PERCEPTION OF TECHNOLOGICAL RISKS: THE EFFECT OF CONFRONTATION

R. Maderthaner*
P. Pahner**
G. Guttmann*
H.J. Otway***

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*Psychological Institute, University of Vienna, and Joint IAEA/IIASA Research Project, International Atomic Energy Agency, P.O. Box 590, A-1011 Vienna.

**International Institute for Applied Systems Analysis, Joint IAEA/IIASA Research Project, International Atomic Energy Agency, P.O. Box 590, A-1011 Vienna.

***Project Leader, Joint IAEA/IIASA Research Project, International Atomic Energy Agency, P.O. Box 590, A-1011 Vienna.

PREFACE

One of the major constraints to the introduction and development of technological systems is the element of risk that such systems bring. This study is part of a joint research effort by IIASA and the International Atomic Energy Agency at Vienna directed at gaining an improved understanding of how societies judge the acceptability of new technologies, and how anticipated responses to the objective and perceived risks may be used in decision making. Specifically, it deals with the perceptions of the relative hazard associated with several widely differing technological facilities and explores the effect of confrontation with specific hazards upon these perceptions.

ABSTRACT

The response of the individual to potentially threatening situations is based upon his perception of the hazard involved. In this pilot study, 148 subjects were asked to quantitatively rank the hazard they felt to be involved in living near seven different types of technological facility. The subjects were divided into four groups: AN, living about 500 m away from a research reactor; AF, living about 1.4 km away from this reactor; two small groups living at similar distances from a district heating facility and a control group about 10 km distant from both facilities.

All groups, except AN, found the item "nuclear reactor" to be the most hazardous (total sample, 3.1 on a 4 point scale). Group AN (N = 32) found this item to be the third most hazardous, 2.88/4.0; group AF (N = 31) rated the item 3.55/4.0. The difference in this response between groups AN and AF is highly significant (Mann-Whitney U-test $p \leq 1\%$). Several explanations for this finding are discussed.

I. INTRODUCTION

Many countries are experiencing a period in which traditional values are being questioned; plans for further technological development are being met by a variety of demands for a closer examination of the benefits and risks of large-scale technologies. An earlier paper by Otway and Pahner (1976) has outlined a conceptual framework for risk assessment studies and presented a research plan in this area. In this research, risk situations are considered to be characterised by a number of "levels". The first level is that of the physical risks presented by a particular facility or technology; the next level is that of how these risks are perceived by individuals; the third level consists of the psychological effects upon individuals as they respond to these perceptions and the final level is the risks to social structures and cultural values as individuals express their concerns through their participation in interest groups.

Although it is clear that the perception of risk situations determines the response to them, there has been little research done to determine how various risk situations are perceived and what factors, psychological or otherwise, influence the perception process. A Canadian study by Golant and Burton (1969a), for example, suggests that experience with certain situations of risk may variously affect assessment of the risk, whereas in a parallel study performed in Austria by Otway et al. (1975), the subjects' ability to imagine themselves in the hazardous situation proved an important variable in ranking the risk involved. Two or three different bases of classification have been found for dealing with the problem of the dimensions of the risk situation, depending on the investigation and methods used. Golant and Burton (1969a) first proposed a sub-division into "physical, natural and social hazards", but in a subsequent factor analysis (1969b) of assigned properties ("semantic differential") they differentiate between "man-made, natural and quasi-natural hazards".

In an Austrian investigation conducted by Swaton et al. (1976), in which graphic models of technical risk situations were subjected to factor analysis, the authors arrived at a bi-polar factor, the extreme expressions of which were described by "active" and "passive", or, according to Kogan and Wallach (1964), by "skill" and "chance". Although the sex of the respondent has been seen to be a significant variable (Otway et al., 1975; Swaton et al., 1976), the incorporation of personality variables (extroversion versus introversion), age and occupation have not revealed any effects on risk perception in the studies conducted so far (Golant and Burton, 1969a; Otway et al., 1975).

The present pilot study was intended to rank the perception of various risk situations and to examine the effect of the degree of confrontation with the risk as a contributing factor, since there are many indications of the significance of this variable to be found in the study of public attitudes. According to the theory of "cognitive dissonance" (Festinger, 1957), for example, certain practices and situational factors can be cause for a change in attitude when they are incompatible with certain other known facts (information on the hazardousness of a situation, for instance) (Insko, 1967). A "cognitive dissonance" (inconsistency) of this kind creates a tension that one generally seeks to reduce by adapting the most easily modifiable variable. Since behaviour patterns, and more especially ways of life, are generally more difficult to alter than attitudes, persons residing near risk objects (or engaged in occupations involving risk) might be expected to evaluate the hazards facing them as less dangerous than would individuals who are not confronted with the situation to the same extent.

Objectives

The intention was to rank the perception of certain risk situations and to test the hypothesis that the degree of confrontation with a risk alters the evaluation of it; this was done by random sampling of persons living at various distances from objects constituting a potential hazard.

Test Description

A random group of 148 persons was questioned by an interviewer. In addition to details regarding sex, age and occupation, they were asked to rate a series of hazardous objects on a four-point scale as to how risky it would seem to live in their proximity. The following seven objects were listed:

1. Gas works
2. District heating facility
3. Oil refinery
4. Mental hospital
5. Nuclear reactor
6. Prison
7. Airport

The 148 persons surveyed were divided into one control group and four test groups. The test groups were composed of persons living at different distances from each of two selected potentially hazardous objects.

Groups

AN (nuclear reactor, near); (N = 32)

occupants of holiday houses near a research reactor ("Prater reactor") (up to a distance of 500 m)

AF (nuclear reactor, far); (N = 31)

occupants of housing further away from the experimental reactor (about 1.4 km);

HN (district heating facility, near); (N = 10)

occupants of holiday houses near a district heating facility (not further than 500 m away);

HF (district heating facility, far); (N = 14)

occupants of housing further away from the facility (about 1.5 km);

CG (control group); (N = 61)

inhabitants of various districts in Vienna.

Of the persons surveyed, 41% were men between the ages of 30 and 60 who came from a very wide variety of occupational categories. Comparability of the experimental groups in terms of these characteristics was checked statistically and confirmed. An interesting aspect is that a high percentage of those approached refused to be interviewed. This can perhaps be attributed to the fact that the population had had a surfeit of problems of this type; in the months preceding the survey discussions on nuclear power plants and environment had been very heavily emphasized in the mass media (in connection with plans for a second nuclear power plant in Austria).

II. RESULTS

A. Risk Confrontation and Magnitude of Risk Estimation

Table I gives an overall picture of risk assessment for the individual objects in each of the five groups with the ratings running from a value of 4 (highly hazardous) to 1 (no risk at all).

In the case of the nuclear reactor groups, there was a highly significant ($p \leq 1\%$) mean difference (Mann-Whitney U-test) between the conditions "near" (AN) and "far" (AF). This is in line with the alternative theory: the persons confronted to a greater extent with the risk of the experimental reactor (i.e. in the immediate vicinity) graded the nuclear reactor risk at a mean value of 2.88, while for those living further away and confronted to a lesser extent the figure was 3.55. A ranking of the risk assessments for the individual objects indicates that it is only for the group with greater confrontation (AN) that the nuclear reactor occupies third place--for all other groups it is regarded as the highest risk.

For the district heating facility there was no significant difference between the "near" (1.60) and "far" (1.64) categories. The reason for this may be either the statistical ratio (random sampling of small group) or the fact that the distance estimated as "far" (HF) for a district heating facility, 1.5 km, may be too small when one considers the far-reaching atmospheric pollution and the objectionable smell. The latter interpretation is supported by the significant difference ($p \leq 5\%$) between the overall mean for both district heating facility groups (HT and HF)--1.62--and that of the remaining groups (AN, AF and CG)--2.00. The results for the reactor and the district heating facility groups are plotted as a function of distance in Figure 1. For this purpose, the control group was assumed to be at an average distance of 10 km. Tables II and III summarise the mean values, variance, and statistical significance between the different groups (AN, AF, HN, HF, CG) for each risk object.

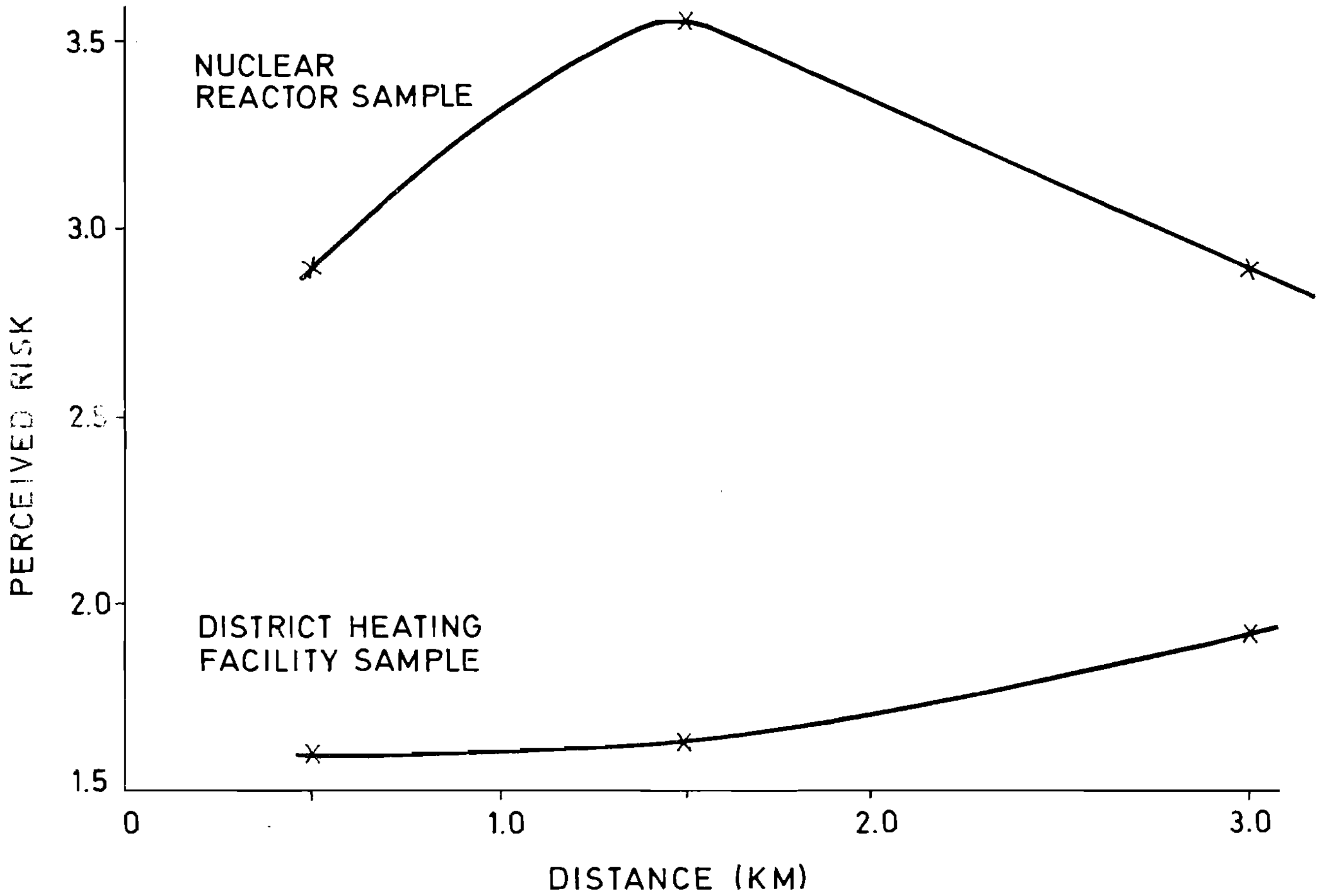

Figure 1. The perception of two specific risk situations (pilot study).

B. Age and Sex

As age and sex were also requested by the questionnaire, the influence of these variables on risk assessment could be checked. There was a small but significantly positive correlation with the age of the persons tested for two of the technical installations. There was a positive correlation with the sex of the respondents in one case.

Risk assessment for nuclear reactor -- age: $r = +0.21$ ($p \leq 1\%$)
Risk assessment for airport -- age: $r = +0.26$ ($p \leq 1\%$)
Risk assessment for nuclear reactor -- females: $r = +0.16$ ($p \leq 5\%$)

It would appear that age in particular is responsible for a slightly higher risk perception for technical installations, while it is less significant in the case of gender. Both age and sex had an influence upon the response to the the item "nuclear reactor".

C. Risk Objects and Their Dimensions of Estimation

However, so that not only the degree of risk assessment per object could be taken into account, but also possible groupings of objects in accordance with their correlative relationship, the intercorrelation matrix (Table II) of the objects for the total sample was evaluated by factor analysis techniques. Two factors were extracted, the first of which seems to represent a quality associated with all objects (possibly a general risk component). This does not require more extensive treatment here. The second bi-polar factor, however, could represent an object according to the origin of the risk (human versus technological). The following diagram shows the arrangement of the risk objects in this dimension (according to the factor weightings) and also gives, for purposes of comparison, the mean of the scaled risk in parenthesis:

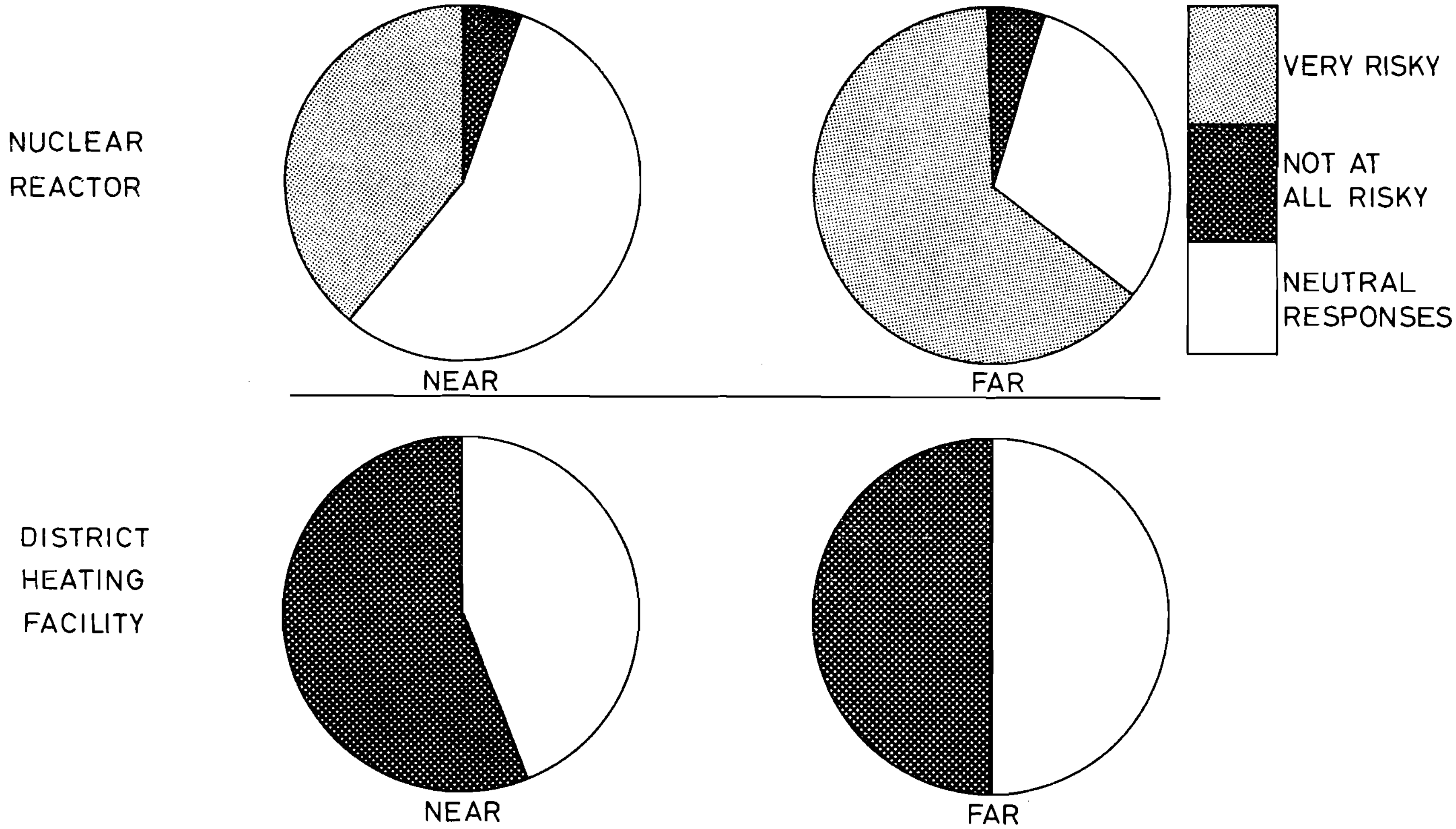

Figure 2. Perception of risk.

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0.59	Mental hospital	(1.7)
0.46	Prison	(2.2)
0.30	Nuclear reactor	(3.1)
0.04	Airport	(2.8)
-0.28	Gasworks	(2.2)
-0.36	Oil refinery	(2.9)
-0.48	District heating facility	(1.9)

(-)

The correlation of the qualitative (human-technological element) and the quantitative (risk assessment) characteristic values of the objects is r = -0.14. This gives an indication that the persons surveyed attribute just as much importance to the human as to the technological element in risk situations.

III. CONCLUDING REMARKS

A qualitative analysis of the seven scaled objects on the basis of their correlative similarities has produced as an important result a bi-polar factor which seems to cover the individual object-associated risks in terms of the degree to which men, as opposed to machines, are involved.

The hypothesis that confrontation with a potential risk situation lowers the perception of risk was confirmed by the results obtained with two groups of surveyed persons living at 500 m and 1400 m distant from a nuclear reactor. Since it was possible to find only a small number of test persons from the environs of the district heating facility, there is no point, statistically speaking, to attempt an interpretation of these latter results.

With respect to the reactor groups, one possible explanation is that the group living nearby was simply better informed about the nature of their risk situation and, therefore, less concerned. There is no reason to believe that this is the case. The theory of cognitive dissonance appears, at least from an external viewpoint, to have been confirmed by this result. This would simply mean that it was much easier for people to change their attitudes about living near the nuclear reactor than to change their residence.

The latter hypothesis implies a seemingly effortless, rational and conscious adjustment. One of the most primitive, and yet most important, of the psychological defense mechanisms is that of denial. When a person can ignore or simply dismiss internal or external events whose perception is anxiety-provoking, he is using this mechanism. Reluctance to acknowledge the death of a loved one or to contemplate one's own death are common examples. Increasingly it becomes evident that denial is a process employed on a larger scale to deal effectively with the realities of everyday life. The technological risks preceived by people in contemporary societies may be so anxiety-provoking at times as to facilitate this process of denying their importance. The use of denial must not be pathological, but may be viewed as an adaptive human mechanism to potentially painful, disturbing situations. There are many psychological mechanisms of defense which individuals use to adapt themselves to daily life and to protect themselves from undue anxiety; these processes may occur on an unconscious as well as conscious level.

Guedeney (1973), in her study of the nuclear controversy in France, Switzerland and Belgium, made similar, empirical observations. She reports on a social research effort at Bagnols-sur-Ceze which indicated that rumours were always more primitive, and reflected a higher level of anxiety, the further away someone was from the nuclear facility. Those living nearest to the plant reported little concern, although it was noted that anxiety was aroused by the slightest incident. She attributes these findings to "mastery through vision"--that those living near the plant, constantly observing the physical nature of the facility, workers coming and going, normal plant operations, gradually adapted themselves to whatever unconscious fears they may have harboured about the risks. It was also noted that physical barriers at different nuclear sites (the Ardennes, the Arree Mountains, the Rhone valley, a desert plateau) seemed to stop the formation of concrete representations and resulted in higher levels of anxiety as reflected in vague and primitively organized rumours.

This seems to suggest the existence of zones of psychological influence. There is evidence of low levels of anxiety in near proximity to the site, a gradual increasing of anxiety and expressed social responsiveness as one moves several (2 - 4) kilometers away from the facility and then a gradual diminution of reaction (as seen in Figure 1). This has also been noticed in an interesting study by Pages et al.(1975) regarding the perception of industrial odours. A similar result, in a different context, was reported by White and co-workers (1968), who found that the perception of flood hazards was lowest in areas of both frequent and infrequent flooding, but highest in areas with intermediate flood frequency. That is, those confronted with the hazard had adjusted to it.

These observations all support the assertion that one determinant of risk perception is the extent to which one is confronted by the situation. This finding is consistent with the theory of cognitive dissonance; however, the possible importance of unconscious mental processes has been introduced and must also be considered. It must be repeated that this was a pilot study. It is planned to revise the questionnaire used and to repeat the survey, with a larger statistical base, near an operating nuclear power plant. The new questionnaire will improve the scaling methods and will be designed to aid in interpreting results. Certainly more research is required to develop a better understanding of the factors influencing risk perception and the effects these perceptions may have upon psychological well-being.

Table I

Nuclear Reactor Group

AN	near	far	AF
Oil Refinery	(3.22)	(3.55)	Nuclear Reactor
Airport	(2.97)	(2.90)	Oil Refinery
Nuclear Reactor	(2.88)	(2.87)	Airport
Prison	(2.38)	(2.35)	Prison
Gasworks	(2.19)	(2.29)	Gasworks
District Heating Facility	(1.97)	(2.10)	District Heating Facility
Mental Hospital	(1.75)	(1.81)	Mental Hospital
	2.48	2.55	
	2.52		

District Heating Facility Group

HN	near	far	HF
Nuclear Reactor	(3.20)	(3.57)	Nuclear Reactor
Airport	(2.80)	(3.29)	Airport
Oil Refinery	(2.70)	(2.93)	Oil Refinery
Gasworks	(2.40)	(2.21)	Prison
Prison	(1.90)	(2.00)	Gasworks
Mental Hospital	(1.70)	(1.79)	Mental Hospital
District Heating Facility	(1.60)	(1.64)	District Heating Facility
	2.33	2.49	
	2.41		

2.47

Control Group

CG	
Nuclear Reactor	(2.87)
Oil Refinery	(2.70)
Airport	(2.54)
Gasworks	(2.11)
Prison	(2.07)
District Heating Facility	(1.93)
Mental Hospital	(1.54)
	2.25

Table II

Total Means and Deviations

	Var. Nr.	Ave.	Distribution
Gasworks	1	2.176	1.001
District Heating Facility	2	1.926	0.941
Oil Refinery	3	2.878	0.968
Mental Hospital	4	1.676	0.890
Nuclear Reactor	5	3.101	1.028
Prison	6	2.196	0.987
Airport	7	2.791	1.051

Inter-correlation Matrix

Row 1	1.00	.55	.44	.27	.39	.30	.37
Row 2	.55	1.00	.53	.22	.18	.29	.51
Row 3	.44	.53	1.00	.26	.23	.33	.51
Row 4	.27	.22	.26	1.00	.32	.54	.34
Row 5	.39	.18	.23	.32	1.00	.29	.46
Row 6	.30	.29	.33	.54	.29	1.00	.41
Row 7	.37	.51	.51	.34	.46	.41	1.00

Table III

Calculation of the Group Statistics

	Mean Value per Group	Standard Deviation per Group	Sample per Group	Mean Value per Rest Group	Standard Deviation per Rest Group	t-Value or U-Test	Normal Distribution group 1	Normal Distribution group 2
Variable 1 Gasworks								
AN	2.19	1.00	32	2.17	1.01	.075	N	N
AF	2.29	1.10	31	2.15	.98	.716	N	N
HN	2.40	.97	10	2.16	1.01	.797	N	-
HF	2.00	1.04	14	2.19	1.00	-.772	N	-
CG	2.11	.97	61	2.22	1.03	-.618	N	N
						Kruskal Wallis Rank Variance Analysis Chi-Square = 1.60 DF = 4		
Variable 2 District Heating Facility								
AN	1.97	.86	32	1.91	.97	.493	N	-
AF	2.10	1.04	31	1.88	.91	.977	N	-
HN	1.60	.84	10	1.95	.95	-1.129	N	-
HF	1.64	.74	14	1.96	.96	-1.073	N	-
CG	1.93	.98	61	1.92	.92	.006	N	-
						Kruskal Wallis Rank Variance Analysis Chi-Square = 3.18 DF = 4		

Table III continued

	Mean Value per Group	Standard Deviation per Group	Sample per Group	Mean Value per Rest Group	Standard Deviation per Rest Group	t-Value or U-Test	Normal Distribution group 1	Normal Distribution group 2
Variable 3 Oil Refinery								
AN	3.22	.83	32	2.78	.99	2.278	N	N
AF	2.90	.91	31	2.87	.99	.124	-	-
HN	2.70	.95	10	2.89	.97	-.712	N	-
HF	2.93	1.07	14	2.87	.96	.224	N	-
CG	2.70	1.02	61	3.00	.91	-1.733	N	-
						Kruskal Wallis Rank Variance Analysis Chi-Square = 6.18 DF = 4		
Variable 4 Mental Hospital								
AN	1.75	.84	32	1.66	.91	.789	N	-
AF	1.81	.98	31	1.64	.87	.885	-	-
HN	1.70	.82	10	1.67	.90	.281	N	-
HF	1.79	.97	14	1.66	.88	.482	N	-
CG	1.54	.87	61	1.77	.90	-1.821	-	-
						Kruskal Wallis Rank Variance Analysis Chi-Square = 3.35 DF = 4		
Variable 5 Nuclear Reactor								
AN	2.88	.98	32	3.16	1.04	-1.665	N	-
AF	3.55	.81	31	2.98	1.05	2.776	-	-
HN	3.20	1.03	10	3.09	1.03	.279	N	-
HF	3.57	.94	14	3.05	1.03	2.050	-	-
CG	2.87	1.09	61	3.26	.96	-2.263	N	-
						Kruskal Wallis Rank Variance Analysis Chi-Square = 15.16 DF = 4		

Table III continued

	Mean Value per Group	Standard Deviation per Group	Sample per Group	Mean Value per Rest Group	Standard Deviation per Rest Group	t-Value or U-Test	Normal Distribution group 1	Normal Distribution group 2
Variable 6 Prison								
AN	2.38	1.01	32	2.15	.98	1.160	N	N
AF	2.35	1.08	31	2.15	.96	1.008	N	N
HN	1.90	.88	10	2.22	.99	-.981	N	N
HF	2.21	.97	14	2.19	.99	.073	N	N
CG	2.07	.95	61	2.29	1.01	-1.349	N	N
						Kruskal Wallis Rank Variance Analysis Chi-Square = 3.74 DF = 4		
Variable 7 Airport								
AN	2.97	1.09	32	2.74	1.04	1.084	N	N
AF	2.87	1.06	31	2.77	1.05	.478	N	N
HN	2.80	1.03	10	2.79	1.06	.032	N	-
HF	3.29	.99	14	2.74	1.05	1.954	N	-
CG	2.54	1.01	61	2.97	1.05	-2.573	N	-
						Kruskal Wallis Rank Variance Analysis Chi-Square = 8.70 DF = 4		

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