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Safety Culture Assessment Programme: Statistical Analysis of a Survey Conducted at IEA-R1 Brazilian Research Reactor

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PRODUÇÃO TÉCNICO CIENTÍFICA
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Abstract. The present study describes the statistical analysis of a survey conducted in September 2002 among the employees of IEA-R1 Brazilian research reactor to evaluate the current status of safety culture in this organization. A questionnaire consisting, mainly, of statements about safety issues was prepared. A total number of 34 individuals participated in the survey representing the personnel of the Operation and Maintenance Division, Irradiation Service Division as well as the technicians specialized in Radiation Protection. The statistical analysis of the survey was developed into three principal steps. In the first step, descriptive techniques were used to estimate the parameters of the sampling distribution of the responses to each question of the questionnaire. In the second step, the aspects of safety culture to be investigated were defined by grouping these questions into issue areas. The final step of the analysis consisted of the calculation of the employees' satisfaction level regarding the safety culture aspects previously mentioned.

1. Introduction

IEA-R1 is a 5 MW pool type reactor, cooled and moderated by light water, and it uses graphite and beryllium as reflectors. First criticality was achieved on September 16, 1957 and the reactor has been operating regularly and safely for almost 46 years. The reactor building is located within the premises of IPEN/CNEN-SP, one of the Brazilian institutes for energy and nuclear research, inside the campus of the University of São Paulo.

The safety culture assessment and enhancement programme of IEA-R1 research reactor was launched by the senior management in 2002. A survey was conducted in order to evaluate the main aspects of safety culture according to its employees' attitudes, opinions and perception. The statistical analysis to be presented in this work shows the quantitative results related to the indicators adopted to identify the main organizational problems and to plan actions, which would result in the improvement of safety culture.

2. Type of Survey Conducted at IEA-R1 Research Reactor

The survey method used was a quantitative written questionnaire previously developed at ANSTO and then adapted by the management of IEA-R1 research reactor to be applied in this organization. The questionnaire was composed of five parts, as follows:

- (i) In the introductory paragraph the objective of the survey was described highlighting the importance of the employees' contribution concerning the results to be obtained. It was also mentioned that the respondents would remain anonymous so that they would express critical views without fear of consequences.
- (ii) In the second part there were 43 statements (closed multiple choice questions). A five-point scale allowed the respondents to indicate the extent to which they agree or disagree with each statement. The adopted scale was: Strongly Disagree, Disagree, No Opinion, Agree, and Strongly Agree. The employees could reveal their opinion in each question by choosing one of these 5 possible alternatives. It is relevant to make some observations in relation to the interpretation given to some of these responses:

- In case the employee had not answered one of the questions, it is possible that he/she had forgotten to answer it or that he/she considered the issue did not pertain to him/her
 - In case the employee had chosen the response "No Opinion", it is possible to infer that either he/she had preferred to adopt a neutral position with respect to the issue or he/she considered that it did not pertain to him/her;
- (iii) In the third part there were two questions regarding the respondent's personal information in order to characterize the observed sample: working area and working time at IEA-R1 reactor site;
- (iv) In the fourth part there were questions regarding work accidents at IEA-R1 reactor site;
- (v) There was a final open question in which the respondent could make any further comments.

The survey was carried out in September 2002. The questionnaire was answered by 34 people involving only part of the staff at IEA-R1 reactor, more specifically those who work at the Operation and Maintenance Division, the Irradiation Service Division as well as the technicians of the Radiation Protection Division. The respondents had a few hours to fill in the questionnaire and to give it back to the reactor management.

3. Analysis Methodology

3.1 Descriptive Statistical Analysis of the Responses to each Question of the Questionnaire

Initially a descriptive statistical analysis of the responses to each question of the questionnaire was carried out so as to classify and to summarize some numerical data. The descriptive analysis basically consisted of the calculation of the sampling distribution of the responses including a table of frequencies and a bar graph. The JMP software of SAS Institute [1] was used to perform this task. An example of this analysis is shown in Fig.1 and Table I.

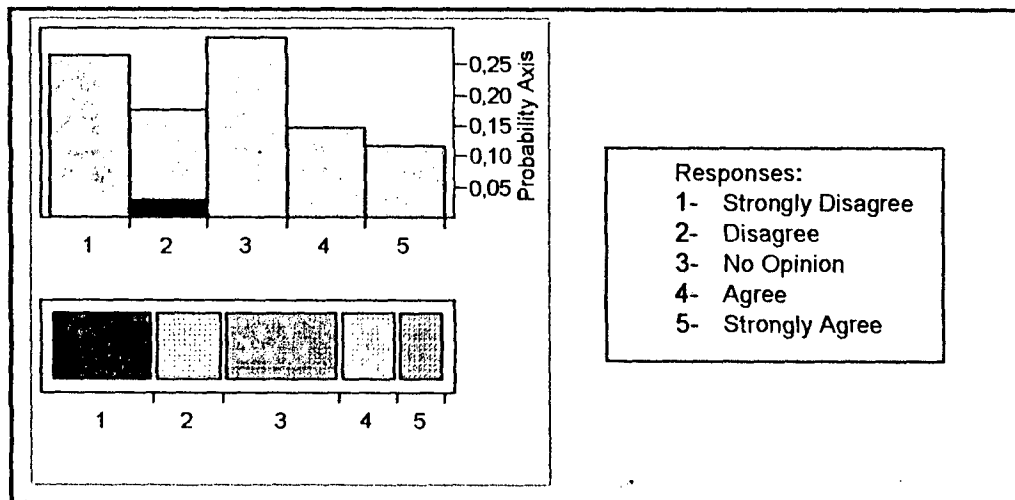


FIG. 1. Sampling Distribution of the Responses to Question 7 – "We have lots of breaches of safety procedures around here"

Table I. Frequency Distribution of the Responses to Question 7 – “We have lots of breaches of safety procedures around here”

Response	Count	Probability
1	9	0.265
2	6	0.176
3	10	0.294
4	5	0.147
5	4	0.118
Total	34	1.000

3.2 Definition of Safety Culture Aspects to be Assessed in the Survey

In the following phase of the analysis, 43 statements presented in the second part of the questionnaire were grouped according to the subject they were related to. For each group, composed of one or more statements, a safety culture aspect was defined. The safety culture aspects, nominated variables 1 to 14, to be analysed in the survey resulted from this grouping task as shown in Table II below:

Table II. Definition of the Safety Culture Aspects to be Analysed in the Opinion Survey Conducted at IEA-R1 Research Reactor

Variable / Safety Culture Aspect	Group of Statements of the Questionnaire
1. PRIORITY TO SAFETY / IMPORTANCE GIVEN TO SAFETY RELATED ISSUES	<p><u>Question 10.</u> In general, I think too much attention is paid to safety in our work. - <i>Positive Statement</i></p> <p><u>Question 13.</u> People in my work unit are more concerned about safety than are people in other units. - <i>Positive Statement</i></p> <p><u>Question 35.</u> Safety improvements are never implemented in my unit because there are not enough resources allocated to this area. - <i>Negative Statement</i></p> <p><u>Question 36.</u> The department assigns a high priority to safety as a rule. - <i>Positive Statement</i></p>
TOP MANAGEMENT COMMITMENT TO SAFETY	<p><u>Question 20.</u> Management gives a consistent message about safety. - <i>Positive Statement</i></p> <p><u>Question 43.</u> If it is a matter of safety, the management endeavours to implement it. - <i>Positive Statement</i></p>
3. EMPLOYEE'S ATTITUDE TOWARDS SAFETY	<p><u>Question 2.</u> In general, there's a good safety attitude in my department. - <i>Positive statement</i></p> <p><u>Question 16.</u> In case my immediate superior gives an order, which although in my opinion compromises safety, I try to obey it without questioning. - <i>Negative Statement</i></p> <p><u>Question 26.</u> Everybody works safely in my workplace. - <i>Positive Statement</i></p>

Table II. Definition of the Safety Culture Aspects to be Analysed in the Opinion Survey Conducted at IEA-R1 Research Reactor (cont.)

Variable / Safety Culture Aspect	Group of Statements of the Questionnaire
4. COMMITMENT AND RESPONSIBILITY OF THE EMPLOYEES	<p><u>Question 9.</u> When a safety rule is violated, I'd rather ignore it so as not to compromise my fellow workers. - <i>Negative Statement</i></p> <p><u>Question 12.</u> We generally report violations of safety practices. - <i>Positive Statement</i></p> <p><u>Question 23.</u> When I find an error in a procedure, I always report it. - <i>Positive Statement</i></p>
5. ASSESSMENT OF THE SAFETY LEVEL IN THE ORGANIZATION	<p><u>Question 17.</u> The general level of safety of my fellow workers in this organization is very high. - <i>Positive Statement</i></p> <p><u>Question 22.</u> The general level of safety in my work unit or department is very high. - <i>Positive Statement</i></p> <p><u>Question 32.</u> My own level of safety performance is very high. - <i>Positive Statement</i></p> <p><u>Question 41.</u> There is still a long way to go to attain a good level of safety culture in our department. - <i>Negative Statement</i></p>
6. "ABSENCE OF SAFETY VERSUS PRODUCTION" CONFLICT	<p><u>Question 8.</u> Management often wants short cuts, regarding safety for increased efficiency. - <i>Negative Statement</i></p> <p><u>Question 25.</u> Management in my workplace is more concerned with production than with people's safety. - <i>Negative Statement</i></p> <p><u>Question 29.</u> Safety works until we are busy, then other things take priority. - <i>Negative Statement</i></p> <p><u>Question 30.</u> If I worried about safety all the time, I would not get my job done. - <i>Negative Statement</i></p>
7. COMPLIANCE WITH REGULATIONS AND PROCEDURES	<p><u>Question 7.</u> We have lots of breaches of safety procedures around here. - <i>Negative Statement</i></p> <p><u>Question 14.</u> As far as safety goes, I find it hard to keep up with all the rules. - <i>Negative Statement</i></p> <p><u>Question 34.</u> I try to keep up with the safety rules set in my department. - <i>Positive Statement</i></p>
8. QUALITY AND ADEQUACY OF DOCUMENTATION AND PROCEDURES	<p><u>Question 3.</u> Our safety procedures are too strict. - <i>Negative Statement</i></p> <p><u>Question 27.</u> The safety rules and procedures in my workplace really work. - <i>Positive Statement</i></p> <p><u>Question 38.</u> In case of accidents, the procedures adopted are correct. - <i>Positive Statement</i></p> <p><u>Question 39.</u> People who work following the safety procedures will always be safe. - <i>Positive Statement</i></p>
9. OPENNESS AND COMMUNICATIONS	<p><u>Question 5.</u> Management would appreciate if we gave suggestions regarding the safest way to do things. - <i>Positive Statement</i></p> <p><u>Question 15.</u> There is good communication about safety between those "higher up" and those "lower down" in this organization. - <i>Positive Statement</i></p> <p><u>Question 18.</u> When I raise a safety issue, people often do not want to talk about it. - <i>Negative Statement</i></p> <p><u>Question 21.</u> Management accepts our safety suggestions. - <i>Positive Statement</i></p>

Table II. Definition of the Safety Culture Aspects to be Analysed in the Opinion Survey Conducted at IEA-R1 Research Reactor (cont.)

Variable / Safety Culture Aspect	Group of Statements of the Questionnaire
10. TRAINING	<p><u>Question 1</u>. It is easy for a new staff member to learn to do things the safe way. - <i>Positive Statement</i></p> <p><u>Question 4</u>. Some of my fellow workers keep making the same dangerous mistake. - <i>Negative Statement</i></p> <p><u>Question 6</u>. Some new staff members just don't see the need to do things safely. - <i>Negative Statement</i></p> <p><u>Question 11</u>. When it comes to safety, most of the people who work around here do not really know what they should be doing. - <i>Negative Statement</i></p> <p><u>Question 33</u>. I am properly skilled to do my tasks completely safe. - <i>Positive Statement</i></p>
11. NOTIONS ON RISK PREVENTION	<p><u>Question 31</u>. Accidents will happen no matter what I do. - <i>Negative Statement</i></p> <p><u>Question 37</u>. Not all accidents are preventable; some people are just unlucky. - <i>Negative Statement</i></p>
12. WORKING CONDITIONS REGARDING SAFETY	<p><u>Question 24</u>. Management checks equipment to make sure it is safe to use. - <i>Positive Statement</i></p> <p><u>Question 40</u>. All things considered I am quite satisfied with my job safety. - <i>Positive Statement</i></p> <p><u>Question 42</u>. In general my working conditions enable me to do job my job safely. - <i>Positive Statement</i></p>
13. MOTIVATION AND JOB SATISFACTION	<p><u>Question 19</u>. What happens to this department is really important to me. - <i>Positive Statement</i></p>
14. SAFETY MANAGEMENT	<p><u>Question 28</u>. Our safety committee is very effective. - <i>Positive Statement</i></p>

3.3 Descriptive Statistical Analysis of the Safety Culture Aspects

After defining the safety culture aspects to be analysed in the survey (see Table II), new bar graphs were plotted to compare the results of each specific group of statements. In Fig.2 an example of this graph is shown for Variable 7 – “Compliance with Regulations and Procedures”.

3.4 Methodology for Deriving the Satisfaction Level of the Respondents in Relation to the Safety Culture Aspects

In order to assess the respondents' opinions regarding the safety culture aspects described in section 3.2, a method based on the *Likert – Attitude Scoring Technique* [2] was adopted. The method consisted of getting an attitude score of each respondent with respect to each variable. This score was calculated summing up the respondent's points got in the statements associated with each variable. The respondent's points in each statement were given following the criteria shown in Table III.

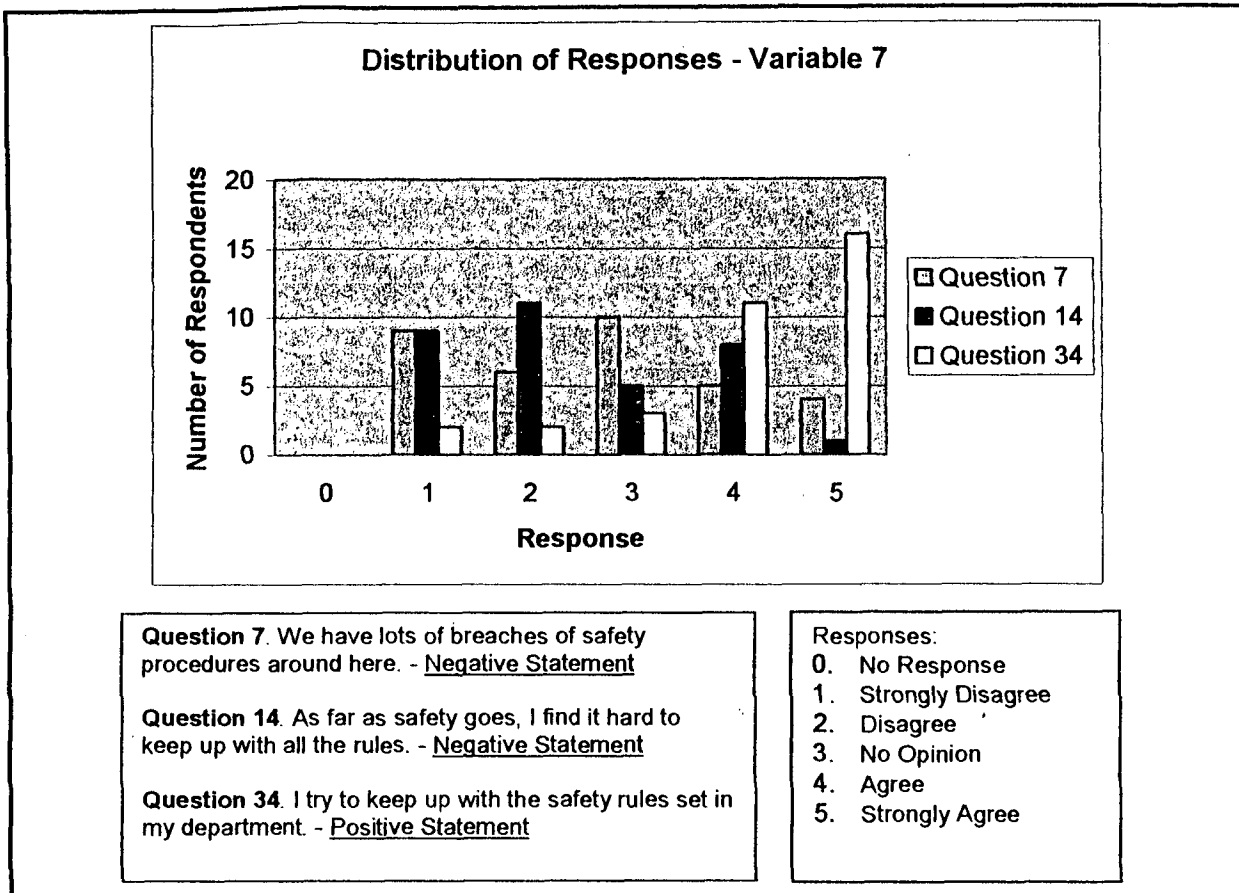


FIG. 2. Distribution of the Responses to Questions 7, 14 and 34 (Variable 7 – “Compliance with Regulations and Procedures”)

Table III. Scoring Criteria for the Response to each Statement

Response	Criteria 1	Criteria 2
	<i>Positive Statement</i>	<i>Negative Statement</i>
No Response	0	0
Strongly Disagree	1	5
Disagree	2	4
No Opinion	3	3
Agree	4	2
Strongly Agree	5	1

After summing up the points of the statements of each group listed in Table II, an attitude score of the respondent was obtained in relation to each variable. Besides the attitude score, the respondent's concept regarding the variable was evaluated according to the scale shown in Table IV.

Table IV. Respondent's Evaluation According to the Attitude Score

Attitude Score	Respondent's Evaluation
less than x_1 points	Very Unsatisfied
from $x_1 + 1$ to x_2 points	Unsatisfied
$x_2 + 1$ points	Indifferent
from $x_2 + 2$ to x_3 points	Satisfied
from $x_3 + 1$ to x_4 points	Very Satisfied

The values x_1 , x_2 , x_3 and x_4 should be defined according to the number of statements grouped to compose the variable. The scale adopted in this study is presented in Table V.

Table V. Scale Adopted to Evaluate the Respondents' Concepts According to the Attitude Score

No. of Statements	Attitude Score				
	1 point	2 points	3 points	4 points	5 points
1 Statement	1 point	2 points	3 points	4 points	5 points
2 Statements	≤ 3 points	$4 \leq x \leq 5$ points	6 points	$7 \leq x \leq 8$ points	$9 \leq x \leq 10$ points
3 Statements	≤ 5 points	$6 \leq x \leq 8$ points	9 points	$10 \leq x \leq 12$ points	$13 \leq x \leq 15$ points
4 Statements	≤ 7 points	$8 \leq x \leq 11$ points	12 points	$13 \leq x \leq 16$ points	$17 \leq x \leq 20$ points
5 Statements	≤ 9 points	$10 \leq x \leq 14$ points	15 points	$16 \leq x \leq 20$ points	$21 \leq x \leq 25$ points
CONCEPT	Very Unsatisfied	Unsatisfied	Indifferent	Satisfied	Very Satisfied

To illustrate the steps described above, consider the example of Variable 7 – "Compliance with Regulations and Procedures". Suppose an employee had answered "Agree" to Question 7 (Negative Statement), "Disagree" to Question 14 (Negative Statement) and "Agree" to Question 34 (Positive Statement). According to Table III, he/she would have got 2 points for Question 7, 4 points for Question 14 and 4 points for Question 34, resulting in 10 points. Consequently, his/her attitude score in relation to Variable 7 is 10, which means, based on Table V, that he/she would be "satisfied" with respect to the safety culture aspect named "Compliance with Regulations and Procedures".

The global satisfaction level in relation to each variable was calculated summing up the proportion of employees of the sample who were "Very Satisfied" and "Satisfied" with the safety culture aspect studied. Thus, the final evaluation of the variable could be obtained following the criteria determined in Table VI.

Table VI. Criteria for the Final Evaluation of the Satisfaction Level of the Respondents in Relation to the Variables Analysed

Satisfaction Index in Relation to the Variable Analysed	Evaluation
$85\% \leq X$	VERY GOOD
$75\% \leq X < 85\%$	GOOD
$65\% \leq X < 75\%$	SATISFACTORY
$50\% \leq X < 65\%$	REGULAR
$X < 50\%$	UNSATISFACTORY

4. Results of the Survey

4.1 Sample Characterization

The sample drawn for the survey carried out at IEA-R1 reactor consisted of 34 employees whose areas of work are presented in Table VII. Based on the responses to the questions of the third part of the questionnaire, it was possible to verify that 50% of the employees have been working more than 7.5

years for IEA-R1 research reactor organization. The maximum observed work time was 24 years and the minimum was 1 year. The mean work time of the employees resulted in 10.1 years.

Table VII. Distribution of the Respondents According to the Work Area

Work Area	No. of Respondents	%
Customer Assistance and Administrative Areas	3	8.82
Irradiation Service	6	17.65
Maintenance Division	6	17.65
Operation Division	10	29.41
Radiation Protection	8	23.53
Other areas	1	2.94
Total	34	100,00

4.2 Final Results

The final results of the survey are summarized in Table VIII and plotted in a "radar type" graph as shown in Fig.3.

Table VIII Summary of the Results of the Assessment of Safety Culture Aspects at IEA-R1 Research Reactor

Safety Culture Aspect	Satisfaction Level (%)	Global Evaluation
1. Priority to Safety / Importance Given to Safety Related Issues	64.70	REGULAR
2. Top Management Commitment to Safety	61.76	REGULAR
3. Employee's Attitude Towards Safety	79.41	GOOD
4. Commitment and Responsibility of the Employees	76.47	GOOD
5. Assessment of the Safety Level in the Organization	58.82	REGULAR
6. "Absence of Safety <i>versus</i> Production" Conflict	67.65	SATISFACTORY
7. Compliance with Regulations and Procedures	64.71	REGULAR
8. Quality and Adequacy of Documentation and Procedures	61.77	REGULAR
9. Openness and Communications	61.77	REGULAR
10. Training	61.77	REGULAR
11. Notions on Risk Prevention	85.30	VERY GOOD
12. Working Conditions Regarding Safety	67.64	SATISFACTORY
13. Motivation and Job Satisfaction	88.24	VERY GOOD
14. Safety Management	38.23	UNSATISFACTORY

Concerning the questions related to work accidents at the installation, 3 employees (8.82% of the respondents) declared they had been involved in at least one event for the period of time they had been working for IEA-R1 research reactor organization. Among these employees, only one had mentioned that he/she had been a 20-day lay-off as a consequence of the accident.

- (iii) Employees' Attitude Towards Safety (Variable 3 – 79.41%)
- (iv) Commitment and Responsibility of the Employees (Variable 4 – 76.47%)
- (v) "Absence of Safety *versus* Production" Conflict (Variable 6 – 67.65%)
- (vi) Working Conditions Regarding Safety (Variable 12 – 67.64%)

– It is important to mention that:

- (i) It would have been better if the safety culture issues to be investigated in the survey had been defined before the selection and development of the questionnaire used to collect data.
- (ii) Some authors recommend that each safety culture aspect should be assessed through at least three statements of the questionnaire. Nevertheless, the ideal format is to have from five to eight statements covering each aspect. Therefore, the aspect corresponding to question 28 named "Safety Management", needs to be better analysed in the next survey.
- (iii) The aspect named "Motivation and Job Satisfaction" was also assessed based on one statement only (question 19). It is possible to consider a more detailed investigation in a future survey.
- (iv) The aspect named "Assessment of the Safety Level in the Organization" may be analysed better in a future survey because the statements 17, 22, 42 and 41 were not covering this issue specifically.

– After concluding the statistical analysis presented in this study, a report was elaborated and became available to IEA-R1 reactor managers and employees. Besides that, a lecture was delivered in order to feed back the results to the group involved in the survey.

– A follow-up stage was already initiated consisting of a scheduled seminar with a view to increase the understanding of the concept of safety culture among the participants of a focus group. The seminar has been planned by a team of professionals, composed of IEA-R1 reactor senior managers, quality assurance personnel and specialists in probabilistic safety analysis. Other purposes of the seminar programme is to look at potential responses to survey findings; to highlight the need for improvements to be made in the management of safety; and to identify the most appropriate solutions.

– Finally, before planning a future survey, it is advisable to conduct interviews to collect some more qualitative information concerning safety aspects at IEA-R1 reactor organization.

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- [2] LIKERT, R., A technique for the Measurement of Attitudes, Archives of Psychology 140 (1932) 5-53.

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