had not been utilized in the major shelter habitability research previously conducted in this country (2-4). First, our subjects had no knowledge of the duration of the test. Second, no reward was offered as an inducement for individuals to volunteer. Thus, within the limited objectives of the research undertaking, an effort was made to simulate actual protective shelter conditions as realistically as possible in peace time.

[1] A condensation of this paper was delivered at the 45th Annual Meeting of The American Dietetic Association in Miami Beach, on October 11, 1962.

[2] The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the Department of Defense or the Navy Department.

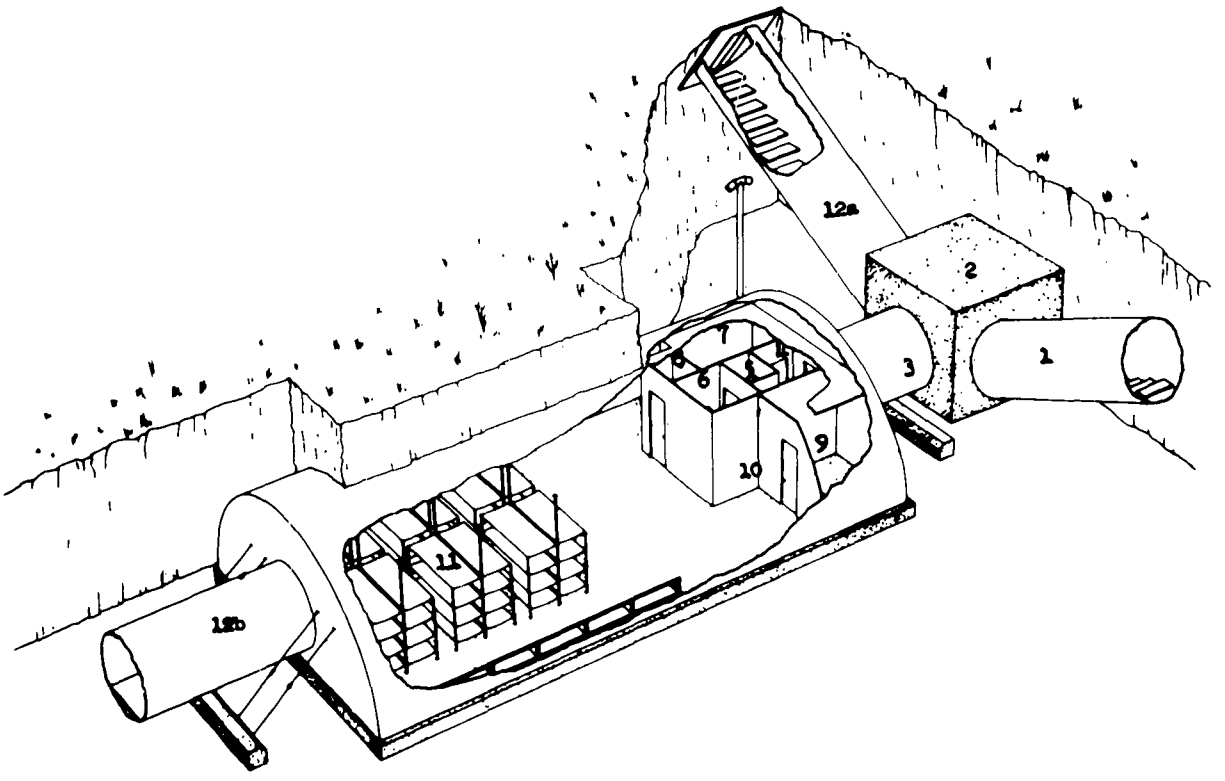

FIG. 1. *Cutaway diagram of shelter.*

1—entrance
2—Diesel generator room
3—entry passage—blast door between 2 and 3 not shown
4—trash room
5—undressing room
6—shower room
7—filter room
8—drying room
9—chemical toilets (6)
10—washtub occupies this space
11—bunks (changed during construction; now 5 double rows 5 bunks high, total of 50 bunks)
12a and 12b—emergency exits

Description of Shelter

The shelter was a standard, corrugated steel, Navy ammunition magazine resembling the Quonset huts of World War II. The structure, 48 ft. long and 25 ft. wide, was buried under 5 ft. of earth. It was designed for a capacity of one hundred people, thus allowing 10 sq. ft. and 100 cu. ft. space for each occupant. In reality, the usable space allowance was somewhat less because of the furnishings and equipment (Fig. 1). Parenthetically, it is interesting that this space provided about one-tenth the roominess found aboard present-day nuclear submarines. It was necessary that the occupants sleep in two shifts as only fifty bunks were provided. The stretcher-like bunks, which occupied slightly less than half of the shelter space, were arranged in ten tiers, five bunks high.

A space measuring 12 by 14 ft. was taken up by bacteriologic and chemical warfare protective facilities, including a collective protector to filter the air, and appropriate facilities for bacteriologic, chemical, and radiologic personnel decontamination. During the winter test, the collective protector was equipped with a blower which permitted a ventilation rate of 600 cu. ft. per minute. However, because of high temperatures expected during the summer test, a 1200-cu. ft. per meter blower was installed for the second trial. Actual ventilation rates were systematically varied during both tests. Incoming air, after purification in the collective protector, was distributed to the living space through three ceiling diffusers.

Power was provided by a 10-kw. emergency generator in a reinforced concrete tunnel just outside the shelter proper. The structure was equipped with six chemical toilet units of 14-gal. capacity, which emptied through a gravity drain into a 1000-gal. dry well located outside the shelter. Use of only three of these units was necessary during the actual tests. Water for drinking and personnel decontamination was stored in a 4000-gal. steel tank buried outside the shelter. Twenty-five foot-candles of light were provided in the activity area of the shelter, while the remainder of the structure was illuminated at a 5-foot-candle level. Trash disposal was accomplished

by placing large plastic bags outside the shelter each day.

Cooking and kitchen facilities consisted primarily of a large coffee urn and an electric deep-fat fryer used to heat soup. Folding tables provided kitchen working space. Further structural and equipment details of the shelter, which are not directly pertinent to this paper, may be found in the technical report on the study (5).

Subjects

One hundred Navy personnel participated in each test. During the winter test, there were ninety-six recruits and four staff members. The staff was increased to eight during the summer test, so that only ninety-two recruits participated. The staff included the Shelter Commander, a Civil Engineer Corps Officer; a Navy Medical Officer, who served both as the Shelter Physician and principal investigator in the physiologic studies; two petty officers who served as section leaders; and three hospital corpsmen.

All participants were volunteers. The recruits had just completed their basic training. Ages of the recruits in the winter test ranged from seventeen to twenty-four years, with a median of nineteen years. Their educational levels ranged from Grades 7 through 16, with a median of 11. Extensive data were collected only on the recruits.

Three broad criteria were used in selecting subjects. First, every effort was made to insure that each subject actually would complete the test. Thus, individuals presenting evidence of possible administrative complications, such as serious illness in the family, expectant wives, and so on, were eliminated from consideration. Second, in view of the extensive physiologic studies which were conducted as part of the engineering habitability experiment, it was considered necessary that men serving as subjects present no evidence of medical defect or disease. A rigid physical examination procedure and a review of medical history were conducted to meet this criterion. Finally, to reduce shelter management problems to a minimum, relatively rigid psychiatric standards were established, and each volunteer was interviewed by a psychiatrist or clinical psychologist. During the winter test, approximately one-third of the volunteers were disqualified for psychiatric and/or medical reasons. Because of the additional stress anticipated in the summer test, even more rigid physical and psychiatric standards were established, with the result that slightly over 50 per cent of the volunteers were disqualified.

Shelter Routine

The subjects were organized into two identical sections, with four teams in each section. These teams were responsible for carrying out the necessary daily routine in shelter management. One team in each section, consisting of approximately twelve men, was responsible for preparing and serving food. Complete details of the shelter organization and routine are contained in the Naval Research Laboratory Report (5). However, several summary comments on the shelter routine appear appropriate here.

Two meals were served daily. The first meal consisted of Survival Ration Crackers served with a variety of jellies. Water and instant coffee were available at this meal. The second meal included the crackers served with hot soup as a topping, as well as peanut butter. To provide some variety, the soups were changed from day to day and included chicken-rice, vegetable-beef, tomato, and beef-noodle. As before, instant coffee and water were available; but, no dishes were available other than the individual drinking cups. In essence, this required a man to finish his dinner before he could have a glass of water or a cup of coffee.

No limit was placed on the amount of drinking water a subject could consume. However, individual water consumption was carefully recorded. Likewise, all food was measured out or weighed before it was served so that caloric intake could be recorded accurately. No water was available for washing or shaving during the two-week period. Small packets containing moist paper washcloths were available to the subjects in lieu of soap and water.

Although the shelter staff was in direct contact with the monitoring station, the recruit subjects had absolutely no contact with the outside world during the two-week period of their confinement. A radioactive source was placed outside the shelter entrance daily by the Navy Medical Center Staff. This was monitored with radiac gear by a team dressed in appropriate protective clothing. By changing the radioactive source each day, it was possible to simulate the decay one would experience under actual fallout conditions. With these readings, and using the known laws of radioactive decay, the subjects were able to plot and compute the actual duration of the trial after several days' readings had been obtained.

Results

WINTER TEST

Generally speaking, no major problems were encountered during the winter test except for failure of the motor generator set. All subjects completed the test; however, a number suffered from upper respiratory infections which required medication and bed rest. The temperature within the shelter rose to 83°F. during the first six days, but it was reduced to 74°F. for the remainder of the test by increasing the ventilation rate. With the relative humidity of the shelter varying from 40 to 60 per

cent, environmental conditions were actually quite comfortable.

Two techniques were used to study psychologic discomfort factors; one required the ranking of twenty-one discomfort indices; and, a second, more precise technique, yielded information on thirteen of the twenty-one indices.[3] Table 1 shows the rank order for these factors in terms of magnitude of discomfort on the seventh day of the test. The methods permitted a twofold distinction in the evaluation of discomfort factors.

The first column in Table 1 lists the factors in terms of their "acuteness" of discomfort. This refers to discomfort which approaches the limits of individual tolerance, regardless of the frequency with which the discomfort was experienced. The second column, labelled "generality," refers to discomfort which was present and noticeable over prolonged periods but did not necessarily approach limits of human tolerance. Generally speaking, the top five factors, which are considered the greatest source of discomfort in terms of generality, assume a similar ranking in terms of acuteness. However, differences which are statistically significant begin to show up as one goes further down the discomfort scale. In terms of the ranking technique, lack of water for washing was the leading discomfort source. Food was considered to provide the second greatest source of psychologic discomfort during the winter test.

The second measurement technique, a Likert-type scale, permitted a more precise quantification of the discomfort factors. Because of the tremendous time required to deal statistically with data from this type of scale, only thirteen of the twenty-one discomfort factors were included. Figure 2 shows the results obtained with the Likert instrument when measures of acuteness and generality were combined through appropriate statistical techniques. Food and lack of water for washing again constituted the two leading sources of discomfort. However, as will be noted, they not only constituted the leading sources of psychologic discomfort but were several scale points removed from the next most significant factors. Moreover, with measurements being made on the twelfth day, there was some shift in rank order of discomfort factors as obtained on the seventh day and listed in Table 1.

The ranking technique alone does not permit one to determine if the discomfort factors differ significantly from each other in terms of their importance in producing psychologic discomfort. However, through computer analysis of the Likert-scale data, it is possible to isolate those factors which cluster together in terms of importance. The circles in Figure 2 indicate items which clustered together without a statistically significant difference between them. It is seen that even though food was the leading source of discomfort in terms of actual scale value, from a statistical standpoint, this superiority over lack of water in the hierarchy of ranking well may be due to chance. Food and lack of water for washing should be considered to be of equal importance as discomfort sources during the winter test. Likewise, although the four bottom factors on this chart assume a hierarchy in ranking, from a statistical standpoint, their numerical positions on the scale do not necessarily reflect genuine differences

TABLE 1 Subjective importance of discomfort sources by ranking scale, Day 7, winter and summer tests

DISCOMFORT SOURCE	ACUTENESS OF DISCOMFORT	GENERALITY OF DISCOMFORT
Winter Test		
Lack of water for washing	1	1
Food	2	2
Crowding of shelter	3	3
Dirt	4	4
Behavior of others	5	5
Boredom	6	6
Noise	7	7
Temperature and humidity	8	9
Toilet facilities	9	12
Lack of exercise	10	11
Odors	11	8
Bunks	12	10
Lack of privacy	13	13
Physical symptoms	14	14
Lights while sleeping	15	15
Lack of organization	16	18
Inability to concentrate	17	16
Concern about outside	18	17
Sleeping difficulty	19	20
Inadequate leadership	20	19
Lights while awake	21	21
Summer Test*		
Lack of water for washing	1	1
Food	4	5
Crowding of shelter	5	3
Dirt	3	4
Behavior of others	8	8
Boredom	9	10
Noise	7	7
Temperature and humidity	2	2
Toilet facilities	15	14
Lack of exercise	12	12
Odors	6	6
Bunks	10	9
Lack of privacy	16	13
Physical symptoms	11	11
Lights while sleeping	14	16
Lack of organization	20	19
Inability to concentrate	17	17
Concern about outside	18	18
Sleeping difficulty	13	15
Inadequate leadership	21	21
Lights while awake	19	20

*Listed in order of importance during winter test.

[3]Lieutenant C. M. Wagner, MSC, USN, was responsible for construction of the scales and primary statistical analysis of the data. A full report of the psychologic studies and their results is contained in the Naval Research Laboratory Report of the habitability tests.

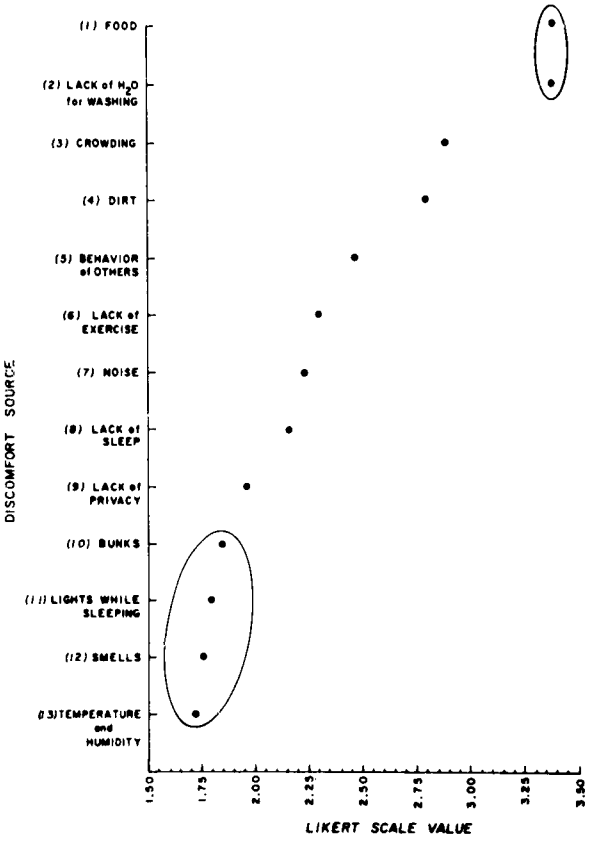

FIG. 2. *Mean scores of discomfort factors based on acuteness and generality with measures from Day 2 and Day 12 combined (winter test).*

as sources of psychologic discomfort. On the other hand, the factors towards the middle of the scale may be assumed to reflect genuine differences in their relative importance as discomfort sources.

While the scaling techniques permit one to obtain a quantitative evaluation of psychologic discomfort, they yield no qualitative information with regard to the nature of the discomfort sources *per se*. Therefore, the subjects underwent a 1-hr. debriefing immediately on conclusion of the test. These interviews, which were conducted by staff psychiatrists and clinical psychologists at the Navy Medical Center, yielded a wealth of information with regard to psychologic discomfort.

The interviews were conducted with groups, each consisting of approximately ten subjects. In general, the most striking aspect of the interviews was the extreme emotional involvement and feeling which the subjects manifested in connection with their shelter diet. Complaints about the food were lengthy and accompanied by more indication of genuine emotional involvement than was evident in connection with any other discomfort factor. Further, the discomfort stemming from food was mentioned not only when the "shelterees" were directly questioned about it, but at almost any other opportunity, such as when they were questioned about morale, lighting, or noise.

The survival crackers were the prime target of criticism. In terms of quality, there was unanimous agreement that, both for any given meal and over the two-week period, the taste and texture of the crackers was highly unpleasant. The crackers were considered too hard (one man reportedly lost a filling while chewing crackers), and the rough texture scratched the roof of the mouth and irritated sore throats. As a result of this irritation, several men reported a definite loss of interest in food on their recovery from upper respiratory infections. The flavor of the crackers also was criticized severely. The criticisms ranged from "nauseating" through "tasteless" to "too sweet." Repeated comment was made about the sweetness being particularly annoying when the crackers were served with chicken-rice soup as a topping.

The soup toppings were almost unanimously considered to constitute one of the single most important morale factors and sources of emotional gratification during the test. The soup meal was anticipated with great relish and considered a high point of the day. A number of men expressed the belief that there was not enough topping served to make the crackers palatable. The peanut butter and jelly toppings generally were well accepted, but not nearly to the degree of the soup toppings. Many men felt the peanut butter was too dry to be served on crackers under shelter conditions. There was rather uniform agreement that insufficient amounts of jelly and peanut butter were served.

In addition to comments on the food *per se*, there was extensive complaint about the unpleasant taste of the drinking water which apparently resulted from its storage in the metal tank. As several men did not drink coffee, there was a feeling that provision should have been made for water-soluble substances, such as "Tang," to provide more variety in liquids.

SUMMER TEST

The first week of the summer test actually provided an extreme heat-stress experience. Although the weather was cooler than anticipated, temperatures during the first week of the test were quite high. Dry-bulb temperatures in the shelter rose to a maximum of 92°F. in the first week; this, combined with the high humidity, resulted in effective temperatures which reached approximately 87°F. The outside temperatures fell during the second week and the ventilation rate was increased so that the shelter was considerably more comfortable, with the effective temperatures fluctuating between 80° and 84°F.

During the first week there were many nonspecific signs of heat stress, such as loss of appetite,

apathy, subjective feelings of irritability, and among some subjects, difficulty in concentrating. Moreover, two cases of heat exhaustion characterized by vertigo, weakness, and in one case loss of consciousness occurred near the beginning of the seventh day. At this time, heat rash also was very much in evidence. Although water consumption during the winter test averaged approximately 1¼ qt. per man per day, this was increased to approximately 3 qt. during the summer test.

It is doubtful whether the test could have been continued for another week with the same external temperatures and a ventilation rate of 600 cu.ft. per minute. However, with the lower outside temperature during the second week and an increase in ventilation rate to 1200 cu.ft. per minute, the second week of the test was relatively uneventful.

A full analysis of the psychologic data on the summer test has not been completed, although tabulations have been made of responses to the twenty-one-factor Ranking Scale. As noted in Table 1, lack of water for washing remained the leading source of psychologic discomfort. However, food dropped from second place on the Ranking Scale as a discomfort source in the winter test to fourth place in acuteness and fifth in generality of discomfort during the summer test. As might be anticipated, temperature and humidity, which were not of particular importance during the winter test, became prime sources of subjective discomfort in the summer. Crowding of the shelter remained the third ranking source of generalized discomfort during the summer but dropped to fifth place in terms of acuteness. Dirt assumed the third position as a source of acute discomfort.

The debriefing interviews rather vividly reflected the shift in importance of discomfort factors. The primary focus of the spontaneous comments of the subjects was on a combination of heat, humidity, and dirt. The heat and humidity were oppressive to the extent that conscious efforts were made to avoid physical activity wherever possible. This went to the extreme of the subjects deciding that fanning themselves with pieces of paper should be avoided. Many subjects were aware of greatly increased irritability with others who might accidentally bump or brush against them. Fortunately, acting-out behavior in retaliation was kept to a minimum because of two factors. First, the conscious awareness of the subjects that everyone was experiencing similar feelings and overt aggression or fighting must be avoided to prevent complete disruption of the group. Second, the apathy and lack of interest in physical activity helped to prevent feelings of irritability and aggressive impulses from culminating in overt, acting-out behavior. It would appear, therefore, that an equilibrium was established which served to reduce overt conflict under these highly crowded and closely confined conditions.

Many men described their perspiration rates as being analogous to having poured water over their bodies. The discomfort in perspiring resulted primarily from the fact that particles of dirt would cling to the skin whenever the body came in contact with a shelter surface. The bunks were a particular source of annoyance. Here, one was faced not only with the problem of dirt and grime clinging to the skin, but the canvas also was wet with the perspiration of its previous occupant. The wash-and-dry pads did little to correct the situation and were, in themselves, a source of annoyance as they left a sticky film on the skin.

Considering the identical diet and the similarity of subject population in the winter and summer tests, the differences in response to food are quite interesting. As noted above, food was ranked as a less significant source of psychologic discomfort during the summer test. Moreover, the complaints verbalized during the debriefing interviews were less emotionally charged and far less frequent. In fact, one group of seven subjects did not mention food during their discussion until directly questioned on the matter.

While Dr. Van Reen's data (1) indicate that food acceptance was high in terms of actual intake, the subjects reported a general lack of appetite. This was particularly true during the week of extreme heat stress. There were complaints as to the lack of variety in the diet and the fact that the food was not appealing; however, one is left with the feeling that the same criticisms might have been made regardless of the diet. Opinions were expressed to the effect that there should have been three meals rather than two. Further, and somewhat inconsistent with the loss of appetite, were the complaints that there was not enough food.

One obtains the feeling that, for the group as a whole, the crackers were considered unpleasant and unappetizing but not unacceptable. As before, taste and texture were the primary complaints. One staff member, who had false teeth, found it extremely difficult to chew the crackers as they made his plates stick together. The soup toppings again were considered to be the most desirable part of the menu, although they obviously did not provide the same degree of emotional gratification as during the winter test. Again, the peanut butter was considered by many subjects to be too dry for use with the crackers. Finally, many complaints were made about the water tasting like the rubber hose through which it was funneled.

Discussion

In these tests, lack of water for washing clearly emerged as one of the two major sources of psychologic discomfort. This is consistent with findings of the American Institute for Research in its Pittsburgh fallout shelter tests (2), as well as with one

of the two major studies conducted by the U. S. Naval Radiological Defense Laboratory in San Francisco (3, 4).

Because of the vastly different experimental conditions, measurement techniques, and subject populations used in these various studies, it would be inappropriate to make direct comparisons of the findings with regard to psychologic discomfort factors. However, it is interesting that in all of the tests, shelter equipment and/or factors in the physical environment ranked ahead of other people *per se* as sources of psychologic discomfort.

Certain discomfort factors, such as noise, inadequate physical space, and lack of water for washing, may well constitute engineering and cost problems which cannot be overcome in constructing protective shelters. However, there are other sources of psychologic discomfort which can be minimized by effective planning. One of the most important of these is food.

During the winter test, subjects lived in a relatively comfortable, although crowded environment. The actual stress on the subjects during the test was emotional rather than physical. Under these conditions, food constituted the subjects' primary source of emotional gratification. Therefore, the finding that food constituted one of the two major sources of psychologic discomfort was fully anticipated before the study began. In the summer test, particularly during the first week, the physiologic stress was extreme. The struggle with the physical environment and its problems of heat, humidity, dirt, crowding, and lack of air flow greatly overshadowed emotional needs. However, it is interesting that food immediately followed these factors as a source of subjective discomfort.

There is extensive literature on the place of food in meeting psychologic needs. This relationship extends beyond mere palatability. The example of an unhappy individual fulfilling emotional needs by eating to the point of obesity is used as a standard case history in textbooks dealing with psychodynamics. The relationship of food to motivation, morale, and emotional well-being of men serving in submarines and Antarctica has been well established by Brozek and Mickelsen (6), Rohrer (7), and Nardini, Herrmann, and Rasmussen (8).

Both on the basis of results obtained in the present studies, and knowledge available from other sources on the importance of food to individuals deprived of normal channels of emotional gratification, it appears self-evident that close attention should be given to the psychologic aspects of shelter diet as well as nutritional, cost, and shelf-life factors. In the final analysis, the morale and emotional well-being of protective shelter inhabitants may be equally as important as physical well-being. Mere physical survival would be only the first hurdle in living through a nuclear attack. As pointed out by Brand-Persson in discussing the psychologic aspects of Swedish shelter studies, "The important thing, in any case, will not be what you face inside the shelter, but what you have to face outside when you finally come out" (9).

Summary and Conclusions

Inasmuch as the Bethesda studies were conducted solely to investigate engineering habitability of a prototype protective shelter, no formal, large-scale behavioral studies were undertaken. However, there is an obvious relationship between environmental variables and psychologic response to these factors in determining man's tolerance to shelter living. In fact, psychologic discomfort conceivably could be sufficiently important to abort a shelter habitability test.

The psychologic investigation in this research effort was focused primarily on identifying and measuring subjective discomfort factors during the shelter experience and secondarily on generalized psychologic or emotional response to the shelter test. Lack of water for washing constituted the leading discomfort factor in both tests. Other factors inherent in the construction of the shelter, such as temperature and humidity, crowding, and dirt, also were identified as major sources of psychologic discomfort. Because of cost limitations, it may not be possible to eliminate these discomfort sources in future shelters.

There are discomfort factors of equal importance which may be reduced or modified within the limitations placed on the building and equipping of protective shelters. One of the most significant of these is food. The diet in the Bethesda tests, while nutritionally adequate, was a major source of psychologic discomfort. This finding is consistent with the results of other research in indicating the importance of food as a source of emotional gratification for persons under stress. Moreover, these studies clearly indicate the need to consider the psychologic or emotional as well as nutritional, storage, and cost aspects in selecting foods for stocking protective shelters. In the event of a nuclear attack, it may be anticipated that food would play an extremely important role in maintaining the psychologic integrity, values, and motivation of individuals who must undertake the work of reconstruction after a period of shelter living. At the very least, methods should be devised to vary the flavor of survival crackers as well as changing the present coarse texture. Consideration also should be given to increasing the variety in diet through the development of additional low-cost food items with a long shelf-life.

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