
Selection of quality inspectors by means of a visual search test: A feasibility study

Interim Report

N Connell

001.3072068
HSRC NIPR PERS 421

Nasionale Instituut vir Personeelnavorsing — NIPN
National Institute for Personnel Research — NIPR



BIBLIOTEEK LIBRARY

RGN

RAAD VIR
GEESTESWETENSKAPLIKE
NAVORSING

HSRC

HUMAN
SCIENCES RESEARCH
COUNCIL



RGN · HSRC



SENTRUM VIR BIBLIOTEEK- EN
INLIGTINGSDIENSTE
CENTRE FOR LIBRARY AND
INFORMATION SERVICES

VERVALDATUM/DATE DUE

--	--	--	--



Selection of quality inspectors
by means of a visual search test:
A feasibility study

Report PERS-421

Selection of quality inspectors by means of a visual search test: A feasibility study

Interim Report

N Connell

N. Connell, B.Sc.(Hons) Senior Researcher

National Institute for Personnel Research
Executive Director: Dr G.K. Nelson

ISBN 0 7969 0519 3

© Human Sciences Research Council, 1987
Printed and published by the HSRC
134 Pretorius Street
Pretoria

RGN BIBLIOTEEK HSRC LIBRARY	
1988 -06- -8	
STANBKODE 001 3672068 HSRC NIPR PERS 421	REGISTERNOMMER
BESTELNOMMER R/O	074124

ACKNOWLEDGEMENTS

National Institute for Personnel Research:

Dr G.K. Nelson : Executive Director
Dr J.M. Verster : Group Head, Human Adaptation

NIPR Environmental Studies Division:

Mr T. Hart : Acting Divisional Head
Mr A.P. Golding
Mrs E Kelbrick

NIPR Psychometrics Division:

Mr C. Chemel

NIPR Computer Services:

Miss D. Blades
Mrs N.J. Gumbi

Mr F.W. Hemmings, Quality Management Consultant

CONTENTS

PAGE

Ekserp / Abstract

vi

1.	INTRODUCTION	1
1.1	Errors in industrial inspection.	1
1.2	Ergonomic research on industrial inspection.	2
1.3	The Visual Search Test.	4
1.4	The acceptability of a specialised selection test. ...	4
2.	METHOD	5
2.1	Informal interviews.	5
2.1.1	Subjects.	5
2.1.2	Procedure.	6
2.2	Questionnaire study.	6
2.2.1	Subjects.	6
2.2.2	Apparatus.	6
3.	RESULTS	7
3.1	Informal interviews.	7
3.2	Questionnaire study.	8
3.2.1	Interest in a task relevant test.	8
3.2.2	Personnel questionnaire 'independent' variables. ...	10
3.2.3	Quality questionnaire 'independent' variables. ...	13
3.3	CHAID analysis of questionnaire responses.	16
4.	DISCUSSION AND CONCLUSIONS	21
	REFERENCES	24

APPENDICES

FIGURES

- Figure 1. Search and decision in visual inspection.
Figure 2. CHAID analysis, personnel questionnaire, test for inspectors.
Figure 3. CHAID analysis, personnel questionnaire, test for production workers.
Figure 4. CHAID analysis, quality questionnaire, test for inspectors.
Figure 5. CHAID analysis, quality questionnaire test for production workers.

EKSERP

Die uitvoerbaarheid van die ingebruikneming van 'n toets van visuele opsporingsprestasië vir die keuring van nywerheidsgehalte-beheerinspekteurs is ondersoek. Amptenare in 12 maatskappye is ondervra, en die inligting so verkry is gebruik om twee vraelyste op te stel : een is op personeelbestuurders gemik en die ander op gehaltebeheer- of produksiebestuurders. Die vraelyste is aan 1533 vervaardigingsmaatskappye ge-pos wat op 'n willekeurbasis vanuit die BM Nywerheidsregister gekies is. Gebaseer op 'n gemiddelde antwoordsyfer van 20,6 persent is daar gevind dat 'n wesenlike belangstelling bestaan in 'n toets van visuele opsporingsprestasië vir die keuring van beide inspekteurs en produksielynwerkers. Die belangstelling is die grootste in maatskappye waar visuele vaardighede beoefen word, of waar keuring- of inspeksieprobleme ondervind word.

ABSTRACT

The feasibility of introducing a test of visual search performance for the selection of industrial quality control inspectors was investigated. Individuals in 12 companies were interviewed and on the basis of the information thus gained two questionnaires were drawn up : one directed at personnel managers and the other at quality control or production managers. The questionnaires were posted to 1533 manufacturing companies selected randomly from the BM Industrial Register. Based on an average response rate of 20,6 percent, it was found that there is substantial interest in a test of visual search speed for the selection of both inspectors and production-line workers. This interest is greatest in companies where visual scanning skills are taught, or where selection or inspection problems are experienced.

1. INTRODUCTION

1.1 Errors in industrial inspection

Statistical Quality Control (SQC) plans originally assumed that the inspection of a sample of products for defects is error-free. Although it has been known for many years that inspectors are far from perfect (Juran, 1935; McKenzie, 1957; Harris and Chaney 1968), the incorporation of information about the pattern of errors made by inspectors into the statistical models used in SQC is a relatively recent phenomenon (e.g. Drury, 1978). This has led to the realisation that inspector errors can contribute to an inflation of the number of defective products in outgoing batches to a level far in excess of that calculated by the SQC plan.

Most research into inspection errors has been concerned with environmental and organisational factors (Gallwey and Czaja, 1981), principally because the optimisation of these usually has a considerable effect on inspector performance (Harris and Chaney, 1968; Wiener, 1975). Nevertheless Gallwey (1982), in a review of several studies on environmental and subject factors, found that individual differences were highly significant and that no other factor was more significant. For example, Harris (1964) found that inspectors who had been selected on the basis of static visual acuity and amount of previous inspection experience differed greatly; typically some inspectors detected more than 10 times the number of defects detected by others. Interestingly it was also found that the amount of relevant inspection experience was not related to inspection accuracy.

Despite the renewed interest in industrial inspection in recent years, few selection tests have been developed. Wiener (1975) attributes this to the fact that 'standard' aptitude tests have been found to be rather poor predictors of inspector accuracy, although they do seem to correlate quite well with supervisor ratings which, as Wiener points out, need not bear any relation-

ship at all to actual inspector performance other than "a dexterity component and a general measure of industrial adaptability".

1.2 Ergonomic research on visual inspection

In the last 25 years a considerable amount of work has been done on the analysis of the inspection task, and this has led to a useful model of inspector behaviour which suggests a new approach to the design of a selection test.

Any inspection device (human or mechanical) has four basic functions:

- (1) present pre-selected items for inspection;
- (2) search the item to locate possible defects ('flaws');
- (3) decide whether each flaw is sufficiently bad to be classified as a defect; and,
- (4) take the appropriate action of acceptance or rejection.

Functions (1) and (4) are highly reliable and do not concern us here. The search and decision components are subject to appreciable error with either human or automatic inspection devices. The interrelationship between search and decision can be expressed succinctly in terms of a flow diagram (Figure 1 - adapted from Drury, 1978).

Since time is of crucial importance in a large number of cases (e.g. a conveyor-belt system), the speed of search may often be the overriding factor. For this reason a large number of studies have investigated the properties of visual search, and have identified several parameters, the most important of which are:

- (1) degree of similarity (discriminability) between targets and non-targets;
- (2) the number and density of non-targets;

- (3) organisation of non-targets (patterned or 'constrained' vs. random);
- (4) the searcher's visual lobe area (functional visual field);
- (5) the searcher's ability to 'disembed' stimuli (field independence).

Factors (1), (2) and (3) are stimulus factors, (5) is a perceptual/cognitive/personality dimension which has received some attention (with mixed results) while (4) is considered to be the most important subject factor, and has been the basis for the development of selection tests by Bellamy and Courtney (1981) and Gallwey (1982).

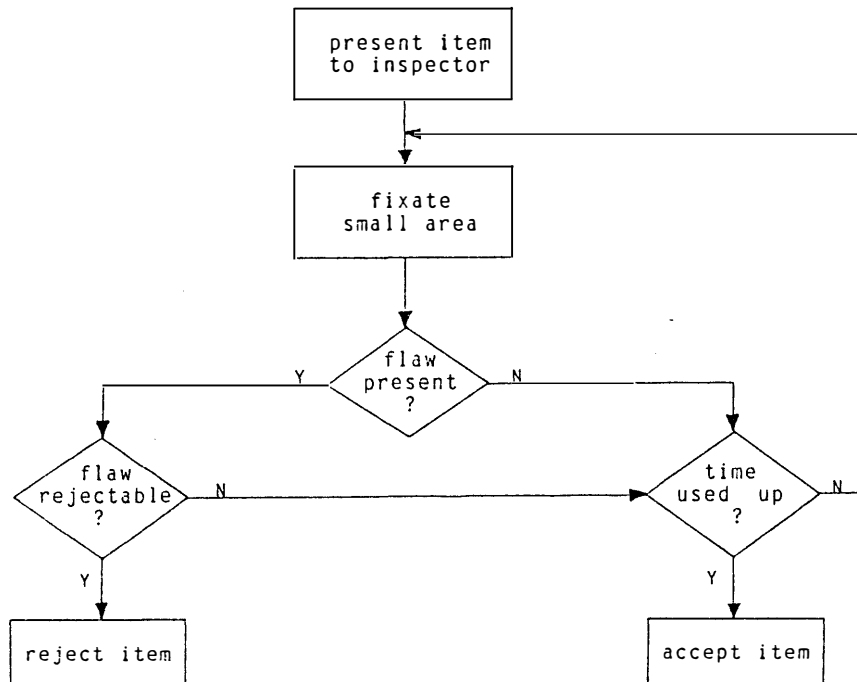


Figure 1. Search and decision in visual inspection.

It should be noted that visual lobe area is not constant; it is much larger for stimuli with few non-targets and when the target is highly discriminable. However, individual differences in visual lobe area remain relatively constant over a fairly large range of these parameters.

1.3 The Visual Search Test.

Since the Gallwey test includes a decision component which is confounded with the search component, it was decided to investigate the Bellamy and Courtney test which correlates well with direct measures of visual lobe area (Bellamy and Courtney, 1981; Courtney and Chan Hoi Shou, 1985), and also has a high face validity.

Bellamy and Courtney's original approach used a card sorting task; however, the technique can easily be adapted for presentation by computer. Initial work in the Environmental Studies Division (Golding, 1986) has made use of a slide projector stimulus presentation technique with stimulus rate and subject reaction time being monitored by microprocessor equipment (the 'Programmable Reaction Tester').

Test stimuli consist of an array of Xs in which is embedded a single Y or V target (these being perceptually very similar to the Xs and to each other). The testee is required to search for the target and indicate which one it is by pressing one of two switches. The initial (developmental) version of the test used a block of 40 stimuli (20 Vs and 20 Ys). It was found that 95% of subjects completed this within 15 minutes. Courtney and Chan Hoi Shou (1985) have shown that a single block of stimuli is sufficient to provide a reliable measure of search time, despite the learning effect which can be appreciable.

1.4 The acceptability of a specialised selection test

In view of the fact that the researchers motivated for the project themselves, it was deemed necessary to ascertain the potential applicability of a visual search test in industry. This was done by means of the following:

- (1) informal interviews with quality assurance and/or personnel managers, followed by
- (2) a more comprehensive survey by means of a questionnaire.

In order to facilitate decision making by members of the project committee, a condensed version of the method, results and discussion is presented in this interim report. More in-depth analyses are to follow in a final report.

2. METHOD

2.1 Informal interviews

2.1.1 Subjects

The companies/individuals visited were the following:

Mr F W Hemmings	-	Quality Management Consultant
Mr R P Chaix	-	Manager, SA Institute of Welding
Prof A T Scher	-	Dept. of Radiology, Wits Medical School
Mr R Foster	-	Quality Manager, ISCOR, Vanderbijlpark
Mr M Destombes	-	Manager, Transvaal Clothing Co.
Mr G Beresford	-	Quality Manager, Standard Telephones and Cables (Pty) Ltd
Mr M Rigby	-	Production Manager, SA Micro-electronic Systems
Mr L Zietsman	-	Personnel Manager, Consol Glass, Pretoria
Mr B Reynolds	-	Quality Manager, Pilkington Glass, Springs
Mr P Kruger	-	Personnel Manager, BMW, Pretoria
Mr N Crofton	-	Packaging Manager, SA Breweries, Isando
Mr A Jochum	-	Quality Manager, Siemens Limited, Pretoria

The above were chosen by means of a contact at the CSIR and did not constitute a random sample of industries.

2.1.2 Procedure

The purpose of the informal interviews was not so much to gather hard data, but rather to get acquainted with a range of inspection jobs and to get a 'feel' for the area. Initially the interviews were informal, but they became more structured as the researchers gained knowledge about quality inspection. Interviews were combined with observations of inspection work.

2.2 Questionnaire study

2.2.1 Subjects

A total of 1533 manufacturing companies were sampled using a mailing list provided by the Bureau of Market Research, UNISA. The BM Industrial Register was used (Steenkamp, 1984) and companies with a minimum of 101 employees were chosen by sampling every third entry of the mailing list. In addition, several companies of note were included.

2.2.2 Apparatus

Using the information gathered from the interviews, two questionnaires were drawn up, one tailored specifically for personnel managers (Appendix A) and the other for quality or production managers (Appendix B). The questionnaires were designed to gather information about:

- (1) the degree of interest in a test such as the Visual Search Test;
- (2) attitudes towards selection testing in general;
- (3) selection procedures and problems;
- (4) recruitment practices;
- (5) training practices and problems;
- (6) the range of inspection jobs (e.g. use of instruments, visual scanning alone, etc);

- (7) inspection problems and the reasons for these;
- (8) the status of quality assurance within the company;
- (9) technical details such as degree of local content, manufacturing sector, number of products produced per hour, etc.

3. RESULTS

3.1 Informal interviews

Details of the interviews were given in an office report (Connell, 1966). The interviews led us to the following conclusions:

- (1) In the present economic climate there is little or no recruitment of inspectors; production workers are trained for inspection wherever possible.
- (2) The more technologically advanced industries require inspectors with an intimate knowledge of the product and little emphasis is placed on inspector selection. "Inspection" then becomes an important activity of production line workers as well. There was at least one significant exception to this trend.
- (3) Interest in the project ranged from enthusiasm through to indifference. In general most interviewees seemed to be satisfied with the status quo and tended to rely on production performance when selecting inspectors;
- (4) The potential for a selection test seems to be greatest in industries recruiting unskilled labour, or where lengthy training of inspectors is required;

- (5) The accent on quality varies considerably. Two companies were upgrading quality, while one company was downgrading it as they were producing items with a quality far in excess of customer requirements;
- (6) We did not interview a representative sample of companies - most required skilled or semi-skilled workers - and thus not enough companies using unskilled labour were sampled.

3.2 Questionnaire study

Quite a few questionnaires were returned undelivered, but as many as possible of these were re-addressed. After the deadline for returns, six personnel and two quality questionnaires were not included in the analysis while 15 pairs of questionnaires remained undelivered.

The number of questionnaires used in data analysis was:

personnel questionnaires : 337 (22,3% return)
 quality questionnaires : 295 (19,5% return)

Initially it was hoped that different individuals would answer each of the two questionnaires. However, it became evident when coding the questionnaires that in quite a few cases the same individual filled in both. Nevertheless, differences in the pattern of answers are worth noting.

3.2.1 Interest in task relevant test.

Item: "Would a more task-relevant test such as a test of visual search efficiency be useful for the selection of:

"(a) inspectors?"

PERSONNEL			QUALITY		
<u>Yes</u>	<u>No</u>	<u>Don't know</u>	<u>Yes</u>	<u>No</u>	<u>Don't know</u>
179	27	92	149	45	68
60,1%	9,1%	30,9%	56,9%	17,2%	26,0%

"(b) production-line workers?"

PERSONNEL			QUALITY		
<u>Yes</u>	<u>No</u>	<u>Don't know</u>	<u>Yes</u>	<u>No</u>	<u>Don't know</u>
137	35	126	133	47	82
46,0%	11,7%	42,3%	50,8%	17,9%	31,3%

These results show a very positive response in favour of a visual search test. Quality managers showed slightly less enthusiasm than personnel managers. Interest in the test for use with production-line workers was somewhat less, although quality managers were more in favour of this than personnel managers, presumably because modern quality assurance philosophy puts greater emphasis on the need for production workers to check for defects while products are being fabricated.

In order to ascertain which factors determine whether an individual will have a favourable attitude towards a visual search test, chi-square tests of independence were performed with other items as 'independent' variables. This analysis should give an indication of which companies to approach for help in validating the Visual Search Test.

For the sake of brevity, bivariate frequency tables will not be provided here, but will be included in the final report. In addition, the analysis of Item 1 (business type) in both questionnaires will be omitted, chiefly because the wide range of companies sampled causes low expected frequencies in many categories and thus prevents a more detailed analysis beyond descriptive statistics. Items not reported here did not show any significant relationships.

3.2.2 Personnel questionnaire (Appendix A)

Item 3. How inspectors are obtained.

Since categories in this item are not mutually exclusive, chi-square tests cannot be performed on the raw data. As the method of inspector recruitment could be an important factor (especially if production-line workers are used), a method of partitioning the data into meaningful groups had to be found. The groupings used in the analyses were as follows:

- Group PLONLY: companies using production line workers exclusively as a source of inspectors (35,5%);
- Group OFFSTR: companies recruiting people 'off the street', and which may also use other sources (40,2%);
- Group THE REST: any company not in the above two groups, and where mostly fully trained quality control technicians or apprentices are used (24,3%).

A 3 x 3 chi-square analysis was not significant for a test for inspectors as well as production-line workers. However, inspection of standardized deviates showed that, for a test for inspectors, group THE REST was significantly different from the other two groups combined ($X^2 = 4,755$; $df = 2$; $p = ,0928$) in that they were less in favour of such a test (49,3% vs 63,6%) and were also more uncertain (38,4% vs 28,4%). For a test for production-line workers, the group PLONLY was significantly more in favour of a test compared to the other two groups combined (53,8% vs 41,7%; $X^2 = 5,816$; $df = 2$; $p = ,0546$).

Item 4. Minimum educational level.

There is some indication that companies requiring a matric qualification or better are slightly less in favour of a test for inspectors (54,0% vs 65,4%), and are also more uncertain (39,1% vs 24,7%; $X^2 = 8,5$; $df = 4$; $p = ,0749$). No significant relationship was found in the case of a test for production-line workers.

Item 5. Sources of information used when recruiting.
Data were transformed by counting the number of different sources used when recruiting and using this as the 'independent' variable. Companies using two or fewer sources of information were less positive towards a test for inspectors than companies using three or more sources (53,1% vs 64,0%; $\chi^2 = 17,706$; $df = 6$; $p = ,007$). A similar pattern was shown for a test for production-line workers, but this did not reach statistical significance.

Item 8. Use of vision tests.

Out of 302 acceptable returns only 129 (42,7%) use any form of vision testing. This is a surprisingly low percentage, but is possibly due to non-response by some companies which encourage or subsidise vision tests, but do not administer them.

Of those companies which use one or more vision tests when recruiting new inspectors, 71,3% were in favour of a test for inspectors, whereas only 55,2% of those not using vision tests were in favour ($\chi^2 = 6,908$; $df = 2$; $p = ,0316$). The same result was obtained for attitudes towards a test for production-line workers ($\chi^2 = 14,239$; $df = 2$; $p = ,0008$).

Items 10 to 14. Attitudes towards selection.

These items were included to gauge the extent to which respondents believe that personnel selection is a cost-effective enterprise. In those cases where the expected response was to agree with the statement, more than 90% of respondents responded favourably. Items 12 and 13, for which the expected response is to disagree, elicited an expected response rate of about 82%. Chi-square tests of independence using these two items showed that there was a significant relationship between belief in the benefits of personnel selection and a positive attitude towards a test for inspectors only.

(Item 12: $\chi^2 = 10,115$; $df = 2$; $p = ,0064$.)

(Item 13: $\chi^2 = 6,401$; $df = 2$; $p = ,0407$.)

Item 15. Selection problem.

Of those reporting a selection problem - or who were not sure if they had a problem - 66,2% were in favour of a test for the selection of inspectors, whereas 58,3% of those reporting no problem were in favour ($\chi^2 = 5,23$; $df = 2$; $p = 0,0732$). In the case of a test for production-line workers, 55,8% of those reporting a problem were in favour, while 42,6% of those with no selection problem were in favour ($\chi^2 = 9,479$; $df = 2$; $p = ,0087$).

Item 17. Training of visual scanning skills.

Of those who train scanning skills, 70,6% were in favour of a test for inspectors while 57,1% of those who do not train these skills were in favour ($\chi^2 = 6,305$; $df = 2$; $p = ,0427$). In the case of a test for production-line workers, the proportion in favour was 62,4% and 40,1% respectively ($\chi^2 = 13,49$; $df = 2$; $p = ,0012$).

Item 18. Trainee inspectors who fail.

Because of a problem with low expected frequencies, categories were collapsed into a dichotomy, viz., 'no problem' = 4% or fewer dropouts; 'problem' = 5% or more. Of those reporting a training problem, 79,6% were in favour of a test for inspectors, while only 57,9% of those reporting no problem were in favour ($\chi^2 = 6,979$; $df = 1$; $p = ,0082$). A similar trend was evident for a test for production-line workers, but this did not reach statistical significance.

Item 20. Recording of inspector performance.

The recording of performance data was not related to attitude towards a test for inspectors, but there was a marginal relationship with attitude towards a test for production-line workers, with those measuring performance being more in favour of a test ($\chi^2 = 4,612$; $df = 2$; $p = ,0997$).

3.2.3 Quality questionnaire (Appendix B)

Item 14. Feasibility of automated inspection.

Inspection of the standardized deviates of a significant 3 x 3 chi-square test (but with unacceptably low expected frequencies in some cells) showed that companies reporting a high or moderate feasibility of automated inspection were qualitatively different in their attitudes compared with companies reporting no likelihood of automated inspection. A 2 x 3 analysis showed that 65,7% of companies where automated inspection is feasible were in favour of a test for inspectors, whereas only 52,8% of the others were in favour ($\chi^2 = 8,193$; $df = 2$; $p = ,0166$).

An analysis of attitudes towards a test for production-line workers showed a similar pattern but did not reach statistical significance.

Item 15. Status of Quality Assurance.

Companies where Quality Assurance (QA) had higher status showed the greatest degree of support (61,1%) compared with companies where QA had lower status (51,5%). Companies where QA had equal status showed fairly good support (60,5%), but also had the highest proportion of 'don't know' responses ($\chi^2 = 8,036$; $df = 4$; $p = ,0903$). No significant relationship was shown for attitudes towards a test for production-line workers.

Item 16. How inspectors are obtained.

Respondents were divided into three groups as in the personnel questionnaire. Analysis of the standardized deviates of a 3 x 3 analysis showed that the group THE REST was qualitatively different to PLONLY and OFFSTR. This was confirmed in a 2 x 3 chi-square analysis which revealed that THE REST showed the lowest degree of support for a test for inspectors (44,6% vs 61,9%), but they also showed the greatest number of 'don't know' responses (35,4% vs 22,2%) ($\chi^2 = 6,318$; $df = 2$; $p = ,0425$).

A similar result was obtained in the analysis of attitudes towards a test for production-line workers ($\chi^2 = 4,786$; $df = 2$; $p = ,091$).

Item 18. Sources of information used when recruiting.
A marginally significant relationship was obtained ($\chi^2 = 4,597$; $f = 2$; $p = ,1004$), showing that 60,9% of companies using three or more sources of information were in favour of a test for inspectors, whereas 50,7% of companies using two or fewer sources of information were in favour. No significant relationship was obtained for a test for production-line workers.

Item 19. Presence of an inspector selection problem.
Of the companies reporting a selection problem - or did not know if they had one - 77,0% were in favour of a test for inspectors, whereas 52,6% of companies with no problem were in favour ($\chi^2 = 11,371$; $df = 2$; $p = ,0034$). However, the latter were more uncertain in terms of their 'don't know' responses (28,4% vs 13,1%). The same result was obtained with respect to a test for production-line workers ($\chi^2 = 6,38$; $df = 2$; $p = ,0321$).

Items 22 to 26. Attitudes towards selection.
Overwhelming support for the need for personnel selection was obtained (over 91%), except for two items (items 24 and 25) for which a negative response is appropriate (over 81% in favour). Crossing these two items with attitudes towards a task relevant test did not reveal any statistically significant relationships except for item 25 and attitude toward a test for inspectors ($\chi^2 = 7,614$; $df = 2$; $p = 0,0222$).

Item 27. Records of work performance.
Seventy per cent of companies using two or more measures of inspector performance were in favour of a test for inspectors, whereas only 52,9% of companies taking no measures of performance were in favour ($\chi^2 = 10,184$; $df = 4$; $p = ,0374$). Companies taking no measures were also more uncertain (32,2% vs. 24,0%). The same result was obtained for attitudes towards a test for production-line workers.

Item 28. Possibility of covert inspector evaluation.

Of the companies willing to insert defective items into the production-line (or answering 'don't know'), 63,2% were in favour of a test for inspectors, whereas 53,8% of companies not in favour of doing this were in favour of a test ($\chi^2 = 4,902$; $df = 2$; $p = ,0362$). No significant relationship was obtained with respect to a test for production-line workers.

Item 31. Inspection problems.

Of companies reporting one or more inspection problem, 69,3% were in favour of a test for inspectors compared with 53,4% of companies not reporting any inspection problems ($\chi^2 = 7,356$; $df = 2$; $p = ,0253$). This trend was expressed even more strongly in the case of a test for production-line workers (69,3% vs 43,8%; $\chi^2 = 17,275$; $df = 2$; $p = ,0002$).

Item 32. Main causes of inspection problems.

While this report has focussed on selection testing as a means for improving inspector performance, it should not be forgotten that environmental, organisational and training factors are probably just as important in their effects. An attempt to assess this was made by asking quality managers to rank 10 factors which may contribute towards inspector problems.

The 10 factors, in decreasing order of importance, are:

	MEAN RANKING	STANDARD DEVIATION
High work rate	3,81	2,68
Difficult judgements	3,84	2,50
Pressure to ignore marginal defects	3,96	2,66
Vague/complicated quality standards	4,61	2,71
Insufficient skills training	4,76	2,46
Ignorance of quality standards	4,81	2,85
Lack of motivation	4,87	2,75
Poor work environment	5,50	2,97
Personnel selection problems	5,82	2,47
Personal problems	6,29	2,99

While most quality managers rank selection problems as relatively unimportant, it is encouraging to note that high work rate is regarded as the most important factor, as the Visual Search Test measures visual scanning speed directly. The use of dynamic visual acuity as a selection test is also suggested by this result.

3.3 CHAID analysis of questionnaire responses

In the analysis of the relationships between various 'independent' variables (to be described in full in the final report), it became obvious that there exists a complex pattern of interaction between variables which is not well described by simple bivariate frequency analysis. In order to provide greater clarity, an automatic interaction detection analysis (CHAID) was performed.

The results of this analysis reveal that, for the personnel questionnaire (Figures 2 and 3), the teaching of visual scanning skills is the single most important factor associated with a positive attitude towards a test for both inspectors and production-line workers. Following this, the keeping of work records of inspectors was associated with a high degree of interest in a test for inspectors. Lastly, companies using either very few, or very many, sources of information when recruiting were least likely to favour a test for inspectors. This is probably because they are either not really concerned about inspector selection, or have a very elaborate selection procedure with which they are reasonably satisfied.

One surprising finding is that training problems did not relate to attitudes towards a test despite the high significance obtained in the simple chi-square test reported earlier. This may be because of correlation (confounding) with other variables in the simple analysis.

Key:

Y = Yes (%)

N = No (%)

D = Don't know (%)

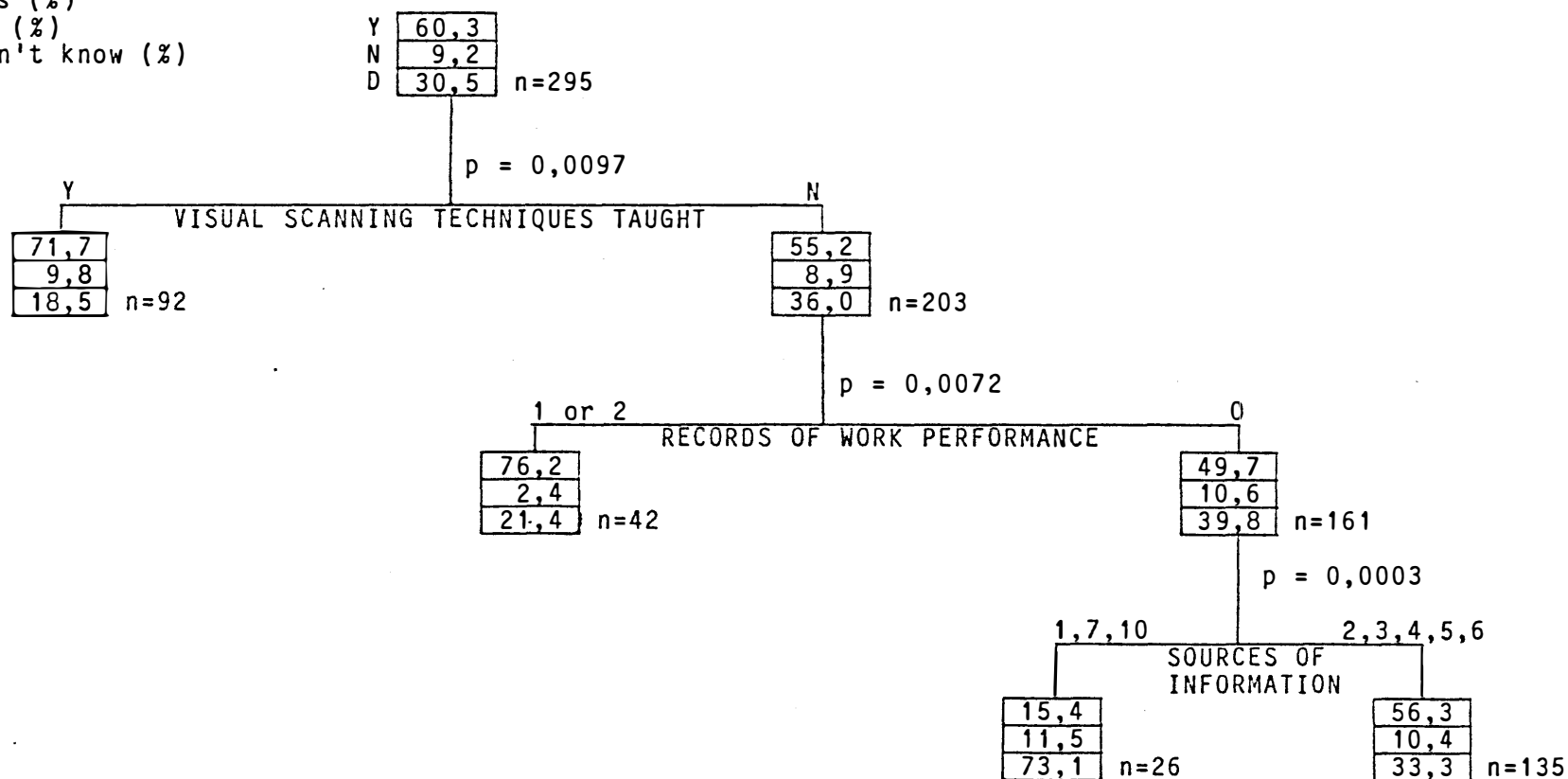


Figure 2. CHAID analysis, personnel questionnaire, test for inspectors.

Key:

Y = Yes (%)

N = No (%)

D = Don't know (%)

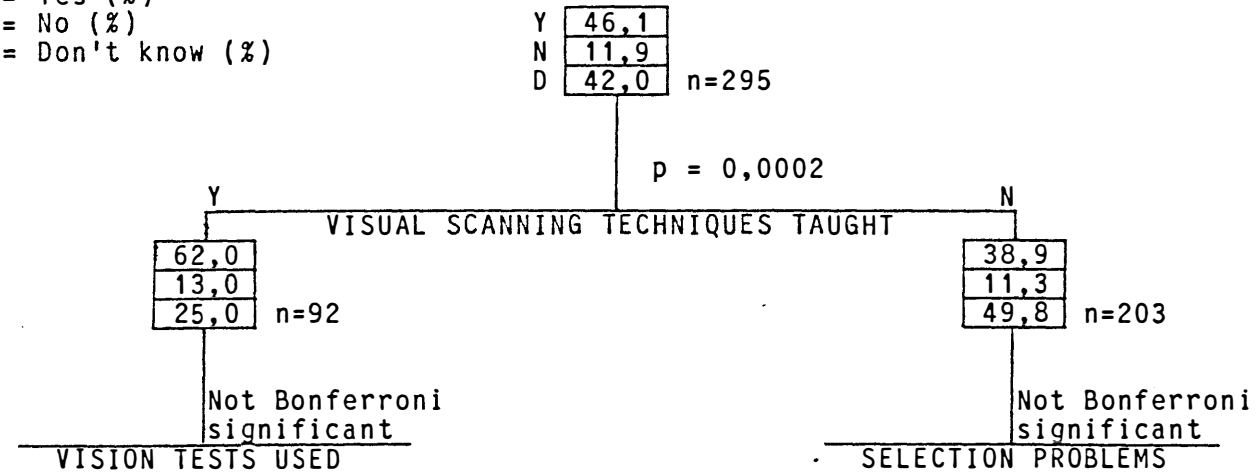


Figure 3. CHAID analysis, personnel questionnaire, test for production workers.

Key:
Y = Yes (%)
N = No (%)
D = Don't know (%)

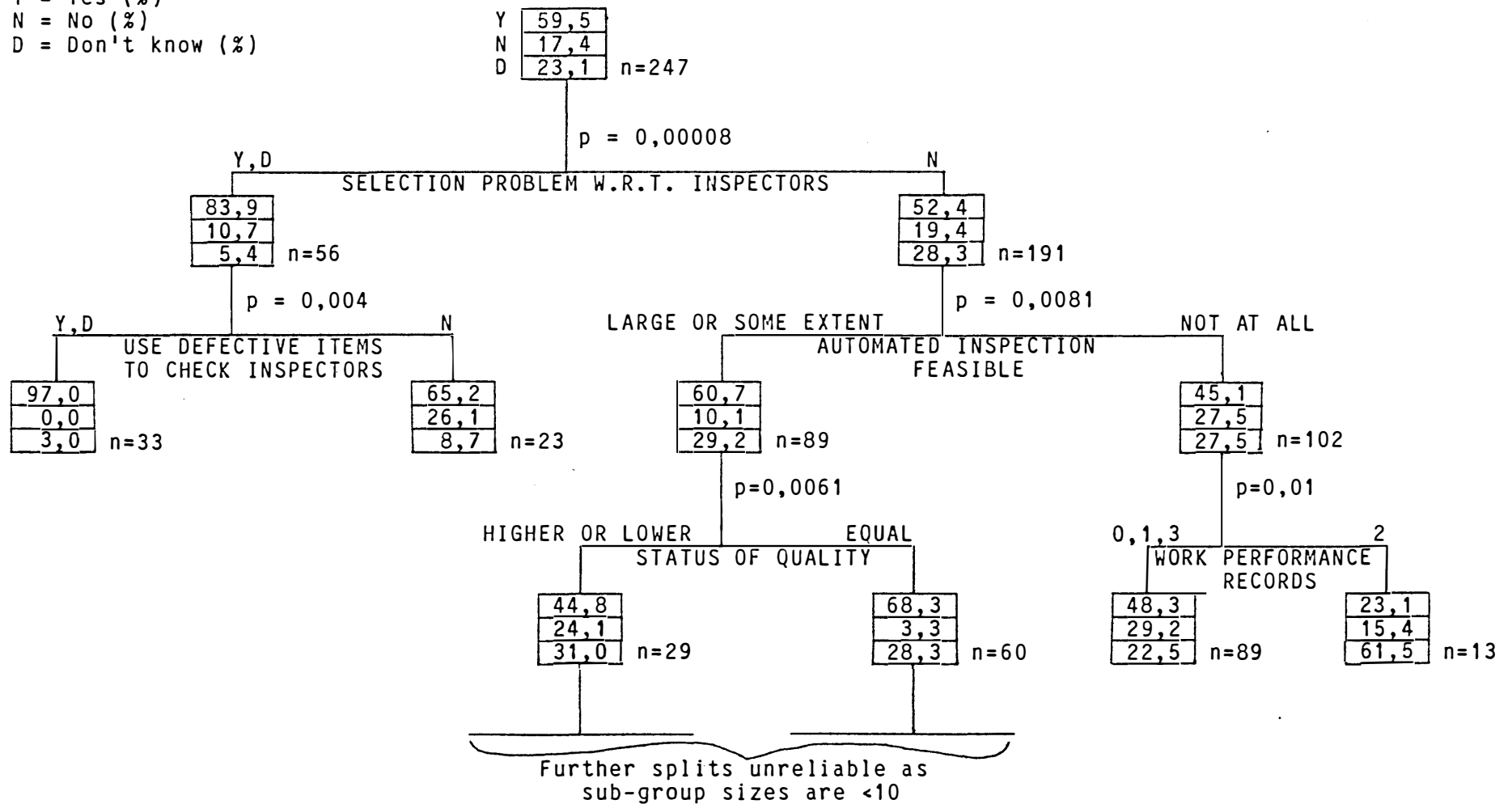


Figure 4. CHAID analysis, quality questionnaire, test for inspectors.

Key:
Y = Yes (%)
N = No (%)
D = Don't know (%)

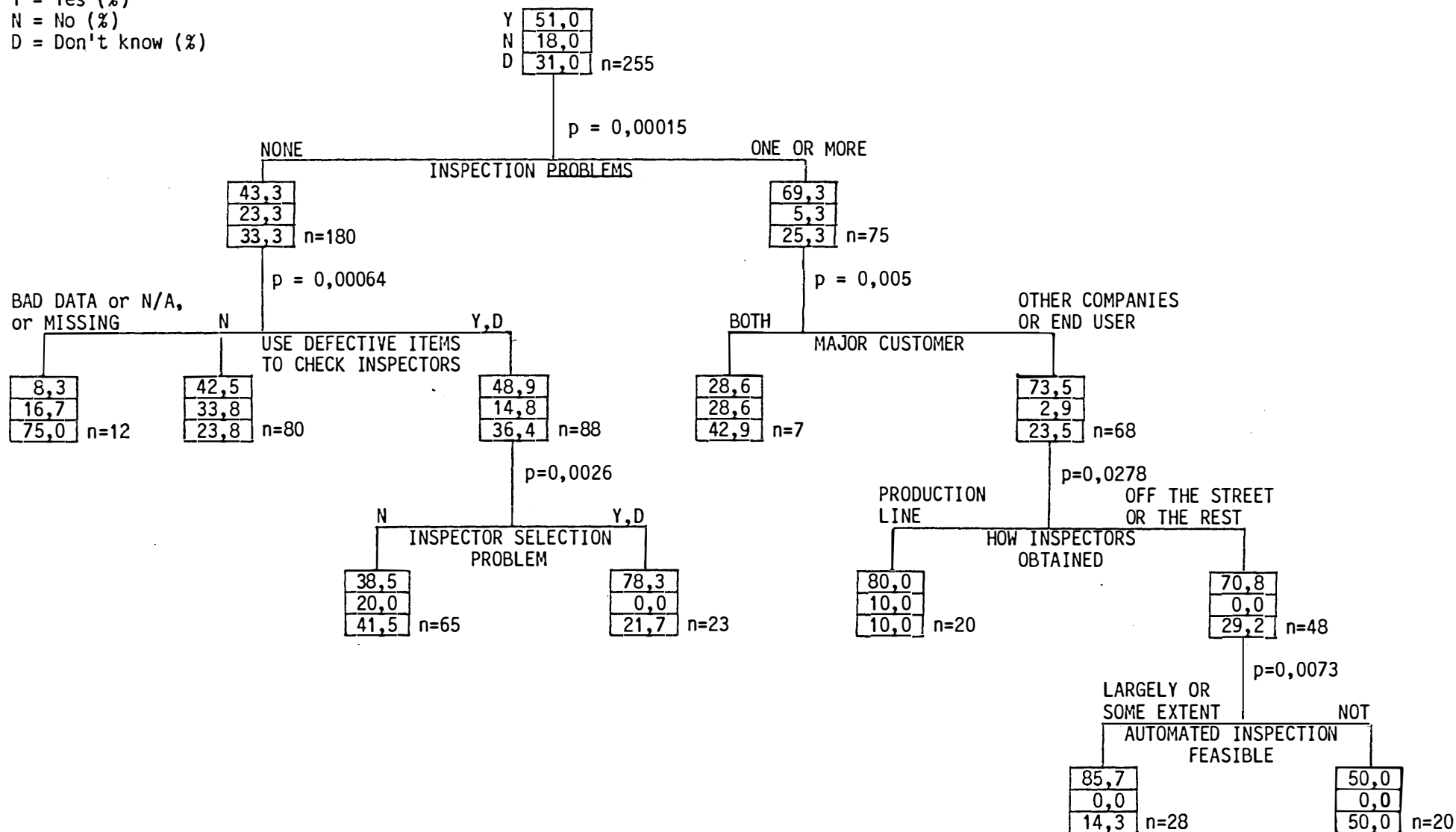


Figure 5. CHAID analysis, quality questionnaire, test for production workers.

The picture for the quality questionnaire (Figures 4 and 5) is more complicated. With respect to a test for inspectors, the most important factor is the perception of a selection problem, while for a test for production-line workers it is the presence of an inspection problem which is associated with a positive attitude towards a test. For both uses of a test, the willingness to use defective items to check on the performance of inspectors is associated with a positive attitude. This is an encouraging finding as this method is the only accurate way of measuring inspector performance, and thus these companies could be useful in the validation of the Visual Search Test (VST).

It is interesting that the feasibility of automated inspection is associated with a greater degree of interest in a test. Although this may superficially appear to be paradoxical, it is probably due to the production of large volumes of relatively simple items in these companies. Since human inspectors are inaccurate under such conditions, quality managers are expressing the hope that increased visual scanning speed in inspectors will improve the effectiveness of inspection.

Another interesting finding in the quality questionnaire is that, for companies with an inspection problem and which recruit inspectors from their own production lines, there is a very large degree of support for the use of a test for the selection of production-line workers.

4. DISCUSSION AND CONCLUSIONS

This survey has shown that there is a high degree of interest in a test of visual scanning efficiency for the selection of industrial inspectors and, to a lesser extent, production-line workers. This finding must, however, be viewed in the light of the rather moderate response rate of 20%. It is not possible to say whether those who did not return their questionnaires are against the use of a test or are neutral in attitude; however, one can, on the basis of the attitudes gleaned from

interviews and from this study, hypothesize that a sizeable proportion of these companies probably make use of production-line workers when obtaining new inspectors.

Interest in a test of visual scanning efficiency varies in a logical way with other variables so that it is possible to determine which companies are likely to employ the test in their selection procedures. Personnel managers who reported that their inspectors are taught visual scanning skills are very likely to be interested in a test. The use of one or more vision tests is also strongly associated with an interest in a test (although this factor does not emerge from the CHAID analysis, possibly because it correlates with the training of visual scanning skills).

Of those companies which do not train visual scanning skills, the keeping of work performance records is associated with a high degree of interest in a test. It is possible that companies which keep records are more sensitive towards the problems which inspectors can experience, or alternatively are more performance oriented.

Companies with a comprehensive selection procedure are more likely to be interested in a test of visual search efficiency than companies with a simple approach to selection. The CHAID analysis shows, however, that some companies which do not train visual scanning and do not keep inspector records, but which nevertheless have a comprehensive selection procedure, are less likely to be interested in a test.

Although not evident in the CHAID analysis, the presence of a selection or training problem is associated with an increased interest in a test amongst personnel managers.

The interest in a test of visual scanning efficiency by quality managers was strongly influenced by their perception of a selection problem. If in addition these managers were willing to use covert measures to evaluate inspector performance, then the level of interest in a test rose to an impressive level of 97%.

For those quality managers not reporting an inspector selection problem, the feasibility of introducing automated inspection is strongly associated with interest in a test for both inspectors and production-line workers. However, this should be interpreted with caution as it is possible that quality managers are hopeful that inspection problems can be solved by better selection alone, whereas high volume production may in many cases warrant automated inspection due to the inherent limitations of the human inspector under these conditions.

In order to test the finding of the CHAID analysis that the training of visual scanning skills is highly predictive of an interest in a test of visual scanning efficiency, 12 companies which reported that they trained visual scanning skills were contacted by telephone and were asked: (1) if they would allow the NIPR to test their inspectors using the VST; (2) if we could visit their factories to discuss validation of the VST, and (3) if they would use the VST if it were validated. Only one company was not at all interested, while eight gave unqualified approval to our testing their inspectors. Ten companies said they were interested in discussing validation with us. Four companies were interested in immediate use of the test, six would use it if it were proved valid, while only one would not use the test because they were satisfied with the recruitment of inspectors from production-line staff.

In the light of these results the researchers are of the opinion that validation of the VST in a number of different inspection environments should be carried out. The usefulness of the VST in the context of production as well as inspection should be determined. The results of this survey should be published in order to foster interest in the test.

REFERENCES

- Bellamy, L.J., & Courtney, A.J. Development of a search task for the measurement of peripheral visual acuity. Ergonomics, 1981, 24(7), 497-509.
- Connell, M. Visual search feasibility study : informal interviews. NIPR Office Report. 1986.
- Courtney, A.J., & Chan Hoi Shou. Simple measures of visual lobe size and search performance. Ergonomics, 1985, 28(9), 1319-1331.
- Drury, C.G. Integrating human factors models into statistical quality control. Human Factors, 1978, 20(5), 561-572.
- Gallwey, T.J., & Czaja, S.J. An evaluation of the Harris Inspection Test. Proceedings of the Human Factors Society - 25th Annual Meeting, 1981, 634-638.
- Gallwey, T.J. Selection tests for visual inspection on a multiple fault type task. Ergonomics, 1982, 25(11), 1077-1092.
- Golding, A.P. Search performance and peripheral visual acuity. (Report PERS-409). Pretoria: Human Sciences Research Council, 1986.
- Harris, D.H., & Chaney, F.B. Human Factors in Quality Assurance. New York: John Wiley & Sons, Inc., 1969.
- Harris, D.H. Development and validation of an aptitude test for inspectors of electronic equipment. Journal of Industrial Psychology, 1964, 2, 29-35.

- Juran, J. Inspector's errors in quality control. Mechanical Engineering, 1935, 57, 643-645.
- McKenzie, R.M. On the accuracy of inspectors. Ergonomics, 1958, 1(3), 258-272.
- Steenkamp, H.A. A guide to the data base of the B.M. registers. Pretoria: Bureau of Market Research, 1984.
- Wiener, E.L. Individual and group differences in inspection. In C.G. Drury and J.G. Fox (Eds.), Human Reliability in Quality Control. London: Taylor and Francis, 1975.

APPENDIX A

INSPECTOR SELECTION AND TRAINING QUESTIONNAIRE (Personnel)

To simplify this questionnaire, people who inspect, check, test or sort items on the basis of quality will be referred to collectively as 'inspectors'.

Please mark one or more blocks where applicable.

office use

- 1 What is the major business of your company?

Chemical		
Electrical		
Food		
Leather		
Metallurgical		
Metal-working		
Motor		
Pharmaceutical		
Textiles		
Clothing		
Printing and publishing		
Other (please specify):		

- 2 Does your company employ people who inspect, check, test or sort items on the basis of quality?

yes	no	
-----	----	--

- 3 How do you usually obtain new 'inspectors'?
(You may mark more than one.)

not applicable		
use production-line workers and train them		
use production-line workers without training		
recruit them 'off the street' and train them		
recruit them 'off the street' without training		
recruit fully-trained 'inspectors'		
other (please specify):		

- 4 What is the minimum educational level for new 'inspectors'?

not applicable		
Std 2 or lower		
Std 4		
Std 6		
Std 8		
Matric		
Post-matric		

- 5 Which of the following sources of information do you use when obtaining new 'inspectors'? (You may mark more than one.)

not applicable	
production-line performance record	
interviews	
reference checks	
supervisor ratings	
aptitude tests	
vision tests	
length of service	
academic record	
health record	
other (please specify):	

- 6 Which of the following aptitude tests/test batteries do you use when obtaining new 'inspectors' OR production-line workers? (You may mark more than one.)

aptitude tests not used	
High Level Battery	
Intermediate Battery	
Normal Battery	
Spot-the-Error	
Mechanical Comprehension (NIPR)	
Mechanical Insight (HSRC)	
Classification Test Battery	
FST/FSTA/FCT	
Continuous Symbol Checking	
NIPR Blox Test	
2- or 3-D Spatial Perception	
OTIS (ISCOR) or SITO (SATS)	
Personality tests	
Other (please specify):	

- 7 Are you satisfied with the performance of these tests?

yes	no	don't know	not applicable
-----	----	------------	----------------

- 8 Which of the following vision tests do you use when obtaining new 'inspectors' OR production-line workers? (You may mark more than one.)

vision tests not used	
visual acuity	
stereopsis (depth perception)	
phorias (muscle balance)	
colour vision	
visual fields	
other (please specify):	

- 9 Would a more task-relevant aptitude test such as a test of visual search efficiency be useful for the selection of:

(a) 'inspectors'? | yes | no | don't know |
(b) production-line workers? | yes | no | don't know |

The following statements reflect various opinions about the role of personnel selection in recruitment and training. Please indicate whether you agree or disagree with each statement.

- 10 Personnel selection is necessary so that production/'inspection' staff are obtained who have the potential to work at an acceptable level. | agree | disagree |

- 11 Suitable methods of selection should be employed to ensure that the costs of training production/'inspection' staff are kept to a minimum. | agree | disagree |

- 12 Lower staff turnover cannot recover the costs of selection testing. | agree | disagree |

- 13 Good production-line performance is a sufficient criterion for the selection of new 'inspectors'. | agree | disagree |

- 14 Specialised selection tests can reveal skills which are important to 'inspection' tasks. | agree | disagree |

- 15 Do you feel that you have a selection problem with special reference to your 'inspectors'?

| yes | no | don't know | not applicable |

- 16 Describe the nature of any selection problems you may have with 'inspection' staff.

- 17 In your 'inspector' training programme are any systematic visual scanning or searching techniques taught?

| yes | no | not applicable |

- 18 Estimate the percentage of trainee 'inspectors' who drop out of or fail the training programme.

not applicable	
1% or less	
2% - 4%	
5% - 9%	
10% - 19%	
20% - 39%	
40% or more	

- 19 Describe briefly the main reason/s for these dropouts/failures.

- 20 What do your records of the work performance of 'inspectors' consist of? (You may mark more than one.)

performance records not kept	
'inspector' errors (per hour, day, etc.)	
supervisor ratings	
other (please specify):	

- 21 You possibly employ 'inspectors' of both sexes and from different ethnic groups. Rank them in terms of the number in each sex/ethnic group category. (1=greatest number, 2=next greatest, etc.)

	rank
White males	
White females	
Black males	
Black females	
Coloured males	
Coloured females	
Asian males	
Asian females	

Thank you very much for your co-operation.

If you have no objection to revealing your name and feel that further contact with the NIPR could be beneficial, please write your name, title and telephone number on the answer sheet.

The results of this questionnaire are strictly confidential and will not be divulged to anyone outside the NIPR.

Please return this questionnaire to the NIPR within one month

APPENDIX B

INSPECTOR SELECTION AND TRAINING QUESTIONNAIRE
(Quality/Production)

To simplify this questionnaire, people who inspect, check, test or sort items on the basis of quality will be referred to collectively as 'inspectors'.

Please mark one or more blocks where applicable.

office use

- 1 What is the major business of your company?

Chemical		
Electrical		
Food		
Leather		
Metallurgical		
Metal-working		
Motor		
Pharmaceutical		
Textiles		
Clothing		
Printing and publishing		
Other (please specify):		

- 2 On a cost basis, what proportion of your product/s is manufactured in South Africa?

0% - 20%		
21% - 40%		
41% - 60%		
61% - 80%		
81% - 100%		

- 3 Do you predominantly supply items to other companies for further processing or do you supply to the end-user?

supply to other companies		
supply to the end-user		

- 4 Does your company employ people who inspect, check, test or sort items on the basis of quality?

yes		no	
-----	--	----	--

- 5 Estimate how many 'inspectors' you have in your company.

not applicable		
1 - 4		
5 - 9		
10 - 19		
20 - 49		
50 - 99		
100 or more		

- 6 To whom does the highest ranking Quality Assurance Officer report? (Give the title within the company).

- 7 Is checking for defects the responsibility of production-line workers?

not at all		
to some extent		
to a large extent		
exclusively		

- 8 Does your company have an annual programme of quality improvement?

yes	no	don't know	
-----	----	------------	--

The following questions may require different answers according to whether incoming inspection, in-process inspection or final inspection is practised. Please mark blocks with a 'y' if the answer is 'yes', 'n' if 'no', and 'n/a' if 'not applicable'.

- 9 Is quality checking done by automated equipment?

incoming	in-process	final	
----------	------------	-------	--

--	--	--	--

- 10 Do you do 100% inspection?

--	--	--	--

- 11 Do you do inspection by sampling?

--	--	--	--

- 12 Do any 'inspectors' use visual inspection only? (i.e., not using micrometers or other measuring instruments)

--	--	--	--

- 13 Do any 'inspectors' check items by means of a measuring instrument only?

--	--	--	--

- 14 Will fully automated quality inspection by means of 'intelligent' machines/robots be feasible within your company's operations?

to a large extent		
to a small extent		
not at all		

- 15 What status does Quality Assurance/Quality Control have in your company compared with Marketing, Finance or Production?

QA/QC has higher status		
QA/QC has equal status		
QA/QC has lower status		

- 16 How do you usually obtain new 'inspectors'?
(You may mark more than one.)

<input type="checkbox"/> not applicable	
<input type="checkbox"/> use production-line workers and train them	
<input type="checkbox"/> use production-line workers without training	
<input type="checkbox"/> recruit them 'off the street' and train them	
<input type="checkbox"/> recruit them 'off the street' without training	
<input type="checkbox"/> recruit fully-trained 'inspectors'	
<input type="checkbox"/> other (please specify):	

- 17 How long, on average, does an individual first have to work on the production-line before he is considered eligible to become an 'inspector'?

<input type="checkbox"/> not applicable	
<input type="checkbox"/> 5 months or less	
<input type="checkbox"/> 6 - 11 months	
<input type="checkbox"/> 1 - 2 years	
<input type="checkbox"/> 3 - 5 years	
<input type="checkbox"/> 6 - 9 years	
<input type="checkbox"/> 10 years or more	

- 18 Which of the following sources of information do you use when obtaining new 'inspectors'? (You may mark more than one.)

<input type="checkbox"/> not applicable	
<input type="checkbox"/> production-line performance record	
<input type="checkbox"/> interviews	
<input type="checkbox"/> reference checks	
<input type="checkbox"/> supervisor ratings	
<input type="checkbox"/> aptitude tests	
<input type="checkbox"/> vision tests	
<input type="checkbox"/> length of service	
<input type="checkbox"/> academic record	
<input type="checkbox"/> health record	
<input type="checkbox"/> other (please specify):	

- 19 Do you feel that you have a selection problem with special reference to your 'inspectors'?

<input type="checkbox"/> yes	<input type="checkbox"/> no	<input type="checkbox"/> don't know	<input type="checkbox"/> not applicable
------------------------------	-----------------------------	-------------------------------------	---

- 20 Describe the nature of any selection problems you may have with 'inspection' staff.

- 21 Would a more task-relevant aptitude test such as a test of visual search efficiency be useful for the selection of:

(a) 'inspectors'? | yes | no | don't know |
 (b) production-line workers? | yes | no | don't know |

The following statements reflect various opinions about the role of personnel selection in recruitment and training. Please indicate whether you agree or disagree with each statement.

- 22 Personnel selection is necessary so that production/'inspection' staff are obtained who have the potential to work at an acceptable level. | agree | disagree |
- 23 Suitable methods of selection should be employed to ensure that the costs of training production/'inspection' staff are kept to a minimum. | agree | disagree |
- 24 Lower staff turnover cannot recover the costs of selection testing. | agree | disagree |
- 25 Good production-line performance is a sufficient criterion for the selection of new 'inspectors'. | agree | disagree |
- 26 Specialised selection tests can reveal skills which are important to 'inspection' tasks. | agree | disagree |

- 27 What do your records of the work performance of 'inspectors' consist of? (You may mark more than one.)

not applicable	
performance records not kept	
'inspector' errors (per hour, day, etc.)	
supervisor ratings	
other (please specify):	

- 28 Would it be feasible to insert known defective items into your production-lines to evaluate 'inspector' errors?

| yes | no | don't know | not applicable |

- 29 Do you have any formal procedures for investigating the cause of poor performance of an 'inspector'?

| yes | no | don't know | not applicable |

- 30 Estimate the maximum number of items viewed by an 'inspector' per hour.

not applicable	
1 - 14	
15 - 29	
30 - 59	
60 - 119	
120 - 239	
240 - 479	
480 or more	

31 Describe any 'inspection' problems you may have.

32 What have you found to be the main causes of 'inspection' problems in your organisation? (Rank from 1 = most important to 10 = least important).

	rank
work environment (noise, lighting, etc.)	
high work rate	
difficult judgements required	
ignorance of required quality standards	
vague or complicated quality standards	
personnel selection problems	
insufficient inspection skills training	
lack of motivation	
pressure to ignore 'marginal' defects	
personal problems	

33 You possibly employ 'inspectors' of both sexes and from different ethnic groups. Rank them in terms of the number in each sex/ethnic group category. (1=greatest number, 2=next greatest, etc.)

	rank
White males	
White females	
Black males	
Black females	
Coloured males	
Coloured females	
Asian males	
Asian females	

Thank you very much for your co-operation.

If you have no objection to revealing your name and feel that further contact with the NIPR could be beneficial, please write your name, title and telephone number on the answer sheet.

The results of this questionnaire are strictly confidential and will not be divulged to anyone outside the NIPR.

Please return this questionnaire to the NIPR within one month using the envelope provided.

HSRC PUBLICATION LIST

A complete list of HSRC publications or a list of publications of a particular Institute of the HSRC is available from the Head: Technical Services

HUMAN SCIENCES RESEARCH COUNCIL RAAD VIR GEESTESWETENSKAPLIKE NAVORSING

President	Dr J.G. Garbers	President
Deputy Presidents	Dr H.C. Marais, Dr J.D. Venter	Adjunk-presidente
Vice-Presidents	Dr K.F. Mauer, Prof. D.J. Stoker	Vise-presidente
Executive Director: Administration	J.G.G. Gräbe	Uitvoerende Direkteur: Administrasie
Chief PRO	Dr G. Puth	Skakelhoof

Functions of the HSRC

The HSRC undertakes, promotes, supports and co-ordinates research in the field of the human sciences. It also determines research priorities, disseminates the findings of human sciences research, facilitates and evaluates the implementation of research findings, stimulates the training of researchers, places the full spectrum of human sciences disciplines at the service of the inhabitants of the RSA and promotes science in general.

Institutes

Institute for Communication Research (ICOMM)
Institute for Educational Research (IER)
Institute for Historical Research (IHR)
Institute for Manpower Research (IMAN)
National Institute for Personnel Research (NIPR)
Institute for Psychological and Edumetric Research (IPER)
Institute for Research Development (IRD)
Institute for Research into Language and The Arts (IRLA)
Institute for Sociological and Demographic Research (ISODEM)
Institute for Statistical Research (ISR)
Bureau for Research Support Services (BRSS)
Administration

Head office

Private Bag X41, Pretoria 0001
Republic of South Africa
Telegrams RAGEN
Tel. (012) 202-9111
Telex 3-20893 SA

NIPR

P.O. Box 32410, Braamfontein 2017
Republic of South Africa
Telegrams NAVORSPERS
Tel. (011) 339-4451
Telex 4-25459 SA

Regional offices

Western Cape, Private Bag X5, Roggebaai 8012
Tel. (021) 419-2572/3/4/5 Telex 5-22260 SA
Natal, P.O. Box 17302, Congella 4013
Tel. (031) 815970 Telex 6-28567 SA
NIPR Eastern Cape, P.O. Box 1124, Port Elizabeth 6000
Tel. (041) 53-2131 Telex 2-43203 SA

Funksies van die RGN

Die RGN onderneem, bevorder, ondersteun en koördineer navorsing op die gebied van die geesteswetenskappe, bepaal navorsingsprioriteite, versprei die resultate van geesteswetenskaplike navorsing, vergemaklik en evalueer die implementering van die resultate van navorsing, stimuleer die opleiding van navorsers, stel die volle spektrum van dissiplines in die geesteswetenskappe ten diens van die inwoners van die RSA en bevorder die wetenskap in die breë.

Institute

Instituut vir Geskiedenisnavorsing (IGN)
Instituut vir Kommunikasie-navorsing (IKOMM)
Instituut vir Mannekragnavorsing (IMAN)
Instituut vir Navorsingsontwikkeling (INO)
Instituut vir Opvoedkundige Navorsing (ION)
Nasionale Instituut vir Personeelnavorsing (NIPN)
Instituut vir Psigologiese en Edumetriese Navorsing (IPEN)
Instituut vir Sosiologiese en Demografiese Navorsing (ISODEM)
Instituut vir Statistiese Navorsing (ISN)
Instituut vir Taal- en Kunstenavorsing (INTAK)
Buro vir Ondersteunende Navorsingsdienste (BOND)
Administrasie

Hoofkantoor

Privaatsak X41, Pretoria 0001
Republiek van Suid-Afrika
Telegramme RAGEN
Tel. (012) 202-9111
Teleks 3-20893 SA

NIPN

Posbus 32410, Braamfontein 2017
Republiek van Suid-Afrika
Telegramme NAVORSPERS
Tel. (011) 339-4451
Teleks 4-25459 SA

Streekkantore

Wes-Kaap, Privaatsak X5, Roggebaai 8012
Tel. (021) 419-2572/3/4/5 Teleks 5-22260 SA
Natal, Posbus 17302, Congella 4013
Tel. (031) 815970 Teleks 6-28567 SA
NIPN Oos-Kaap, Posbus 1124, Port Elizabeth 6000
Tel. (041) 53-2131 Teleks 2-43203 SA

ISBN 0 7969 0519 3