

# Categorisation errors and differences in the quality of questions across countries

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## Abstract

The European Social Survey (ESS) has the unique characteristic that in more than 20 countries the same questions are asked and that within each round of the ESS Multitrait-Multimethod (MTMM) experiments are built in to evaluate the quality of a limited number of questions. This gives us an exceptional opportunity to observe the differences in quality of questions over a large number of countries. The MTMM experiments make it possible to estimate the reliability, validity and method effects of single questions (Andrews, 1984; Saris et al., 2004; Saris and Andrews, 1991). The product of the reliability and the validity can be interpreted as the explained variance in the observed variable by the variable one would like to measure. It is a measure of the total quality of a question.

These MTMM experiments showed that there are considerable differences in measurement quality across countries. Because these differences in quality can cause wrong conclusions with respect to differences in relationships across countries this paper studies the possible effect that categorisation can have on the quality. We assume that each category represents a range of values of a latent continuous variable that have been grouped together, causing grouping errors. It depends on the distribution of values of the latent response variable in each category whether the intervals between the categories are equally far apart. If they are not, there is also transformation error. Both grouping and transformation are sources of measurement error due to categorisation and therefore possible explanations for differences in the quality of questions. The results show that this effect is quite strong.

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# Introduction

Measurement error can invalidate conclusions drawn from cross-country comparisons if the errors differ from country to country. For this reason, when different groups such as countries are compared with one another, attention should not only be given to absolute levels of errors, but also to the differences between the groups. Different strategies have been developed to deal with the problem, for example within the context of invariance testing in the social sciences (Jöreskog, 1971), differential item function in psychology (Muthén and Lehman, 1985), and differential measurement error models in epidemiology and biostatistics (Carroll et al., 1995).

In the ESS a lot of time, money, and effort is spent to make the questions as functionally equivalent across countries as possible (Harkness et al., 2002) and to make the samples as comparable as possible (Häder and Lynn, 2007). Nevertheless, considerable differences in quality of the questions can be observed across countries. To study these differences is important because they can cause differences in relationships between variables in different countries which have no substantive meaning but are just caused by differences in quality in the measurement (Saris and Gallhofer, 2007a). In order to avoid such differences it is also important to study the reasons behind them.

In an earlier study, we investigated differences in translations, differences in the experiments' design, and differences in the complexity of the question as possible reasons for differences in question quality across countries (Oberski et al., 2007). Because these factors did not explain much of the differences we now consider differences in categorisation errors as a source of differences between countries.

Categorisation errors arise when a continuous latent response variable is split up into different categories. This leads to two types of errors: grouping and transformation errors (Johnson and Creech, 1983). Grouping errors occur when different opinions are grouped together in the same category. Transformation errors occur when the differences between the numerical values of adjacent categories do not correspond to equal distances between the means of the latent response variables in those categories. If, for instance, the distances between categories are not the same in two different countries, this can lead to larger categorisation errors in one country than another, leading in turn to lower question quality. This is why the distance between categories is a possible explanation for differences in question quality across countries.

The first section will discuss the models we use to estimate the measurement error coefficients of survey questions starting from a basic response model. We will then present the data from the European Social Survey that will be used. A short discussion of previous results follows. First the estimates from our previous research are shown. In a previous study, we already examined some possible explanations for the large differences in these estimates found across countries. These will be shortly reviewed. We then go on to present the model that will be the focus of this study, which accounts for categorisation errors. It will be shown what we mean by such errors and how we compare the results we get from categorical models with those from continuous models. The statistical method of estimation is presented, after which we discuss our results. Since we have many such results, they are followed by a meta-analysis of the results. Finally, we discuss our general conclusions from this meta-analysis.

# 1 Theory

In Figure 1 we show the basic response model (Saris and Gallhofer, 2007a) we use as our starting point.

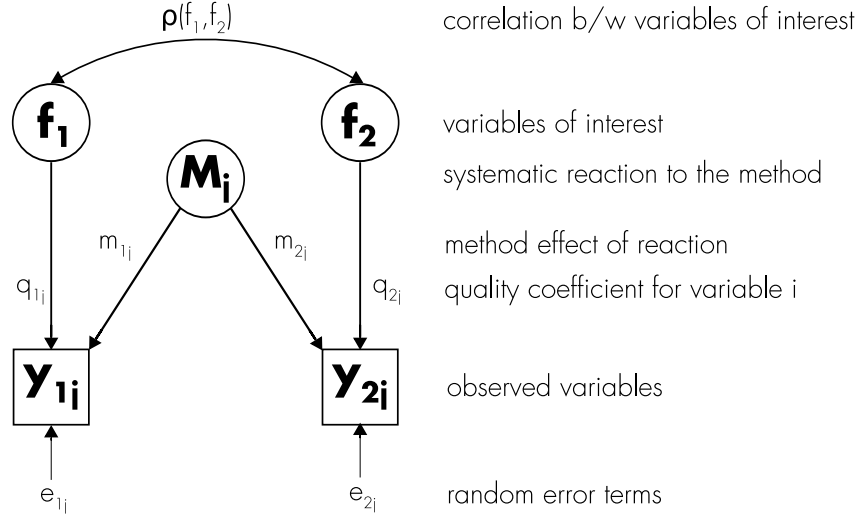


Figure 1: The continuous response model used in the MTMM experiments.

The difference between the observed response ( $y$ ) and the variable of interest or concept by intuition ( $f$ ) is both random measurement error ( $e$ ) and systematic error due to the respondent's reaction to the method ( $M$ ).

An example of a method effect is when each respondent chooses her own reference points for all 11 point scales. For instance, an 11 point agree-disagree scale might label the highest category with the text 'disagree'. But in principle one can also disagree 'strongly' or even 'completely', although such opinions are not marked with a number on the answer scale. Thus it is up to the respondent to choose a location for these most extreme reference points. This choice will influence which category is finally chosen, given any opinion. Different reference points are generally chosen by different people if these points are not fixed by the question, causing non-substantive random variation. If the same points are chosen by the same people given the same answer scale, then there will also be a correlation between the answers to all 11 point scales that has nothing to do with the respondents' opinions (Saris, 1988). This systematic variation can be considered method variance.

The coefficient  $q$  represents the quality coefficient and we call  $q^2$  the total quality<sup>1</sup>. This quality—sometimes also called the reliability ratio—equals  $\frac{Var(f)}{Var(y)}$ : it can be interpreted as the proportion of variation in the observed variable that is due to the unobserved trait of interest. The correlation between the unobserved variables of interest is denoted by  $\rho(f_1, f_2)$ .

Several remarks should be made. The first is that the correlation  $\rho(y_{ij}, y_{kj})$  between

<sup>1</sup>One can also separate the reliability and method variance. This response model is known as the true score model and is more easily interpreted but mathematically equivalent to the classic MTMM model used here. For more details of the different models we refer to (Saris and Andrews, 1991)

two observed variables measured with the same method is:

$$\rho(y_{ij}, y_{kj}) = \underbrace{\rho(f_i, f_k)}_{\text{Correlation of interest}} \cdot \underbrace{q_{ij} \cdot q_{kj}}_{\text{Attenuation factor}} + \underbrace{m_{ij} \cdot m_{kj}}_{\text{Correlation due to method}} \quad (1)$$

where  $i \neq k$  index the concepts by intuition and  $j$  a method.

This means that the correlation between the observed variables is normally smaller than the correlation between the variables of interest, but can be larger if the method effects are considerable. A second remark to make is that one can not compare correlations across countries without correction for measurement error if the measurement quality coefficients are very different across countries: this follows directly from the above equation (1). A third point is that one can not estimate these quality indicators from this simple design with two observed variables. In this model there are two quality coefficients, two method effects and one correlation between the two latent traits, leaving us with five unknown parameters, while only one correlation can be obtained from the data. It is impossible to estimate these five parameters from just one correlation.

There are two different approaches to estimate these coefficients. The first is the use of MTMM experiments. The second is the use of the prediction program SQP<sup>2</sup>. SQP predicts the quality coefficient and method effect of a single question from many of its characteristics such as the topic, the number of categories, etc. It is currently based on a meta-analysis of 87 MTMM experiments and 1028 different questions, while many more experiments are soon to be added (Oberski et al., 2004). Because we use the MTMM approach here, it is briefly introduced below. A more elaborate introduction to MTMM and SQP can be found in Saris and Gallhofer (2007).

## 1.1 MTMM models

Campbell and Fiske (1959) suggested using multiple traits and multiple methods (MTMM). The classical MTMM approach recommends the use of a minimum of three traits that are measured with three different methods leading to nine different observed variables. An example of such a design is given in Table 1.

Collecting data using this MTMM design, data for nine variables are obtained and from that data a correlation matrix of  $9 \times 9$  is obtained. The model formulated to estimate the quality coefficients and method effects is an extension of the model presented in Figure 1. This figure illustrates the relationships between the observed variables and their general factors of interest. Figure 2 shows that each trait ( $f_i$ ) is measured in three ways. It is assumed that the traits are correlated but that the method factors ( $M_1, M_2, M_3$ ) are not correlated. To reduce the complexity of the figure, it is not indicated that for each observed variable there is a random error term as was previously introduced in the model in Figure 1.

The model indicated, called the ‘classic’ MTMM model, is not the only one possible that can be applied to data from MTMM experiments. Notable other models are the so-called true score (Saris and Andrews, 1991), CTC(M-1) (Eid, 2000), correlated uniqueness (Kenny, 1976), and multiplicative models (Campbell and O’Connell, 1967).

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<sup>2</sup>See the website <http://www.sqp.nl/>

Table 1: The classic MTMM design used in the ESS pilot study.

The three traits were presented by the following three requests:										
<ul style="list-style-type: none"> <li>• <i>On the whole, how satisfied are you with the present state of the economy in Britain?</i></li> <li>• <i>Now think about the national government. How satisfied are you with the way it is doing its job?</i></li> <li>• <i>And on the whole, how satisfied are you with the way democracy works in Britain?</i></li> </ul>										
The three methods are specified by the following response scales:										
(1) <i>Very satisfied</i> ; (2) <i>Fairly satisfied</i> ; (3) <i>Fairly dissatisfied</i> ; (4) <i>Very dissatisfied</i>										
<i>Very dissatisfied</i>										<i>Very satisfied</i>
	0	1	2	3	4	5	6	7	8	9 10
(1) <i>Not at all satisfied</i> ; (2) <i>Satisfied</i> ; (3) <i>Rather satisfied</i> ; (4) <i>Very satisfied</i>										

The main difference between our model and the CTC(M-1) and true score models is that the latter distinguish between a ‘true score’ and the concept by intuition on theoretical grounds. This allows one to separately examine the method effects and the reliability coefficients. In the CTC(M-1) one method factor is also omitted to stabilise the results. We do not do this by default, but test whether the method variance can in some cases be constrained to be zero. Another difference between ours and the CTC(M-1) model is that correlations between the traits and the methods are fixed at zero because from our response model there is no motivation for the estimation of these correlations. Also the correlations among the methods are fixed at zero in our approach. This is mostly done to stabilise the estimates. Even if this assumption turns out to be false, we in general do not expect large bias in the quality estimates due to omitted correlations between methods (Corten et al., 2002).

It can be shown that our model is a special case of the true score and correlated uniqueness models, and is equivalent to those models in the specific design used here (Coenders and Saris, 1998). A study by Corten et al. (2002) furthermore suggests that such models fit better to MTMM data than a multiplicative model, in which the method effects are proportional to the correlation between the traits. For this reason we continue with the classic MTMM model using confirmatory factor analysis.

The MTMM design of 3 traits and 3 methods generates 45 covariances and variances. In turn, these 45 pieces of information provide sufficient information to estimate 9 quality coefficients, 3 method effect coefficients and 3 correlations between the traits. There are only 3 method effects because in our basic model we constrain the unstandardised method effects to be equal to unity, thus providing a scale for the method factors and effectively constraining the method effects within the same factor to be equal. This aids the estimation process greatly but where necessary we have relaxed this constraint. We also provide a scale for each trait by setting the loading on one of its indicators to unity. In total there are 15 parameters to be estimated. This leaves  $45 - 15 = 30$  degrees of freedom, meaning that the necessary condition for identification is fulfilled. It also can be shown that the sufficient condition for identification is satisfied and given that  $df = 30$

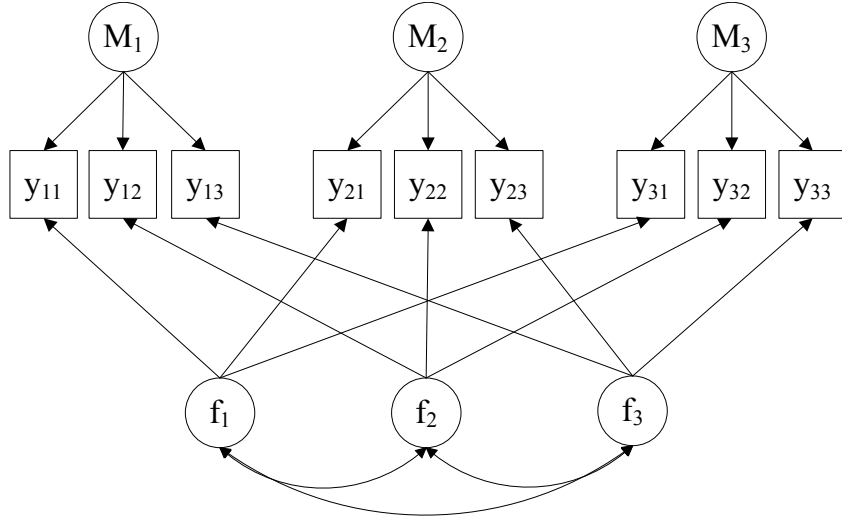


Figure 2: MTMM model illustrating the observed scores and their factors of interest.

a test of the model is possible.

Table 2 presents the correlations that we derived between the 9 measures obtained from a sample of 481 people in the British population. Using the specifications of the model indicated above and the ML estimator to estimate the quality indicators, the results presented in Table 3 are obtained<sup>3</sup>.

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<sup>3</sup>The estimation is done using the covariance matrix as the input matrix and not the correlation matrix. Thereafter, the estimates are standardised to obtain the requested coefficients. As a result, the standardised method effects are not exactly equal to each other.

Table 2: Correlations between nine measures obtained from a sample of 481 people from the British population. Correlations between a repetition of a trait using a different method (‘monotrait-heteromethod’ correlations) are indicated in boldface.

		Method 1			Method 2			Method 3		
		F1	F2	F3	F1	F2	F3	F1	F2	F3
Method 1										
F1	$y_{11}$	1.00								
F2	$y_{12}$	.481	1.00							
F3	$y_{13}$	.373	.552	1.00						
Method 2										
F1	$y_{21}$	<b>-.626</b>	-.422	-.410	1.00					
F2	$y_{22}$	-.429	<b>-.663</b>	-.532	.642	1.00				
F3	$y_{23}$	-.453	-.495	<b>-.669</b>	.612	.693	1.00			
Method 3										
F1	$y_{31}$	<b>-.502</b>	-.374	-.332	<b>.584</b>	.436	.438	1.00		
F2	$y_{32}$	-.370	<b>-.608</b>	-.399	.429	<b>.653</b>	.466	.556	1.00	
F3	$y_{33}$	-.336	-.406	<b>-.566</b>	.406	.471	<b>.638</b>	.514	.558	1.00
Mean		2.42	2.71	2.45	5.26	4.37	5.13	2.01	1.75	2.01
Standard Deviation		.77	.76	.84	2.29	2.37	2.44	.72	.71	.77

Table 3: The standardised estimates of the classic MTMM parameters (figure 2), which are obtained when analysing the sample covariance matrix above.

	Quality coeffs			Method effects		
	F1	F2	F3	M1	M2	M3
$y_{11}$	0.73			0.28		
$y_{12}$		0.80		0.30		
$y_{13}$			0.77	0.27		
$y_{21}$	0.83				0.37	
$y_{22}$		0.86			0.37	
$y_{23}$			0.86		0.35	
$y_{31}$	0.70					0.43
$y_{32}$		0.76				0.43
$y_{33}$			0.74			0.40

## 2 Data

The European Social Survey (ESS) has the unique characteristic that in more than 20 countries the same questions were asked and that within each round of the ESS Multitrait-Multimethod (MTMM) experiments are built in to evaluate the quality of a limited number of questions. This gives us an exceptional opportunity to observe the differences in quality of questions over a large number of countries. In this paper we have used the MTMM experiments of round 2 of the ESS, collected in 2004.

The questionnaires were administered by face to face interviewing in all countries. In Finland, France, Ireland, Italy, the Netherlands, Norway, and Sweden, the supplementary questionnaire with the repetition questions was self-completed with the interviewer present rather than asked face to face. This confounds mode effects with country effects for these countries. The countries we compare in subsequent sections all used face to face interviewing for both questionnaires, however. Therefore mode effects are not an issue in this particular study.

The topics of the 6 MTMM experiments in the second round of the ESS were the following:

1. Time spent on housework;
2. The social distance between the doctor and patients;
3. Opinions about job;
4. The role of men and women in society;
5. Satisfaction with the political situation;
6. Political trust.

Concerning each of these topics 3 questions were asked and these three questions were presented in 3 different forms following the discussed MTMM designs. The first form, used for all respondents, was presented in the main questionnaire. The two alternative forms were presented in a supplementary questionnaire which was completed after the main questionnaire. All respondents were only asked to reply to one alternative form but different groups got different version of the same questions (Saris et al., 2004). For the specific questions in the 6 experiments we refer to the ESS website where the English source version of all questions are presented<sup>4</sup>, and for the different translations we refer to the ESS archive<sup>5</sup>.

Each experiment varies a different aspect of the method by which questions can be asked in questionnaires. The ‘housework’ experiment compares numeric estimates by respondents with other scales. The ‘social distance’ experiment examines the effect of choosing arbitrary scale positions as a starting point for agreement-disagreement with a statement. The ‘job’ experiment compares a 4 point true-false scale with direct questions using 4 and 11 point scales. In the ‘role of women’ experiment agree-disagree scales are reversed, there is one negative item, and a ‘don’t know’ category is omitted in one of

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<sup>4</sup><http://www.europeansocialsurvey.org>

<sup>5</sup><http://ess.nsd.uib.no>



the methods. The ‘satisfaction’ experiment varies the extremeness and number of fixed reference points of the scale. And finally, the experiment on political trust was meant to investigate the effect of repeating the same question in the same format.

A special group took care that the samples in the different countries were proper probability samples and as comparable as possible (Häder and Lynn, 2007).

The questions asked in the different countries have been translated from the English source questionnaire. An optimal effort has been made to make these questions as equivalent as possible and to avoid errors. In order to reach this goal two translators independently translated the source questionnaire and a third person was involved to choose the optimal translation by consensus if differences were found. For details of this procedure we refer to the work of Harkness et al. (2002).

Despite these efforts to make the data as comparable as possible, large differences in measurement quality were found across the different countries. Table 4 shows the mean and median standardised quality of the questions in the main questionnaire across the experiments for the different countries.

Table 4: The quality of all 18 questions included in the experiments in the main questionnaire.

Country	Mean	Median	Minimum	Maximum
Portugal	0.79	0.81	0.63	0.91
Switzerland	0.79	0.84	0.56	0.90
Greece	0.78	0.79	0.64	0.90
Estonia	0.78	0.85	0.58	0.90
Poland	0.73	0.85	0.51	0.90
Luxembourg	0.72	0.73	0.53	0.88
United Kingdom	0.70	0.71	0.56	0.82
Denmark	0.70	0.70	0.52	0.80
Belgium	0.70	0.73	0.46	0.90
Germany	0.69	0.70	0.53	0.83
Spain	0.69	0.64	0.54	0.90
Austria	0.68	0.68	0.51	0.85
Czech Republic	0.65	0.60	0.52	0.87
Slovenia	0.63	0.60	0.46	0.82
Norway	0.59	0.59	0.35	0.83
Sweden	0.58	0.58	0.43	0.68
Finland	0.57	0.54	0.42	0.78

A remarkable phenomenon in this table is that the Scandinavian countries have the lowest quality of all while the highest quality has been obtained in Portugal, Switzerland, Greece, and Estonia. The other countries are in between these two groups. The differences are considerable and statistically significant across countries ( $F = 3.19$ ,  $df = 16$ ,  $p < .001$ ) and experiments ( $F = 92.65$ ,  $df = 5$ ,  $p < .0001$ )<sup>6</sup>. The highest mean quality is .79 in Portugal while the lowest is .57 in Finland. If the correlation between the constructs of interest is .60 in both countries and the measures for these variables have the above quality

<sup>6</sup>The significance of the differences in the quality coefficients was determined using their observed distribution.

then the observed correlation in Portugal would be .47 while the observed correlation in Finland would be .34. Most people would say that this is a large difference in correlations which requires a substantive explanation. But this difference can be expected because of differences in data quality and has no substantive meaning at all.

### 3 Explanations for cross-country differences in question quality

The previous section showed that in some cases large differences were found in question quality across the countries of the ESS. In a previous study, we examined a few possible explanations of these discrepancies (Oberski et al., 2007).

The first explanation we studied were errors in the translation. Although in the ESS a lot of care has been taken to ensure the correct translation of the questions, we found that a few questions in the supplementary questionnaire had not been translated in the way intended. In particular, one item in the ‘social distance’ experiment had been translated in all French questionnaires as ‘Doctors rarely tell their patients the whole truth’ rather than ‘Doctors rarely keep the whole truth from their patients’. Since these sentences have opposite meanings, it is unsurprising that we should find a different relationship with the trait of interest.

Another alternative explanation for differences across countries is differences in the implementation of the experimental design. Here one difference existed between the implementations in Norway, Sweden, and Finland and the other countries: in these countries respondents could send in the supplementary questionnaire containing the repetitions at a time chosen by themselves, while the general design used in other countries was that the supplementary questionnaire should be administered directly after the main interview. Since in some cases quite some time passed before the second questionnaire was completed, it is possible that the opinion had in this time changed or that other unique considerations were used to form an opinion at the second moment than at the first moment. An MTMM analysis of a sample split according to whether the questionnaire was returned within two days or later provided strong evidence that this was indeed the case. In fact, the sample of people who had returned the questionnaire on the same day was by itself very similar in the quality to other countries.

The third alternative we considered was that the language of the questions might be more complex in one language than in another. Previous meta-analyses found that language complexity can have an effect on the quality (Saris and Gallhofer, 2007b). However, we found no strong evidence that the complexity of the questions caused differences in question quality in this case.

Thus, in some cases we found artificial differences in quality which are likely to be due to an erroneous translation or different implementation of the experimental design—notably in the Scandivian countries except Denmark and for one item in the French-speaking countries. However, these cases are not so numerous that they can explain the large overall variations in question quality found in the ESS. Therefore we now turn to the possibility that the distance between the categories in the categorical questions differs from country to country. Before we proceed to investigate the influence of categorisation errors on the quality in different countries and experiments, we explain in more detail

the model used to estimate the distances between the categories.

### 3.1 The categorical response model

The response model discussed so far makes no mention of the fact that many of the measures we use are in fact ordinal—that is, they are most likely ordered categories rather than measured on an interval scale. Broadly speaking, two types of measurement models have been proposed for this situation. The first assumes that there is an unobserved discrete variable, and that errors arise because the probability of choosing a category on the observed variable given a score on the unobserved variable is not equal to one. That is, the errors are modelled by the conditional chances of choosing a category on the survey question given the unobserved score. Such models are often referred to as latent class models (Lazarsfeld and Henry, 1968; Hagenaars and McCutcheon, 2002).

The second approach deals with the case where a continuous scale or ‘latent response variable’ (LRV) is thought to underly the observed categorical item. Such models are sometimes called latent trait models. Several extensions are possible, but we focus on a special case described by Muthén (1984). This is the model we will use in our subsequent analysis of the data (figure 3)<sup>7</sup>.

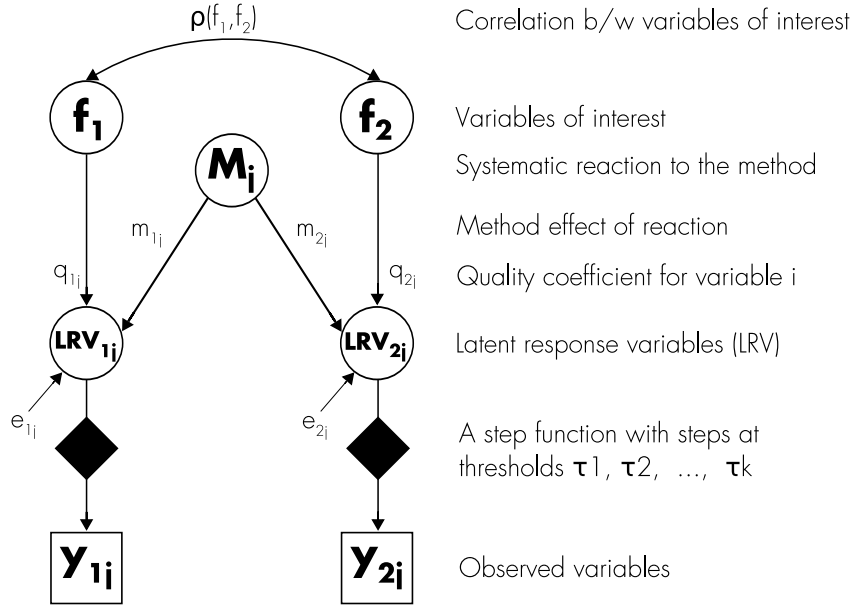


Figure 3: The categorical response model used in the MTMM experiments.

Errors may arise at two stages. The first is the connection between the latent response variable ( $LRV_{ij}$  in figure 3) and its latent trait ( $f_i$ ). This part of the error model is completely analogous to factor analysis or MTMM models for continuous data: the scale

<sup>7</sup>It can be shown that analysing polychoric correlations in an MTMM model is a special case of the model we use (Muthén and Asparouhov, 2002). However, we do not use polychoric correlations because it would be necessary to assume that the variances of the latent response variables are equal across countries. Since we try to separate categorisation errors from differences in the continuous part of the model, this is not a desirable assumption. The model we use is equivalent to a multi-dimensional two parameter graded response model in item response theory (Muthén and Asparouhov, 2002).

is modelled as a linear combination of a latent trait ( $f_i$ ), a reaction to the particular method used to measure the trait ( $M_j$ ), and a random error ( $e_{ij}$ ), and interest then focuses on the connection between the trait and the scale ( $q_{ij}$ ), which we again term the ‘quality coefficient’ (see also figures 1 and 2).

The second stage at which errors arise differs from the continuous case. This is the connection between the variables  $LRV_{ij}$  and  $y_{ij}$  in figure 3. Here the continuous latent response variable is split up into the different categories, such that each category of the observed variable corresponds to a certain range on the unobserved continuous scale. The sizes of these ranges are determined by threshold parameters. In figure 3 this step function has been represented by a black triangle. Examples of step functions are illustrated in figure 4.

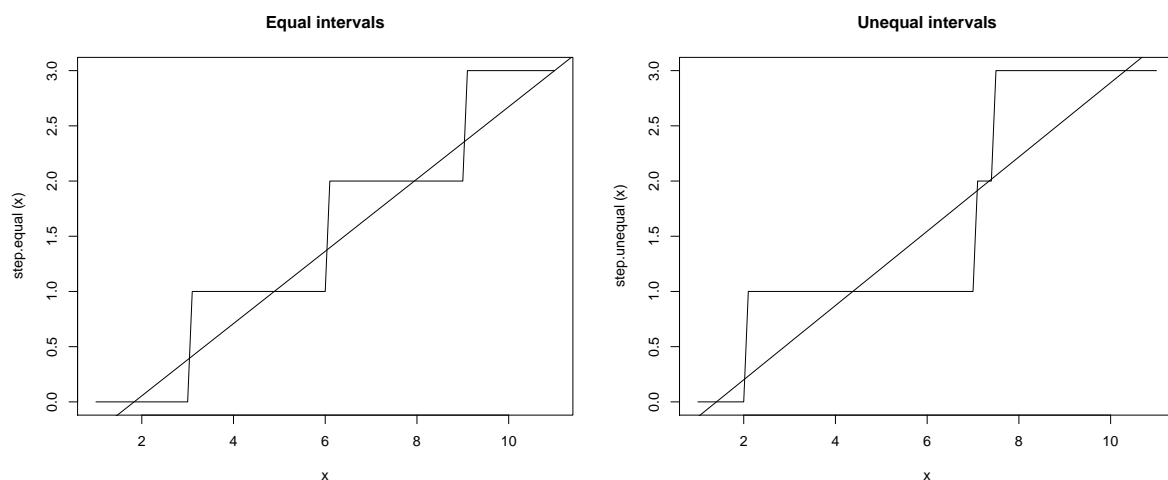


Figure 4: Two hypothetical step functions which result from categorisation. The diagonal lines plot the expectation of the LRV and the latent trait on the same scale.

In figure 4, the steps show the relationship between the LRV and the observed variable, while the straight line plots the expectation of the LRV given the latent trait. In the step function on the left-hand side, the LRV has been categorised into more or less equal intervals. The error that is added by the categorisation is the vertical distance between the straight (diagonal) line and the step. It can be seen that the error is zero when the straight line crosses the steps, and that at each step, the error is the same (at 3, 6, and 9). The expectations within the categories have the same interval as the thresholds of 1, and so if the values 1,2,3,4 are assigned to the categories, no transformation occurs.

Conversely, the right hand side shows a latent response variable that has been categorised with very unequal thresholds. At the second step there is almost no extra error, while at the first and third steps the errors are much larger. Here a transformation occurs because the distances between the expectations in the categories are not equal to the distances between the categories if the numbers 0 through 3, or any other set of numbers with equal distances, are assigned to them.

To sum up, two types of errors can be distinguished at this stage (Johnson and Creech, 1983):

1. *Grouping errors* occur because the infinite possible values of the latent response

variable are collapsed into a fixed number of categories (the vertical distances between the diagonal line and the steps in figure 4). These errors will be higher when there are fewer categories;

2. *Transformation errors* occur when the distances between the numerical scores assigned to each category are not the same as the distances between the means of the latent response variable in those categories. This happens when the thresholds are not equally spaced, or when the available categories do not cover the unobserved opinions adequately.

Categorisation, then, can be expected to be another source of measurement error besides random errors and method variance. If these errors differ across countries, then so will the overall measurement quality, and differences in means, correlations, regression coefficients, and cross-tables across countries result which are due purely to differences in measurement errors.

Thus, the model we use allows to a certain extent for the separation of errors due to the categorisation, errors due to the reaction to the method and random errors. In this paper we take advantage of this separation to compare the amount of error due to categorisation introduced across countries.

### 3.2 Categorisation errors in survey questions

The previous sections showed that, using the MTMM design, it is possible to obtain a measure ( $q^2$ ) of the total quality of a question. If a continuous variable model (hereafter referred to as CV model) is used, this quality is influenced by errors in both stages of the categorical response model: not only random errors and method effects are included, but also errors due to the categorisation. For this reason Coenders (1996) argued that the linear MTMM model assuming continuous variables does not ignore categorisation errors, but absorbs them to a certain extent in the estimates of the random error and method correlations. The extent to which this holds in general is a topic that is still under discussion.

However, since the quality coefficient is estimated from the covariance matrix of the measures, it can be both reduced and increased by categorisation errors. In general all correlations between measures increase after correction for categorisation, but they need not all increase equally. For example, consider again table 2. If categorisation errors are higher using the first method, the correlations between the latent response variables using this method (the upper-left triangle of the matrix) will increase more relative to the observed correlations than the correlations of each variable with its repetition using a different method (in bold). In this case the amount of variance in the response variable due to the method will be larger in the categorical model than in the CV model, and the estimated quality of the measure in the categorical response model can become lower than the estimated quality in the continuous MTMM model. This is because there are method effects (correlated errors) on the level of the continuous latent response variables which do not manifest themselves in the observed (Pearson) correlations between the categorical variables. Categorisation can therefore in some cases inflate estimates of the quality of categorical observed variables, even though, at the same time, it causes errors

which reduce the quality. There are thus two processes at work, which have opposite effects on the estimates of the quality.

Because it can both reduce and artificially inflate estimates of quality, categorisation error is an important possible cause of finding differences in question quality across countries. If either of these two processes differs from one country to another, the estimates of the quality can be expected to differ as well. Therefore, we focus here on the changes in the quality coefficient one observes in a continuous response model relative to a categorical model. This allows us to study the attenuation or inflation of quality estimates across countries.

As noted before, the quality of a variable is defined as the ratio of the true trait variance to the observed variance (see also figure 1 in the first section):

$$q^2 = \frac{Var(f)}{Var(y)}. \quad (2)$$

However, we have now seen that  $y$  is itself a categorization of an unobserved continuous variable ( $c$ ), and therefore the above equation 2 can be ‘decomposed’ into

$$q^2 = \frac{Var(f)}{Var(c)} \cdot \frac{Var(c)}{Var(y)}. \quad (3)$$

The scale of  $c$  is arbitrary, except that it may vary across countries due to relative differences in variance (Muthén & Asparouhov, 2002). However, the ratio  $Var(c)/Var(y)$  can easily be calculated once  $q_{con}^2$ , the quality from the continuous analysis, and  $Var(f)/Var(c)$ , the quality from the categorical MTMM analysis ( $q_{cat}^2$ ), have been obtained. So equation (3) shows that  $q_{con}^2 = q_{cat}^2 \cdot c$  and

$$c = \frac{q_{con}^2}{q_{cat}^2},$$

where  $c$  is the categorization effect, or

$$\ln(q_{con}^2) = \ln(q_{cat}^2) + \ln(c).$$

This correction factor is a useful index of the relative differences between the quality estimates of the continuous and categorical models.

In the present study, we estimate this ‘categorisation factor’ for different countries and experiments, and examine to what extent it can explain the differences in quality across countries.

## 4 Methods

In almost every country of the ESS, respondents were asked to complete a supplementary questionnaire containing the repetitions used in the experiments. Not all respondents completed the same questionnaire. The sample was randomly divided into subgroups, so that half of the people answered the first and second form of the questions, and the other half answered the first and third form.

This so-called split-ballot MTMM approach lightens the response burden by presenting fewer questions and fewer repetitions. Saris et al. (2004) showed that the different

parameters of the MTMM model can still be estimated using this planned missing data design. If the different parts of the model are identified, so is the entire model. Since we can identify the necessary covariances in the categorical model, this is identified as well (Millsap and Yun-Tein, 2004).

For each experiment, two different models were estimated. The continuous analysis was conducted using the covariance matrices as input, and estimated using the maximum likelihood estimator in LISREL 8. The results presented in the tables below were standardised after the estimation.

The categorical model can in principle also be estimated using maximum likelihood. However, in order to deal with the planned missing data (split-ballot) a procedure such as full-information maximum likelihood would be necessary. This requires numerical integration in the software we used (Mplus 4), making the procedure prohibitively slow and imprecise. We therefore used an alternative two step approach, whereby in the first step the covariance matrices of the latent response variables were estimated, and in the second step the MTMM model is fitted to the estimated matrices. The estimation in the first step was done using the weighted least squares approach described by Flora and Curran (2004), and the second step again employed the maximum likelihood estimator<sup>8</sup>.

This approach has the advantage that consistent and numerically precise estimates can be obtained within seconds rather than days (Muthén and Asparouhov, 2002). The disadvantages are that the standard errors of the estimates of the categorical MTMM model are incorrect, and that the chi-square statistic and modification indices may be inflated. Although the problem could in principle be remedied by using the asymptotic covariance matrix of the covariances as weights in the estimation (Jöreskog, 1990), in the present paper we compare only the consistent point estimates of this model.

We model categorisation errors using threshold parameters. These thresholds are the theoretical cutting points where the continuous latent response variable (LRV) has been discretized into the observed categories. If the thresholds are different across countries, the questions are not directly comparable, since differences in the frequency distribution are partly due to differences in the way the LRV was discretized. If the thresholds are the same across countries the questions may still not be comparable due to differences in linear transformations (loadings) and random errors. But in that case it is not categorisation error that causes incomparability. A final possibility is that loadings, random errors and thresholds are all the same across countries. In that case the frequency distributions can be directly compared.

In this paper we will perform only a basic invariance tests on thresholds. If the thresholds are equal, categorisation error is not a likely cause of differences in quality. However, we do not continue with tests for invariance on loadings and error variance, but will compare the results of two different models.

The two models are the same with respect to the covariance structure of the response variables (the ‘MTMM part’ of the model). However, they differ in their basic assumptions about the ‘observation part’ of the model: the CV model assumes that the

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<sup>8</sup>We note here that the categorical MTMM model is equivalent to the ‘graded response model’ in item response theory. There is a simple relationship between the threshold and quality coefficients of our model and difficulty and discrimination parameters in IRT models: the quality coefficients are scaled discrimination parameters, while a scaled difficulty for each category can be obtained by dividing each threshold by the corresponding quality coefficient (Muthén and Asparouhov, 2002).

continuous response variables have been directly observed, while the categorical model assumes a threshold connection between the response variables and the observed ones.

Both models assume normality of the response variables, but the differences in basic assumptions cause the categorical model to be more sensitive to departures from normality. While in the CV model, under quite general conditions, violation of normality will not affect the consistency of the estimates (Satorra, 1990), this is not so in the categorical model. There, the threshold estimates are derived directly from quantiles of the normal distribution which the latent response variable is assumed to follow. Therefore, if the LRV's are not normally distributed, the threshold estimates will be biased. The MTMM estimates depend on the thresholds and can also change, though the precise conditions under which such estimates would change significantly have, to our knowledge, not been investigated analytically. It has been found in several different simulation studies that bias may occur especially when the latent response variables are skewed in opposite directions (Coenders, 1996).

Thus, while the categorical model may be more realistic in modelling the observed variables as ordinal rather than interval level measures, the CV model may be more realistic in that it is robust to violations of normality<sup>9</sup>. In any particular analysis, whether one or the other model provides a more adequate estimate of the quality of the questions therefore depends on the degree to which these assumptions are violated<sup>10</sup>. This should be kept in mind in the interpretations of the results.

We estimated the quality of the measures based on the CV model and based on the categorical model for four experiments which used an answer scale of five categories or less in the main questionnaire. For each experiment, the countries with the highest and the lowest qualities in the CV model were analysed. For each of the questions we took the ratio, called 'categorisation factor', of the two different quality measures as an index of the effect that categorisation has on the continuous quality estimates. The next section presents the results.

## 5 Results

### 5.1 Results of the experiments

The first experiment's results will be described in some detail, while we provide the results of the other experiments in the appendix.

The first experiment concerned opinions on the role of women in society (see table 5). We first turn to the hypothesis that all thresholds are equal across different countries. If this hypothesis cannot be rejected there is also little reason to think that the categorisation is causing differences in the quality coefficients.

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<sup>9</sup>One important point to make here is that even when univariate distributions such as histograms and tables of the observed categorical variables are highly non-normal, this does not necessarily imply that the normality assumption of the categorical model is violated. The reason is that a very non-normally distributed observed variable may be the consequence of a perfectly normally distributed variable that has been categorised in a very uneven way.

<sup>10</sup>In principle the normality assumption on the latent response variables is testable. However, the question then still remains what impact any non-normality would have on the estimates. This question is beyond the scope of the present paper.



We selected the two countries with the highest and the country with the lowest quality coefficients. In this experiment, the wording of the question reversed in the second method. For example, the statement ‘When jobs are scarce, men should have more right to a job than women’ from the main questionnaire was changed to ‘When jobs are scarce, women should have the same right to a job as men’ in the supplementary questionnaire. The countries with high quality coefficients were, in this case, Portugal and Greece. The lowest coefficients for this experiment were found in Slovenia. To be able to separately study misspecifications in the categorisation part of the model, we imposed no restrictions on the covariance matrix of the latent response variables at this stage.

Table 5: The ‘role of women’ experiment: questions and threshold estimates (in z-scores).

‘A woman should be prepared to cut down on her paid work for the sake of her family’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Agree strongly</i>		<i>Agree</i>		<i>Neither disagree nor agree</i>		<i>Disagree</i>		<i>Disagree strongly</i>
Slovenia		-1.4		-0.1		0.6		1.8	
Greece		-1.1		-0.2		0.5		1.4	
‘A woman should not have to cut down on her paid work for the sake of her family.’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
Slovenia		-1.5		-0.0		0.6		2.0	
Greece		-1.5		-0.3		0.4		1.5	
‘Men should take as much responsibility as women for the home and children.’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
Slovenia		-0.5		1.3		1.9		2.6	
Greece		-0.6		0.7		1.6		2.3	
‘Women should take more responsibility for the home and children than men’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
Slovenia		-1.7		-0.7		-0.2		1.2	
Greece		-1.6		-0.5		0.0		1.4	
‘When jobs are scarce, men should have more right to a job than women.’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
Slovenia		-1.8		-0.8		-0.3		0.9	
Greece		-0.9		0.1		0.6		1.4	
‘When jobs are scarce, women should have the same right to a job as men.’									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
Slovenia		-0.8		0.7		1.1		1.9	
Greece		-1.1		-0.1		0.7		2.0	

In the first analysis, all thresholds were constrained to be equal across the five countries. This yields a likelihood ratio statistic of 507 on 48 degrees of freedom. The country with the highest (128) contribution to this chi-square statistic is Portugal. When we examine the expected parameter changes, it also turns out that in this country these standardised values are very large with some values close to .9 while in other countries the highest obtained and exceptional value is .6. For some reason, the equality constraint on the Portuguese thresholds appears to be a particularly gross misspecification.

As it turns out, this particular misspecification is very likely due to a translation error. The intention of the experiment was to reverse the wording of the question in the second method. But in Portugal the reverse wording was not used, and the same version was

presented as in the main questionnaire. To prevent incomparability when the MTMM model is estimated, we omit Portugal from our further analyses and continue with two countries.

The model where all thresholds are constrained to be equal yields a likelihood ratio of 351 and 36 degrees of freedom ( $p < .00001$ ). This model should therefore be rejected: the thresholds are significantly different across countries.

We use the procedure of Saris and Satorra (ming) to determine whether misspecifications are present in the model. For this test we need the Expected Parameter Change (EPC), Modification Index (MI) and the power of the test. The EPC gives direct estimates of the size of the misspecification for all fixed parameters, while the MI provides a significance test for the estimated misspecification (Saris et al., 1987).

However, these two indices are not sufficient for determining misspecifications because the MI depends on other characteristics of the model. For this reason, the standard error of the EPC the power of the MI test are necessary to determine whether a restriction is misspecified. We use these quantities to incrementally free parameters that were indicated to be misspecified.

Using the modification indices and power as guides, we formulated a new model in which some thresholds were constrained to be equal, while others were freed to vary. Equality of thresholds is not required to estimate the relationships, but it is useful because the equality of thresholds allows for differences in variances of the response variables across the groups. This is in contrast with the use of polychoric correlations where the variances are constrained to be equal across the groups.

The resulting model has an approximate likelihood ratio of 2.8 on 2 degrees of freedom ( $p = .24$ )<sup>11</sup>. The resulting estimates of the threshold parameters are presented in table 5. These estimates have been expressed as z-scores in order to make them comparable.

Table 5 presents three different traits, each asked in two different forms. The first form of each trait is the form asked in the main questionnaire, while the second form was asked in the supplementary questionnaire (the third form has been omitted for brevity).

The thresholds in this model represent how extreme the ‘agreement’ has to be before the next category is chosen rather than the previous one. This strength is expressed in z-scores, i.e. standard deviations from the mean. Take, for instance, the third statement in the table: “Men should take as much responsibility as women for the home and children”. Slovenians need to have an agreement differing from the country mean 2.6 times more than the standard deviation, before they will respond ‘disagree strongly’.

Note that the threshold part of the relationship between LRV and observed response is deterministic. However, not all Slovenians with an *opinion* on the indicator of 2.6 standard deviations or more away from the mean will necessarily answer ‘disagree completely’. This is so because the latent response variable is also affected by random measurement error. The combination of the threshold model and random measurement error gives rise to a familiar probit relationship between indicator and response. Because the random error plays an important role in this relationship, not only the thresholds should be discussed here, but also the quality coefficients.

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<sup>11</sup>It is also possible to free more parameters and put no restrictions at all on the model. This might lead us to find differences between countries more easily, since the parameters are allowed to vary. However, we prefer to aid our estimation by imposing these restrictions: if they do not hold in the population, this leads us to be conservative in ascribing differences between countries to the categorisation.

Table 6: Quality ( $q^2$ ) and method effects ( $m$ ) according to the continuous and categorical models, with categorisation factors for the experiment on opinions about the role of men and women in society.

		‘Women’		
		CutDown	Respsib.	MenRight
Continuous analysis				
$q^2$	Greece	0.71	0.66	0.71
	Slovenia	0.54	0.25	0.68
$m$	Greece	0.15	0.15	0.15
	Slovenia	0.17	0.24	0.15
Categorical analysis				
$q^2$	Greece	0.51	0.35	0.48
	Slovenia	0.69	0.29	0.65
$m$	Greece	0.49	0.14	0.32
	Slovenia	0.33	0.75	0.19
Categorisation factor				
		Greece	1.4	1.9
		Slovenia	0.8	1.0

Looking at the first question, it can be seen that the distances between the thresholds are unequal for these two countries and different from one. One can also see that the endpoints are somewhat distant, especially in Slovenia: there the category ‘disagree strongly’ is 1.8 standard deviations or more away from the mean, reducing the number of scale points that are available for some people.

The second form of the same question is similar to the first form in this respect, except that here both of the endpoints are rather distant in both countries, again reducing the number of scale points. As noted above, a reduction in scale points can be expected to increase grouping errors.

The second trait (‘responsibility’) presents a radically different picture. In both countries the ‘disagree’ and ‘disagree strongly’ categories are quite far away from the mean. This again reduces the number scale points, while, at the same time, the scale is cut off in this manner only from one side. Large transformation errors can be expected. Moreover, in Slovenia this effect is much worse than in Greece: the category ‘neither disagree nor agree’ is already 1.3 standard deviations or more away from the mean, reducing the amount of information provided by this variable in Slovenia even further.

The second phrasing of this question seems to provide a better coverage of the prevailing opinions on women and men’s responsibility for the home and children.

For the third and last trait—the right to a job—the most striking feature of the thresholds is that in Slovenia, the first three categories represent opinions below the mean, while in Greece only the first category does. Beyond this, it is difficult to say which scale might produce fewer categorisation errors. Surprising, however, is that the second form of the same question seems to produce much more comparable scales with respect to the thresholds than the first one.

It is also clear from the table that the two forms of phrasing are not exactly opposite in the way they are understood and/or answered. This is especially true for the ‘right to a job’ item. However, the choice for one phrasing or the other seems arbitrary. This particular way of phrasing a question is therefore inadvisable, because an arbitrary decision

will lead to different results. The key problem in this case may be the complex sentence structure in which men are compared to women, given an attribute (right to a job) under a certain condition (when jobs are scarce), and then a ‘degree of agreement’ with a norm (‘should have’) is asked. A more accurate way of measurement that may be less sensitive to such arbitrary shifts in response behaviour might be to ask questions about the rights men and women should have according to the respondent directly.

The thresholds provide some insight into the nature of differences in categorisation. However, the final quality of the measure depends also on other parameters of the categorical response model such as the quality coefficients and the error variances, and on the latent response variable distribution.

Besides the thresholds also the correlations between the LRVs are estimated. Based on these correlations the MTMM model mentioned before has been estimated and so estimates of the quality and method effects of the measures corrected for categorization are estimated for all questions. The quality and method effects of the CV model have also been estimated. The results are presented in table 6. Based on these results the categorisation effect can be derived because it is the ratio of the two coefficients. This result, too, is presented in table 6.

The top two rows of table 6 show that the quality in Greece was higher than in Slovenia using the CV model; this is, indeed, the reason we chose these particular countries to compare. The quality in Slovenia is lower for the first question, dramatically lower for the second question, and very similar for the third question. This is in principle in line with the descriptions given above of our expectations of categorisation errors.

However, table 6 also shows that such interpretations of the possible influence of the thresholds are not as straightforward as they might seem. We fitted the MTMM model to the estimated covariance matrix of the latent response variables, and obtained a model which seemed to fit reasonably well ( $\chi^2 = 20$ ,  $df = 10$ ,  $p = .02$ ). While for the first and second questions the low qualities are indeed corrected upwards somewhat after the categorisation has been taken into account, the opposite happens in Greece. In that country all of the quality coefficients are lower using the categorical analysis than they are in the continuous analysis.

A consequence of this is that, using the CV model, a higher quality is obtained in Greece than in Slovenia, while the reverse is true in the categorical model for the first and last items. This is rather striking given that, taken over all questions in the main questionnaire, Greece had a substantially higher quality estimate than Slovenia (see table 4).

The analyses of the other three experiments show that sometimes no large differences between the countries are found, while in others the thresholds are rather different. In particular we found several cases where the same question did not cover the distribution of the opinion in one country, but provided more information in another. We also found both examples of cases where differences in the quality do not go together with differences in the thresholds, and examples of cases where they do. A more detailed discussion of the results for the other three experiments can be found in the appendix.

Now that we have presented and discussed the results of one experiment in detail, the question remains whether there is a connection between the categorisation factor and the quality of the question. The next section therefore presents the results of a meta-analysis we conducted on the categorisation factors.

## 5.2 A meta-analysis of the results

The question remains whether the categorisation factor affects the quality or not. Using the results presented in the previous sections, we constructed a data set consisting of the categorisation factor for all questions—including those from the supplementary questionnaire not shown above—in the four different experiments for which this index was available. This yielded 72 cases in total.

As shown before, the categorisation factor equals  $c = q_{con}^2 / q_{cat}^2$ , and so  $q_{con}^2 = q_{cat}^2(c)$ . If there were no effect of the categorisation, then there would be no relationship between  $c$  and  $q_{con}^2$ , since  $q_{cat}^2$  would be higher or lower by a constant factor. If  $c$  and  $q_{con}^2$  are plotted against one another, one would then expect to find the points randomly distributed along a horizontal line. Figure 5 shows the scatterplot of these two quantities. Estimates from different experiments have been indicated with different symbols.

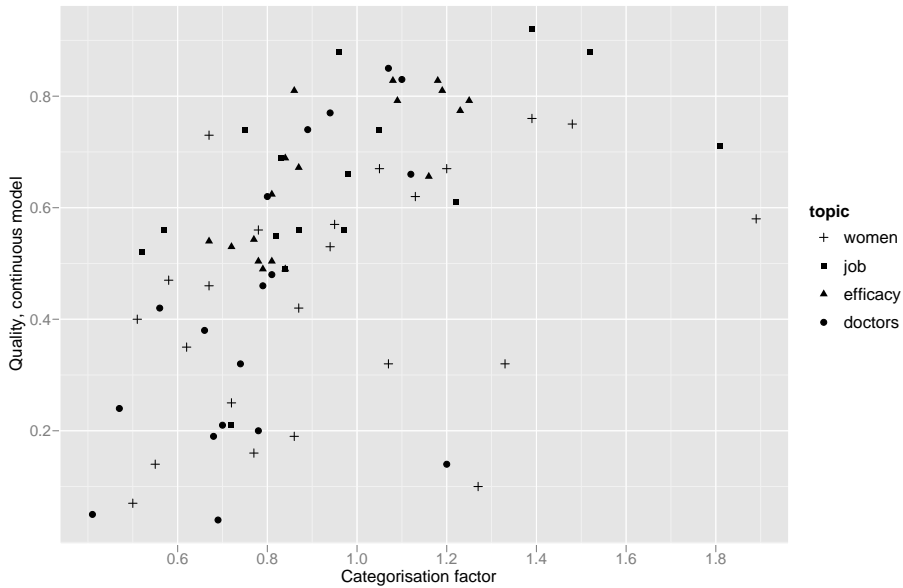


Figure 5: Scatterplot of the categorisation factor ( $c$ ) and the total quality of a measure ( $q_{con}^2$ ) across the experiments.

The clear relationship that can be seen in the figure indicates that high quality coefficients from the continuous model tend to be lower in the categorical model, and vice versa. Figure 5 shows that categorisation factors above unity were mostly found for questions with a high quality. We can estimate the relationship between the quality from the continuous model for each experiment easily by the transformation  $\ln(q_{con}^2) = \alpha_k + \beta_k \ln(c)$ . Here  $k$  indexes the four different experiments. Note that the base level of  $q_{con}^2$  is  $\exp(\alpha_k)$ . We then fit a linear regression to the transformed variables. The resulting predictions for each experiment are shown in figure 6 on the original scales<sup>12</sup>.

Figure 6 shows that both the intercepts and slopes for the ‘efficacy’ and ‘job’ experiments are rather similar, while the coefficients for the ‘role of women’ and ‘social distance’ experiments are completely different. The effect of the categorisation factor is strongest

<sup>12</sup>There are several outliers in our data set, but a sensitivity analysis showed that they do not affect the estimates of the coefficients very much. We therefore prefer to keep them in the analysis.

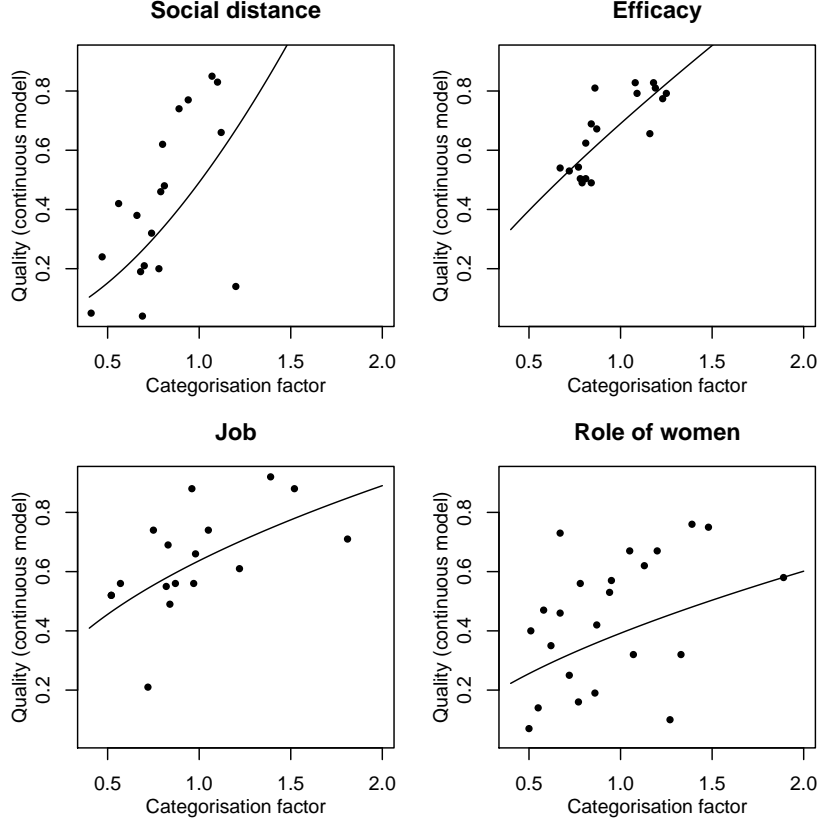


Figure 6: Scatterplot of the categorisation factor ( $c$ ) and the total quality of a measure ( $q^2_{con}$ ) by experiment. The prediction line of the model  $\ln(q^2) = \alpha + \beta \ln(c)$ , as estimated for each experiment separately, is also given.. For the numerical estimates of these coefficients, please see the appendix.

in the ‘social distance’ experiment, where also some large differences between the threshold distances were found (see appendix). The experiment with the smaller number of categories, ‘job’, does not have a high coefficient.

We now turn to the question if these factors are also different between the countries with ‘high’ and ‘low’ quality coefficients. If the sample is split according to whether the quality was ‘high’ or ‘low’, the means of the categorisation factors of the two groups are 1.25 and 0.85, respectively, for the questions in the main questionnaire ( $t = 3.7$ ,  $df \approx 18$ ,  $p = 0.002$ ). For the questions in the supplementary questionnaire, the difference is in the opposite direction, but not statistically significant ( $t = -1.70$ ,  $df = 28$ ,  $p = 0.10$ ). This suggests there is a considerable effect of the categorisation, at least in the main questionnaire.

One possible explanation for the interaction effect found here is that the method factors were often constrained to zero for the main questionnaire. The questions in the main questionnaire were selected especially because they were expected to have the highest quality and lowest method effects. After the initial continuous analysis the model often indicated that the questions in the main questionnaire indeed had zero method correlation. Since the categorical model tends to increase the correlations, if the monomethod correlations for the main questionnaire go up more than the other correlations, then it

can happen that in the categorical model a method factor is found where none was found before.

A test was done of the hypothesis that questions for which the method effect was constrained to zero in the continuous model have the same categorisation factor as other questions, controlling for country effects. This hypothesis was rejected ( $p = 0.02$ )<sup>13</sup>. The explanation that constraining the method factors to zero causes the interaction found above therefore seems plausible.

## 6 Discussion and conclusion

Using the multitrait-multimethod design and model in the ESS, we found large differences between countries in the quality of survey questions. Because such differences can have important implications for cross-country research and survey design, we set out to discover whether these differences could not be attributable to errors due to the use of a small number of categories.

Overall, we found that categorisation errors do occur besides random errors and method effects. These errors have two types of effects on the quality of the questions, which can work in opposing directions. The first is that the quality is lower when there is more categorisation error. The second, that the categorisation attenuates the relationships between different variables in the model differently, affecting not only the quality, but also the method effects and other parameters of the model. This in turn has as its consequence that the quality parameter under the CV model is not always smaller than the quality under the categorical model, as evidenced by the many ‘categorisation factors’ above unity which we found.

A caveat should be added to the interpretation of this result, because a violation of the assumptions of the models (no categorisation error versus bivariate normality) can have different consequences for the estimates. It is therefore not necessarily true that a categorisation factor above unity indicates overestimation of the quality in the CV model. Several studies of the robustness of factor analysis models to categorisation errors exist (see Olsson 1979). However, we found that their results do not necessarily apply in the MTMM model, which also includes method factors. Given the ubiquity of correlated errors in survey questions, it would be useful to study more closely the robustness of this particular type of measurement error model to categorisation error. This, however, is beyond the scope of the present paper.

In the meta-analysis, we gathered the results from our four different experiments and analysed the relationship between the categorisation factor and the quality in the continuous model. Effects were found for all four experiments.

If the categorisation factors were equal for countries with the highest and lowest quality coefficients, they could not explain the differences in quality which we found earlier. The meta-analysis suggested that there is a considerable difference in the categorisation factor between countries where the highest and the lowest quality coefficients were found given whether the question was part of the main or supplementary questionnaire.

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<sup>13</sup>Result of a hierarchical linear model fit using R 2.6.1 with fixed effects of country and restricting the method to zero or not (0/1), and a random intercept across topics to account for the dependency among the observations.

The methods in the main questionnaire were chosen beforehand based on other experiments as the ones least likely to cause method effects. For example, direct questions rather than batteries were used. After re-examining the experiments on which the meta-analysis was based, it appears this is closely related to the interaction effect found there.

The main reason for the interaction effect we found in the meta-analysis appears to be that the method variance for the main questionnaire method was sometimes fixed to zero. This was done in cases where leaving this method variance free resulted in a very small variance, not significantly different from zero. The general rise in correlations that results from correction for categorisation seems to have ‘pushed’ the monomethod correlations of the main questionnaire variable to the point where the method variance could not anymore be constrained to zero. And as the method variance rises, the quality must decrease in our model.

In other words, the correction for categorisation has a negative influence on the quality. When the method factors were constrained to zero in the first instance, the effect was that the quality was in general lower in the categorical model than in the continuous model. This is contrary to what one might expect considering that all of the polychoric correlations are higher than their Pearson counterparts.

In this study we have shown that it is possible to split the measurement error model into three parts:

- A part due to random errors;
- A part due to systematic errors;
- A part due to splitting the variable into just a few categories: ‘categorisation error’.

This study has been largely descriptive of the effects of categorisation error. Given our findings, it seems important to better judge the relative merits of the continuous and categorical models, and the effects that different question characteristics have, not only on quality and method effects, but also on the categorisation errors.

Our study also has some limitations due to the assumptions made to attain the above separation. These are: normality of the latent response variables, linearity of the relationship between the latent traits and latent response variables, and interval measurement of the latent traits. In another paper these issues will be addressed by examining ways to relax the assumptions. Future research might also focus on finding other explanations for differences in quality across countries.

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## A The results for experiments 2-4

### A.1 Experiment 2

The second experiment concerned some aspects of the respondent's job. The questions are presented in table 7 with the thresholds for the country with the highest and lowest quality coefficient. The model in which all thresholds were constrained to be equal was rejected. Table 7 again shows the threshold estimates after acceptable models for the threshold structure had been found while leaving the covariance matrices free to vary (the test statistics for the two split-ballot groups were 2.4 with 4  $df$ ,  $p = .66$ , and 2.8 with 2  $df$ ,  $p = .24$ , respectively.).

Table 7: The 'job' experiment: questions and threshold estimates (in z-scores).

'There is a lot of variety in my work.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all true</i>		<i>A little true</i>		<i>Quite true</i>	<i>Very true</i>
Belgium		-1.4		-0.7		0.2
Slovenia		-1.7		-0.8		0.4
'Please choose one of the following to describe how varied your work is.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all varied</i>		<i>A little varied</i>		<i>Quite varied</i>	<i>Very varied</i>
Belgium		-1.5		-0.7		0.3
Slovenia		-1.7		-0.6		1.0
'My job is secure.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all true</i>		<i>A little true</i>		<i>Quite true</i>	<i>Very true</i>
Belgium		-1.2		-0.7		0.1
Slovenia		-1.5		-0.6		0.7
'Please choose one of the following to describe how secure your job is.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all secure</i>		<i>A little secure</i>		<i>Quite secure</i>	<i>Very secure</i>
Belgium		-1.6		-0.8		0.3
Slovenia		-1.6		-0.4		1.3
'My health or safety is at risk because of my work.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all true</i>		<i>A little true</i>		<i>Quite true</i>	<i>Very true</i>
Belgium		0.0		0.9		1.3
Slovenia		-0.3		0.6		1.6
'Please choose one of the following to say how much, if at all, your work puts your health and safety at risk.'						
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$
	<i>Not at all at risk</i>		<i>A little at risk</i>		<i>Quite a lot at risk</i>	<i>Very much at risk</i>
Belgium		-0.1		0.9		1.8
Slovenia		-0.5		0.8		1.9

It can be seen that in all cases, the endpoints for Slovenia are further away than the same endpoints for Belgium. Transformation errors are also present, as the thresholds are sometimes one-sided or not equidistant.

Taking the estimated covariances of the latent response variables as our input, we estimated the quality in order to compare the results of this analysis with the results

from the continuous analysis. This model resulted in a test statistic of 40 on 23 degrees of freedom ( $p = .01$ ). The different estimates, including the method effects, for the main questionnaire items are presented in table 8.

Table 8: Quality ( $q^2$ ) and method effects ( $m$ ) according to the continuous and categorical models, with categorisation factors for the experiment on certain aspects of the job of the respondent.

		'Job'		
		Varied	Secure	Risky
Continuous analysis				
$q^2$	Belgium	0.88	0.88	0.92
	Slovenia	0.61	0.21	0.55
$m$	Belgium	0.06	0.06	0.06
	Slovenia	0.17	0.29	0.18
Categorical analysis				
$q^2$	Belgium	0.92	0.58	0.66
	Slovenia	0.50	0.29	0.67
$m$	Belgium	0.19	0.56	0.51
	Slovenia	0.00	0.00	0.00
Categorisation factor				
	Belgium	0.96	1.52	1.39
	Slovenia	1.22	0.72	0.82

The low quality of .21 for the second item in Slovenia catches the eye in table 8. Interestingly, there is nothing in the thresholds to suggest where such a low quality should come from. The change in this coefficient when using the categorical model is relatively small, going from .21 to .29, suggesting the low quality is not so much tied to the thresholds as to other parameters of the model.

For the second and third question, the country with the higher quality estimates in the continuous analysis again finds its estimates in the categorical model corrected substantially downwards. Belgium retains its position as the country with higher quality measurements according to this model, however.

## A.2 Experiment 3

The third experiment concerned the respondent’s perception of the behaviour of doctors in general<sup>14</sup>. The questions are presented in table 9 with the thresholds for the country with the highest and lowest quality coefficient. The model in which all thresholds were constrained to be equal was rejected. Table 9 displays our estimates of the threshold parameters for the different questions.

Table 9: The ‘social distance’ experiment: questions and threshold estimates (in z-scores).

‘Doctors keep the whole truth from their patients.’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
	<i>Never or almost never</i>		<i>Some of the time</i>		<i>About half of the time</i>		<i>Most of the time</i>	
Denmark		-0.6		0.6		0.8		1.4
Estonia		-0.5		1.0		1.4		2.1
‘Doctors rarely keep the whole truth from their patients’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
	<i>Agree strongly</i>		<i>Agree</i>		<i>Neither disagree nor agree</i>		<i>Disagree</i>	
Denmark		-1.4		0.0		0.6		1.8
Estonia		-1.4		0.0		0.6		1.8
‘GPs treat their patients as their equals.’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
Denmark		-1.8		-0.9		-0.7		0.3
Estonia		-1.3		-0.6		-0.2		0.8
‘GPs rarely treat their patients as their equals’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
Denmark		-2.3		-0.9		-0.4		1.2
Estonia		-1.9		-0.6		-0.1		1.4
‘Before doctors decide on a treatment, they discuss it with their patient.’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
Denmark		-1.6		-0.7		-0.4		0.5
Estonia		-1.3		-0.5		-0.1		0.9
‘Before doctors decide on a treatment, they rarely discuss it with their patient’								
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$
Denmark		-1.9		-0.7		-0.3		1.4
Estonia		-1.8		-0.6		-0.1		1.5

The parameter  $\tau_3$  for the first question differs across the countries. Considerably more information is provided by this question in Denmark than in Estonia, since in the latter country only the first two categories are less than one standard deviation away from the mean. If we examine the distribution of this variable, this corresponds to a strong difference in skew: in Estonia 85% of the observations fall in the first two categories, while in Denmark this percentage is a more modest, though still skewed, 72%. Whether this is due to the thresholds themselves or to a skew in the underlying distribution, we can not say.

In addition, there is a difference between the countries for threshold  $\tau_1$  for the third

<sup>14</sup>The test statistics for the first and second split-ballot groups were 6.3 with 7 *df*,  $p = .50$ , and 4.5 with 3 *df*,  $p = .22$ , respectively.

Table 10: Quality ( $q^2$ ) and method effects ( $m$ ) according to the continuous and categorical models, with categorisation factors for the experiment on perception of the behaviour of doctors.

		‘Doctors’			
		Truth	Equals	Discuss	
Continuous analysis					
$q^2$	Estonia	0.42	0.85	0.83	
	Denmark	0.05	0.74	0.77	
$m$	Estonia	0.00	0.00	0.00	
	Denmark	0.00	0.00	0.00	
Categorical analysis					
$q^2$	Estonia	0.75	0.79	0.75	
	Denmark	0.12	0.83	0.82	
$m$	Estonia	0.48	0.37	0.42	
	Denmark	0.49	0.17	0.17	
Categorisation factor					
		Estonia	0.56	1.07	1.10
		Denmark	0.41	0.89	0.94

question, ‘GPs treat their patients as their equals’. In Denmark this extreme cutting point is more distant than in Estonia.

Not everything about categorisation error can directly deduced by looking only at the thresholds. The categorical model produced results which might seem surprising if this is not taken into account. Table 10 shows the results we obtained for this experiment. The likelihood ratio in this case was 26 with 21 degrees of freedom ( $p = .19$ ).

An extremely low quality for the first question was obtained in Denmark; this variable had very low correlations with its repetitions—and every other variable in the model. These low correlations were corrected upwards somewhat after taking the categorisation into account, but they remained low, producing an also low quality of .05 in the continuous and .12 in the categorical analysis<sup>15</sup>. As suggested before, an explanation for this is that the random errors are very large for this question.

In Estonia the quality using the CV model is also estimated to be rather low. However, the categorical model estimates the quality of the underlying scale at a level similar to that of the other two questions.

For the other two questions, it is worth noting that while the estimates are slightly lower in Denmark in the CV model, these differences are reduced in the categorical model.

### A.3 Experiment 4

The topic of the last experiment was the subjective feeling of competence to participate in politics, also called ‘efficacy’. This was the only experiment we analysed from the first round of the ESS. The questions are presented in table 11 with the thresholds for the country with the highest and lowest quality coefficient. The model in which all thresholds

<sup>15</sup>The data were subjected to a search for mistakes, but no coding or other such errors became apparent.

were constrained to be equal was rejected. The results of the threshold model<sup>16</sup> are presented in table 11.

Table 11: The ‘efficacy’ experiment: questions and threshold estimates (in z-scores).

'How often does politics seem so complicated that you cant really understand what is going on?'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Never</i>		<i>Seldom</i>		<i>Occasion- ally</i>		<i>Regularly</i>		<i>Frequently</i>
Switzerland		-1.4		-0.5		0.6		1.3	
Denmark		-1.3		-0.5		0.6		1.3	
'Sometimes politics seems so complicated that I cant really understand what is going on.'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Agree strongly</i>		<i>Agree</i>		<i>Neither disagree nor agree</i>		<i>Disagree</i>		<i>Disagree strongly</i>
Switzerland		-1.5		-0.1		0.4		1.5	
Denmark		-1.4		-0.1		0.4		1.4	
'Do you think that you could take an active role in a group involved with political issues?'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Definitely not</i>		<i>Probably not</i>		<i>Not sure either way</i>		<i>Probably</i>		<i>Definitely</i>
Switzerland		-0.4		0.3		0.7		1.3	
Denmark		-1.0		-0.6		-0.3		0.4	
'I think I could take an active role in a group involved with political issues'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Agree strongly</i>		<i>Agree</i>		<i>Neith.d.n.a.</i>		<i>Disagree</i>		<i>Disagree strongly</i>
Switzerland		-1.8		-0.6		-0.3		0.6	
Denmark		-1.2		-0.0		0.2		1.2	
'How difficult or easy do you find it to make your mind up about political issues?'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Very difficult</i>		<i>Difficult</i>		<i>Neither difficult nor easy</i>		<i>Easy</i>		<i>Very easy</i>
Switzerland		-1.5		-0.6		0.3		1.5	
Denmark		-1.8		-0.9		-0.2		1.0	
'I find it easy to make my mind up about political issues'									
	1	$\tau_1$	2	$\tau_2$	3	$\tau_3$	4	$\tau_4$	5
	<i>Agree strongly</i>		<i>Agree</i>		<i>Neith.d.n.a.</i>		<i>Disagree</i>		<i>Disagree strongly</i>
Switzerland		-1.2		0.0		0.7		1.9	
Denmark		-1.2		0.1		0.6		1.7	

For the first two questions belonging to the first trait, no relevant differences were found between the thresholds. The third questions exhibits differences in the sense that the skew of the thresholds in Switzerland and Denmark are in different directions. At the same time, the skew of the fourth question in Switzerland is in the opposite direction as for the third question. This is what might be expected given the answer scales. However, one consequence is that the continuous analysis may contain two variables that are skewed in opposite directions. It has been shown that this situation in particular causes differences between categorical and continuous analyses (Johnson and Creech, 1983).

The same does not happen in Denmark though; here the fourth question exhibits more or less symmetrical thresholds. This is somewhat surprising given the thresholds

<sup>16</sup>The test statistics for the first and second split-ballot groups for this eperiment were 3.3 with 6 *df* ( $p = .78$ ) and 5.0 with 6 *df* ( $p = .54$ ), respectively.

of the same question using a direct question rather than an agree-disagree scale; if the scales were equally good but simply a reverse way of phrasing then one would expect also a reversal of the thresholds. The fact that this does not occur suggests that other factors play a part besides the categorisation errors, such as the quality coefficients, random errors and method variance.

The comparison between the categorical and CV models for this experiment is shown in table 12.

Table 12: Quality ( $q^2$ ) and method effects ( $m$ ) according to the continuous and categorical models, with categorisation factors for the experiment on the respondent’s subjective political competence (political efficacy).

		‘Efficacy’		
		Complex	Active	Mind
Continuous analysis				
$q^2$	Denmark	0.77	0.83	0.79
	Switzerland	0.49	0.81	0.50
$m$	Denmark	0.00	0.00	0.00
	Switzerland	0.00	0.00	0.00
Categorical analysis				
$q^2$	Denmark	0.63	0.70	0.63
	Switzerland	0.62	0.94	0.62
$m$	Denmark	0.11	0.08	0.11
	Switzerland	0.00	0.00	0.00
Categorisation factor				
	Denmark	1.23	1.18	1.25
	Switzerland	0.79	0.86	0.81

A seemingly puzzling phenomenon in table 12 is that the estimates for the first question should be so different in the categorical model<sup>17</sup> after we have seen in table 11 that for this question the differences between the thresholds are minimal. This stresses again the fact the thresholds alone cannot provide all the necessary information. It can be seen, however, that the categorisation factors and the differences between them across the two countries are very similar for all three questions.

## B Numerical results of the meta analysis

More details on the estimates of the coefficients which are summarised in figure 6 are presented here. Note that the linear regressions listed are of the natural logarithm of the quality on the logarithm of the categorisation factor. The computer program R 2.6.1 was used to estimate these regressions.

<sup>17</sup>The chi-square test statistic of our final categorical model was 28 with 2 degrees of freedom ( $p = .10$ ).



## Social distance

	Estimate	Std. Error	t value	p-value
(Intercept)	-0.71	0.25	-2.84	0.01
Cat. factor	1.69	0.65	2.61	0.02

Residual standard error: 0.78 on 16 degrees of freedom  
Multiple R-Squared: 0.30, Adjusted R-squared: 0.25  
F-statistic: 6.78 on 1 and 16 DF, p-value: 0.02

## Efficacy

	Estimate	Std. Error	t value	p-value
(Intercept)	-0.37	0.03	-11.22	5.42e-09
Cat. factor	0.80	0.15	5.19	9.03e-05

Residual standard error: 0.13 on 16 degrees of freedom  
Multiple R-Squared: 0.63, Adjusted R-squared: 0.60  
F-statistic: 26.88 on 1 and 16 DF, p-value: 9.03e-05

## Job

	Estimate	Std. Error	t value	p-value
(Intercept)	-0.45	0.08	-5.94	2.73e-05
Cat. factor	0.48	0.21	2.27	0.04

Residual standard error: 0.30 on 15 degrees of freedom  
Multiple R-Squared: 0.26, Adjusted R-squared: 0.21  
F-statistic: 5.15 on 1 and 15 DF, p-value: 0.04

## Role of women

	Estimate	Std. Error	t value	p-value
(Intercept)	-0.94	0.13	-7.21	3.2e-07
Cat. factor	0.62	0.31	1.98	0.06

Residual standard error: 0.63 on 22 degrees of freedom  
Multiple R-Squared: 0.15, Adjusted R-squared: 0.11  
F-statistic: 3.90 on 1 and 22 DF, p-value: 0.06