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RADIOACTIVE WASTES:

PUBLIC ATTITUDES TOWARD DISPOSAL FACILITIES

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Topical Report

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EXECUTIVE SUMMARY

Although some observers have concluded that the technology required to assure safe disposal of nuclear wastes is currently available, others have expressed concern about the stability of the institutions that might be required to maintain the isolation of nuclear wastes. Questions about institutional stability and other factors associated with nuclear power and nuclear waste have been the subject of some study in public opinion research. Since these surveys have, with few exceptions, been administered to national probability samples, it has been difficult to accurately characterize the similarities and differences of opinion of the most strongly pro- and antinuclear portions of the public.

In order to provide a basis for a more intensive study of these groups, the sampling strategy followed in the present study was the selection of 17 geographically widespread, established groups which were expected, a priori, to vary in their attitudes from strongly pronuclear to strongly antinuclear. In comparison to probability samples, our sample more heavily represented the middle--30 to 60--age categories, had a higher proportion of males and was characterized by higher income and educational levels. Our sample was not, however, designed to be representative of the population in general. Instead, we wished to tap those people who tend to be politically active and therefore functionally important in matters related to energy use patterns and questions of waste management. Since the sample overrepresents those who tend to be most politically active, it appears that the sampling strategy fulfilled its purpose.

Based upon statistical analyses, the 17 groups were assigned to 6 relatively distinct clusters which were compared on their level of involvement with various activities related to environmental concern. These

activities, especially those concerned with support for nuclear power and opposition to nuclear power, provided strong confirmatory evidence of the validity of the classification of the respondent groups into clusters. For the clusters which were designated as antinuclear, a few of the respondents had engaged in activities supporting nuclear power and many reported being involved in activities opposing nuclear power, opposing environmental pollution and supporting energy conservation. Though pronuclear respondents reported many activities in support of nuclear power, and a few in opposition to nuclear power or environmental pollution, they also actively supported energy conservation.

The clusters of respondents were found to differ substantially on some questions and very little on other questions designed to measure specific beliefs about the need for and the efficacy of three potential characteristics of a nuclear waste repository: site control, site monitoring, and information transfer. Questions on site control were designed to address issues associated with physical control of the location of the stored wastes. Questions on site monitoring addressed the need for and efficacy of measures to detect the release of radioactive wastes from their storage site. Information transfer questions were oriented toward problems of maintaining knowledge of the location of buried wastes over long periods of time.

The highest level of consensus was found on the items concerned with the need for site monitoring, site control, and information transfer. Respondents were generally agreed that there is a need for these features in a waste repository. The responses to the items which addressed the efficacy of these factors showed more disparate attitudes. The data showed that antinuclear respondents are pessimistic about the success of site control efforts. Most of the respondents fell within the neutral range on the

the efficacy of information transfer. On the issue of site monitoring, respondent groups ranged from neutral to strong endorsement on the possibility that technological monitoring can be maintained over hundreds of years. They appeared less optimistic that monitoring will insure that hazardous conditions will be corrected. A similarly wide range of responses was found for items which addressed the safety of geologic storage and confidence that technical experts are able to select and construct a facility that is safe enough.

Concerns about repository safety were also in evidence in another section of the questionnaire in which respondents were asked to report the minimum distance that they would be willing to live or work from each of a number of energy related facilities. These data indicate that natural gas and oil burning power plants were generally the most acceptable facilities. The least acceptable facilities differed by cluster. Insecticide factory, nuclear power plant, and nuclear waste repository were generally the least acceptable facilities for the antinuclear clusters. For the pronuclear clusters, the coal fired power plant and the insecticide plant were the least acceptable. There were significant differences among clusters in the distances reported for all facilities. Antinuclear respondents consistently reported greater distances, regardless of facility, than did pronuclear respondents.

Overall, the results indicate that pronuclear respondents believe that the hazards of nuclear waste are similar to other industrial risks and that problems which are currently unresolved will ultimately be settled. Antinuclear respondents, by contrast, are less optimistic about the prospects for safe storage of nuclear wastes. They believe that nuclear power is different and have less faith in the efficacy of technological solutions.

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INTRODUCTION

One of the advantages of nuclear power often stated by its proponents is the controllability of its wastes. In contrast to other currently available sources for generating electric power--especially coal--radioactive wastes from nuclear power plants are highly compact. The concentration of nuclear wastes, in turn, makes it economically feasible to separate the most highly radioactive products and isolate them.

Since the products of the fission process include isotopes which are hazardous for long periods of time, great care must be taken in the handling and disposal of the wastes to ensure that they pose no significant risk to life. Many observers have concluded that the technology required to assure safe disposal is currently available. According to Cohen (1977), radioactive wastes buried 600 meters beneath the earth's surface in stable geologic formations would produce negligible harmful effects on human health.

Although there are some remaining questions about the stability of goelogical formations, about the resistance of technological barriers to waste dispersal and about the behavior of certain waste forms, these are not so great that they are likely to lead to rejection of the basic concept of geologic disposal.

Others have expressed concern about stability of the institutions that might be required to maintain the isolation of nuclear wastes. Weinberg (1972), for example, has claimed that "the price that we demand of society for this magical energy source is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to." Institutional questions are but one of a number of nontechnical issues which are associated with nuclear waste disposal.

These nontechnical issues--areas of choice which cannot be resolved by means of technological solutions--have been the subject of much debate in the scientific and technical literature and in the popular media. They include questions about the acceptability of burdens of risk on future generations, concerns about the effects of security measures on civil liberties, and international implications of nuclear waste management. Many of these issues have been addressed in a report by Hébert, Rankin, Brown, Schuller, Smith, Goodnight, and Lippek (1978). In their discussion of institutional issues, these authors suggested that three functions of a waste repository are of particular concern: site control, waste monitoring, and information transfer.

Site control refers to the need for and usefulness of complete control of the site where the nuclear wastes would be stored underground. This might exclude all surface uses including agriculture, habitation, commerce, and industry. Site monitoring addresses the need to install and maintain sensing devices capable of detecting a leak in the buried waste containers. Finally, information transfer involves the need for assurance that knowledge of the location in which the wastes are buried is maintained over very long periods of time.

It is possible to handle each problem--site control, site monitoring, and information transfer--in a variety of ways. Since there has been no clear justification for believing that one alternative is better than any of the others, we thought it would be helpful to seek information about the public's perceptions of the alternatives. It is for this purpose that we developed some questionnaire items addressing the need for and probable success of several strategies for handling nuclear wastes.

There is, in addition to questions about the need for and efficacy of different institutional design factors, a practical question about the

public's general feelings about any waste repository. One particularly important aspect of public acceptability is the willingness of respondents to have a facility of this type sited near the place where they live or work. There are many characteristics of a waste facility which might affect this aspect of acceptability. Concerns about impacts on property values, taxes, local public services, and public health and safety are all likely to be considered by local residents. The frequency with which concerns about health and safety impacts are mentioned in the responses to opinion polls (Harris & Associates, 1975, 1977) suggests that this is a particularly salient factor for many individuals. For this reason, respondents were asked to report, considering only health and safety, the minimum distance from the place where they lived or worked that they would be willing to have a waste repository sited.

A questionnaire was constructed to cover a number of areas of public concern about risks and benefits associated with technologies for generating electricity. This report describes the results of those parts of the questionnaire which are most directly concerned with issues associated with nuclear waste repositories. This includes 14 items which covered the need for and perceived efficacy of the three different factors associated with the implementation of a nuclear waste repository: site control, site monitoring, and information transfer. Additional items addressing respondents' overall evaluations of the need for and efficacy of waste respositories and items which specifically referred to nuclear power or waste were also included.

Another part of the questionnaire contained the names of eight energy related facilities. These included power production facilities, nuclear and coal power plants, for example, as well as storage facilities such as nuclear waste repositories and liquified natural gas storage areas.

Respondents were asked to write, in the space adjacent to the name of the facility, the number of miles that they would be willing to live or work from one of these facilities. The last part of the questionnaire was comprised of items which were intended to provide information on the social and demographic characteristics of the respondents. Information on respondents' age, education and other characteristics was assessed in order to provide a better indication of the types of respondents that our sampling strategy had produced. In addition to the demographic items, respondents were asked to report on their level of involvement with various activities related to environmental concern. These activities were: opposition to environmental pollution, support for nuclear power, opposition to nuclear power, and support for energy conservation. For each of these areas, respondents were asked to check those activities in which they had engaged in the last year.

RESPONDENTS

Sampling

The sampling strategy followed in the present study was the selection of geographically widespread, established groups with known attitudes on a key issue, variously called "theoretical sampling" (Glaser and Strauss, 1968:41-62), "scope sampling" (Willer, 1967:97-115), or "sampling of publics" (Blumer, 1948:S42-549). Without regard to the name one uses, the object of such selection procedures is to obtain a sample of the opinions (or attitudes, or values, etc.) of the "concerned" or "socially and politically active" population. As Blumer points out, social scientists are not always interested in a cross sectional assessment of the opinions of a population; in terms of studying the dynamics of communities, it is important to determine how the active (or participation-oriented) citizens react.

Questionnaires were administered to members of seventeen groups which were expected to vary in their attitudes from strongly pronuclear to strongly antinuclear. Since others (Melber, Nealey, Hammersla and Rankin, 1978) have reported geographical differences in attitudes toward nuclear power, we attempted to balance the sample by selecting groups of respondents from states in five different areas of the country: Massachusetts, Illinois, Texas, Colorado, and California. Within each of these regions, a consultant was selected who was to identify three or more groups: one pronuclear group, one antinuclear group, and one relatively neutral group. The pronuclear and antinuclear groups were to be identified on the basis of their public stands on the issue of nuclear power. The neutral groups were selected on the basis of interest of group members in energy issues and absence of a prior policy explicitly supporting or opposing nuclear power.

Questionnaires were distributed to group members, who were asked to complete them and return them to the consultant for forwarding. Return rates for these questionnaires , that is, the number of questionnaires returned divided by the number of questionnaires distributed, varied across some groups. In some groups, the response rate was as high as 100 percent--all questionnaires were returned. In other groups, the response rate was as low as 20 percent. There were also some groups which were contacted but which declined to distribute questionnaires to their members. Significant rates of nonresponse, and especially differential rates of nonresponse, are often indicative of selective response. If respondents are, in part, self-selected, they may be significantly different from those who were asked to respond, but who did not. In most public opinion polling situations, significant levels of nonresponse can lead to biased estimates of the proportion of the public which supports or opposes a stand on an issue.

We do not consider differential response rates to be a problem since, in this study, we are not proposing to estimate the proportion of the members of the public who support or oppose nuclear power. We are interested, rather, in finding out which beliefs or values are more significantly related to support for or opposition to nuclear power. As a consequence, nonresponse, whether uniform or differential across groups, can affect our conclusions largely to the extent that the most strongly pronuclear and antinuclear respondents are missing from our sample. Those who were asked to fill out the questionnaire but did not, fell, for the most part, into one of three groups. There were those who did not return it because they considered it to be <u>too pronuclear</u> or because they felt that the

results would be slanted to support nuclear power. A second group was composed of those who did not fill out the questionnaire because they felt that it was too antinuclear. Last, there were those who felt that the questionnaire was too long or too difficult to understand. Reservations about "pronuclear slant" were, not surprisingly, expressed most often by members of groups which were selected for their antinuclear position. Equally predictable was just the oppose response from the groups expected in advance to be pronuclear. To the degree that extremely pronuclear or antinuclear individuals withdrew themselves from the sample, we would expect our ability to accurately classify individuals as pronuclear or antinuclear to be reduced. This is due to a statistical phenomenon known as "restriction of range." However, since the data showed significant variation across clusters, and relatively high levels of classificatory accuracy, we have concluded that our sample has adequately represented the range of respondents and that nonresponse by those holding extreme attitudes is not a problem for our purposes.

The absence of those who declined to complete the questionnaire because of its length or complexity is also not a serious problem. The absence of these individuals would have a minimal effect on the conclusions drawn from the data if the attitudes of this group of nonrespondents consistely fell between those of the pronuclear and antinuclear respondents. For questions directly addressing nuclear power this would certainly be the case. For other issues, including those questions which were related to energy conservation, for instance, this would not necessarily be true. Since the primary emphasis of this report is on beliefs and attitudes which are closely related to nuclear power, the effect of nonresponse due to questionnaire length is probably minor.

Formation of
Respondent Clusters

In order to provide a clearer understanding of the factors which distinguish between pronuclear and antinuclear respondents, the 17 groups of respondents were aggregated into six clusters. The assignment of these groups to clusters was accomplished in two steps. First, the data from all the respondents were entered into a stepwise multiple discriminant analysis in which the predictor variables were items from another part of the questionnaire dealing with several more energy attitudes and the dependent variable was group membership. This analysis used the Multiple Discriminant program from the Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975). Since no additional discrimination of any practical significance was achieved after ten variables had been included in the equation, the matrix of dissimilarity indices among groups from step ten was used as the basis for forming clusters. Inspection of this intergroup distance matrix indicated that some clusters of groups were readily apparent. Other clusters, especially among the more neutral groups, were less clearly defined. A satisfactory assignment of groups to clusters was finally accomplished by use of two criteria. The first criterion involved minimization for the maximum distance between groups in a cluster. This is a clustering criterion that is well known in the literature on cluster analysis, and is frequently referred to as the "complete link" or "furthest neighbor" criterion (Anderberg, 1975). The objective of the second criterion was to equalize the sample sizes among the various clusters. Although it was not possible to satisfy the latter criterion exactly, it was possible to make the sample sizes approximately equal without distorting the differences among the clusters of the similarities within clusters.

Table 1 shows a list of the groups, identified by geographical region and a short label describing the group. The table also shows the cluster to which each of these groups was assigned. Clusters are assigned numbers from one to six, with cluster one being the most antinuclear and cluster six being the most strongly pronuclear.

Demographic Characteristics of the Respondents

Like any other sampling technique, scope sampling has both advantages and disadvantages. One advantage is sampling efficiency. Since strongly pro- and antinuclear individuals constitute minorities of the total population, a large probability-based sample (selection on the basis of proportion of the total population) would be required to generate the same number of pro- and antinuclear respondents as the established-group procedure used here. Given that one is interested in the attitudes and beliefs of those for whom nuclear power is a central, salient issue, i.e., those most likely to act to affect nuclear policy, established-group sampling is most efficient. A second advantage is that the study of smaller numbers of persons allows the exploration of issues in greater depth and the use of items requiring more complex, time-consuming judgments. Compared with probability-sampling, then, established-group sampling provides more information, more efficiently, about those persons of greatest interest.

The primary disadvantage of established-group sampling is that the degree to which a sample is representative of a population is not specified statistically; while the representativeness of a probability-sample is statistically assured, that of an established-group sample is not (Kish, 1965). Lacking a statistical guarantee, the quality of an established-group sample must be demonstrated. One demonstration of

TABLE 1

Cluster Assignments of
Survey Groups

CLUSTER	STATE	TYPE OF GROUP	ANTICIPATED ATTITUDE
1	Massachusetts	Public-interest research	anti
	Massachusetts	Political education	neutral
2	Texas	Environmental action	anti
	Colorado	University social science class	anti
	Illinois	Political education	neutral
	Illinois	Environmental	anti
3	Colorado	Research	neutral
	Colorado	Environmental	anti
	Colorado	Computer Professionals	neutral
4	Texas	Recreational	neutral
	California	Public safety	neutral
5	Colorado	Business	pro
	Illinois	Business	pro
	California	Business	pro
6	Massachusetts	Labor	pro
	Texas	Utility employees	pro
	California	Nuclear technologists	pro

quality consists of comparisons between the demographic characteristics of the sample (or its subgroups) and those of other samples (or their subgroups).

In comparison to the typical samples reported in polls of adults, the present sample tended to overrepresent middle-age categories. There were, in addition, statistically significant differences among the clusters with respect to the age of the respondents. Inspection of Table 2 shows that this effect is largely due to the disparity between the mean age of respondents from cluster five and the mean ages of the respondent from other clusters.

The strength of association between age and cluster membership can be described by a coefficient, η^2, which ranges from 0 to 1. For these two variables, the obtained value of this coefficient was .129. This indicates a moderate level of association between increasing age and membership in pronuclear clusters. This finding, that older respondents tended to be more likely to be associated with pronuclear clusters, is consistent with survey data summarized by Melber, Nealey, Hammersla and Rankin (1978, p. 80). They concluded that a number of recent national polls indicated that opposition to nuclear power was greatest among the young and decreased consistently from younger to older respondents. In contrast to the data represented by Melber et al., who reported a curvilinear relation between age and support for nuclear power, our data showed a simple linear relationship. This apparent discrepancy can probably be accounted for by the underrepresentation of the oldest age category (65 and over) in our sample. If one considers only the range from 25 to 65--which accounts for almost all of our sample, the discrepancy disappears.

TABLE 2

Mean Age of Respondents by Cluster

CLUSTER	COUNT	MEAN	STANDARD DEVIATION
Cluster 1	31	38.5484	14.3337
Cluster 2	60	35.3167	10.4354
Cluster 3	63	34.8182	9.6904
Cluster 4	39	43.5641	14.3835
Cluster 5	18	50.3889	14.2834
Cluster 6	48	40.9167	10.0188
Total	229	39.4454	12.6207

$\eta^2 = .129$ $F\ (5,223) = 6.59$ $p < .01$

Our sampling procedure produced an overrepresentation (61.3%) of men. The strength of association between cluster membership and sex of respondent is described by Cramer's V, a measure which ranges from 0 to 1. The obtained value, .500, is statistically significant (see Table 3). Women predominate in the antinuclear clusters, while men are in the majority in the pronuclear clusters. Eighty percent of the women in the sample are found in the most antinuclear clusters. Men, on the other hand, are more likely to be found in the pronuclear clusters (60%) than in the antinuclear clusters (40%). This is a more extreme result than is found in the summarized survey data, although a tendency for women to be less supportive of nuclear power has been found in many polls (see Melber et al., 1978).

Although the typical level of education in the sample was consistently high (see Table 4), there was an appreciable relationship between education and cluster membership. The direction of this relationship varied at different levels of education. While the respondents in the first three educational categories (high school, technical school or some college) tended by a two to one margin to be in the pronuclear clusters, those with a college degree were more evenly split. Those with greater levels of formal education (some graduate school, post graduate degrees) tended to be found more often in antinuclear clusters. This finding is somewhat at variance with the results found in national probability samples. The majority of the polls have found opposition to nuclear power to be approximately constant over levels of education, while support increased with rising levels of education. The most recent polls (Harris, 1975, 1976; Roper, 1976), however, have found both support and resistance to nuclear power increasing with education. Increases in both categories are possible, of course, because of the decrease in the number of undecided respondents with increasing levels of education. Even these recent polls have reported a two to one margin of support for nuclear power at the

TABLE 3

Classification of Respondents by Cluster and Sex

SEX	CLUSTER						
	(Anti)					(Pro)	
	1	2	3	4	5	6	Row Total
Male	6	25	24	26	17	43	141 61.3
Female	25	35	9	13	2	5	89 38.7
Column Total	31 13.5	60 26.1	33 14.3	39 17.0	19 8.3	48 20.9	230 100.0

Cramer's V = .500 $\chi^2_{(5)} = 57.57, p < .01$

TABLE 4

Classification of Respondents by Cluster and Education

EDUCATION	CLUSTER (Anti) 1	2	3	4	5	(Pro) 6	Row Total
Completed High School	0	0	0	3	0	2	5 2.2
Technical or Trade School	0	0	0	4	0	4	8 3.5
Some College	3	11	2	16	3	11	46 20.1
Bachelor's Degree	9	20	4	9	2	12	56 24.5
Some Graduate Work	5	12	12	1	6	9	45 19.7
Post Graduate Degree	14	17	15	6	7	10	69 30.1
Column Total	31 13.5	60 26.2	33 14.4	39 17.0	18 7.9	48 21.0	229 100.0

Cramer's V = .236 $\quad \chi^2_{(25)} = 64.10,\ p < .01$

highest levels of education; the bottom two rows of Table 4 indicate that, for this sample, the margin is two to one against nuclear power at this level of education.

The incomes of our respondents are, for the most part, quite high. Table 5 displays the distribution of respondents across clusters for each level of income. Although the distribution of respondents is not random, it is not systematic across levels of income; no relationship is apparent in the data. Although the reason for this is not clear, it may be that the relation between attitudes toward nuclear power and family income (the data requested in the survey) is more complex than is the relationship between these same attitudes and personal demographic characteristics, such as age, sex and education.

In comparison to probability or quota samples obtained by polling organizations, our sample more heavily represents the middle--30 to 60--age categories, has a higher proportion of males, and is characterized by higher income and educational levels. Our sample, however, was not designed to be representative of the population in general. Instead, we wished to tap those people who tend to be politically active and therefore functionally important in matters related to energy use patterns and questions of waste management. Since the sample overrepresents those who tend to be most politically active (cf. Brown & Ungs, 1972; Hamilton, 1972), it appears that the sampling strategy fulfilled its purpose.

Activities of Respondents

As was the case with the sampling procedure, it is important to provide data which suggest the validity of the results of the clustering procedure. Data on the activities of the respondents provide a satisfactory means of resolving this issue. In brief, the rationale is that aggregation

TABLE 5

Classification of Respondents by Cluster and Family Income

INCOME		CLUSTER						
		(Anti)					(Pro)	
		1	2	3	4	5	6	Row total
5000 or less	1	1	1	3	0	0	0	5 2.2
5001 to 10000	2	4	0	4	2	0	0	10 4.4
10001 to 15000	3	2	4	5	4	0	4	19 8.4
15001 to 20000	4	5	8	2	4	2	5	26 11.5
20001 to 25000	5	4	13	6	11	2	17	53 23.5
25001 to 30000	6	3	11	3	5	1	11	34 15.0
30001 to 35000	7	2	10	4	1	4	3	24 10.6
35001 to 40000	8	4	5	2	5	0	3	19 8.4
More than 40000	9	2	8	4	7	10	5	36 15.9
Column Total		27 11.9	60 26.5	33 14.6	39 17.3	19 8.4	48 21.2	226 100.0

Cramer's V = .256 $\quad \chi^2_{(40)} = 74.06, p < .01$

of groups into clusters is supported only to the degree that relevant activity measures differentiate among those clusters. The more closely related the behavior is to the attitudes which were the basis for forming the clusters, the more strongly the clusters should differ on the behavioral measures.

Opposition to environmental pollution. Respondents were asked to indicate if they had in the past year engaged in any of several activities which indicated opposition to environmental pollution. The total number of different activities was computed for each respondents. This produced a score for each respondent which could range from zero activities to seven activities reported.

Table 6 shows the number of respondents in each of the six clusters who reported engaging in each of eight levels of activity in opposition to environmental pollution. There is a statistically significant difference among the clusters which can be seen from the table to be attributable to the difference between the three most strongly pronuclear and the three most strongly antinuclear sets of clusters. Antinuclear respondents are, in general, much more highly involved in antipollution activities than are the pronuclear respondents.

Opposition to nuclear power. The same section of the questionnaire also included a list of five activities which showed opposition to nuclear power. As with the items on opposition to environmental pollution, a sum score was computed for each respondents which measured the extent of involvement with antinuclear activities (see table 7).

As expected, few of the members of the clusters classified as pronuclear have engaged in activities opposing nuclear power. Many of the members of the clusters which had been formed on the basis of antinuclear sentiment have reported being involved in one or more antinuclear activities.

TABLE 6

Classification of Respondents by Cluster and Level of Opposition to Environmental Pollution

Number of Activities	CLUSTERS (Anti) 1	2	3	4	5	(Pro) 6	Row total
0	1	5	4	26	11	27	74 32.6
1	3	10	5	9	3	15	45 19.8
2	5	13	7	4	3	4	36 15.9
3	5	10	6	0	1	0	22 9.7
4	6	12	4	0	0	0	22 9.7
5	4	5	4	0	0	0	13 5.7
6	2	3	1	0	0	2	8 3.5
7	4	2	1	0	0	0	7 3.1
Column total	30 13.2	60 26.4	32 14.1	39 17.2	18 7.9	48 21.1	227 100.0

Cramer's V = .331 $\quad \chi^2_{(35)} = 124.67,\ p < .01$

TABLE 7

Classification of Respondents by Cluster and Level of Opposition to Nuclear Power

Number of Activities	CLUSTERS (Anti) 1	2	3	4	5	(Pro) 6	Row total
0	14	36	17	38	17	47	169 74.4
1	4	9	8	1	1	0	23 10.1
2	3	6	4	0	0	1	14 6.2
3	3	5	2	0	0	0	10 4.4
4	1	3	1	0	0	0	5 2.2
5	5	1	0	0	0	0	6 2.6
Column Total	30 13.2	60 26.4	32 14.1	39 17.2	18 7.9	48 21.1	227 100.0

Cramer's V = .264 $\quad \chi^2_{(25)} = 79.21, p < .01$

Support for nuclear power. The questionnaire listed five activities showing support for nuclear power. These data, displayed in Table 8, are virtually a mirror image of those in the previous table. These activities are most strongly concentrated among the members of cluster six, and, to a lesser degree, among the members of clusters four and five, which are the most pronuclear clusters.

Support for energy conservation. Strength of support for energy conservation was assessed by summing the number of activities reported by each of the respondents. The seven conservation activities in the list made possible scores at eight levels. The crosstabulation of activity sum scores by respondent cluster is presented in Table 9.

Although there are statistically significant differences among the clusters with respect to level of involvement with activities related to energy conservation, it is clear from Table 9 that these differences are substantially less important than those associated with support for or opposition to nuclear power. As one might expect, there is a small tendency for antinuclear respondents to report engaging in more energy conservation activities. However, it is evident that the pronuclear clusters also actively support energy conservation.

In summary, the activity measures, especially those concerned with support for nuclear power and opposition to nuclear power, provide strong confirmatory evidence of the validity of the classification of the respondent groups into clusters. Although it is not common to find measures from the same questionnaire offered as confirmatory evidence for the reasonableness of a cluster solution, such an argument is appropriate in this situation because the activity measures were used as a "holdout sample" of items. None of the data from the activity measures was used in forming the clusters. Indeed, none of the activity measures was

TABLE 8

Classification of Respondents by Cluster and Level of Support for Nuclear Power

Number of Activities	CLUSTERS (Anti) 1	2	3	4	5	(Pro) 6	Row total
0	27	59	29	33	12	9	169 75.1
1	0	0	3	4	4	6	17 7.6
2	0	0	0	2	1	14	17 7.6
3	1	1	0	0	0	5	7 3.1
4	0	0	0	0	0	9	9 4.0
5	0	0	0	0	1	5	6 2.7
Column Total	28 12.4	60 26.7	32 14.2	39 17.3	18 8.0	48 21.3	225 100.0

Cramer's V = .354 $\chi^2_{(25)} = 141.17, p < .01$

TABLE 9

Classification of Respondents by Cluster and Level of Support for Energy Conservation

Number of Activities	CLUSTERS (Anti) 1	2	3	4	5	(Pro) 6	Row total
0	1	2	1	8	3	5	20 8.8
1	1	1	0	0	2	5	9 4.0
2	2	2	3	6	1	4	18 7.9
3	3	9	9	5	4	8	38 16.7
4	5	14	8	7	5	15	54 23.8
5	10	18	9	8	2	9	56 24.7
6	4	13	2	5	0	2	26 11.5
7	4	1	0	0	1	0	6 2.6
Column Total	30 13.2	60 26.4	32 14.1	39 17.2	18 7.9	48 21.1	227 100.0

Cramer's V = .240 $\chi^2_{(35)} = 65.49, p < .01$

even analyzed until after the clusters had been formed. As a consequence, there is adequate reason for believing that the clusters are correctly ordered along a continuum from antinuclear (Cluster one) to pronuclear (Cluster six).

ATTITUDES TOWARD NUCLEAR WASTE DISPOSAL FACILITIES

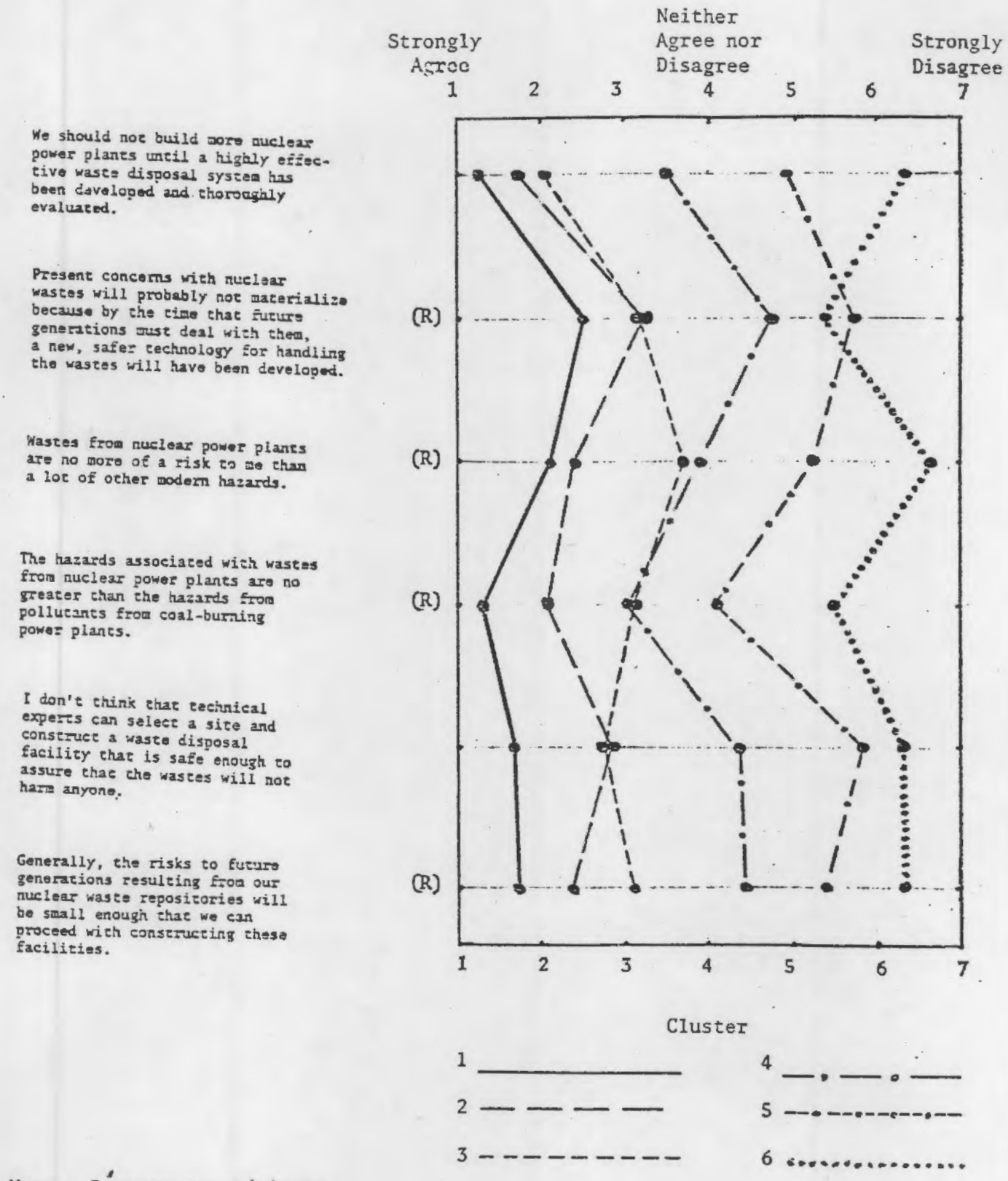
This section addresses respondents' attitudes and beliefs about the general concept of a nuclear waste repository, and about three specific functions of such a repository. Both the need for and the efficacy of each of the functions--site control, information transfer, and site monitoring--and of the overall concept were explored. As indicated earlier, questions on site control were designed to address issues associated with physical control of the location of buried wastes. Questions on information transfer were oriented toward problems of maintaining knowledge of the location of buried wastes over long periods of time. Site monitoring addressed the need for and efficacy of measures to detach the release of radioactive wastes from storage. In order to improve the clarity of the figures which follow, the mean responses of the clusters on certain items are reverse scored. Respones of "1" ("strongly agree") have been recoded as "5" ("strongly disagree"), and vice versa, in order to produce an exact mirror image of the original pattern of responses. Reverse scoring has been applied to those items for which agreement denotes pronuclear attitudes so that the most antinuclear clusters are always plotted on the left side of the figure and the most pronuclear clusters appear on the right.

General Concept

Need. Several items were designed to assess respondent's attitudes and beliefs about the general need for a nuclear waste repository (see Figure 1). One item suggested that no more nuclear power plants should be built until a highly effective waste disposal system has been developed and thoroughly evaluated. This item strongly separated the pronuclear and

FIGURE 1

Mean Responses to "General Concept" Items, Plotted by Cluster



Note: Reverse scored items denoted by (R)

antinuclear respondents. Only members of cluster six strongly disagreed with the item. That is, the most strongly pronuclear respondents were alone in indicating that further construction of nuclear power plants should not depend on having a highly effective waste disposal system. The three most antinuclear clusters strongly agreed with the item, while two were neutral (i.e., fell between "3" and "5" on the response scale). Most respondents, then, agreed on the need for an effective nuclear waste disposal system as a condition for further development of nuclear power.

A second item proposed that "a new, safer technology for handling the wastes" will be developed in the future, suggesting that any present concerns are unwarranted. This optimistic forecast was strongly endorsed by the two most pronuclear clusters, while only the most antinuclear cluster strongly disagreed. Three clusters, containing the majority of the respondents, were neutral, neither optimistic nor pessimistic about the prospect of future technology solving the problems of nuclear waste.

Two items compared the risks associated with nuclear wastes with other risks respondents face. There was strong disagreement among the clusters as to whether nuclear wastes "are no more of a risk to me than a lot of other hazards." The two most pronuclear clusters strongly agreed that nuclear wastes pose no special hazard. Two clusters were neutral. The two most antinuclear clusters strongly rejected the idea that nuclear wastes were just another hazard of modern life. A second item explicitly compared the hazards of nuclear wastes with the hazards of pollutants from coal-burning power plants. Only the most pronuclear cluster supported the idea that the hazards of nuclear waste and coal pollutants are equal. Three clusters were neutral, while the two most antinuclear groups strongly disagreed.

In summary, the items assessing the general need for a nuclear waste repository show that the strongly pronuclear respondents do not believe that an effective waste disposal system is a prerequisite to further nuclear power development. In part, they have faith that future technological developments will solve the problems of nuclear waste; they also see nuclear wastes as posing no greater risks than other modern hazards, particularly those associated with burning coal. To the strongly pronuclear respondents, then, the problems of nuclear wastes are technical problems no different from those faced in the past and more or less successfully solved. The strongly antinuclear respondents, on the other hand, do believe that an effective waste disposal system is a prerequisite to further nuclear power development. This appears to be due, in part, to the fact that they do not have faith that the problems of nuclear waste will be solved by future technology. Moreover, they believe that the risks of nuclear wastes are greater than other modern hazards, specifically including the hazards of pollutants from coal-burning power plants. For the strongly antinuclear respondents, the hazards of nuclear wastes are different from and greater than hazards faced in the past, perhaps not subject to technological solution, and requiring an effective disposal system.

Not all of the respondents were in strong agreement or disagreement with each of the items assessing the general need for a nuclear waste repository. While a majority of the respondents indicated that an effective waste disposal system should be required for future nuclear power development, a minority of about 25% was neutral on this issue. A 35% minority neither agreed nor disagreed that nuclear waste risks were no greater than other modern risks. And, finally, a majority did not choose

between nuclear wastes and coal-burning pollution as posing the greater risks.

Efficacy. Respondents' beliefs regarding the efficacy of a nuclear waste repository were assessed by two items. One item proposed that technical experts cannot "select a site and construct a waste disposal facility that is safe enough to assure that wastes will not harm anyone." The three most antinuclear clusters strongly agreed with this statement, while the two most pronuclear clusters strongly disagreed. Only one cluster was neutral. The second item suggested that "the risks to future generations resulting from our nuclear waste repositories will be small enough that we can proceed with constructing these facilities." Since the implications of the second item are opposite those of the first, we would expect the positions of the pro- and antinuclear groups to be reversed. And so they are: the two most pronuclear groups strongly agreed with the second item, two groups were neutral and the two most antinuclear groups strongly disagreed. The second item separates the groups very clearly.

The results from the "efficacy" questions thus support and extend the results from the "need" questions. A majority of the respondents on the first item indicated that a nuclear waste repository cannot be made "safe enough to assure that the wastes will not harm anyone." Since a nuclear waste repository cannot be made "safe enough," we should not proceed with construction. Again, antinuclear clusters are not confident that a satisfactory technical solution to nuclear waste problems will be found. The pronuclear clusters disagreed: technical experts can construct a nuclear waste repository so safe that no one will be harmed. Given a belief in no risk, it is clear that we should proceed with construction. Pronuclear clusters once more demonstrated their belief that

highly satisfactory solutions to nuclear waste problems are or will be within our technical ability. Only a minority of respondents were neutral on these two items, one group on the first and two groups on the second.

Site Control

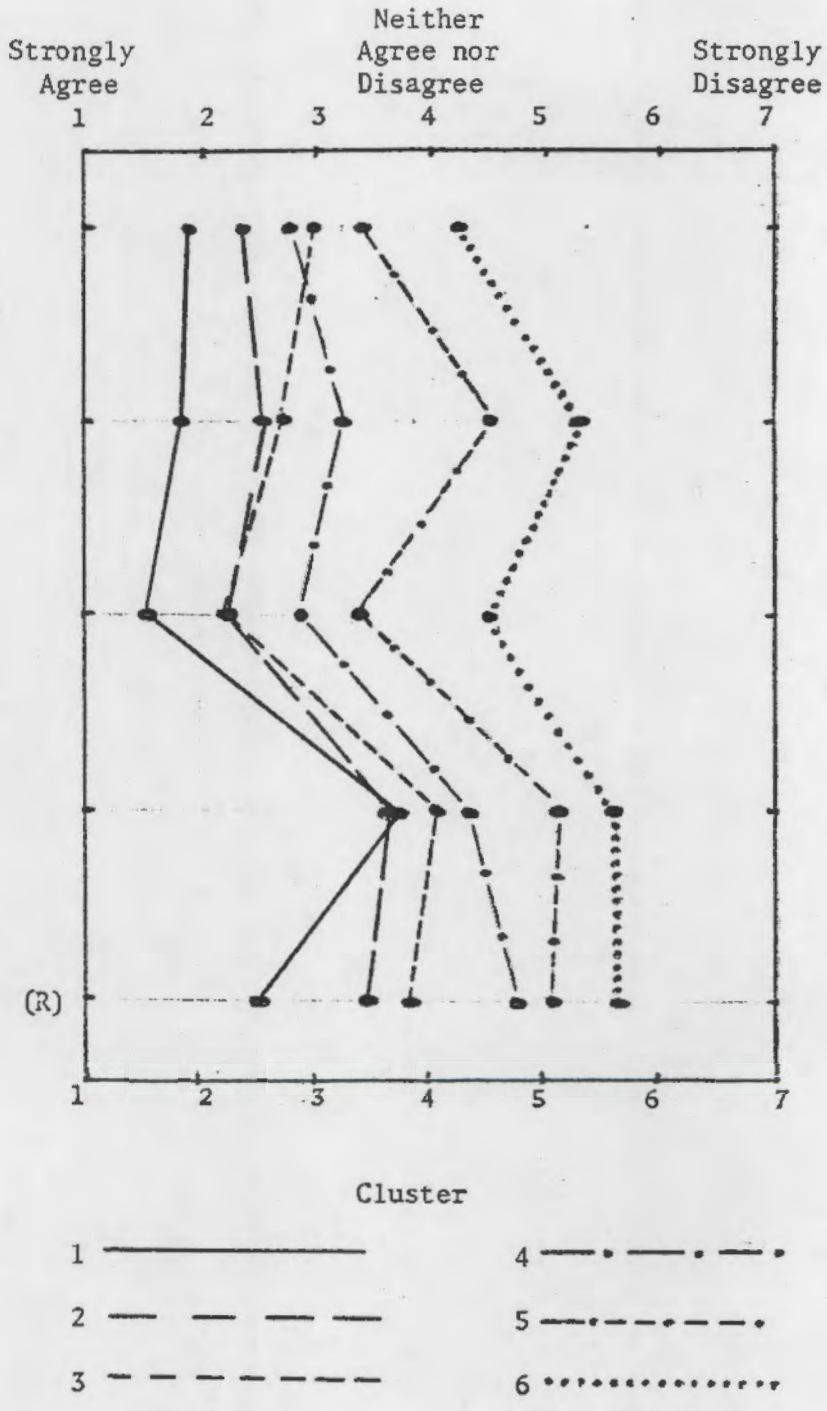
Need. The need for site control was measured by a single item: "As long as nuclear wastes in a deep geological waste repository remain potentially hazardous, it will be necessary for security guards to patrol the facilities." There was a high degree of consensus on this item, with no cluster strongly disagreeing (see Figure 2). The four most antinuclear clusters strongly agreed, while the two most pronuclear clusters were neutral. The uncertainty of the pronuclear clusters may have been due to the particular form of site control suggested by the item (security guards); perhaps other forms of control would elicit more extreme responses.

Efficacy. Two items were designed to assess respondents' beliefs about the efficacy of site control (see Figure 2). One item proposed that control at a nuclear waste repository could not be maintained "over many hundreds of years." There was fairly strong consensus on this item, with no cluster disagreeing strongly. The three most antinuclear clusters strongly agreed. Two clusters were neutral and the most pronuclear disagreed. The second item suggested that complete control could not be guaranteed "even with the presence of on-site guards." The consensus on this item was even stronger than that on the first: The four most antinuclear clusters strongly disagreed. In sum, the need and efficacy results indicate a high degree of consensus among respondents. Site control is believed to be necessary, but complete control over a very long period of time is not considered to be possible by most respondents.

FIGURE 2

Mean Responses to "Site Control" and "Information Transfer" Items,

Plotted by Cluster



Note: Reverse scored items denoted by (R)

Information Transfer

Need. No cluster strongly agreed that "keeping records on the location and contents of repositories only increases the chance that someone would deliberately sabotage the site in the future." Only the two most pronuclear clusters strongly disagreed, while the remainder of the respondents (the great majority) were neutral (see Figure 2). The need for information transfer, at least as posed in this item, is a need that was not strongly felt by most respondents.

Efficacy. The item proposed that multiple records would allow people a thousand years from now to know all they need to know about our nuclear waste repositories. Only the most strongly pronuclear cluster agreed with this item, while only the two most strongly antinuclear cluster disagreed (see Figure 2). The vast majority of the respondents were neutral on this item. There was some consensus, then, on the issue of information transfer: Most respondents felt no strong need for it and had no strong beliefs on whether or not it can be made to work. This neutral consensus may have been due to a lack of concern about the issue or ambivalence about the possibility of positive and negative outcomes of information transfer.

Site Monitoring

Need. In the strongest consensus on any item in this section, all clusters strongly agreed that frequent site monitoring is necessary "as long as the wastes are potentially hazardous" (see Figure 3).

Efficacy. Two items were used to assess the efficacy of site monitoring (see Figure 3). There was fairly strong consensus that "modern technology can make it possible to monitor the environment around a nuclear waste repository for many hundreds of years." The three most pronuclear clusters strongly agreed, while the three most antinuclear

clusters were neutral. No cluster strongly disagreed. The second item suggested that "technical monitoring of stored nuclear wastes will insure that no potentially hazardous condition will go uncorrected." Given agreement on the technical possibility of monitoring, one might expect a similar level of agreement on whether or not the monitoring would work. This was, however, not the case. Only the two most pronuclear clusters strongly agreed, the three most antinuclear clusters strongly disagreed and one cluster was neutral. In summary, all respondents strongly believed that there is a need for site monitoring, most respondents believed that it was technically possible, but only the most strongly pronuclear clusters believed that it would work. Again, the most strongly pronuclear respondents indicated their faith in technological solutions to nuclear waste problems, while most of the other respondents were less sanguine in their views of the future of nuclear wastes.

Related Issues

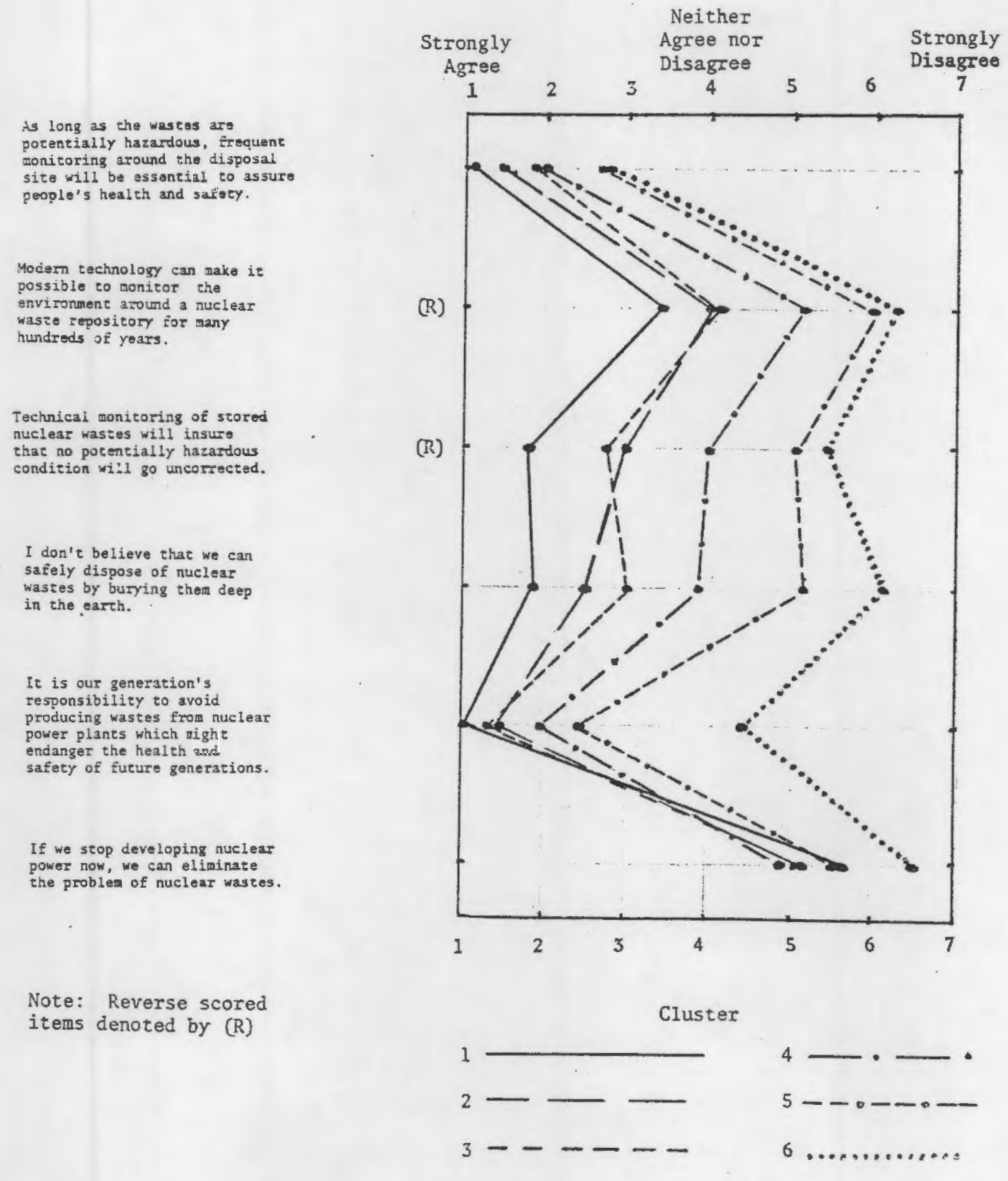
In addition to the items relating directly to nuclear waste repositories and their functions, several items dealing with closely related issues were also included. The two issues are the safety of geologic storage and the possible avoidance of nuclear waste problems (see Figure 3).

Geologic Storage. The geologic storage item presented the belief that we cannot "safely dispose of nuclear wastes by burying them deep in the earth." There was no consensus on this item. The two most pronuclear clusters , as we would expect, strongly disagreed, while the three most antinuclear clusters strongly agreed. One cluster was neutral. As with all of the previous nuclear waste repository items, antinuclear respondents indicated a lack of faith in technological solutions, while pronuclear respondents did not.

FIGURE 3

Mean Responses to "Site Monitoring" and "Related Issues" Items,

Plotted by Cluster



Note: Reverse scored items denoted by (R)

Avoidance of nuclear waste problems. Two items explored different aspects of the avoidance of nuclear waste problems. The first item suggested that "it is our generation's responsibility to avoid producing wastes from nuclear power plants which might endanger the health and safety of future generations." There was a surprisingly strong consensus on this item: Only the most extreme pronuclear cluster was neutral, while all the remaining clusters strongly agreed.

A second item also produced a surprisingly strong consensus. The item proposed that "if we stop developing nuclear power plants now, we can eliminate the problem of nuclear wastes." Three groups strongly disagreed, including the most extreme antinuclear group and the two most pronuclear clusters. Three clusters were neutral and no cluster strongly agreed.

Given the salience of the nuclear waste issue for the most extreme groups, one would expect both pro- and antinuclear groups to disagree since nuclear power is not the only source of nuclear wastes and some wastes already exist. The simplest explanation for the results, then, is that most respondents indicated that stopping the development of nuclear power will not eliminate the problem of nuclear waste. Taking the two "avoidance" items together, we see that there is fairly strong consensus among respondents that while nuclear wastes are not limited to those to be produced by nuclear power plants, steps should be taken to avoid the production by power plants of those wastes that might endanger the health of future generations.

"Don't Know" Responses

The twelve items in the Nuclear Waste Disposal section of the survey included an eighth response option in addition to the usual numbers 1

through 7 indicating "strongly agree" through "strongly disagree." The eighth option was "I don't know." Since they constituted a small minority, discussion of "don't know" responses was not included in the main results; the distribution of these responses, however, merits description.

Use of the "don't know" option within items ranged from less than 1% to 15.2%. Of the five items which generated the highest percentages of "don't know" responses, four referred to predictions of the future and the remaining item dealt with a technical issue about which some respondents might have believed themselves uninformed. For example, the highest percentage of "don't know" responses was for this item: "Modern technology can make it possible to monitor the environment around a nuclear waste repository for many hundreds of years." Respondents presumably checked "don't know" for this item because they did not believe they could predict the capabilities of future technology or because they believed themselves uninformed about the technical issues involved. In contrast, of the five items which generated the lowest percentages of "don't know" responses, four implied both present or near-future time and also a layman's view of technical issues (i.e., you don't have to be an expert to have an opinion.) For example, the lowest percentage of "don't know" responses was for this item: "As long as the wastes are potentially hazardous, frequent monitoring around the disposal site will be essential to assure people's health and safety." The dimension along which the percentages of "don't know" responses varied, then, was the dimension with the future and technical expertise at one end, and the present and layman's knowledge at the other.

"Don't know" responses also varied among clusters of respondents. The two neutral clusters, Clusters 3 and 4, had the highest percentages of "don't know" responses, 10.1% and 9.8% respectively. The two anti-nuclear clusters, 1 and 2, had mid-range percentages, 6.2% and 7.6%.

The two pronuclear clusters, 5 and 6, had the lowest percentages, 3.7% and 3.3%. An examination of the individual items revealed no pattern of differences across items between the antinuclear, neutral and pronuclear clusters. That is, respondents in all clusters tended to check "don't know" to the same set of items (described above). The differences among the clusters, then, are based on degree alone: the neutrals check "don't know" most frequently, followed first by the antinuclears, and then, far behind, by the pronuclears. Given the previous discussion of the dimension along which the "don't know" responses varied, these results would be expected. Compared to other respondents, members of the neutral clusters presumably were less well-informed about nuclear waste issues. Since nuclear energy was not a central issue for them, they perhaps were freer to respond "don't know" rather than give a response consistent with a particular point of view. Antinuclear respondents, while more committed than the neutral clusters, tended to be more skeptical about technology and its promise for the future; such a position would tend to produce negative, and some "don't know," responses. Pronuclear respondents were both committed and protechnology; this position would tend to produce endorsements of items supportive of the role of protechnology, and few "don't know" responses. From the cluster point of view, then, there are two factors underlying the distribution of "don't know" responses: first, technology (as in the discussion of the items), and, second, a cluster-related factor, commitment to a point of view.

Predicted Group Membership

Another issue centers on the following question: How effectively did the survey items described in Figures 1-3 discriminate among the clusters

of respondents? Respondents were drawn from existing groups with known views on energy-related issues but with unknown specific views on nuclear waste disposal. Since the items in this section were designed to explore respondents' views on nuclear waste disposal issues, the responses of the members of any one cluster should, ideally, differ reliably from the responses of the members of other clusters. That is, given that the views among clusters differ on general energy attitudes issues, the responses among clusters to nuclear waste disposal survey items should also differ. This is a test of the "goodness" of the survey items: how well do they discriminate among respondents with differing views? If the items in the survey discriminate perfectly, then it should be possible to accurately classify every respondent solely on the basis of his responses to questionnaire items. The means by which the proportion of correct classifications is produced is based upon the "prediction" of the cluster membership of each individual. Multiple discriminant analysis achieves this prediction by applying a set of weights to the score of each respondent on each of the items. The weighted sum of item scores for each respondent is compared to a classification criterion to produce the statistically "predicted" cluster membership of each respondent. This statistically predicted membership can be compared to the actual membership to determine the adequacy with which the questionnaire items have classified the respondents into their appropriate clusters. The obtained percentage of correct classification can be compared to the upper limit (perfect classification) and the expected lower limit (the number of correct classifications that would be expected by chance alone). While the upper limit is, of course, always 100% the expected level of chance prediction depends upon the number of groups. In this case it is 16.7%. If the questionnaire items were classifying respondents at or near this level

of accuracy, one would conclude that the items do not discriminate among the respondents: a blind roll of a die would do as well.

Table 10 presents the classification results of a discriminant analysis performed on the nuclear waste disposal items and the six clusters of respondents. To illustrate the use of the table, note that Cluster 1 has 32 members and that the discriminant function constructed from the responses of the members of all six clusters classified 16 members of Cluster 1 (50.0%) into Cluster 1, 12 (37.5%) into Cluster 2 and 4 (12.5%) into Cluster 3. The percent of correct classifications ranged from 26.3% for Cluster 5 to 85.4% for Cluster 6. Correct classification of cluster membership increases with homogeneity of responses within the cluster and heterogeneity of responses between clusters. We see then, as we would expect, that Cluster 6, the most extreme pronuclear group was the best classified cluster; this cluster was internally homogeneous and different from the others. Cluster 5 was less homogeneous than Cluster 6, with some members tending toward extreme pronuclear responses while others tended toward neutrality. The predicted membership of Clusters 3 and 4, the neutral clusters, was distributed over several clusters; membership in these clusters was difficult to correctly classify since the responses of members, because of their neutrality, were close to the responses of many members of other clusters. In general (all other things being equal), the more extreme the group, the more homogeneous and different, the easier the classification; this is illustrated by the high levels of correct classification in Clusters 1 and 2, the most strongly antinuclear groups. These classification results support the construction of the respondent clusters; the extreme groups were distinct and behaved very differently, while the neutral group were less distinct and behaved in ways similar to other groups.

TABLE 10

Discriminant Analysis Classification Results

Actual cluster membership	Predicted Cluster Membership						Number of cases
	1	2	3	4	5	6	
1	50.0	37.5	12.5	0	0	0	32
2	14.8	65.6	8.2	9.8	0	1.6	61
3	21.2	27.3	33.3	12.1	6.1	0	33
4	0	22.5	7.5	42.5	10.0	17.5	40
5	0	5.3	5.3	26.3	26.3	36.8	19
6	0	2.1	4.2	0	8.3	85.4	48

Percent cases correctly classified: 55.79%

Percent expected by chance: 16.67%

Across all clusters, the discriminant analysis correctly classified 55.8% of all respondents; an additional 26.7% of the respondents were classified into clusters one removed from their own; and 15.5% were classified into clusters two removed from their own. Only 2.0% of the respondents were classified into clusters three or more removed from their own; of twelve such cells in the classification matrix, eight were empty (0.0%). These results indicate a relatively high success rate, and that the vast majority of the misclassifications were into closely neighboring (and thus similar) clusters. In sum, the nuclear waste disposal items effectively discriminated among the respondent clusters.

DISTANCES FROM HAZARDOUS FACILITIES

Based on the assumption that a person's attitude toward a particular hazardous facility would be highly related to how close to the facility the person would locate herself or himself, respondents were asked to judge the minimum distances from several industrial facilities that they would be willing to live or work. In making their judgments, respondents were asked explicitly to consider risks to health and safety. The eight industrial facilities were: natural-gas-burning power plant, coal-burning power plant, oil refinery, storage area for liquified natural gas, nuclear-waste storage site, insecticide factory, nuclear power plant and oil-burning power plant. Respondents made their distance judgments in miles.

Results

The distance judgments for each facility were crosstabulated with six clusters of respondents by eight categories of distance. The distance categories corresponded to powers of 10: Greater than (GT) 0 but less than or equal to (LE) 10^0 (1 mi), GT 10^0 to LE $10^{.5}$ (3.16 mi), GT $10^{.5}$ to LE 10^1 (10 mi), GT 10^1 to LE $10^{1.5}$ (31.6 mi), GT $10^{1.5}$ to LE $10^{2.0}$ (100 mi), GT $10^{2.0}$ to LE $10^{2.5}$ (316 mi), GT $10^{2.5}$ to LE 10^3 (1000 mi), GT $10^{3.0}$. The two dimensions, distances and clusters, of each 8 X 6 matrix were tested for independence by a χ^2 test. All eight χ^2 tests were significant beyond the $p = .01$ level. For each facility, then, clusters were related to judgments of distance. The strengths of these relationships were assessed by Cramer's V statistic which ranges from 0.00 (no relationship) to 1.00 (perfect relationship). All eight Cramer V's were of moderate size (ranging from .21 to .36), indicating a consistent, moderately strong relationship between clusters of respondents and distances across all eight industrial facilities (see Tables 11-18)

TABLE 11

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Natural Gas Burning Power Plant

Distance (miles)

Cluster	LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	N
1	3.6	10.7	57.1	78.6	96.4	96.4	100.0	28
2	24.1	34.5	67.2	82.8	96.6	100.0		58
3	22.6	41.9	77.4	93.5	100.0			31
4	15.8	42.1	86.8	92.1	97.4	100.0		38
5	41.2	58.8	88.2	94.1	100.0			17
6	58.3	70.8	97.9	97.9	97.9	97.9	100.0	48
Σ	28.6	43.6	79.1	89.5	97.7	99.1	100.0	220

TABLE 12

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Coal Burning Power Plant

Distance (miles)

Cluster	LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1	3.6	10.7	35.7	67.9	89.3	89.3	96.4	100	28
2	0.0	8.6	39.7	70.7	93.1	98.3	100.0		58
3	3.2	19.4	48.4	71.0	83.9	100.0			31
4	2.6	21.1	50.0	68.4	94.7	100.0			38
5	17.6	41.2	64.7	94.1	94.1	100.0			17
6	27.1	41.7	79.2	89.6	95.8	95.8	100.0		48
Σ	8.6	22.3	52.7	75.9	92.3	97.3	99.5	100	220

TABLE 13

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Oil Burning Power Plant

Cluster	Distance (miles) LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	N
1	7.1	14.3	46.4	67.9	92.9	92.9	100.0	28
2	5.2	17.2	51.7	77.6	94.8	96.6	100.0	58
3	3.2	25.8	58.1	80.6	93.5	100.0		31
4	10.5	21.1	57.9	78.9	92.1	97.4	100.0	38
5	17.6	52.9	76.5	94.1	94.1	100.0		17
6	33.3	52.1	85.4	95.8	97.9	97.9	100.0	48
Σ	13.2	29.1	62.3	82.3	94.5	97.3	100.0	220

TABLE 14

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Oil Refinery

Cluster	Distance (miles) LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1	0.0	3.6	17.9	46.4	89.3	92.9	96.4	100.00	28
2	1.7	6.9	32.8	55.2	93.1	96.6	100.0		58
3	3.2	6.5	48.4	67.7	90.3	93.5	100.0		31
4	2.6	5.3	36.8	65.8	94.7	97.4	100.0		38
5	5.9	29.4	70.6	88.2	94.1	100.0			17
6	8.3	14.6	81.3	89.6	97.9	97.9	100.0		48
Σ	3.6	9.5	47.3	67.7	93.6	96.4	99.5	100.0	220

TABLE 15

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Storage Area for Liquified Natural Gas

Cluster	Distance (miles) LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1	0.0	3.6	32.1	60.7	89.3	92.9	96.4	100.0	
2	5.4	12.5	41.1	67.9	92.9	100.0			56
3	9.7	22.6	58.1	74.2	100.0				31
4	2.6	10.5	52.6	78.9	100.0				38
5	29.4	35.3	82.4	88.2	100.0				17
6	14.6	22.9	83.3	91.7	97.9	97.9	100.0		48
Σ	8.7	16.5	56.9	76.6	96.3	98.5	99.5	100.0	218

TABLE 16

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Nuclear Waste Storage Site

Cluster	Distance (miles) LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1			10.7	14.3	39.3	53.6	89.3	100.0	28
2	1.7	1.7	5.2	8.6	51.7	72.4	89.7	100.0	58
3			12.9	35.5	67.7	71.0	90.3	100.0	31
4		2.6	13.2	31.6	68.4	78.9	97.4	100.0	38
5	11.8	17.6	47.1	58.8	88.2	100.0			17
6	34.0	40.4	85.1	91.5	97.9	97.9	97.9	100.0	47
Σ	8.7	11.0	29.2	38.8	68.0	78.5	93.6	100.0	219

TABLE 17

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Insecticide Factory

Distance (miles)

Cluster	LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1	0.0	3.6	17.9	35.7	67.9	75.0	92.9	100.0	28
2	0.0	3.4	19.0	46.6	82.8	93.1	98.3	100.0	58
3	0.0	3.2	29.0	48.4	87.1	93.5	96.8	100.0	31
4	0.0	0.0	36.8	52.6	89.5	89.5	100.0		38
5	11.8	29.4	70.6	76.5	94.1	100.0			17
6	10.6	14.9	74.5	83.0	97.9	97.9	100.0		47
Σ	3.2	7.3	39.3	56.6	86.8	91.8	98.2	100.0	219

TABLE 18

Cumulative percentages of respondents willing to live or work within each distance category, by cluster

Nuclear Power Plant

Distance (miles)

Cluster	LE 1	LE 3.16	LE 10	LE 31.6	LE 100	LE 316	LE 1000	GT 1000	N
1	0.0	0.0	14.3	28.6	53.6	60.7	92.9	100.0	28
2	5.2	6.9	13.8	29.3	70.7	84.5	94.8	100.0	58
3	0.0	3.2	19.4	48.4	77.4	80.6	90.3	100.0	31
4	13.2	15.8	44.7	50.0	81.6	86.8	97.4	100.0	38
5	23.5	35.3	58.8	82.4	94.1	100.0			17
6	52.1	72.9	93.8	97.9	97.9	97.9	97.9	100.0	48
Σ	16.8	23.6	40.9	54.5	79.1	85.5	95.5	100.0	220

The statistical tests showed that a relationship of a certain strength existed; the analyses did not indicate how distance judgments varied with respondent clusters, only that systematic variation occurred. In order to closely explore the effects of cluster membership on distance judgments, an examination of the distribution of cell entries in each matrix is required.

As in previous tables, the respondent clusters are ordered according to increasing pronuclear beliefs: Cluster 1 is most extreme antinuclear and Cluster 6 is most extreme pronuclear. Table 11 clearly shows how distance judgments varied with clusters in the Natural Gas Power Plant matrix. Only 2.1% of the extreme pronuclear respondents in Cluster 6 chose to live or work more than 10 miles from the natural gas facility. In contrast, 42.95% of the extreme antinuclear respondents in Cluster 1 chose distances greater than 10 miles. There is a consistent increasing ordering of long distance choices across the clusters from Cluster 6 to Cluster 1. The relationship in the Natural Gas matrix, then, is simple: clusters and distances are negatively related. As the degree of pronuclear beliefs increase, the distance judgments decrease. Pronuclear respondents seem to be willing to live or work very close to a Natural Gas Power Plant, while antinuclear respondents seem more determined to keep their distance.

The same general relationship between clusters and distances found in the Natural Gas matrix also was found in the matrices for each of the other industrial facilities (Tables 12-18). In each matrix, Cluster 6 produced the smallest percentage of long-distance judgments; in all but two matrices (where it came in second), Cluster 1 produced the highest percentage. The increasing-ordering of distance choices as pronuclear beliefs decrease is perfect for three facilities; in the remaining five

TABLE 19

Percentage of respondents willing to live or work within ten miles of facility, by cluster and facility

FACILITY	CLUSTER (Anti) 1	2	3	4	5	(Pro) 6	Total
Natural Gas Power Plant	57.1	67.2	77.4	86.8	88.2	97.9	79.1
Coal Power Plant	35.7	39.7	48.4	50.0	64.7	79.2	52.7
Oil Power Plant	46.4	51.7	58.1	57.9	76.5	85.4	62.3
Oil Refinery	17.9	32.8	48.4	36.8	70.6	81.3	47.3
LNG Storage Site	32.1	41.1	58.1	52.6	82.4	83.3	56.9
Nuclear Waste Site	10.7	5.2	12.9	13.2	47.1	85.1	29.2
Insecticide Factory	17.9	19.0	29.0	36.8	70.6	74.5	39.3
Nuclear Power Plant	14.3	13.8	19.4	44.7	58.3	93.8	40.9

only one case is misplaced. There are differences among clusters, however. For some facilities the ordering of clusters is smoothly progressing (Natural Gas, Table 11), in others, Clusters 5 and 6 seem isolated (Oil Refinery, Table 14), and for some facilities, Cluster 6 stands alone (Nuclear Power Plant, Table 18).

In order to make it easier to make comparisons between clusters across facilities an aggregated table (Table 19) was constructed which displays the data from column three of each of the tables 11-18. Thus, Table 19 shows the proportion of respondents in each cluster who reported being willing to live or work within ten miles of each facility. This table also provides, in the Total column, an overall comparison among facilities across clusters. The Natural Gas Power Plant received the lowest percentage of long-distance (greater than 10 miles) choices indicating that respondents were more willing to live or work close to it than to any of the other facilities. The highest percentage of long-distance choices was received by the Nuclear Waste Site. The contrast between Natural Gas and Nuclear Waste is clear: Natural Gas is commonly thought to be relatively clean-burning and safe, while Nuclear Waste is considered by many to be pure pollution of a dreaded kind. When facilities that received similar percentages of long-distance choices are grouped together and compared with other groups formed in the same way, an overall pattern emerges: the two facilities with the lowest percentages (Natural Gas Power Plant and Oil Power Plant) are those whose popular images are that they are relatively clean-burning, safe, and familiar (many members of the public burn these fuels in their own homes); the three facilities with moderate percentages (LNG Storage Site, Coal Power Plant and Oil Refinery) are typically associated with more significant pollution or risks of large-scale accidents (explosions and leaks); the three facilities with the highest

percentages (Nuclear Power Plant, Insecticide Factory and Nuclear Waste Site) have the potential to produce catastrophic accidents with unknown, feared and far-reaching effects.

Summary

The basic idea underlying the items in this section was that the beliefs and attitudes of persons toward industrial facilities would be reflected in the proximity to each of the facilities that they would be willing to live or work. Specifically, the more pronuclear (antinuclear) a person was, the closer to (further from) a nuclear facility he would be willing to locate himself. The results strongly supported this relationship. Consider the Nuclear Power Plant (Table 18) for example. In the most extreme antinuclear clusters, 39.25% indicated they would be willing to live or work no closer than 316 miles ($10^{2.5}$), while in the most extreme pronuclear cluster, 52.2% were willing to locate within one mile. Similar extremes showed up in the case of the Nuclear Waste Disposal Site (Table 16): 46.4% of the extreme antinuclear respondents would locate no closer than 316 miles; 34.0% of the extreme pronuclear respondents would live or work within one mile.

The inverse relationship between pronuclear attitudes and distances of industrial facilities from work or home was not restricted to nuclear facilities; the relationship held for all of the facilities studied. The pro- and antinuclear attitudes of respondents, then, were not isolated, unrelated to other attitudes held by them. Instead, there was evidence the pro- and antinuclear attitudes were tied to attitudes toward other industrial facilities. Comparisons among groups of similarly-judged facilities suggested that distance-judgments for all facilities were

consistent with popular images of the risks to health and safety posed by these facilities. Short-distance (low-risk) facilities, such as a Natural Gas Power Plant, tended to be associated with relatively low but chronic levels of familiar, accepted pollutants and risks of accidents having limited, well-known effects. Long-distance facilities, such as a nuclear waste site, on the other hand, were associated with unfamiliar, unaccepted pollutants and risks of catastrophic accidents having wide-ranging, unfamiliar and dreaded effects. Interpreting the distance judgments as indicators of attitudes, the results showed that pronuclear respondents favored all industrial facilities because they believed them to be relatively safe; antinuclear respondents were generally less willing to live or work near any industrial facilities.

DISCUSSION

The nuclear waste disposal items produced consistent patterns of agreement, disagreement and neutrality among the clusters of respondents. In addition to these overall patterns, the items also produced profiles of the views of strongly pro- and antinuclear respondents.

Agreement, Disagreement and Neutrality

Patterns of agreement, disagreement and neutrality among the clusters were produced by the nuclear waste disposal items. These terms are used in a relative sense. The mean responses of clusters differed on each item; there was disagreement on each item. But degree of disagreement varied and on those items for which the degree of disagreement was lowest, the clusters are said to "agree." On several items the mean responses of the clusters centered on the neutral point with relatively little variance; on these items the clusters are said to be neutral.

Agreement. Responses among clusters tended to agree on items related to both the need and efficacy of site control and site monitoring. Concerning site control, there was agreement that: a) guards are needed at nuclear waste disposal sites, b) guards cannot guarantee complete control, and c) control cannot be maintained over hundreds of years. On site monitoring, it was agreed that frequent monitoring of disposal sites is essential; the agreement was weaker that modern technology makes monitoring possible for hundreds of years; and there was some disagreement over whether or not monitoring will insure against hazards. In addition to the site control and site monitoring items, there was agreement on two items related to the avoidance of nuclear waste problems; respondents agree that while nuclear wastes are not limited to those produced by

nuclear power plants. This undoubtedly reflects an awareness of the substantial inventory of nuclear waste generated in the production of nuclear weapons. They agree, moreover, that steps should be taken to avoid the production by power plants of those wastes that might endanger the health of future generations.

Disagreement. Responses among clusters disagreed on the need and efficacy of the general concept of a nuclear waste repository. Members of antinuclear clusters took these positions: a) no more nuclear power plants should be built until the waste problem is solved, b) future technology will not solve the waste problem, c) nuclear wastes pose a greater risk than other modern hazards, d) nuclear wastes produce greater hazards than pollution, produced by coal burning power plants, e) technical experts cannot build a nuclear waste disposal facility that is safe enough, f) the risks to future generations are too great for us to proceed with the construction of nuclear waste repositories and g) nuclear wastes cannot be safely disposed of by burying them deep in the earth. Respondents in the pronuclear clusters disagreed with each one of these positions.

Neutrality. Only the items referring to the need and efficacy of information transfer tended toward consistent neutrality across clusters. Respondents neither agreed nor disagreed that record keeping: a) is possible for thousands of years, and b) just increases the chance of sabotage.

In summary, agreement was elicited by items referring to responses to clear and present dangers; given a hazard exists, most agreed that something should be done. Agreement was also produced by items requiring predictions of the future; most agreed that the future cannot be forecast

with an acceptable level of confidence. Agreement, then, was associated with the pragmatic and the present. Disagreement, on the other hand, was elicited by items referring to broad policy issues and to global evaluations of nuclear power and its wastes.

Strongly Pro- and Antinuclear Respondents

The differing patterns of responses by members of the strongly pro- and antinuclear clusters produced contrasting profiles of their positions regarding nuclear waste management.

Strongly pronuclear. These respondents did not see nuclear waste problems as serious impediments to the further development of nuclear power. Nuclear waste hazards are similar to other industrial risks such as those associated with coal. Technical solutions have been developed to deal with past hazards, and the problems of nuclear wastes will be similarly solved. Construction of nuclear power plants should proceed. There are two main aspects to this position: a) nuclear is not special, and b) technology works. Nuclear power is simply another form of technology; nuclear power does work and the associated problems will ultimately be solved.

Strongly antinuclear. For these respondents, nuclear waste problems were serious enough to halt further development of nuclear power. Their position on nuclear power and on nuclear waste disposal seems to be based on different underlying assumptions. In contrast to the pronuclear respondents, members of the antinuclear clusters believed that: a) nuclear is special, and b) technology can fail. Nuclear power, while a form of technology, is different; technology is hazardous and nuclear power is more so than most. Nuclear power therefore may not only fail, but if it does

fail (if the waste disposal and other problems are not solved) the consequences will be far-reaching and dreadful.

Comparison with Other Surveys

As is the case with any single survey, the question arises as to the consistency of the results of that survey with the results of other surveys. We compared responses to selected items from the Nuclear Waste Disposal Facility section to the data generated from responses by probability-samples to similar items. The comparison-items were selected solely on the basis of similarity, the number of items is small because previous surveys have included few items dealing with the specific issues covered here. In the present survey, the data have been reported in the form of group means; data in the comparison-surveys, however, consisted of percentages of the sample choosing various response alternatives. This difference in results-reporting precludes precise comparison, although it does not adversely affect the clarity of the general implications that can be drawn. The comparison-surveys were drawn from the exhaustive review by Melber et al. (1978).

Nuclear Waste Disposal

A key finding in the present study is the relationship between favorability toward nuclear power and belief that modern technology will solve the problems of nuclear waste: pro-nuclear respondents expressed faith in technology; antinuclear respondents did not. The review by Melber et al. points out two survey results that support this conclusion. First, three nation-wide surveys by Cambridge Reports, Inc. (1975, 1976) found that about 46% of the respondents favored the construction of nuclear power plants, and about 50% believed that modern technology can find a

safe method for waste storage; about 31% opposed construction, and about 23% believed that wastes are too dangerous to be produced. Presumably, the 23% who believed that wastes are too dangerous also opposed construction; similarly, the 46% who favored construction most likely also believed in the efficacy of modern technology. A second source of support comes from a random-sample survey of voters in Sacramento County, California (Groth and Schutz, 1976). Those results showed that 67% of the antinuclear respondents either disagreed or strongly disagreed with "We have the technology to cope with waste disposal from nuclear power plants"; only 15% agreed. For pronuclear respondents, 20% disagreed or strongly disagreed, and 48% agreed or strongly agreed.

In addition to their review of published results, such as those cited above, Melber et al. also analyzed responses to subsets of items from two national surveys (Harris, 1975, 1976) in order to identify those items which best discriminated between pro- and antinuclear respondents. These authors conducted a step-wise discriminant analysis, much like that used in the present study. Thirty-two items that measured attitudes about nuclear power issues were selected for the analysis, and the first item chosen, the most discriminating item, dealt with the respondents' attitude about nuclear power plant safety: pronuclear individuals believed that nuclear power plants are safe; antinuclear individuals disagreed. The sixth item to enter the discriminant function measured the respondent's attitude about the seriousness of the nuclear waste problem: 86% of the antinuclear respondents indicated that nuclear waste was a major problem; only 59% of the pronuclear respondents agreed. These two results from the secondary analysis by Melber et al. support the present study by linking antinuclear attitudes to concerns about plant safety and nuclear wastes, and by connecting antinuclear attitudes to increased concern about these issues.

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