MEASURING ATTITUDES TOWARDS THE USE OF NUCLEAR POWER: AN ANALYSIS OF A MEASUREMENT INSTRUMENT

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PREFACE

The recent public discussions about new technologies, in particular the controversy about various energy supply systems, demonstrate the need to improve our understanding of how society judges the acceptability of these technologies. Such insights can best be gained by way of the attitude concept.

Over the past five years,the Joint IAEA/IIASA Project has developed a methodology for quantitatively assessing the structure of public attitudes; see RM-76-80 and RM-77-54 (Otway and Fishbein 1976 and 1977), as well as RR-80-15 and RR-80-18 (Thomas et el. 1980a,b). At the present time, this method is being applied in various countries to identify common underlying structures of as well as discrepancies in public attitudes towards energy systems. The insights gained could prove to be useful for decision-making.

This working paper presents a summary of the methodological implications reflects our own doubts and the experience gained before the method of this approach is adopted for the cross-cultural study, and reports suggestions for a standard procedure of data analysis. It is hoped that this paper will be helpful to those actively participating in this cross-cultural effort and to those who might want to apply the method to related problems.

ABSTRACT

A questionnaire was designed to obtain three independent measures of public attitudes towards energy systems, one of which is based on the concept developed by Fishbein.

A sample of 147 university students was examined to investigate the meaningfulness of a set of 30 items designed to capture attitudes towards the use of nuclear energy. High correlations were found to exist among all the attitude measures taken, which indicated the appropriate selection and formulation of the attributes used. Analysis of the belief factor scores of the questionnaire yielded four factors: Societal Risks, Economic Benefits, Safety Considerations and Technological Implications. Comparison of sub-groups,pro and con the use of nuclear energy,showed significant differences in their perceptions of the four categories of issues.

In addition, the Fishbein model was demonstrated to be insensitive to modifications of scaling as well as to the inclusion of an additional weighting parameter. A standard procedure for the data analysis is suggested.

CONTENTS

INTRODUCTION

The past decade was characterised by a broad public discussion about technological progress and industrial development. Since availability of cheap energy has been the basis for industrial growth and a rapid increase in the standard of living, much of the discussion centres around energy systems and especially around nuclear power, which provides the potential to meet the future energy demand of an undisturbed quantitative growth. Opinion polls in various countries demonstrated that instead of a convergeance of opinions there is a growing disagreement among the public how to evaluate alternative options for future developments of our technology-oriented society. This situation has raised broad scientific interest in improving the understanding of people's beliefs, evaluations, and attitudes towards such issues. Of particular interest is the question about the growing resistance against technologies that are currently developed and implemented, especially against nuclear energy.

Several studies have investigated this problem in an attempt to identify those elements important for public acceptance or rejection. Not only are the results and conclusions drawn in these studies manifold, but also the measurement techniques applied. While Fischoff et al. (1978) applied a ranking technique with subsequent rating of the same items, other researchers (Eiser and Van Der Pligt, 1979) used a combination of ranking and rating of different sets of items. A different approach was adopted by Otway and Fishbein (1976; 1977) and Thomas et al. (1980a,b) who introduced a model designed to measure attitude, which is based on a more highly standardised concept and therefore seems appropriate for application in a cross-cultural effort.

The present study was designed to investigate the applicability of this approach in general and to test a set of items designed to be applicable both in developed and developing countries.

ATTITUDE MEASUREMENT

To understand the current discussions and emotions, it seems necessary to try to reveal the structure of attitudes, i.e. the essential elements and their interrelation. In such a structural analysis general attitudes need to be decomposed into meaningful units which can be measured and recombined by a suitable model or composition rule, into an overall measure of attitude.

Several such models have been proposed of which the most well known are Rosenberg's (1956) instrumentality-value theory and Fishbein's (1963) attitude theory which is closely related to expectancy-value theory. The latter model assumes that the attitude of an individual towards an attitude object depends on two kinds of elements, or parameters: the degree of belief that the attitude object does or does not have a certain attribute, and the evaluation of that attribute. The beliefs correspond to the cognitive aspects of attitude, whereas the evaluations correspond to the affective, or "good-bad" connotations. These parameters are measured for a set of "salient" attributes of an attitude object in question, that is, for those aspects that are within the span of attention of an individual at the time of measurement. The measures of these two elements for a set of attributes are then combined according to the following equation:

$$A_j = \sum_{i=1}^{n} b_{ij} e_i \quad , \qquad (1)$$

where

A_j is the measure of attitude towards an attitude object j, which can be a person, a concept, an object, or an act;

b_{ij} is the strength of the belief which links the attitude object j to attribute i;

e_i is the evaluation of this attribute i;

$i=1,2...,n$ is the number of salient beliefs, i.e. those currently within the span of attention of the respondent.

Since the attitude score derived from application of Equation (1) is the sum of the eb-products, it will be called $\sum$eb-model. It is structurally similar to other bilinear models, e.g. Rosenberg's (1956) instrumentality-value model and the expected utility models of Savage (1954), and Edwards (1954). As documented in Fishbein and Ajzen (1975) and Ajzen and Fishbein (1977), the $\sum$eb-model was very successful in measuring attitudes.

In a strict sense, the $\sum$eb-model is only applicable on an individual level since different individuals will certainly have different sets of salient beliefs. In applying the $\sum$eb-model to a large number of respondents, the salient attributes, which have to be obtained through individual elicitations, are replaced by a set of attitude-related statements that are called "modal salient beliefs". These are the statements which occur most often in a set of individual elicitations.

It must be noted that the kind of elements used, and the rules to combine these elements, or measures thereof, are stated by the theorist. Whereas it is not possible to really test which elements are most adequate, the model's two composition rules can be tested: (1) multiply each b_i and e_i, and (2) add these pairwise products over all attributes considered. The behavioural adequacy of both of these rules can be demonstrated, e.g. by using a functional measurement approach; (Anderson, 1974), or using conjoint-measurement analysis; (Krantz and Tversky, 1971). Although a final judgement about the adequacy of the $\sum$eb-model, or variants of it, is not yet possible, the composition rules are at least not rejected by empirical evidence (Bettmann et al., 1975).

In attitude research it is indicated not to base results on a single attitude measurement technique; rather, to apply several techniques and to check the convergent validity. Therefore, in addition to Equation (1), the evaluative scale of the Semantic Differential (SD) was applied (Osgood, Suci and Tannenbaum, 1957). The SD uses a list of contrasting adjectives that are usually rated on a seven-point, bipolar scale. Factorisation of SD-scores is known to yield three dimensions, identified as evaluation, potency, and activity. Of those, only evaluation is closely linked to attitude, at least as it is captured by applying the $\sum$eb-model. The measure of attitude for an individual is then defined as the sum of the scores of those scales of the SD that load highly on the evaluative dimension. This will be called the $\sum$SD-score.

Finally, attitude was measured by a direct measurement of the overall favourableness towards the attitude object on a graphical rating scale (DM-scores). The main emphasis of the present study is not to analyse the attitudes of a specific sample of respondents towards a specific technology, but to analyse the applicability of a parametric approach to the measurement of attitudes towards a very complex issue and to reveal the cognitive structure underlying these attitudes.

Furthermore, some extensions and modifications of the $\sum eb$-model were investigated.

METHOD

Subjects

Subjects were 147 undergraduate students at the University of Vienna who participated on a voluntary basis. The experiment was run in early 1979 on two consecutive days, with about 74 participants on each day; a session lasted about 20 minutes.

Material and Procedures

Participants were asked to fill out a questionnaire the purpose of which was described as to get the participants' opinion about energy sources. It was pointed out that there were no right or wrong answers in filling in the questionnaire, and that it was only one's personal opinion that counted. The questionnaire was handled confidentially, neither personal nor biographical information was collected. The basis of the questionnaire was a list of 30 statements, covering the wide range of arguments from the energy debate. Although the items were meant to be applicable to all kinds of energy systems, some items were more specific to the use of nuclear energy (see Note 1).

The questionnaire consisted of four parts, each of which was preceded by a detailed introduction explaining the use of the scales. Part 1 contained the evaluation of the 30 statements on a seven-point bipolar rating scale, the ends of which were labelled "bad" and "good". An example of such a statement is "leading to technical progress". It should be noted that at this point of the experiment no reference was made to any specific energy source. This part of the questionnaire served to scale the evaluative elements of the attitude model.

In Part 2 of the experiment, the same 30 items of the evaluative part were used, however, in combination with the attitude object, i.e. the use of nuclear energy to express the respective beliefs. The belief items were also scaled on a seven-point bipolar rating scale, anchored "unlikely" and "likely". Subjects were asked to indicate how likely or unlikely they thought the various beliefs were. To use the above example, the belief item would read: "the use of nuclear energy leads to technological progress". Note that the attitude object is termed "the use of nuclear energy", not just "nuclear energy" per se. This was done to state the attitude object as precisely as possible, thereby avoiding ambiguities.

In Part 3 of the experiment, the attitude toward "the use of nuclear energy" was measured with the Semantic Differential technique. Again, seven-point rating scales were used, with 16 pairs of contrasting adjectives. All scales described so far were scored from -3 to +3.

Part 4 of the experiment consisted of two sections. Firstly, subjects had to rate the same 30 statements with regard to their importance in the debate about the use of nuclear energy. A ten-centimeter graphical rating scale was applied. The endpoints were labelled "very unimportant" and "very important", respectively. Secondly, participants had to indicate their personal opinion on the use of nuclear energy on a ten-centimeter graphical rating scale,the end-points of which were labelled "very unfavourable" and "very favourable", respectively. Only 14 out of 147 subjects did not respond to this scale, otherwise missing values were extremely rare. The latter two scales were calibrated from 0 to 10, using an 11-point equidistant grid.

RESULTS

Favourableness of Attitudes towards the Use of Nuclear Energy

The general distribution of responses for the $\sum$-eb, $\sum$-SD- and DM-scores are given in Figure 1 (see Note 2).

Respondents generally had quite critical personal opinions (DM-scores) toward the use of nuclear energy; 46 out of 134 respondents indicated a "very unfavourable" attitude. Similarly, both the frequency distribution of the SD- and the $\sum$eb-scores peaked in the negative range, though less extreme than the DM-scores, again indicating unfavourable attitudes.

Two explanations could account for the differences in these frequency distributions. Firstly, the number of statements used strongly influences the distribution because, in order to obtain an extreme value of the $\sum$eb-scores, 60 statements have to be intensively rated, whereas there are only 15 measure points for the $\sum$SD-scores and only 1 measure point for the DM-scores. In addition, the observed end-of-scale effects of responses in the extreme intervals of the DM-scale indicated that the verbal anchoring was not strong enough to distinguish within this group of respondents.

Secondly, there are considerations which relate to the interpretation of the zero points that would correspond to a neutral attitude. As to the general favourableness rating, it is tempting to interpret the central category (Category 5) of the scale,calibrated from 0 to 10, as neutral, as was indicated in the instructions. But it is well known from other research (e.g. Messick, 1957) that the "true" zero point need not fall into the central category of such scales. The same observation holds true for the Semantic Differential. As to the $\sum$eb-model, the average attitude score can also be influenced by the selection of statements. Consider the following: if to a given list of attributes, statements are added which - for the total sample - are obviously positive,with respect to the attitude in question, this will add positive eb-terms, thus inducing a shift of the $\sum$eb-scores' average in a positive direction. Therefore, strictly speaking, it is not possible to tell whether a small negative (positive) attitude score really indicates the existence of a negative (positive) attitude.

Convergent Validity

In the present study, it was possible to determine the convergent validity of three attitude measures: the $\sum$eb-model, the sum score of these scales that load highly on the evaluative dimension of the Semantic Differential (the $\sum$SD-score), and the direct measurement of attitude as a favourableness rating (DM-score). The attitude score derived from the $\sum$eb-model correlated with the Semantic Differential at $r = .82$, the correlation between $\sum$eb and DM-score was $r = .72$, which is high considering the fact that the DM-score is just represented by a single rating. The correlation between the $\sum$SD and the DM-score was $r = .81$. All correlations are highly significantly different from zero ($p \ll .01$).

These results may, in part, be attributed to a very careful and appropriate selection of the attitude statements used for the $\sum$eb-model.

Structural Analysis of Attitudes

Factor structure of the belief scores. Beliefs are the cornerstone of the conception of attitudes as was laid out by Fishbein. To quote from Fishbein and Ajzen (1975, p.131):

> "... beliefs about an object provide the basis for the formation of attitude toward the object, and we have shown that attitudes are usually measured by assessing a person's beliefs".

Therefore, after having established the validity of the attitude scales, a detailed analysis of the belief scores was undertaken. The main question is: which are the cognitive dimensions underlying attitudes toward the use of nuclear energy, and can statements be grouped together to describe these dimensions?

To answer this question, the belief scores of the Fishbein model were factor-analysed. The principal components method with subsequent varimax rotation was applied to extract the factors; the software package used was BMDP (Dixon, 1975). Six factors were found to have an eigenvalue greater than one. However, since a four-factor solution exhibited by far the clearest pattern of results, this solution was adopted.

The interpretations of the four factors are shown in Table 1, together with the variances explained by them, which corresponds to the eigenvalues. The meaning and content of the four factors can best be interpreted from the listing of the four statements loading highest on each factor.

As can be seen from the eigenvalues, the first two factors were of major and roughly equal importance. The single,most important Factor I was identified as Societal Risks. The meaning of this factor is very well captured by the item loading highest on that factor,"restricting options for future societal development", which was formulated to reflect fears that today's decisions about the large-scale use of nuclear power plants would narrow-down future possibilities for the development of society. This is further illustrated by the item "concentration of power in big industries".

Economic Benefits, Factor II, was considered nearly as important as Societal Risks, which indicates the respondents' awareness of energy needs, industrial development and economic independence. It will be most interesting to analyse how strongly groups pro and con the use of nuclear energy believe that nuclear will, in fact, lead to those benefits.

Factors III and IV were less important in terms of the explained variance. Factor III can be identified as a "Safety Considerations" factor. It is not surprising that the"management of dangerous waste"is the item which loads highest on that factor since it was a predominant issue in the discussions about nuclear energy in the past years. Health impacts are also related to this factor.

Factor IV describes Technological Implications of the use of nuclear energy. They may be considered good, by stimulating research and leading to a more equal distribution of wealth among the nations, or bad, as indicated by item 3, "Diffusion of knowledge for construction of weapons".

Factor Structure of the eb-scores

Since the $\sum$eb-score represents the measurement of attitude, obtained through Equation (1), it would be interesting to subject this combined attitude measurement to a factor analysis and compare this structure to the structure of the cognitive elements (b's) alone. A factor analysis of the eb-scores (principal components with subsequent varimax) of the respondents to the 30 attitude statements yielded nine factors having an eigenvalue greater than one.

There was hardly any similarity between the factor structure of the beliefs and the eb products. This result indicates that either there exists no clear-cut pattern for the structure of combined evaluation-belief terms or such a structure is more complex than in the cognitive domaine of the belief system.

It is impossible to draw definite conclusions based on a factor analysis of one sample. Larger representative samples from various countries, which are being obtained in the course of this ongoing research, will have to be analysed to provide an answer to this problem.

Analysis of Attitudes PRO and CON the Use of Nuclear Energy

In order to obtain a separate analysis of the respondents' attitudes for and against the use of nuclear energy, two groups of 37 and 44 persons were formed. The PRO sub-group had $\sum$SD-values in the range of +45 to +6, and scores on the DM-scale between 5 and 10; the CON group had $\sum$SD-scores between -45 and -35 and DM-scores between 0 and 2. As most of the respondents had $\sum$SD-scores below 0, that is, clustered on the negative side of the scale, the range of scores had to be wider for the PRO than for the CON groups in order to get a roughly equal number of respondents in each group.

Because a separate factor analysis for the two sub-groups formed was clearly not possible due to insufficient item/respondent ratio, the following test was carried out. The four items loading highest on the four factors (as shown in Table 1) were selected to represent those factors. For each factor j the following four indices were constructed:

$E_j = \bar{e}_{ij}$, the average of the evaluations of the four statements loading highest on each factor j, $j = 1,2,3,4$;

$B_j = \bar{b}_{ij}$, the equivalent for beliefs;

$W_j = \bar{w}_{ij}$, the equivalent for importance weights;

$EB_j = E_j x B_j$.

The first two indices are to be interpreted as factor-level evaluation and belief scores, respectively. Similarly, the third index represents the factor-level importance score, while index 4 is the factor-level attitude score (see Note 3). The rationale for forming these indices is that if each factor represents a meaningful cognitive concept, the items of major prominence (in terms of factor components) are the building-blocks of such a component.

Individual t-tests were carried out to test these factor summary scores for PRO/CON differences. The results are shown in Table 2. With the exception of the evaluations and importance weights on Factor IV, all differences were highly significant.

These results clearly indicate that respondents PRO and CON the use of nuclear energy held considerably different beliefs and evaluations, and perceived the attitude statements as being of different importance in the nuclear debate, and that all four factors contributed differently towards their attitudes. This contrasts with earlier findings by Otway and Fishbein (1977), where comparisons of factor summaries between respondents PRO and CON nuclear energy yielded very similar evaluations whereas differences mainly occurred in the belief scores. An explanation for this divergence might be due to the use of different items, which not only led to other factor interpretations but might also have tapped issues of principal disagreement between proponents and opponents of nuclear power. This discrepancy could be of considerable interest for the understanding of the nuclear debate and the possibility of consensus of proponents and opponents. While it might be conceivable to rationally bridge the gaps between different beliefs through discussion and information exchange, such a convergence will be much more difficult to achieve in the evaluative, i.e. emotional, domaine (see Note 4).

Analysis of Importance Weights

It can be assumed that not all the statements included in an extensive list of attributes are of equal importance. Therefore, besides measuring beliefs and evaluations, respondents also had to rate the importance of the 30 statements in the nuclear debate. In principle, importance weights can be used in two conceptually different ways: (a) as an additional parameter in a model such as Equation (1), or (b) as a basis for the selection of attributes. Both of these possibilities will be discussed in the following.

Incorporation of importance weights into the model equation (Equation 1) expands the $\sum$eb-model into a $\sum$web-model, that is the attitude scores are weighted by their respective importance ratings. Thus, one can test these two models as well as the other combinations that can be formed from the three parameters e, b, and w, that is a $\sum$wb- and a $\sum$we-model.

The $\sum$wb-model was previously used by several authors (Bass and Talarzyk, 1972; Sheth and Talarzyk, 1972; Hansen, 1969). According to Cohen, Fishbein and Ahtola (1972), it was inferior to the standard $\sum$eb-model. A test of the $\sum$we-model is not known to have been reported. In Table 3, all three two-parameter models, as well as the three-parameter model, are evaluated in terms of their correlations with the $\sum$SD and DM-scales, which serve as an external validation criterion (see Note 5).

Results of Table 3 indicate that the use of importance weights as an additional parameter in the model equation did not improve the model's predictive validity. This supports the conclusion drawn by Fishbein and Ajzen (1975), based on the results obtained by Kaplan and Fishbein (1969), Anderson (1965), or Wyer (1970), that most of what is captured by an independent measurement of importance is already captured by the beliefs and evaluations - although they are completely different concepts. If this were generally true, incorporation of a third parameter would merely provide redundant information that would tend to attenuate convergent validity (see Note 6), or prediction in general.

It is also interesting to investigate the intercorrelations of the parametric models, as is shown in Table 4. Of the two parameter models, only the $\sum$we-$\sum$eb-intercorrelation is modestly high, while $\sum$web correlates highly (r = .94) with the $\sum$EB-model, indicating again that inclusion of a weighting parameter does not significantly influence the evaluation-belief-based attitude measure.

As noted above, another use of importance weights is to select a subset of salient attributes from a more comprehensive list of attributes. To achieve this, the entire set was split up into subsets of 15, 10 and 5 attributes having the highest/ lowest average importance weights, respectively. Again, the $\sum$SD- and DM-scores served as criterion measures. Results of this analysis are shown in Table 5.

As was to be expected, the correlations between the $\sum$eb and the other two attitude measures $\sum$SD and DM decreased with the number of items, but remained at a fairly high level, even for the five <u>least</u> important statements. This seems to support the notion that the items were well selected in terms of relevance of the issues covered to the attitude object, i.e. nuclear energy.

Sensitivity of $\sum$eb-Model to Scale Properties

As described earlier, e- and b-scores were obtained from seven-place, bipolar rating scales anchored bad/good and likely/ unlikely, respectively. The interval properties of the scales were enhanced by written instructions and graphical display. If mathematical procedures, such as adding, multiplying, averaging, etc., are to be applied, interval properties of the scales are a necessary, though not sufficient, condition. While there are some studies demonstrating interval properties of these scales, it seems nevertheless important to test the sensitivity of results based on scale properties.

<u>Scoring of eb-products</u>. The use of a scale scored ± 3 in a bilinear model leads to the fact that the integers ± 5, ± 7 and ± 8 cannot occur. This leads to an unevenly spaced scale of ... ± 4, ± 6 and ± 9, integers which are then added to form the $\sum$eb-score. This is a somewhat implausible property of the $\sum$eb-model. For an alternative scoring, a simple transformation on the eb-products was performed by assigning a value of 5 to the product 2 x 3, and a value of 6 to 3 x 3. The new scale for the eb-products ranges from -6 to ± 6, in steps of one, thus avoiding "gaps" in the scale. A further effect of this transformation is to de-emphasise eb's based on extreme e- and b-scores (± 2 and ± 3, respectively). The correlations of the modified, transformation-based $\sum$eb-model with the other attitude measures were almost identical to the correlations of the original model, that is the adjusted scoring had no effect.

Transformations on the evaluative scale. While it can be assumed that the beliefs are at least interval scaled, since they correspond to subjective probabilities, there is no reason to assume interval properties for the evaluations, which resemble subjective worth or utility. If it is assumed that subjects responded to the e-scales as if they were making value judgements, these value judgements could be trasnformed into utilities, by appropriate assumptions. Taking into account the behavioural principle that good things saturate and bad things escalate, as in Coombs and Avrunin (1977), a non-linear (exponential) utility function was assumed for the positive and negative branches of the e-scales. An exponentially-shaped function conforming to this behavioural assumption, which runs through the zero point at a steepness of one, can be given as

$$f(e) = a(1 - E^{-\frac{a}{e}}) ,$$

where

a is a free parameter determining the shape of the function;

E is a constant 2.718..., base of natural logarithm;

e is the score on the ± 3 evaluative scale.

The functions actually used are graphed in Figure 2.

The sensitivity of the $\sum$eb-model based on the transformation on the e-scales, $\sum$f(e)b-model, was again assessed by inspecting the correlations of the model with the other attitude measures. As can be seen from the results given in Table 6, this transformation had also only little impact on the intercorrelations of the attitude scores.

These results demonstrate the robustness of the $\sum$eb-model to assumptions (or manipulations) of the scale, if the correlations of the $\sum$eb-scores with other attitude measures are used as the criterion.

SUMMARY AND CONCLUSIONS

The high correlations between the $\sum$eb-model and its variants and two independent attitude measures demonstrate the validity of the approach. It is possible to elicit a meaningful measure of attitudes vis-a-vis such a complex attitude object as the use of nuclear power for energy production. One of the advantages of models based on a decomposition paradigm is that further structural analyses can be performed. In analysing the belief structure underlying the attitudes of a sample of 147 undergraduate students, a four-factor solution was retained. These factors were labelled as societal risks, economic benefits, technological implications and safety considerations. When contrasting groups PRO and CON the use of nuclear energy, significant differences were found for the beliefs and evaluations on all factors. Differences in evaluations have not been reported to this extent in previous studies. This finding might be of interest to policy-makers, who might not only have to deal with rational arguments in the public debate but also with emotions.

A number of variations of the Fishbein model produced very similar results to those of the original model, especially scaling modifications. Furthermore, the inclusion of an additional weighting parameter did not improve the results. Possible explanations of this finding have been presented. Thus, a standard procedure for data analysis has been developed, including procedures most meaningful for subsequent interpretation (see Appendix B).

In summary, the newly-adapted questionnaire proved to be adequate for measuring attitudes towards the use of nuclear power. Application of this research instrument in different countries is expected to further demonstrate its usefulness for determining the underlying principles for public acceptance or rejection of particular energy carriers. The ultimate objective of these cross-cultural studies is to identify common basic principles which could be important for energy-related decisions.

NOTES

(1) The list of statements used is given in Appendix A.

(2) The individual SD-scores were factor analysed since only those scales of the SD were to be used that loaded mainly on an evaluative, or good-bad, factor. All but one scale loaded most highly on this factor. Therefore, 15 scales were retained to yield the $\sum$SD-score. The eigenvalue of the first factor was 9.04, compared with 1.30 of the second factor. It is known (Komorita and Bass, 1967) that for single concept ratings the evaluative dimension tends to split up into two or three sub-dimensions. Therefore, the second factor could be considered as a second evaluative factor. Since the first factor was much more important in terms of explained variance, the second factor was neglected. The single item loading highest (.92) on the first factor was the "bad-good" dimension.

(3) A detailed consideration of the importance weights is given in the next section.

(4) From a Bayesian point of view, if different people who may start with different prior beliefs receive the same information the posterior beliefs should converge; such a scheme may not be applicable to value judgements.

(5) This is not to be misunderstood as a validation of a specific model but rather to assess the convergent or predictive validity in terms of correlations. Correlation is not used here as an index of fit (see Birnbaum, 1973).

(6) The observed result may partly be due to a response bias exhibited by a considerable number of the respondents. The bias consisted of a tendency to use the endpoints of the scales most of the time. This scale-checking tendency reduces the information content of the importance ratings, and consequently, tends to reduce the correlations between $\sum$web and the other attitude measures. Such a response bias was also observed by other researchers (Peabody, 1962); it seems to be a rather stable individual trait.

TABLE 1. Factor structure of beliefs.

Factor I. Societal risks.

The use of nuclear energy

.74	Restricts options for future societal development
.71	Concentrates power in big industrial enterprises
.70	Leads to a consumption-oriented society
.67	Involves hazardous agents which cannot be detected by man's senses

Eigenvalue: 6.524

Factor II. Economic benefits.

The use of nuclear energy

.80	Is a long-term solution to energy needs
.79	Provides a cheap energy source
.77	Promotes my nation's industrial development
.75	Increases my nation's prestige

Eigenvalue: 6.382

Factor III. Safety considerations.

The use of nuclear energy

.80	Requires management of dangerous wastes
.69	Restricts personal freedom through rigorous security measures
.46	Has an impact on people's health
.45	Exposes people to hazards which they cannot influence by any actions of their own

Eigenvalue: 2.808

Factor IV. Technological implications.

The use of nuclear energy

.59	Stimulates scientific and technological research
.46	Leads to a more even distribution of income among nations
.44	Leads to diffusion of knowledge for construction of weapons
.43	Leads to technological progress

TABLE 2. Differences between factor-level scores for PRO and CON sub-groups.

	E_j $(\pm3)^a$			B_j $(\pm3)^a$			W_j $(0-10)^a$			EB_j $(\pm9)^a$		
Factor	PRO	CON	Diff.	PRO	CON	Diff.	PRO	CON	Diff.	PRO	CON	Diff.
I Societal risks	-1.608	-2.492	**	-0.791	1.925	**	4.217	7.550	**	1.398	-4.873	**
II Economic benefits	2.033	0.791	**	1.025	-1.583	**	6.942	4.033	**	2.365	-1.275	**
III Safety considerations	-0.675	-1.333	**	0.942	2.900	**	6.560	9.492	**	-0.879	-3.848	**
IV Technological implications	0.667	0.450	NS	0.258	-0.558	**	5.475	5.158	NS	0.135	-0.513	*

[a]Mean Value of the four items loading highest on each factor.

* Difference significant $p < .05$
** Difference significant $p < .01$
NS Difference non-significant

$N_{PRO} = 37$
$N_{CON} = 44$

TABLE 3. Correlations of two- and three-parameter attitude models with $\sum SD$ and DM as criterion variables.

Type of model	Model specification	Criterion variables $\sum SD$	DM
Two parameter models	$\sum eb$	.82	.72
	$\sum we$	.58	.55
	$\sum wb$	-.34	-.37
Three parameter model	$\sum web$	.78	.70

TABLE 4. Intercorrelations of the parametric attitude models.

Type of intercorrelation	Model intercorrelation	
Two-parameter model inter-correlations	$\sum we - \sum wb$	-.55
	$\sum we - \sum eb$	.67
	$\sum wb - \sum eb$	-.37
Correlation of the three-parameter model with the two-parameter models	$\sum web - \sum eb$	.94
	$\sum web - \sum wb$	-.48
	$\sum web - \sum we$	.74

TABLE 5. Degree of intercorrelations of attitude measures depending on number of attitude statements.

	All items 30 $\sum eb$	Factor items 16 $\sum eb$	High imp. 15 $\sum eb$	Low imp. 15 $\sum eb$	High imp. 10 $\sum eb$	Low imp. 10 $\sum eb$	High imp. 5 $\sum eb$	Low imp. 5 $\sum eb$
$\sum$ SD	.8186	.7880	.8143	.7223	.7990	.6915	.7211	.5684
DM	.7205	.6795	.7335	.6092	.7338	.5950	.6947	.4769

TABLE 6. Correlations after Coombs' transformation of e's (total sample) (N = 147).

	Positive branch			Negative branch			
	a=2 $\sum$ eb	a=4 $\sum$ eb	a=6 $\sum$ eb	a=2.5 $\sum$ eb	a=3 $\sum$ eb	a=6 $\sum$ eb	a=10 $\sum$ eb
$\sum$ SD DM	.816 .730	.819 .727	.819 .726	.810 .720	.813 .721	.817 .722	.818 .722
PRO $\sum$ SD	.691	.692	.691	.690	.691	.691	.690
CON $\sum$ SD	.675	.678	.678	.668	.671	.675	.676

FIGURE 1. Smoothed frequency distributions of attitude scores. (Σeb, ΣSD Interval: 1.5; DM Interval: 1.6)

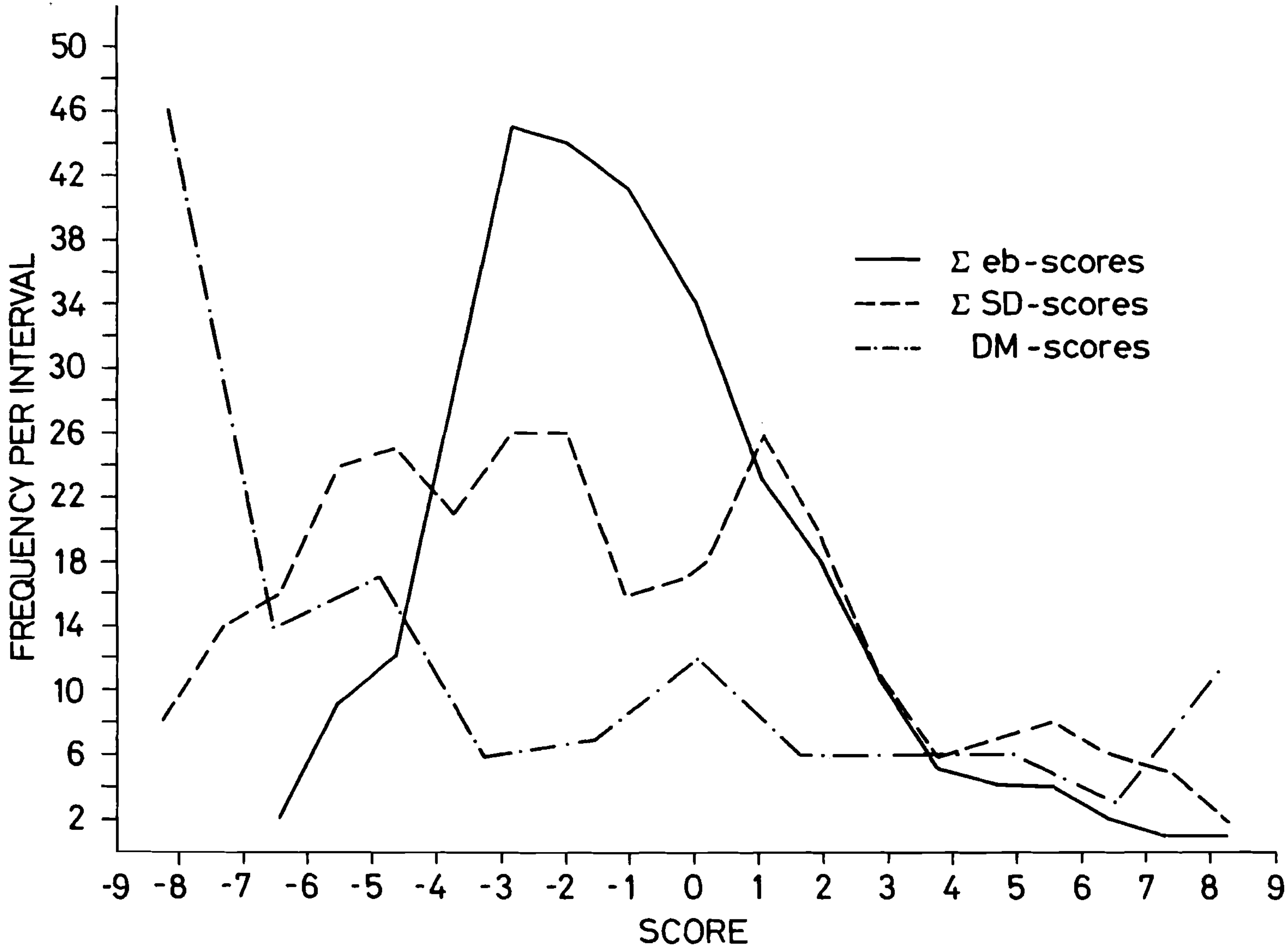
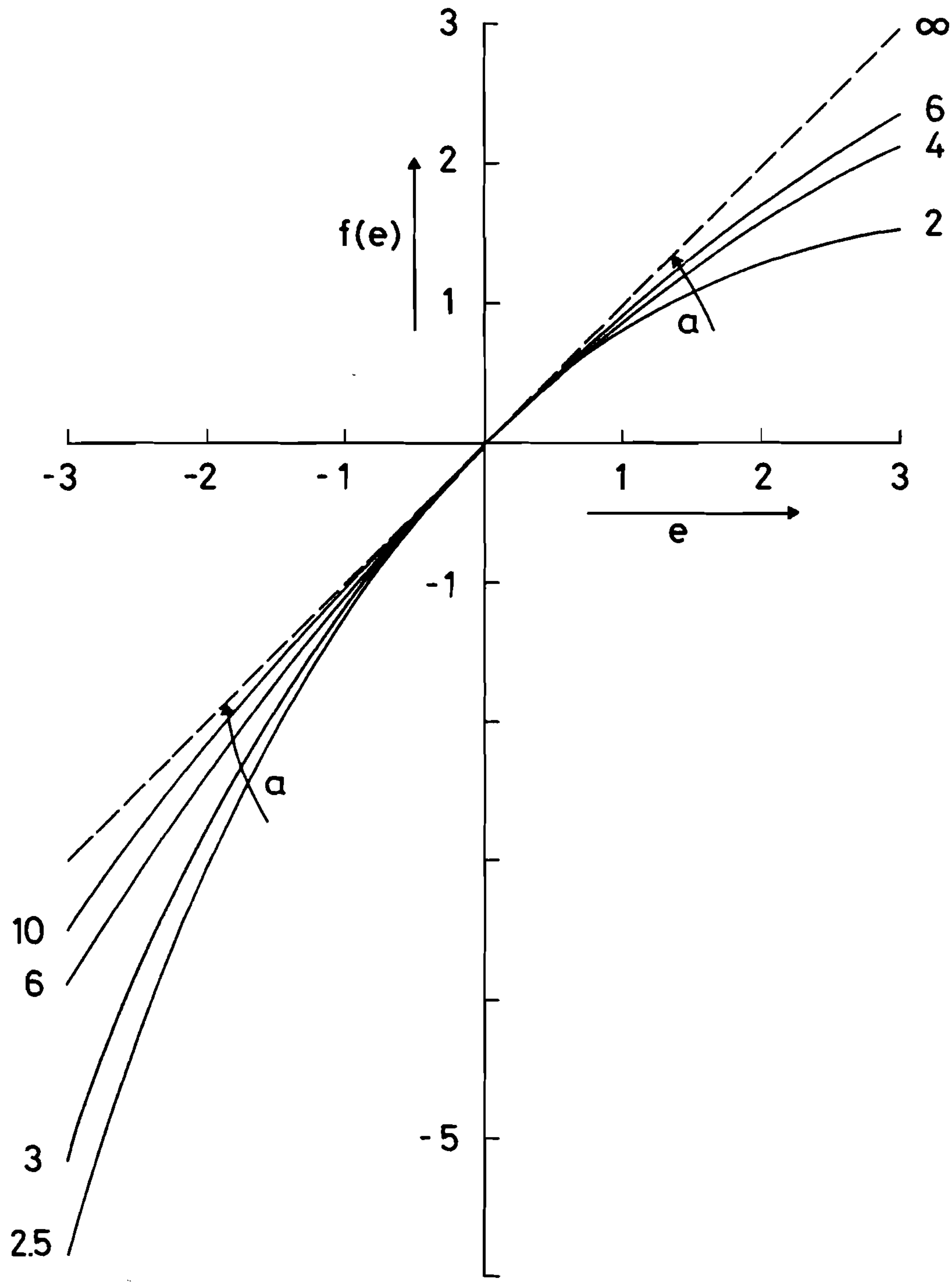


FIGURE 2. Utility transformations used for evaluative scale.



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APPENDIX A: List of Statements

The use of nuclear energy

... improves our standard of living

... restricts personal freedom through rigorous security measures

... promotes my nation's industrial development

... is harmful to future generations

... leads to technological progress

... requires management of dangerous wastes

... helps to conserve natural resources

... provides a source of threats from terrorists

... uses up valuable land

... leads to dependency on small groups of specialists

... exposes people to hazards which they cannot influence by any actions of their own

... assures the economic independence of my country

... has an impact on people's health

... postpones the development of alternative energy sources

... involves a technology which is usable as a tool in international politics

... has a long-term impact on climate

... provides a cheap energy source

... leads to accidents which affect large numbers of people at the same time

... is a long-term solution to energy needs

... leads to environmental pollution

... restricts options for future societal development

... increases my nation's prestige

... leads to consumption-oriented society

... concentrates power in big industrial enterprises

... leads to increased employment

... stimulates scientific and technical research

... reduces the need to conserve energy

... leads to diffusion of knowledge for construction of weapons

... involves hazardous agents which cannot be detected by man's senses

... leads to a more even distribution of income among nations

APPENDIX B: Standard Procedure for Data Analysis

1. Frequency distributions of scale values for each item

This rather simple procedure has proven to be useful for checking the scores of the individual items for inconsistencies, such as significant percentages of positive scores for negatively-formulated items or extreme clustering of scores at the positive or negative endpoints of the scale.

2. Factor analysis of the adjectives of the Semantic Differential

This step is necessary to determine those pairs of adjectives which represent the evaluative dimension of the semantic differential. The unrotated version should be used for this purpose, and it is expected that one strong factor (and some weak factors) would emerge. The key item "good-bad" is expected to load high on the strong factor, thus indicating that this factor is representing the evaluative dimension for the concept in question. Consequently, the $\sum$SD score is derived by adding the scale values of these selected adjectives. The other adjectives not loading on this factor are eliminated.

3. Correlations between various attitude measures

To test the validity of the model, several PEARSON correlation coefficients should be calculated. The variables to be included in this analysis are: the $\sum$SD score (to be created as outlined above), the PRO/CON scale, the sum of the products of evaluations times beliefs for each item, i.e. the $\sum$eb score, and the sum of the products of evaluations times beliefs times importances for each item, i.e. the $\sum$ebw score. The resulting 6 correlation coefficients give an indication of the adequacy of the attributes selected.

4. Graphical display of correlations

An illustrative way to present and interpret correlations is to obtain plots. Specifically the pattern of coherence between the direct attitude measure ($\sum$SD) and the indirect attitude measure ($\sum$eb) can be displayed showing the relationship of these measures for each respondent.

5. Factor analysis of belief scores

For determining an underlying cognitive structure in the belief system a factor analysis with subsequent VARIMAX rotation is suggested. Generally about 5 to 6 factors emerge in this analysis but experience showed that a 4-factor solution yields the best results for interpretation, where one of the factors usually includes risk-oriented items, another one benefit-oriented items. Interpretation of the other factors should try to capture the aspect which is common to those items constituting that particular factor. It is recommended to report not only the loadings of the items for each factor but also the eigenvalues and/or the percentage of variance explained by this factor.

6. Correlations between factor sums and direct measurement

The direct measurement of attitude, i.e. the $\sum$SD and the PRO/CON scale should then be correlated with the factor sums to determine the contribution of each single factor to attitude. In order to create the factor sums it is advisable to inspect items loading on each factor beforehand and define the number of items. About 4 to 5 only should be included, but each factor should consist of an equal number of items. When the respective items are defined, the factor sums can be created in two ways:

1. Add for each factor separately the evaluation x belief products of those items identified to constitute the factor ($\sum$eb).

2. Add for each factor separately the evaluations and the beliefs over those items identified to constitute the factor and multiply these two sums ($\sum$e x $\sum$b). In accordance with the explanations given on p8, it is recommended to use this second procedure for creating the factor sums.

7. Plots of factor contributions vs $\sum$SD scores

To get an insight into the distribution of factor contributions to attitude, a plotting procedure is suggested where the $\sum$SD scores are displayed on the abscissa against which the factor sum scores are plotted. This should be done separately for each factor. A more sophisticated procedure makes use of smoothed means, where the factor sums for each interval of the $\sum$SD are weighted by the respective number of respondents, then these values are added over a predefined interval of the SD (about 10% of total range). This value should be divided by the total number of respondents falling into such intervals and finally the value thus obtained is plotted against the middle of the $\sum$SD interval. This should be done for overlapping intervals.

8. Multiple regression

Multiple regression is a statistical procedure whereby the relationship between a dependent variable ($\sum$SD) and a set of independent variables (factor items) can be analysed to determine the accuracy of the indirect attitude measure as predictor for the direct measurement. Thus, an indication can be derived which items seem the best predictors of overall attitude.

9. Compare means between subgroups

Depending on the sample subgroups of special interest can be defined (e.g. PRO/CON age-groups, students/employees, etc.). These subgroups can then be compared with each other applying the t-test procedure. All measurements (e,b,eb, importances) can be used and their means compared, giving insights into differences specific to the subgroups selected.