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pag 104 - 120

DISCRETE OR CONTINUOUS MEASUREMENT:WHAT DIFFERENCE DOES IT MAKE ?

A case study of the effect of alternative measurement procedures on the estimation of structural parameters.'

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ABSTRACT.

Normally category scaling is used in survey research to obtain scores from the respondents. The results of such a study are compared with results obtained by an alternative measurement procedure (the comparison method). It is shown that the alternative procedure provides more precise information .Besides this it turns out that the strengths of the effects of the major variables in the study are quite different from those found when using category scales. These results make the commonly accepted results doubtful and suggest improvement of the standard procedures.

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INTRODUCTION.

In surveys one method of measurement is used almost exclusively: category scaling. Typical examples of survey studies using category scaling are the voting studies done in different countries. In these studies the vote or preference for a candidate or party is explained by party identification, confidence in the candidate, issues and several other variables (Campbell et al. 1960, Ch. VI; Goldberg 1966, Brody et al. 1972, Schulman et al. 1975, Page et al. 1979, Markus et al. 1979). Mostly three point scales are used, indicating the respondents attitude or opinion towards party, candidate or issue etc.

The category scaling procedure however is not without problems. Some of these problems are:

(1) The level of measurement is not higher than ordinal, but often statistical analysis is used which requires at least interval level measurement. And although it is assumed by some (Asher 1976, p.66; Bohrnstedt and Carter 1971) that this may not be a very serious drawback in analysis, others (Lodge 1981, p.71; Wilson 1971) maintain it is.

(2) In many cases different questions are asked to raise the reliability. Very often however these questions don't measure the same variable. The combination of the scores of these different questions then leads to a higher reliability but a lower validity of the measurement (Duncan, 1979, p.252; Wendt, 1979, p.522; Piazza, 1980, p.590; Saris 1980, p.146). In order to maintain the validity one would prefer to repeat the same measurement (which is the method used in the exact sciences). This is however hardly possible with questions of the category type, because it is quite easy for the respondents to remember the answers they gave before (Bruinsma et al., 1980, p.126).

(3) The category scale forces the respondent to give his answers in a limited number of categories which may result in loss of information and not-homogeneous extreme categories (Lodge et al.,1979, p.57).

(4) Category measurement of variables that are of a continuous character makes statistical control less optimal, as was indicated by Blalock (1964, p.151). And Olsson (1979, p. 498) has shown that models are rejected more often than expected, when continuous variables are categorized. This is of course a serious problem for the analysis.

These problems seem to make the research into other measurement procedures worth trying. The points we want to discuss in this paper are:

1. Can the respondents give more information than can be conveyed using the category scaling procedure ?
2. If so do the results obtained with the other methods also lead to substantially different results ?

The answers to these two questions will be given using data from a study by Lodge et al.(1979, p.62). Before we turn to the data however, we have to say something about the measurement procedure which can be used as an alternative to categorical judgment procedures, the comparison method.

THE COMPARISON METHOD.

This scaling procedure originates in psychophysics. Research into the relationship between physical stimuli and responses has been done for more than a century. For a great number of stimuli the relationship turned out to be a 'powerfunction' (Stevens 1975, p.13; Marks 1974 and Gescheider,1975).

We will however not go into the comparison method (or psychophysical scaling) using physical stimuli and refer to Stevens (1975, Ch.3,4) for an overview of research employing that kind of stimuli.

As an example of the task of the respondent when using the comparison method with social science stimuli we will give the instruction for one of the questions of which the data are used in this study. Before the respondents answered the substantive questions they had practised the comparison method with the assignment of numbers to different linelengths (magnitude estimation) and the drawing of lines to different numerical stimuli (line production). Part of the instruction was read to the respondents and this part is presented here between brackets.

Suppose the presidential election were to be held tomorrow. Which of the two would you be most likely to vote for?
(Please make your choice)

____Gerald Ford

____Jimmy Carter

____Undecided

(Now draw a line to express the opinion of someone who was unsure as to whom to vote for.)

Standard line

(If you are also unsure, you draw a line as long as your standard line. If on the other hand, you are almost certain that you would vote for your candidate, draw a very long line relative to your standard. If you only favor your candidate a little bit over the other candidate, draw a line only somewhat longer than your standard. The more intensely you favor one candidate, the longer your response line should be.)

Response line

(Next page. Write a number to represent the number of someone who was undecided as to which of the candidates to vote for. Then write a number, relative to your standard, to express how much you support your choice.)

standard number____

response number____

As can be seen two modalities were used for this study, line production and the assignment of numbers (magnitude estimation). When more than one response modality is used for one set of social stimuli the experiment is called multimodality matching. For more details concerning these procedures we refer to Lodge et al. (1975, 1976, 1981), Saris et al.(1980) and Neijens et al.(1981).

It can be derived that the relationship between the responses on different modalities for the same stimuli is a powerfunction and that a linear relationship is obtained by taking the logarithm of the responses. It can also be derived that for a multimodality experiment a model can be used that is a specific case of the congeneric test model (Saris et al. 1980, p.8).

The methode of measurement described above, makes it possible to express opinions, attitudes etc. on a continuous scale. Therefore the comparison method can be used to answer the questions raised in the introduction.

1. Can the respondents give more information than can be conveyed using the category scaling procedure ?
2. If so do the results obtained with the other methods also lead to substantially different results ?

In the next section these questions will be answered. The data on which this study is based are discussed first.

THE DATA.

The data were collected by the Laboratory for Behavioral Research during 1976,a presidential election year in the USA. In October an interview was conducted with 105 respondents, all living in Suffolk County, New York. Complete data were available for 60 respondents and our analyses were done for these respondents only. This sample is of course too small and too biased to permit generalizations to the population of the US, but it can be used to compare the results for different measurement procedures for the same respondents, which is the aim of this study.The reason for this is that it is very unlikely that this subpopulation is completely different from other people, with respect to response behavior. According to our opinion the effects found can therefore be generalized to any other population that is studied by survey research. The questions asked, are identical to the questions of the SRC election surveys and each item was presented word for word, option by option, exactly as specified in the codebook. In this study we will use three variables, that are very often used in election studies:Party Identification,Confidence in the Candidate and, of course, Candidate Preference (or the Vote).

Each variable was measured three times, using category scaling and two comparison method response modalities: magnitude estimation and line production.The questions and instructions as used in the interview, are described by Lodge et al. (1979, p.52). The coding and transformations of the variables are discussed in the appendix.

The means, standard deviations, skewnesses and correlations for these three times three variables and of the geometric mean of the line and number responses are presented in Table 1.

	PIc	CCc	CPc	PIl	CCl	CPl	PIn	CCn	CPn	PIg	CCg	CPg
PIc	1											
CCc	.74	1										
CPc	.87	.83	1									
PIl	.80	.72	.74	1								
CCl	.69	.84	.75	.76	1							
CPl	.73	.74	.80	.82	.88	1						
PIn	.77	.73	.72	.92	.74	.77	1					
CCn	.67	.81	.73	.77	.94	.90	.76	1				
CPn	.70	.73	.75	.78	.85	.95	.76	.90	1			
PIg	.80	.74	.74	.98	.76	.81	.98	.78	.79	1		
CCg	.69	.84	.75	.78	.97	.90	.76	.99	.88	.79	1	
CPg	.72	.74	.78	.81	.87	.99	.77	.91	.99	.81	.90	1
me	2.18	.13	2.18	.13	.22	.14	.08	.32	.17	.11	.27	.16
sd	.95	.83	.95	.37	1.13	.68	.37	1.14	.74	.36	1.12	.70
sk	-.38	-.29	-.38	.59	.01	.57	.23	.51	.98	.46	.25	.82

Table 1.Datamatrix with means (me), standard deviations (sd), skewness (sk), and the correlations for the twelve variables employed in this study. PI=Party Identification, CC= Confidence in the candidate, CP= candidate Preference. Subscripts: c=category, l=line, n=number responses, g=geometric average of the line and number responses.N=60

CATEGORICAL INFORMATION OR MORE ?

In psychophysics it is generally accepted that people are capable of giving meaningful responses on a continuous scale for the type of stimuli used in that kind of research (loudness of sound, brightness of light, taste of sugar-solutions,length of lines etc.)

According to Krantz (1972, p.175) the lawlike empirical psychophysical relationships can be explained by the fact that the subjects store their sensations also in the form of scores on continuous scales. But in social science research many people are tempted to expect that subjects can at most give ordinal information. Much attention is therefore given to the development of ordinal measurement and of methods of analysis suited for that type of data. It seems however worthwhile to see whether these modest expectations with respect to the capabilities of the respondents are justified. We should therefore test if it can

reasonably be assumed that the respondents can give more information than can be recorded by category scaling. Before that however we have to be confident that both types of measurement measure the same variables and that we are not measuring something else when the mode in which the responses have to be given differs. To test this we categorized the continuous responses of the line and number scores of each variable, using the distribution of the original category response to the same question. For example : the line responses for the variable Candidate Preference were devided into a three point category scale with (as far as possible) the same distribution as the category responses to the same question. The correlations between these categorized continuous scores and the original category responses should be 1 if the comparison method is measuring the same variable. The mean value of these correlations turned out to be .972 which we consider as close enough to unity to justify the conclusion that both types of measurement measure the same variable. Now we are confident on this point, we can go on to answer the first question whether we obtain more information with the continuous measurement of the comparison method.

If the comparison method provides as much information as much information as the category scale the scores on the line and number responses will not differ much from the category judgements and the correlations between the three measures will be approximately the same. If there is more information much higher correlations between the continuous variables than between continuous and category scores can be expected. The reason for this is that there will still be a lot of systematic variation within each category which remains unexplained. As can be seen in Table 1, it turns out that the correlations between the category scores and the line respectively number scores for the same variables are considerably lower than between the line and number scores. The average correlation between category and line respectively number scores is .78 and between lines and numbers it is .94. And this difference in the correlations is indeed caused by variation in the categories which remains unexplained. This can be seen in the scatterdiagrams between these scores for the variable Confidence in the Candidate that are presented below as an example. When the line respectively number scores are plotted against the category scores a quite large variation is present in each category (Diagrams 1 and 2). When however the line and number scores are plotted against each other, this unexplained variation diappears. Therefore we can say that the respondents have systematic information available that they cannot express in the category scale, but can express when they use the comparison method.

Combining the results we can give an affirmative answer to the first question in the introduction : respondents can give more information than can be recorded by category scaling, when the comparison method is used.

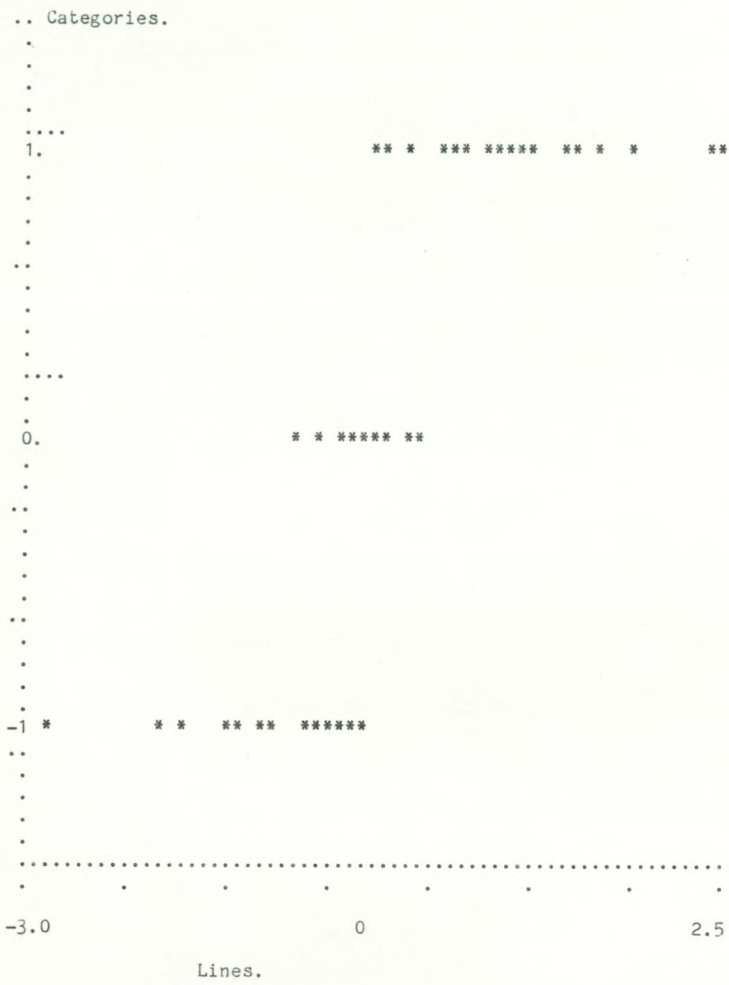

Diagram 1.Scatterdiagram of the line and category responses for the 'Confidence in the candidate ' variable.N=60.

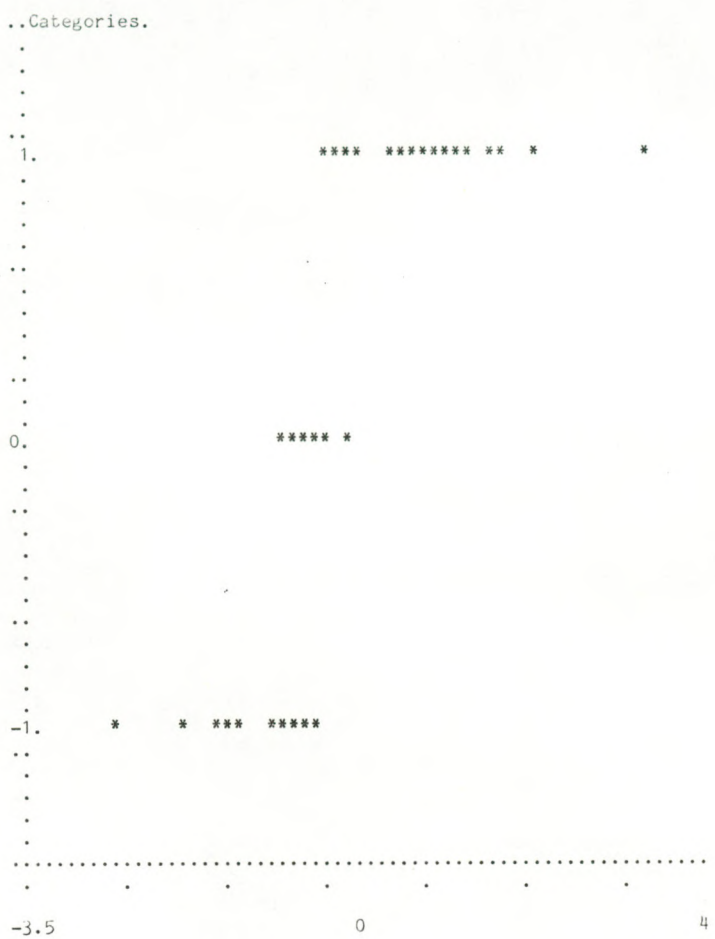

Diagram 2.Scatterdiagram of the number and category responses for the 'Confidence in the candidate ' variable.N=60.

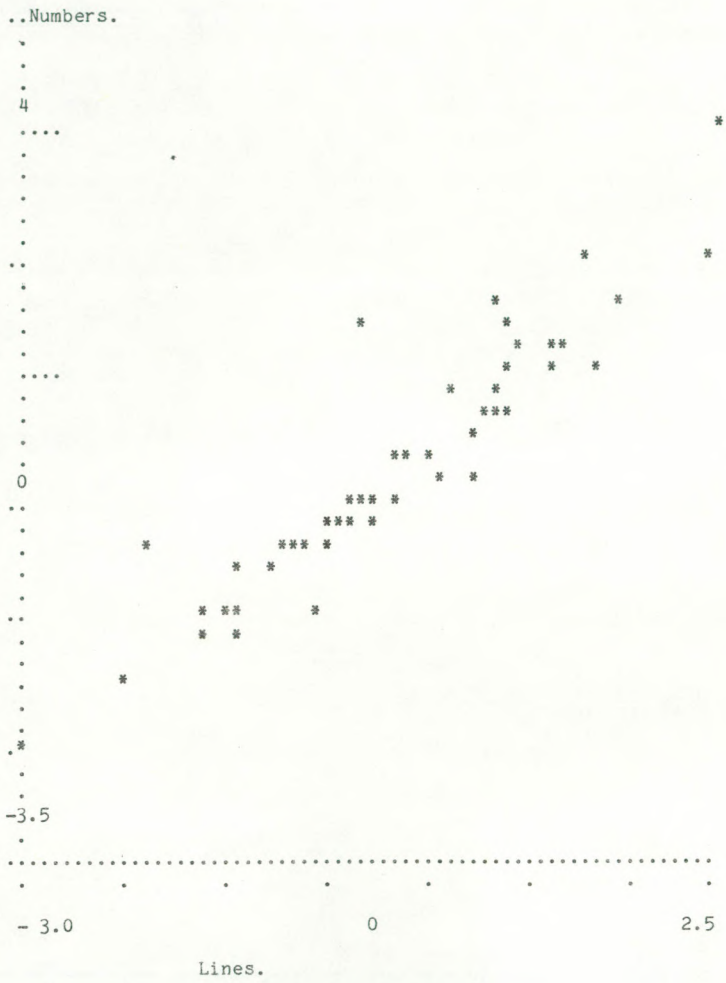

Diagram 3.Scatterdiagram of the line and number responses for the 'Confidence in the candidate ' variable.N=60.

DO THE DIFFERENT PROCEDURES LEAD TO DIFFERENT SUBSTANTIAL RESULTS ?

After answering the first question in an affirmative way we can turn to the second question :Do the results obtained with different methods also lead to substantially different results ? A first step to answer this question can be made by comparing the correlations between the variables when measured in different ways. It is possible to use the Lisrelprogram (Joereskog and Soerbom, 1978) to test if different variance-covariance matrices can be considered as equal, except for random error. The variances are very different however, so we prefer to test whether the correlation matrices remain the same from method to method while the variances may vary.

Two hypotheses were compared, in the first the correlation matrices for all three kinds of responses (categories, lines and numbers) are hypothized to be equal. In the second only the correlation matrices of the line and number responses are assumed to be equal and the correlation matrix for the category responses can vary. In both cases the variances are estimated independently for the three types of scores. This gives a test whether or not the different measurement methods produce the same relationships between the variables. The results of the goodness of fit test for the two hypotheses are summarized in the top half of Table 2.

Although both models have an acceptable fit, which might be due to the small N, Table 2 indicates that the second hypothesis fits significantly better. The difference in chi-square is 8.27 with 3 degrees of freedom, which is significant at the .05 confidence level. This leads to the conclusion that the line and number responses do produce correlations between the variables that are significantly different from those produced by the category responses.

for continuous line and number responses		
	Rlin=Rnum=Rcat	Rlin=Rnum≠Rcat
chi sqare	10.5	2.23
degrees of freedom	6	3
probability	.10	.53
for categorized line and number responses		
	Rlin=Rnum=Rcat	Rlin=Rnum≠Rcat
chi square	1.14	.53
degrees of freedom	6	3
probability	.98	.91

Table 2.Goodness of fit statistics for the two models concerning the equality of the correlation matrices for the line (Rlin), number (Rnum) and category responses (Rcat) respectively category and categorized line and number responses.

The same test could of course also be done with the categorized continuous scores discussed above. In the bottom half of Table 2 the test statistics for these variables are presented. The difference found for the different measurement methods has disappeared after categorization of the continuous scores.

In this case the fit of the first, more restrictive, model is not significantly different from that of the second model (difference in chi-square is .61 with 3 degrees of freedom). This could of course be expected since the correlations between the categorized line and number scores and the original category scores were .972 in average.

Given these differences in the correlations for the original scores it is of interest to see whether they lead to substantially different estimates of the effects. As said in the introduction the variables used in this study have been used extensively in election studies in the United States. The causal models in which they have been employed usually contained more variables but the relationships between the three variables in the present study were often assumed to be as in the model depicted in diagram 4 (Niemi and Weisberg, 1976,p.202 ; Goldberg 1969, p.919).

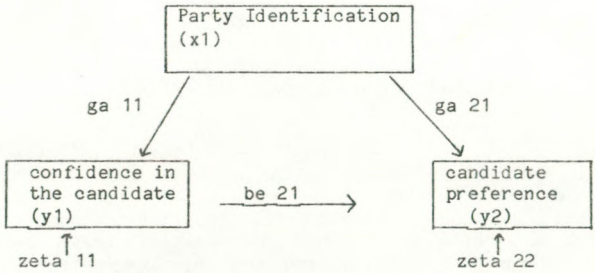

Diagram 4.Path diagram of the structural model for three election study variables.

The effects of the variables on each other will be estimated from the four datasets obtained by:

1. Categorical responses.
2. Responses obtained by the comparison method. 1)
3. Geometric averages of line and number scores.
4. Combination of the line and number scores in a measurement model with latent variables.

We expect the analysis to improve in this order.From 1 to 2 because of the fact that more information is used, and no arbitrary categorization is introduced and therefore statistical control is better possible (Blalock, 1964, p.151).
From 2 to 3 since measurement error (Goldberger, 1973) is partially eliminated by taking averages in the 3th case.
From 3 to 4 because the results are completely corrected for measurement error. How this can be done in practice is discussed by Joereskog (1973). A necessary condition is that more than one independent observation is available for each variable of interest. This procedure can therefore be used for the data obtained by the comparison method. The estimates of the parameters of the model for the four different data sets are presented in Table 3.

	responses expressed in category	lin+num equal	geom. mean	measurement model
	1	2	3	4
ga 11	.742	.761	.785	.810
ga 21	.565	.266	.259	.251
be 21	.408	.684	.699	.726
r1 squared	.550	.580	.616	.657
r2 squared	.828	.815	.840	.885

Table 3.The parameters of the structural model depicted in diagram 4. 1: responses expressed in categories, 2:lines & numbers estimated as equal 1), 3: geometric averages of the line and number responses, 4: employment of line and number responses in a measurement model with latent variables.

When we look at the results we find that there are considerable differences for the parameters obtained for the different datasets. The results show that the effect of Party Identification on Candidate Confidence (ga 11) becomes larger than suggested by the category-scale data. The difference in the estimates of the effect of Candidate Confidence on Candidate Preference (be 21) is even larger:instead of .408 it becomes .726. On the other hand the effect of Party Identification on Candidate Preference (ga 21) might be overestimated when using category scaling, since this effect is considerably reduced by improvement of measurement and controling for measurement error. In this dataset this effect goes from .565 to .254; what is only just significant. These results clearly demonstrate that we can get a quite wrong impression of the strength of the effects of these variables on each other when categorical measurement is used. It is important to realize that these differences in the estimates must be caused by the extra information obtained with the continuous measurement of the comparison method.

Given the results of this section the answer to the second question of this study can also be affirmative:the different measurement procedures produce quite different substantive results in analysis.

DISCUSSION.

In this study two types of measurement procedures have been compared, (category scaling and the comparison method), to answer two questions.The first question was:

1. Can the respondents give more information than can be conveyed using the category scaling procedure ?

And after having shown that both methods measure the same variables (by categorizing the continuous responses of the comparison method) it was shown that indeed more information can be given by respondents than can be recorded by category scaling. This extra information can be recorded when the comparison method is employed.

The second question:

2. If so do the results obtained with the other methods also lead to substantially different results ?

could also be answered positively. It was shown that the obtained estimates of the parameters are also very different, depending on the measurement procedure used. In the past much time was spend on the choice of the proper estimation procedure in order to obtain in some way optimal estimation of the parameters. This study shows that the choice of a proper measurement procedure is at least as important since it can have considerably effects on the results.

When we take a look at the advantages of the comparison method compared to category scaling (see introduction) on the basis of the results of this study and others we find that:

(1) The level of measurement is loginterval according to Stevens (1966) , Marks (1974) and Saris et al. (1980, p.9).

(2) In a multimodality experiment repeated measurement of the same stimulus is obtained. This makes it possible to raise the reliability by repeated measurement without affecting the validity (Saris 1980, p.15). In this study this was done in two ways. First by taking the geometric average of the line and number responses and using these averages as data. This averaging reduces the amount of measurement error. A second, more informative and optimal method is using the line and number responses of the comparison method as indicators in a model with latent variables. This can be done with the Lisrel program (Joereskog, 1973). This type of analysis provides estimates of the structural model but also of the reliability of the indicators. Further it gives an overall goodness of fit test, which permits us to say whether the indicators measure the same variables or not.

(3) No investigator-imposed constraints are placed upon the response, thereby enabling the respondents to express (and investigators to record) judgments as precisely as possible. If an individual is capable of distinguishing between two stimuli, that information can be conveyed through psychophysical scaling. And in this study it was shown that, with the variables used, respondents are capable of giving extra information.

(4) Because the responses can be given on a continuous scale, the control for spuriousness in multivariate analysis can be optimal. This gives a more valid insight in the strength of the effects the different variables may have on each other. In this study an example of this was the effect of Party Identification on Candidate Preference, which became much smaller when utilizing continuous measurement.

This overview suggests that the comparison method should be used on a nation wide scale in order to get a better impression of the effects of the variables used in this study. Our hypothesis from this study is that the results may be quite different from what has been found sofar for categorical variables.

APPENDIX.

Some transformations and recodes of the data were necessary and will be described below. For the Party Identification variable the following recodes were performed. The obtained 7 point category scale was transformed in a three point scale, as is commonly done for analyses (Niemi and Weisberg, 1979, p.180,199). The three Republican scores (strong republican, weak republican, leaning republican) were combined into one and the same was done for the Democratic scores. The effect of this recode on the correlations with the other variables is minimal. Further it maybe should be mentioned, that the effect of categorization of continuous variables on the relationships with other variables might be caused mainly by the skewness of the resulting distributions and not by the number of categories (Olsson 1979, p.498). The logarithm of the responses of the comparison method was taken in order to linearize the relations (Saris 1980, p.5). For these responses another recode was necessary because only the strength of the opinion is measured and not the direction. This makes the Republicans and the Democrats indistinguishable. The recode was that when someone declared himself a Republican in the category question his psychophysical responses in lines and numbers were given a negative sign.

The variable Candidate Preference was asked for pairs of candidates In the present study only the pair that actually did run for president as nominees of the two major parties, Ford and Carter, were included in the analyses. For the categorical questions this gives us again a three point scale:
Ford-undecided-Carter.
On this variable a transformation was performed similar to that for Party Identification:those who selected Ford were given a negative sign for their line and number responses.

The third variable is Confidence in the Candidate as a President. This question was asked seperately for each candidate, whereas the other variables have both the candidates or both the parties on one dimension. We found that the two original variables, confidence in Ford and confidence in Carter, when employed separately in the analysis did not have a distinctive effect on the Candidate Preference or voting decision of the respondent. We decided to use a combination of the two confidence variables, based on the following considerations. If a respondent has confidence in both candidates we expect that he has to base his vote on other considerations (as the candidate's party for instance). And we expect the same if he doesn't have confidence in any of the candidates.So the confidence variables will only have an effect if they are not equal. First this combination will be described for the category responses.Both variables, 'confidence in Ford as a president' and 'confidence in Carter as a president' are dichotomies and the combination of the two gives us thus four possibilities.

-confidence in Carter:yes	confidence in Ford:no	code:1
-confidence in Carter:yes	confidence in Ford:yes	code:0
-confidence in Carter:no	confidence in Ford:no	code:0
-confidence in Carter:no	confidence in Ford:yes	code:-1

The four possibilities are coded such that a new variable results: 'Confidence in the candidate'. It combines both confidence variables into a three point category scale, with an extreme score for each candidate when the respondent has more confidence in him.

To obtain the psychophysical scores of the 'Confidence in the candidate variable the following transformations were done. As the psychophysical . scores again only contain the strength of the opinion, the scores of the two original variables were given a negative sign when the categorical response for that question was 'not confident'. The combination of the two scores (recoded if appropriate) into the 'Confidence in the candidate' variable consisted of subtracting the score for Ford from the score for Carter. Thus if a respondent has expressed more confidence in Carter in his psychophysical scores he will have a positive score and if his confidence in Ford is greater, his score will have a negative sign.

NOTE.

1) As the correlations based on the line and number scores were not significantly different from each other, (see Table 2) we decided to use the estimated correlationmatrix from the Lisrelrun where the correlations of line and number scores were tested on equality, as data. This restricts the number of presentations.

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