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# What you don't know can hurt you: I. Control Settings

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## 1. Introduction

As the discipline of ergonomics has matured it has become more involved in cognitive aspects of the problems involving the interaction of humans with their manufactured environment. Attention to these aspects of the human-machine interaction has often resulted from failures or accidents involving inappropriate use of the products.

Each year failure to use correct procedures produces countless injuries and numerous deaths the world over. In some cases individuals knowingly tempt fate, as it were, such as by driving while drunk. However, many avoidable accidents occur because the acts are performed by individuals who have no idea that they are at risk. In many instances the victims may even assume they are protecting themselves. An illustration is the case of an individual using a tree branch to manipulate a downed electric wire. Many people know the importance of insulating themselves from an electrical current, but they may not realize that a tree branch may be wet and the water or possibly even the sap can carry the current.

It is very important from an ergonomic standpoint to ensure that the information given the public about hazards they may be dealing with is correct. Unfortunately, the information provided is often faulty in that it fails to communicate the message in a way that is understandable to the public, despite the fact that its essence is correct. Several factors may be related to erroneous communications. Poor phrasing may be misunderstood (cf. Chapanis, 1965), and some terms may be used in a technical sense not understood by the general public in that sense (e.g., Leonard & Digby, 1992). Further, concepts that generally have the same meaning for both experts and laymen may be applied to different variables, leading to a misunderstanding.

The present study originated with a problem generated by misunderstanding of control terminology. It is almost a classic case of the failure to apply human factors principles. Ideally, analysis of the interaction of the human with device of concern will be performed in one of the earliest stages of development and will incorporate hazard analyses and training needs as well as mission requirements. A design is then developed and tested for its adequacy in terms of mission accomplishment, economy, and safety. Further, the likely operators of the equipment will be identified and information about their skills, physical capabilities, and task knowledge will be determined. All too often, however, equipment designers assume that the users of the equipment will be know as much about the equipment and about physical factors related to the operation of the equipment as the designers do.

Because of many reports that individuals were scalded because temperature settings on water heaters were too high, the present study was undertaken to determine how the general public would use the terms commonly found on water heater controls. If the temperature of the water is too great, severe burns can result. As a rule most people mix the water to achieve the desired temperature, but very young children and elderly adults may be unable to react rapidly enough to avoid burns. Thus, it is important that the individual setting the

control, (often the occupant of the house) understand the meanings of the settings. That is, the settings must mean what the layman considers them to mean, or explicit definitions and instructions must be presented in a fashion to be readily available and attended to by the user. It appears likely from the present study that the controls of many water heaters are inappropriately labeled for use by the typical residential dweller. In the precipitating event the temperature setting of 140° F was labeled medium. Lacking knowledge about what 140° F means in terms of sensations, many individuals might assume that medium refers to the temperature that they find to be not too hot or cold for activities such as bathing.

We hypothesized that untrained users do not know the correlation of skin sensation with water temperature. Thus, they may rely on the assumption that the designations on the controls are related to sensations. However, if the control is labeled in terms of the range of possible temperatures produced by the heater, "medium" on the control may be associated with 140° F. Thus individuals setting the temperature in relation to their desired sensations may be mislead by the terms used on the control.

A portion of a study concerning scaling of temperature sensations reported in a brief fashion previously (Leonard & Cummings, 1995) will be described first. We will call it Experiment 1. The results of this study led to examination of the question of how the public at large relates temperatures to various terms and to common activities.

## 2. Experiment 1

*Method*

The meaning of the terms tepid, well-heated, and scalding were rated on a five-point scale with warm as the lower anchor, medium as the central description, and hot as the upper anchor by 29 respondents. Another 18 persons performed the scaling procedure with very hot as the upper anchor. The respondents were also asked to rate various temperatures in Fahrenheit (F) degrees (the dominant temperature scale in the USA) on the same scale.

*Results and discussion*

As seen in Table 1, the rating for well-heated was 3.31 which indicates that the respondents considered medium to be slightly less hot than needed for optimal use. A rating of 3.00 would presumably occur if the setting "medium" coincided with the respondents notion of well-heated. The ratings in conjunction with temperatures suggest that these individuals considered "medium" to be between 110° F and 120° F.

Despite considerable variability in the data, the term medium seems appropriate to use for the sensations that most people associate with a tolerable temperature. The use of medium to indicate the middle of the physical range that might go from 100° F to 180° F, is clearly not consonant with the subjective meaning of the term for most respondents.

## 3. Experiment 2

Because the procedures used in Experiment 1, constrained the responses of the participants to those temperatures presented, Experiment 2 was performed to get an idea of how individuals interpreted temperature sensation terms in relation to quantitative values.

*Method*

Participants included 29 males and 56 females drawn from student populations at the University of Georgia (UGA) and at Metropolitan State College of Denver (MSCD). These

Table 1

Mean Ratings Obtained for Descriptions of Temperature .

| Terminal Points of Scale | N | Terms Rated | | | Temperatures Rated | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Tepid | Well-heated | Scalding | 110° | 120° | 130° | 140° | 150° |
| Warm to Hot | 29 | 1.97 | 3.31 | 5.00 | 2.90 | 3.31 | 3.86 | 4.55 | 4.97 |
| Warm to Very Hot | 18 | 1.67 | 3.11 | 5.00 | 2.72 | 3.22 | 3.83 | 4.28 | 4.61 |

Table 2

Means and Standard Deviations of Temperature Estimates

| Terms Used | N | Mean | SD |
|---|---|---|---|
| Boiling | 86 | 157.8 | 47.4 |
| Warm | 86 | 76.9 | 12.6 |
| Freezing | 86 | 17.9 | 16.9 |
| Tepid | 79 | 54.4 | 28.5 |
| Cold | 86 | 37.9 | 14.4 |
| Hot | 86 | 99.1 | 21.8 |
| Frigid | 86 | 17.8 | 22.8 |
| Scalding | 86 | 157.7 | 62.0 |
| Lukewarm | 32 | 68.9 | 17.6 |

| Activities | N | Mean | SD |
|---|---|---|---|
| Bathing | 82 | 84.2 | 14.7 |
| Swimming | 82 | 70.8 | 15.2 |
| Dishes | 82 | 89.8 | 21.3 |
| Drink Coffee | 82 | 98.4 | 25.6 |
| Child's Bath | 82 | 74.9 | 17.1 |
| Drink Soda | 82 | 40.8 | 13.0 |
| Wash Hands | 82 | 69.6 | 16.4 |

institutions are widely separated geographically and their student bodies are somewhat different. The students at UGA are homogeneous with respect to age and background. Those at MSCD are more diverse, especially with respect to age.

Respondents were tested in small groups and were presented a two lists: one list included words commonly used to describe temperatures; the other list included activities commonly related to use of water. The respondents were asked to indicate the temperatures (in Fahrenheit) they associated with the words and the activities. After some data had been collected it became apparent because of a number of omissions that many of the respondents were unfamiliar with the word "tepid." Hence, the term "lukewarm" was added to the list.

*Results and Discussion*

As shown in Table 2, the mean values for most of the temperature terms are about what one might expect, although the values for freezing and boiling might have been expected to be closer to the physical values of 32° and 212°. However the variability of the responses about the means was extremely large. This suggests that there is a substantial number of individuals whose ability to use values stated in quantitative terms is so poor that some additional information needs to be given them if they must use controls based on physical terms. It appears that lukewarm is somewhat better understood than tepid as the standard deviation for it was significantly smaller than that for tepid ($F_{78,31} = 2.6; p < .01$).

## 4. General Discussion

Two significant points can be seen from the experiments described here. The use of terminology on controls needs to be presented in terms that are comprehended by the public at large, and the public at large is rather poor at estimating the physical values of temperatures. Although the present study has considered only controls associated with water temperatures, the principle of determining the responses that users will make given subjective descriptions of points on controls applies to many circumstances.

The ability of individuals to estimate temperatures for various activities is not particularly surprising in retrospect, because if one is engaging in a activity such as swimming, one may simply test the water to see if it is tolerable for the activity. It was somewhat surprising to see such wide variability concerning the boiling and freezing points. Perhaps that knowledge might be easier to retain if the Celsius scale were taught. In conjunction with these results, one can suspect that there are other physical values that might be poorly understood and for which the relations to some important events are significant. One that immediately comes to mind is the stopping distance of automobiles at various speeds. The relevance of research in understanding how the public in general interprets information of this sort seems obvious.

## 5. References

Chapanis, A., 1965, Words, words, words. *Human Factors*, 7, pp.1-17.

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