EMPIRICAL STUDY OF THE MEANING OF THE HEDGE "VERY"

Patricia Cerrito[1], Waldemar Karwowski[2], and Krzysztof Ostaszewski[1]
[1]Department of Mathematics
[2]Center for Industrial Ergonomics, Department of Industrial Engineering
University of Louisville
Louisville, KY 40292, U.S.A.
FAX: 1-502-588-7397
e-mail addresses: pbcerr01@ulkyvm, w0karw01@ulkyvm, kmosta01@ulkyvx

ABSTRACT

In an empirical study designed to test the meaning of the linguistic hedge VERY, and using statistical techniques, the concentration operator is shown to model the human perception in the context of load heaviness better than the shift operator and the fuzzy normalization operator.

INTRODUCTION

The theory of fuzzy sets developed by L.A. Zadeh [5,6] has been successfully applied to modeling all forms of human reasoning. In [8] Zadeh introduces the concept of a linguistic variable whose values are natural language words identified with certain fuzzy sets via a specified rule. The linguistic hedge VERY modifies the value of a linguistic variable in a manner resembling the natural language. Several models of this hedge have been proposed: the concentration operator, see Schmucker [4]; the horizontal shift operator, see: Hersh and Caramazza [1], Macvicar-Wheelen [3]; and fuzzy normalization operator, see Karwowski and Ostaszewski [2]. In this work we analyze the applicability of those operators in modification of the values of the linguistic variable *load heaviness*.

THE EXPERIMENT

To test the above models, nine subjects, all male, whose weights and heights were known and used to derive a composite strength parameter, lifted boxes with loads ranging from 10 to 65 pounds, in increments of 5 pounds. They were asked to lift each box repeatedly until they were certain that they could make a judgement about the box, as if the task was to be performed for an eight-hour work day. The subjects then filled out a questionnaire concerning each box. They were asked to assign a number between 0 and 10 which would best describe the degrees of membership to which each of the boxes belonged to the following four categories: HEAVY, VERY HEAVY, LIGHT, VERY LIGHT. The resulting numbers were normalized by dividing by 10.*

STATISTICAL ANALYSIS

We have regressed the membership function $f_{VH}(x)$ for the VERY HEAVY category against $f_H(x)$, the membership function for HEAVY to get:

$$f_{VH}(x) = .89 f_H(x) - .027 \text{ with a correlation of } R^2 = .859.$$

* The exact data from the experiment is available upon request from the authors.

If we also regress against the actual load heaviness (denoted here by $LOAD$), R^2 increases slightly to .867 with

$$f_{VH}(x) = .78 f_H(x) + .003(LOAD) - .09.$$

Both models are highly significant. The results clearly indicate that the fuzzy set-theoretical model claiming the existence of a relationship between membership function of HEAVY and VERY HEAVY is justified. Analogous analysis for the membership functions of LIGHT and VERY LIGHT produced

$$f_{VL}(x) = 1.39 f_L(x) + .004(LOAD) - .023 f_L(x)(LOAD) - .19 \text{ with } R^2 = .826.$$

The results indicate the existence of a relationship and the applicability of the fuzzy set-theoretic model of the hedge VERY.

In order to test the claim of the applicability of the concentration operator for the hedge VERY, we have also regressed the values of $f_{VH}(x)$ on the values of $(f_H(x))^2$. We obtained:

$$f_{VH}(x) = .909\,(f_H(x))^2 + .062 \text{ with } R^2 = .846,$$

indicating the applicability of the concentration operator in this setting. Similarly

$$f_{VL}(x) = .892\,(f_L(x))^2 + .02 \text{ with } R^2 = .79.$$

The results clearly indicate that the concentration operator is an excellent model for the hedge VERY.

Next we tested the applicability of the translation operator, as suggested by Hersh and Caramazza [1] and Macvicar-Wheelen [3]. The exact value of the appropriate shift is difficult to exhibit and may require additional studies. The best model obtained by us was:

$$f_{VH}(x) = .403\,(f_{H1}(x))^2 + .009(LOAD) - .179 \text{ with } R^2 = .657,$$

where $f_{H1}(x) = f_H(x-5)$ represents the shifted HEAVY membership function. We have concluded that the shift operator is less applicable than the classical concentration operator.

Finally we have tested the fuzzy normalization operator of Karwowski and Ostaszewski [2]. This was done by introducing the modified functions $f_{H2}((x+65)/2) = (f_H(x))^2$ and $f_{L2}(x/2) = (f_L(x))^2$. The results were

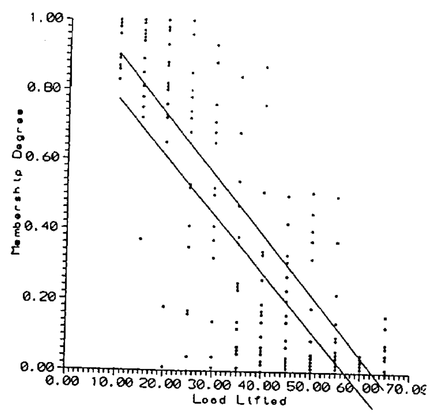
$$f_{VH}(x) = .574 f_{H2}(x) + .045 \text{ with } R^2 = .324,$$

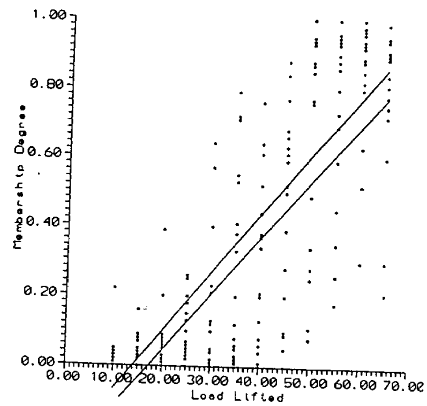
and

$$f_{VL}(x) = .54 f_{L2}(x) - .165 \text{ with } R^2 = .155.$$

The operator turns out to be the least appropriate of the three considered.

As the last conclusion of our statistical analysis we present below the graphical representations of the regression lines of load lifted heaviness versus the value of the membership function for LIGHT vs. VERY LIGHT and HEAVY vs. VERY HEAVY. They show the respective pairs of lines almost parallel stressing the underlying relationship between the values of the linguistic variable studied.





***** Light category
***** Very light category
Light regression: y=-.017x+1.077
v light regression:y=-.016x-0.941

***** Heavy category
***** Very heavy category
Heavy regression: y= .016x-.236
v heavy regression:y= .016x-.941

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