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Technical Note 4-72

PERCEPTION OF SYMMETRICALLY DISTRIBUTED WEIGHT ON THE HEAD

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April 1972

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Thirty-eight enlisted men, 18 Ordnance and 20 Infantrymen, judged whether experimentally weighted helmets were heavier, lighter or the same weight as the reference M1 helmet. The findings indicate a lower difference threshold of 2.0 pounds and an upper difference threshold of 3.85 pounds for the combined groups. The Ordnance group's lower difference threshold was 2.25 pounds, while the Infantry group's lower threshold was 1.8 pounds. The upper threshold for the Ordnance group was calculated to be 3.9 pounds, while the Infantry group's upper threshold was 3.8 pounds. The differences were statistically significant. It was concluded that complaints about the present helmet being "too heavy" are not based on particularly accurate perception of weight on the head and that Infantrymen are not as accurate in their judgments of weight on the head as the soldier with less field experience with the M1 helmet.

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ABSTRACT

Thirty-eight enlisted men, 18 Ordnance and 20 Infantrymen, judged whether experimentally weighted helmets were heavier, lighter or the same weight as the reference M1 helmet. The findings indicate a lower difference threshold of 2.0 pounds and an upper difference threshold of 3.85 pounds for the combined groups. The Ordnance group's lower difference threshold was 2.25 pounds, while the Infantry group's lower threshold was 1.8 pounds. The upper threshold for the Ordnance group was calculated to be 3.9 pounds, while the Infantry group's upper threshold was 3.8 pounds. The differences were statistically significant. It was concluded that complaints about the present helmet being "too heavy" are not based on particularly accurate perception of weight on the head and that Infantrymen are not as accurate in their judgments of weight on the head as the soldier with less field experience with the M1 helmet.

PERCEPTION OF SYMMETRICALLY DISTRIBUTED WEIGHT ON THE HEAD

INTRODUCTION

The experiment described in this report is one of a number of current and projected investigations aimed at developing comprehensive criteria for the evaluation of life support systems. As a participant in the U. S. Army Materiel Command Five-Year Technical Plan for Personnel and Protective Systems, the primary responsibility of the Human Engineering Laboratory is to develop a battery of standardized tests applicable to existing and prototype armor ensembles. The overall experimental approach shown in Figure 1 indicates that the standardized tests will ultimately be based on both laboratory experiments and field studies, objective and subjective measures, and individual and group performances.

Frequently, when asked to describe the existing M1 helmet and liner the infantryman will say, "It's too heavy." (5). Statements like this have lead to the evolution of the LINCLOE Standards (1965) and the U. S. Army Materiel Command Five-Year Technical Plan for Personnel Protective Systems (4). But what does "It's too heavy," really mean? Is the helmet one pound too heavy or two ounces too heavy?

In an effort to learn to what degree the present infantry helmet is "too heavy," an experiment was conducted to assess the ability of a soldier to subjectively determine what is heavy and what is light. It was hypothesized that an individual will not be able to accurately judge the weight on his head to within ± one half of a pound when compared to a reference weight. This hypothesis is based on laboratory studies which used weighted aircrew helmets to investigate the effects of helmet weight on psychomotor performance of subjects operating a complex flight coordinator (1). Further, the nature of the sensory system thought to mediate the experience of weight is complex. Unlike the senses of vision and audition, the perception of weight has no centrally located receptor organs. Weight is sensed through the diffuse series of receptors which signal the central nervous system on the contraction and tension of muscles, as these muscles are recruited to support the added weight on the body. Other cues to perception of weight are provided by sensations of pressure at the points of contact on the body. The summation of the neural activities associated with this total stimulation results in the feeling of weight. With such a system it is logical to predict some loss of information due to sub-liminal stimulation and adaptation over time.

METHOD

Subjects

Eighteen male U. S. Army enlisted men, ages 18 to 21, who had just completed Advanced Individual Training in various maintenance courses at the U. S. Army Ordnance Center and School, Aberdeen Proving Ground, Md., served as subjects.

Twenty additional subjects participated in the experiment approximately four months later. This second group was composed of enlisted infantrymen, grades E-2 through E-6, ages 18 to 38.

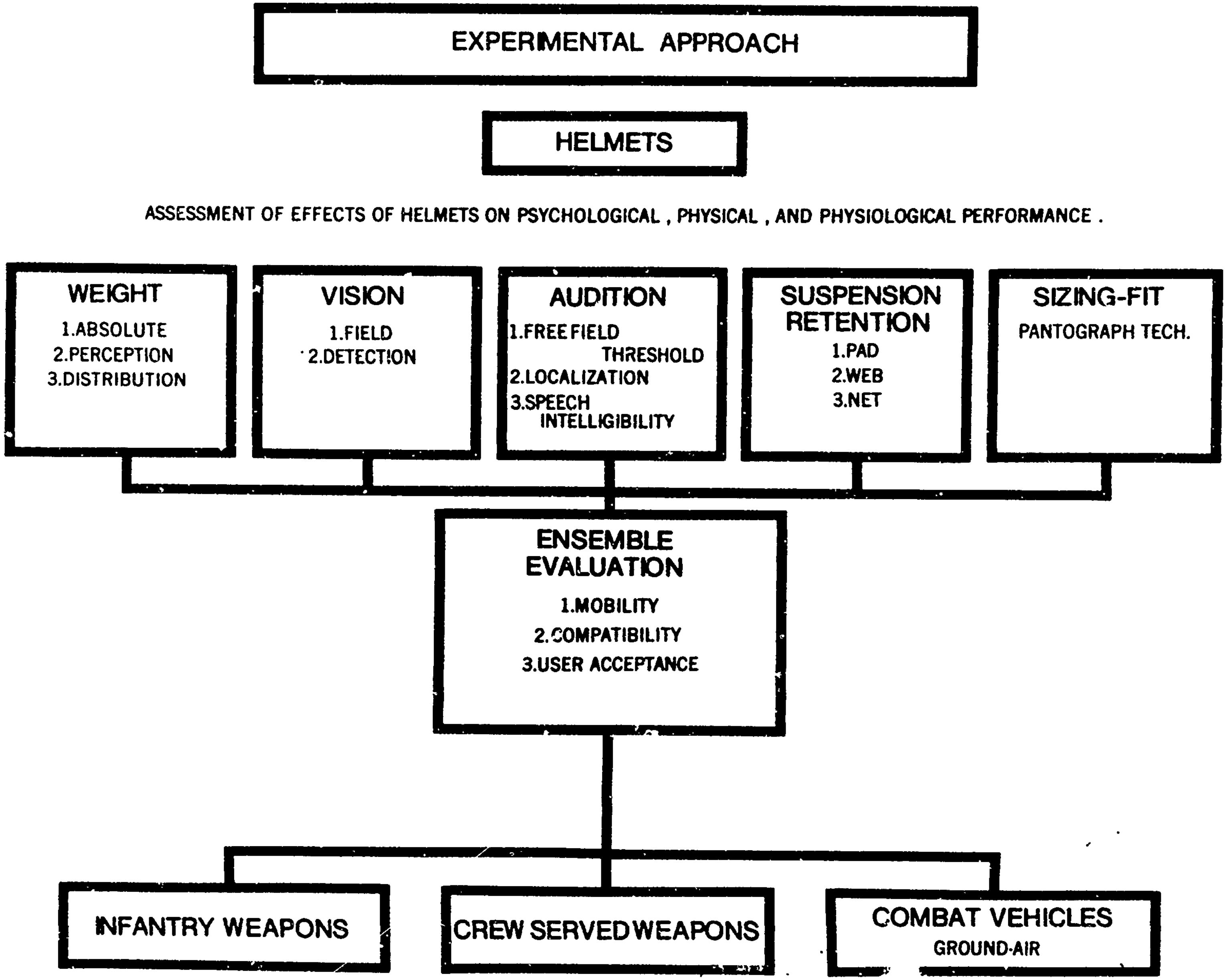

Fig. 1. GENERAL EXPERIMENTAL APPROACH TO HELMET [illegible]LUATION

Apparatus

The M1 helmet and liner was used as the reference weight in this experiment. This combination weighs 3 pounds, 2 ounces. In order to manipulate the weight of an experimental helmet, a standard helmet liner was covered with 2 ounces of loop Velcro. This addition produced an experimental helmet of 1 pound, 2 ounces. Lead weights, ranging in weight from 2 to 16 ounces were covered on one side with loop Velcro material. This method allowed the experimenter to manipulate helmet weight by symmetrical placement of weights around the circumference of the helmet liner. The total weight of the experimental helmet could then be quickly changed in half pound increments from 1 pound, 2 ounces to 5 pounds, 10 ounces. (To simplify discussion, references to the 2 ounce base will be omitted so that the 1 pound, 2 ounce weight will be referred to as 1 pound; 1 pound, 10 ounces will be referred to as 1 and a half pound, etc.).

PROCEDURE

Using the psychophysical method of Constant Stimuli in which the subject is presented an experimental helmet and a reference helmet on each trial, subjects were asked to judge whether the second helmet was heavier, lighter or the same weight as the first helmet. To control for well-documented presentation errors which result from this technique, the order of presentation was randomized. This randomization was accomplished in advance and presentation orders were listed on individual data sheets. A coded system was used to assist the experimenter in establishing helmet configuration for each experimental condition. Inter-trial interval and stimulus presentation time was held at 30 seconds for each trial. A cloth cover was placed over the experimental helmet on each trial so that the subject was not able to gain visual cues of the experimental weight.

Each subject received the following instructions at the beginning of his participation in the experiment:

> "Adjust these helmets to fit you."
>
> "You are about to take part in an experiment to determine how well you can judge weight on your head. We are trying to design a new helmet and we need to know just how well you can tell how much a helmet weighs."
>
> "I will place a helmet on your head. Get the feel of it. I'll take the first helmet off and give you another one. I want you to tell me if the second helmet is heavier, lighter or the same weight as the first. After a brief pause we'll repeat the procedure. We'll do this 20 times. You may move your head around, but don't touch the helmet. If you want the position of the helmet changed, tell me and I'll move it. Do you understand? OK, let's get started."

RESULTS

The Just Noticeable Difference (JND) for the upper weight threshold (responses of heavier 75 percent of the time) was calculated to be 3.85 pounds, while the JND for the lower threshold (responses of heavier 25 percent of the time) was 2.0 pounds (Fig. 2). Ordnance and Infantry Groups were plotted independently. Figure 3 depicts the results of the Ordnance group who do not normally wear the M1 helmet. The upper JND for this group was calculated to be 3.9 pounds while the lower JND was 2.25 pounds. Point of Subjective Equality (PSE) was 3.0 pounds.

Figure 4 shows results for the Infantry Group. The lower threshold appears to be 1.8 pounds while the upper threshold is 3.8 pounds. The PSE for this group is 2.25 pounds.

A X^2 Goodness of Fit test was conducted to determine if the frequency distributions of the two groups were similar. The results of this test show that the two groups are significantly different ($p < .005$, df9, $X^2 = 47.85$).

DISCUSSION

The results of this investigation support the hypothesis that an individual cannot accurately judge absolute weight on the head to within $\pm$ .5 pounds about a reference weight of 3 pounds. The results also show that Ordnance soldiers and Infantry soldiers differ significantly in their ability to determine absolute weight on the head.

Several notions must be considered before these findings can be applied to helmet design. Since the distribution of weight on the experimental helmet was symmetrical, consistent with the shape of the helmet liner, the extent to which these findings can be generalized to future helmet forms must be determined empirically. Further, the reference weight in this investigation (3 pounds) is heavier by 1.5 pounds than the helmet weight requirements as listed for LINCLOE (1965). It is quite possible that a lower reference weight will yield different levels of sensitivity to a given increment of weight. This conclusion is consistent with both the power function (3) and the adaptation level theory (2).

Direct comparison of lower thresholds as determined for experienced infantrymen to the lower thresholds of inexperienced Ordnance personnel indicates that sensitivity of weight judgment may be adversely affected by longer field exposure to the M1 helmet and liner. This effect could result from muscular development, adaptation or some psychological variables such as discipline and attitudes.

While the findings of the present investigation suggest the individual's inability to accurately discriminate symmetrically-distributed weight on the head, it should be noted that this lack of sensitivity is an advantage to designers. If the findings showed a more sensitive level of perception the problem of designing a new helmet form may have become more complicated than it presently appears. However, a recent pilot study, designed to evaluate perception of asymmetrically distributed weight on the head, indicates individuals are able to determine imbalances of as little as 2 ounces. A more systematic investigation of this effect is presently being conducted.

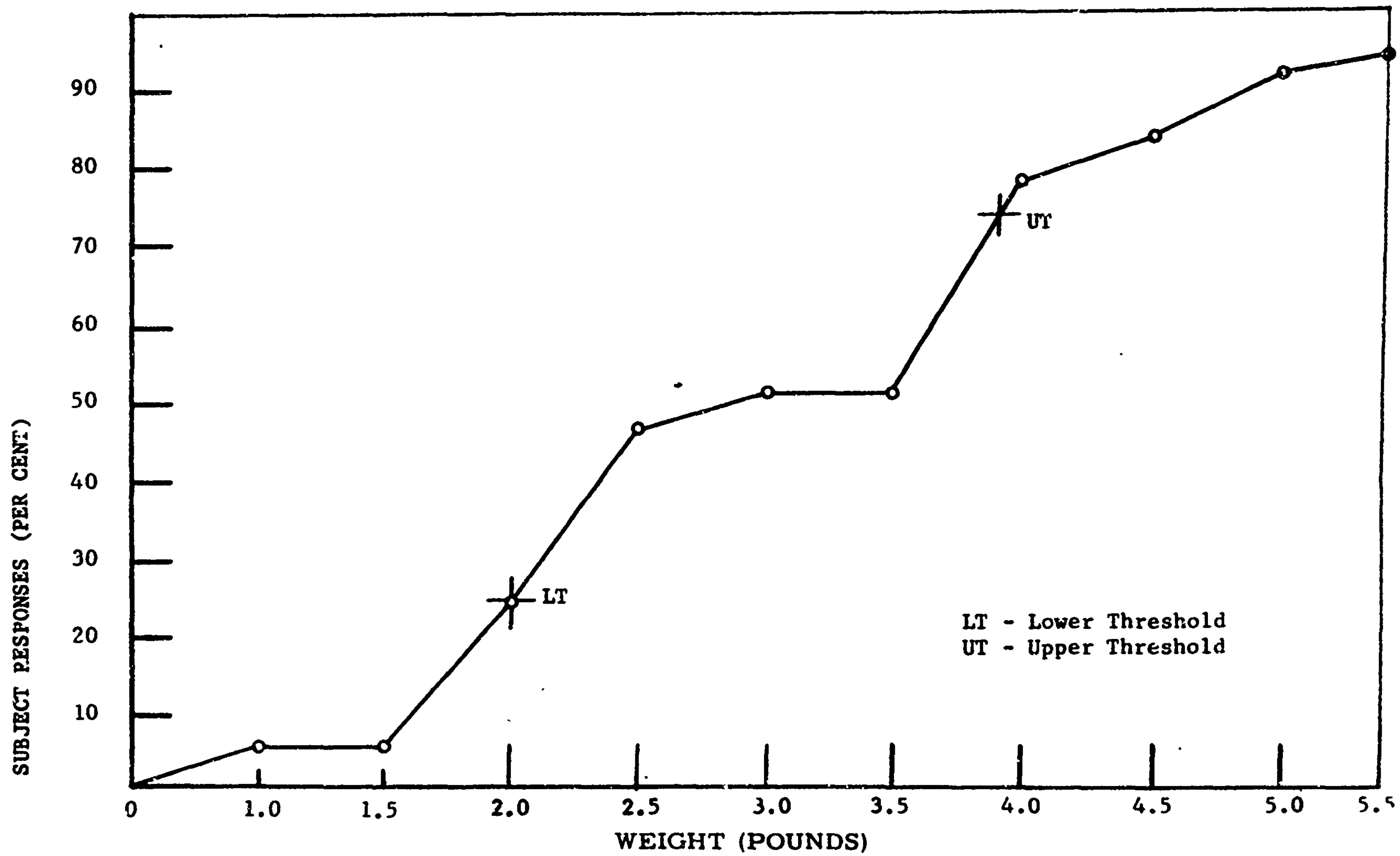

Fig. 2. COMBINED ORDNANCE AND INFANTRY RESPONSES

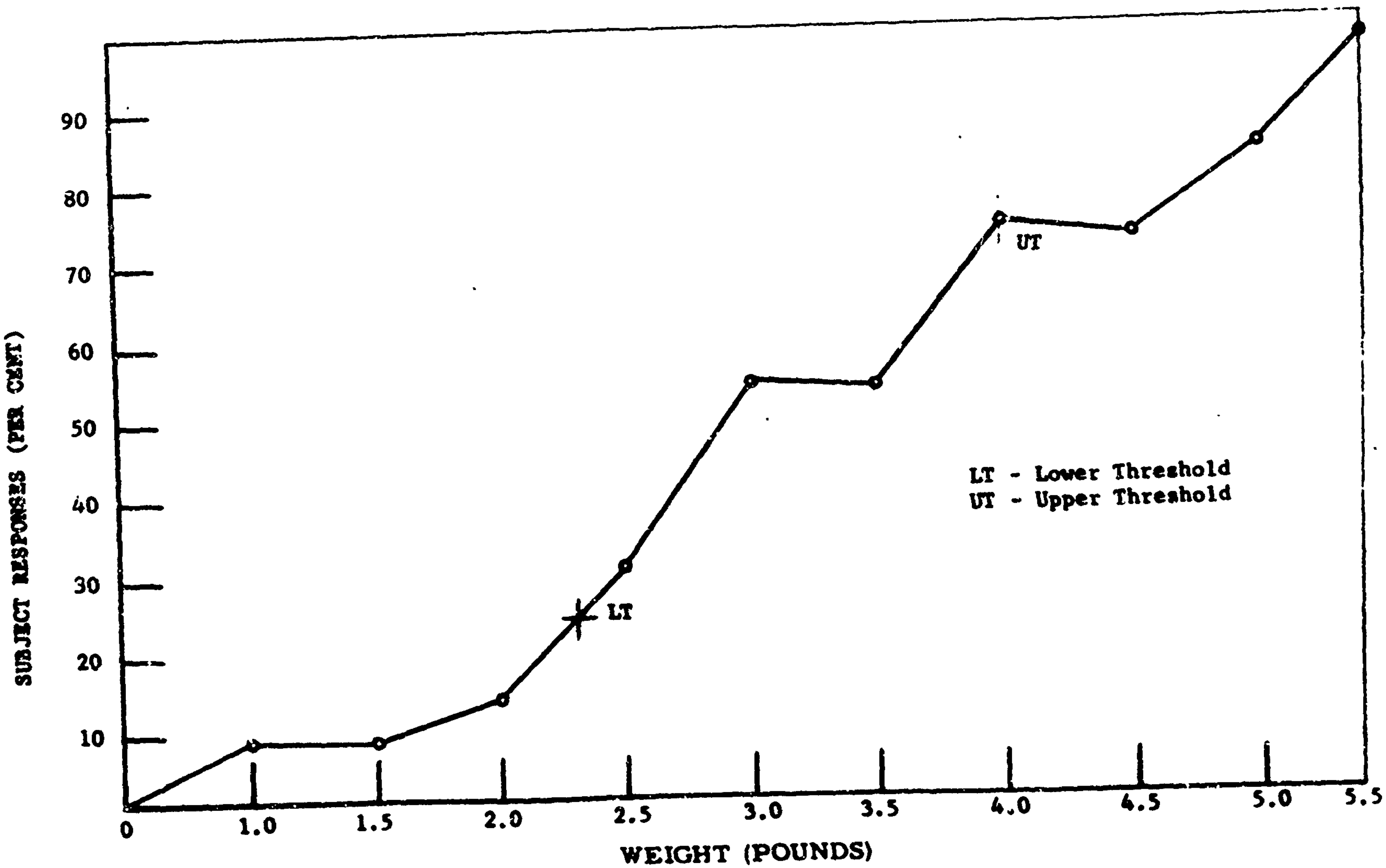

Fig. 3. ORDNANCE GROUP RESPONSES

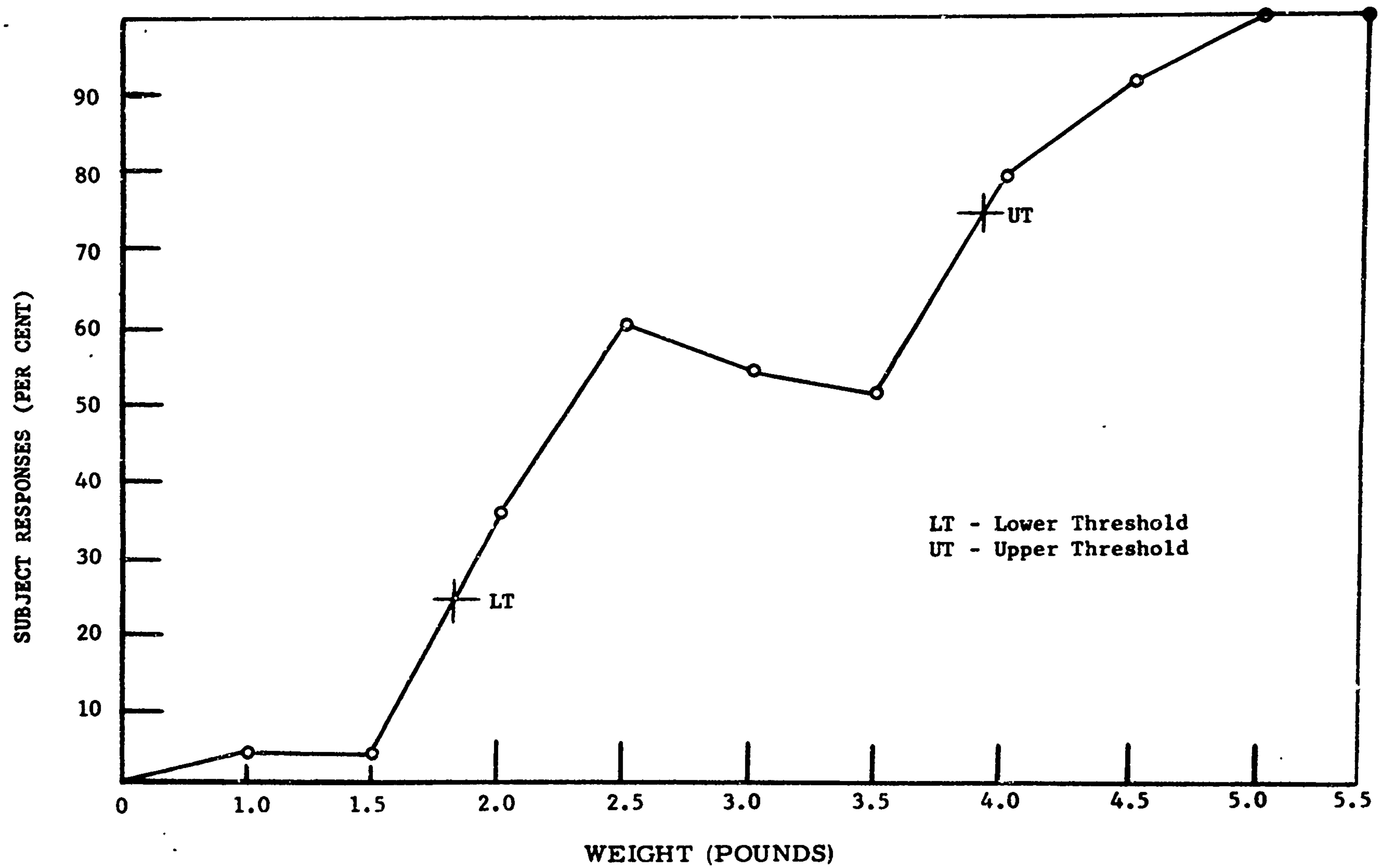

Fig. 4. INFANTRY GROUP RESPONSES

SUMMARY AND CONCLUSION

In an effort to determine how well the individual can determine the degree of weight on the head, it was found that an area of indecision of approximately 1.85 pounds exists around the 3.0 pound reference weight. This area extends from 2.0 pounds (lower JND) to 3.85 pounds (upper JND). Further, it appears that Ordnance personnel (with less field experience with the M1 helmet) are more accurate in their judgments of weight than the infantryman who wears the helmet in the field regularly.

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