STABILITY OF BOUNDARIES BETWEEN RESPONSE OPTIONS OF RESPONSE SCALES
Does 'very happy' remain equally happy over the years?

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Abstract
The differences between response scales in number and wording of response options make it hard to compare data from survey research and to perform research syntheses. A recent method that we have developed to tackle this problem is rooted in the idea that the transition points on a bounded continuum, on which verbal response options from a primary scale transit from one point to another, for instance from 'happy' to 'very happy', remain unchanged over time. The idea behind this is that although people may change their perception of, for example, their own happiness intensity over time, they are assumed not to change the degree of appreciation they attribute to the terms used to label response options. This is an important assumption for research syntheses that requires that everything remains unchanged, except for the change of interest. It means that if our method is applied to measurements at distinct points in time, differences in estimates of the mean and standard deviation can be attributed solely to changes in the frequency distributions on the primary scale. In this paper we apply the method to happiness and show that it is reasonable to assume that the transition points between the response options are stable over time.

Keywords: verbal response scales; comparability; scale transformation; beta distribution; reference distribution; research synthesis

1 THE PROBLEM

1.1 Incomparability of survey research

Survey research is a major tool of the social sciences and builds on responses to questions using given response options. There is little uniformity in the survey items, the questions and the corresponding response options, which is the result of the many considerations and choices that need to be made when designing a questionnaire for survey research (Saris & Gallhofer 2007). This limited uniformity reduces our accumulation of knowledge and calls for methods to transform ratings on different scales to attain comparable results. In the course of time a number of such methods have been developed. The simplest of these is the Linear Stretch method, an early version of which was already in use almost a century ago (Hull 1922). In Linear Stretch the ranks of the response options are stretched to a common range from for example 0 to 10 and the sample mean is calculated as the sum of all transformed numbers, each of which is weighted with its corresponding relative frequency. At present, the

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Linear Stretch Method is for example still applied in the World Database of Happiness for numerical scales with at least seven points and in the percentage of scale maximum method developed by Cummins (1997, 2003).

More advanced transformation methods deploy judges to rate the verbal labels of the response options on a common numerical scale. We distinguish two variations in these types of transformation methods. In the first variation judges are asked to rate the degree of appreciation denoted by the labels of verbal response options on a common numerical scale. The average rating given to each label is kept fixed for every response scale of which it is part. The studies conducted by Jones and Thurstone (1955) and Lodge (1981), and more recently the work done by Bălţătescu (2002) and Lim (2008) are illustrative for this variation. In the second variation judges assess the points on a common, bounded continuum at which verbal response options for a given response scale transit from one to another (Veenhoven 2008). The mid-interval value between the two transition points of a verbal response is adopted as the secondary rating of this response option.

In all these transformation methods the sample mean is calculated on the basis of all ratings of this 'secondary scale' in the same way as is done in the Linear Stretch method. This sample mean is adopted as the estimator of the mean happiness value of the happiness distribution in the population. The variance and standard deviation of the latter distribution are estimated accordingly.

These desired estimators can also be obtained using the Continuum Approach (Kalmijn 2010), in which happiness in the population is postulated to be a latent variable with a continuous probability distribution function. Within a specified 'family' of distributions, the one is selected that best fits the transitions points combined with the frequency distribution of the primary verbal response scale. Contrary to the methods described previously this method is referred to as a non-transformation method, because in this approach no secondary ratings are introduced nor is there a relation between the corresponding parameters of the discrete sample distribution and the continuous one in the population. We will describe the Continuum Approach more comprehensively in Sect. 2 of this paper.

1.2 Introduction of the Reference Distribution Method

None of the methods mentioned above is effective for solving the incomparability of responses from different surveys, due to the non-uniformity of the items used. For a given year and a given population, distribution means of responses to similar questions asked about the same topic in different representative surveys, estimated after scale transformation should be approximately the same irrespective of the primary response scales used: yet this is not the case when using the methods mentioned above (DeJonge et al 2014). For this reason, DeJonge et al developed the Reference Distribution Method in which 1) a reference distribution is used to derive the transition points on a bounded continuum at which response options from a primary scale transit from one point to another, for example from 'happy' to 'very happy', followed by 2) applying the Continuum Approach to estimate the mean and the standard deviation of the best fitting continuous distribution in the population. The Continuum Approach is thus applied in the Reference Distribution Method, but it is not that method itself.

One of the basic assumptions of the Continuum Approach is that a variable is continuously distributed in the population, whereas in measurements in general a discrete scale is used. The specific shape of the continuous distribution can be approximated on the basis of the measurements on a discrete primary scale and the transition points on the continuum between the response options.

1.3 Research question

When the Continuum Approach is applied to the time series of a survey which has remained unchanged over time, the transition points are kept fixed. The idea behind this is that, although people may change the perception of the intensity of, for example, their own happiness intensity over time, they are assumed not to change the degree of appreciation they attribute to the terms used to label response options. This is an important assumption for research syntheses that require that everything remains unchanged, except for the change of interest. It means that if the Continuum Approach is applied to measurements at distinct points in time, differences in estimates of the mean and standard deviation can be solely attributed to changes in the frequency distributions on the primary scale.

Thus our research question was: Is it reasonable to keep the transition points between response options fixed when we apply the Continuum Approach? We explore this question and answer it in detail in the rest of this paper.

2 THE CONTINUUM APPROACH

In survey research it is common practice to treat variables as discretely distributed and to use their ranks to calculate a sample mean and standard deviation, which are adopted as unbiased estimates of the corresponding parameters of the distribution in the population. The Continuum Approach is an innovative method that diverges from this common practice.

2.1 Happiness: A discretely or continuously distributed variable?

The use of discrete scales in survey research is often practically motivated, for example in several modes of surveying it is easier to ask a respondent to make a choice from a limited number of options than to have them point out an exact individual value on a continuous scale that corresponds to their perception. Respondents are asked to answer a closed question with a limited number of response options which together make a survey item. The response scales, both verbal and numerical, vary in the number of response options available, some including only two options, for example ‘yes’ or ‘no’, and others eleven, for example the integer numbers from 0 to 10. A more valid approach, as Kalmijn (2010; Ch. VI) argues, is to consider the existence of a latent continuous variable underlying the survey variable, the distribution of which is estimated using the survey item and the response to it.

The use of discrete scales explains the variety of response scales that has developed over time. This variety limits the comparability of answers to survey questions in general and using happiness as an exemplary topic. Kalmijn (2010; Ch. VI) developed the Continuum Approach to tackle this comparability problem in combination with the notion that happiness[5] is to be treated as a continuous variable.

2.2 Outline of the Continuum Approach applied to happiness

The Continuum Approach postulates a latent happiness variable in the population, which is continuous over the interval [0, 10]. In the case of happiness, a beta distribution is the most appropriate to use in the Continuum Approach, due to at least three interesting properties it has (Kalmijn et al 2011; p. 509-510)

[5] With the term happiness in this paper, we refer to its common definition of being the subjective enjoyment of one’s life as a whole (Veenhoven 1984). In this definition ‘happiness’ is synonymous with ‘life satisfaction’. This concept of happiness is currently the one most commonly used in the social sciences (Veenhoven 2013a).

(i) it is a continuous distribution, which makes it suitable as a model for the continuous latent happiness variable in the population
(ii) the random variable has a two-sided bounded domain, which makes it suitable for happiness as it is measured using two-sided bounded primary scales.
(iii) the distribution has two shape parameters, which makes beta distributions cover a wide class of different distribution shapes, including skew distributions, both positive and negative.

We do not know any other distributions with these properties. More generally known alternatives as the normal distribution and the logistic distribution are less suitable than the beta distribution, among other things because their domain is infinite and because they are bell-shaped and symmetric around their mean (Kalmijn (2012), whereas happiness has clearly skew distributions (Lee et al 1982, Cummins 2003, Frijters et al 2008, Guven et al 2011).

The family of beta distributions consists of a series of distributions each member of which being characterized by two shape parameters, α and β.

A beta distribution can be expressed using the complete beta function:

(1) $$B(\alpha,\beta) := \int_0^1 t^{\alpha-1}(1-t)^{\beta-1}dt$$

where the parameters α and β are positive real numbers.

Given the formula (Eq. 1) the probability density function of the beta distribution on the continuum from 0 to 10 can be written as:

(2) $$f(x|\alpha,\beta) := \begin{cases} [10B(\alpha,\beta)]^{-1}x^{\alpha-1}(10-x)^{\beta-1} & \text{for } x \in [0,10] \\ 0 & \text{otherwise} \end{cases}$$

The mean μ and standard deviation σ of a beta distribution with parameters α and β on the continuum from 0 to 10 are equal to:

(3) $$\mu = 10\frac{\alpha}{\alpha+\beta}$$

(4) $$\sigma = 10\sqrt{\frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}}$$

To make this less abstract we give some examples of the probability density functions and the cumulative distribution functions for different values of α and β in Appendix A.

A starting point for the Continuum Approach to happiness is provided by the cumulative frequencies of measured happiness on a discrete primary scale and the values on the continuum from 0 to 10 at which respondents change their judgment from one to the adjacent response option on this primary scale, for example from ‘happy’ to ‘very happy’. On basis of the cumulative frequencies and the values on the continuum of the boundaries between the response options of the primary scale, the shape parameters α and β of the best fitting beta distribution are estimated in the Continuum Approach as maximum likelihood estimators. This estimation procedure is described into more detail in Kalmijn (2010; p. 160-162). There is always a perfect fit in the case of a primary scale with three response options. If the number of response options is restricted to only two, then there is no single solution: the number of perfectly fitting beta distributions is infinite, and use of the Continuum Approach is therefore invalidated. In the case of at least four response options, then in general there will be no perfectly fitting beta distribution and the best fitting solution should be taken. Those who are interested in the methodological considerations of the Continuum Approach can find more information about it in Kalmijn (2010, Ch. VI) and Kalmijn et al (2011).

3 THE REFERENCE DISTRIBUTION METHOD

Two requirements have to be fulfilled to apply the Continuum Approach. One, the frequency distribution of a variable measured on a discrete primary scale must be available. Two, the values on a continuum from 0 to 10 at which respondents change their judgment from one to the adjacent option of the primary scale need to be determined. We applied the Reference Distribution Method to assess these transition values and used the Continuum Approach to derive a reference distribution from a numerical scale.

3.1 Outline of the Reference Distribution Method

The Reference Distribution Method (DeJonge et al 2014) is a method used to determine the transition points on a bounded continuum at which response options for a given response scale transit from one to another. We will refer to the transition from a response option with rank i ($i < k$ = the number of response options of the verbal scale) to the response option with rank i+1 as 'reference boundary i'; the upper end of the continuum acts as the k-th boundary. These reference boundaries follow straightforwardly from the estimated cumulative distribution of the reference distribution and the cumulative frequencies for the response options in the verbal scale: reference boundary i is equal to the point on the continuum from 0 to 10 where the value of the cumulative reference distribution is equal to the sum of the frequencies corresponding to the response options ranked 1 up to and including i in the primary scale. For a detailed description of the Reference Distribution Method see DeJonge et al (2014; Ch. 5). In the present paper we restrain ourselves to giving an example of the method, describing in Sect. 3.2 how the Continuum Approach can be applied to a discrete numerical primary scale to obtain a reference distribution, and in Sect. 3.3 we describe how this distribution can be used to apply the Reference Distribution Method to derive the reference boundaries.

3.2 The Continuum Approach and discrete numerical scales

All accepted items of happiness are gathered in the collection 'Measures of Happiness' of the World Database of Happiness (Veenhoven 2013b). About half of these are single questions which have to be rated on a numerical scale with ten or eleven response options. If the number of options of these numerical scales is less than ten, then in three out of four cases the number is equal to seven. There are also response scales which are not labelled with numbers or text, for example merely consisting of a series of boxes such as

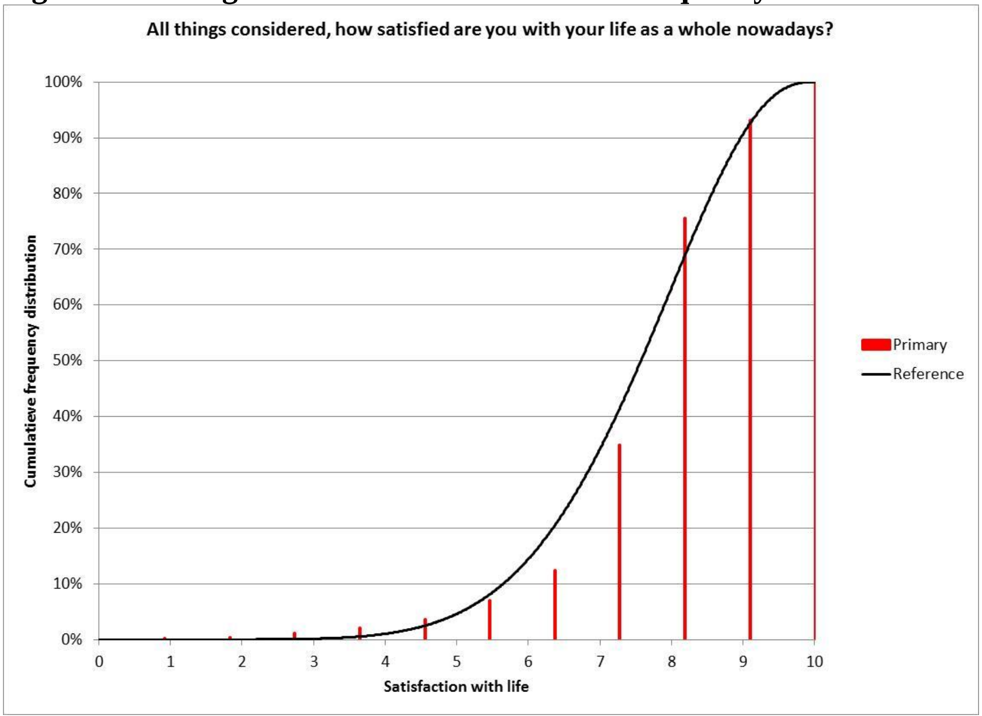
□□□□□□□□□□□

When applying the Continuum Approach these scales are treated as quasi numerical by assigning a rank to each option. If the Continuum Approach is to be applied to survey items with numerical scales, a pragmatic choice to identify the reference boundaries on the 0 to 10 continuum is to assume that they are equally distanced (Kalmijn 2013). This methodological choice for numerical scales has been found to be very useful for providing a basis for the Reference Distribution Method.

We derived a reference distribution from the response to the question: 'All things considered, how satisfied are you with your life as a whole nowadays?' and an 11-point numerical scale from 0 to 10 with the anchor points of the scale labelled by 'Extremely unsatisfied' and 'Extremely satisfied'. This item is in the core questionnaire of the European

Social Survey (ESS)[6]. Following the description above, we fixed eleven reference boundaries 0.91 apart, starting at 0.91 for the response option at the lower end of the scale and ending at 10.0 for the option at the upper end of the scale. We then applied the Continuum Approach to these boundaries and the life satisfaction frequency distribution for 2008 in The Netherlands. The result is depicted in Fig. 1.

Fig. 1 Best fitting beta distribution to the ESS frequency distribution 2008



The parameters of the beta distribution in Fig. 1 are α = 7.92 and β = 2.76, which, according to Eq. 3 corresponds to a mean of 7.41. From Fig. 1 it is clear that the estimated beta distribution does not fit perfectly to the cumulative frequency distribution on the primary scale. Look for example at the response options 8 and 9 of the ESS, which are positioned at 7.27 and 8.19, respectively, on the 0 to 10 continuum. The beta distribution has a horizontal deviation and vertical deviation to the position of both response options. The horizontal deviation is equal to -0.21 for option 8 and +0.25 for response option 9. The vertical deviation is equal to +6.5% for response option 8 and equal to -6.7% for response option 9. These noticeable deviations may have a number of causes, among which the assumed equidistance of the response options, and additionally the actual distribution of life satisfaction in the population is not likely to be perfectly shaped as a beta distribution.

In a similar way we derived a reference distribution for happiness in the population from the response to the question: ‘Taking all things together, how happy would you say you are?’ on an 11-point numerical scale from 0 to 10 with the anchor points of the scale labelled by ‘Extremely unhappy’ and ‘Extremely happy’. This item is also in the core questionnaire of the ESS. The reference distribution we found has parameters α = 10.20 and β = 3.33, which gives a mean of 7.54.

3.3 Illustration of the application of the Reference Distribution Method

The best fitting beta distribution described in Sect. 3.2 serves as a reference for the application of the Reference Distribution Method to other response scales with an equivalent leading

[6] http://www.europeansocialsurvey.org/

question and a frequency distribution for 2008. The Reference Distribution Method forces the cumulative frequency of a verbal scale item into the curve of the reference distribution to guarantee that the estimated mean of the verbal scale after this transformation in the reference year is equal to the mean of the reference distribution. For example, applying the Reference Distribution Method to an item on life satisfaction from the Permanent Onderzoek Leef Situatie[7] (POLS) of Statistics Netherlands with the leading question ‘To what extent are you satisfied with the life you currently lead?’ with a 5-point verbal response scale, the frequency distribution of the responses to this item in 2008 in The Netherlands is:

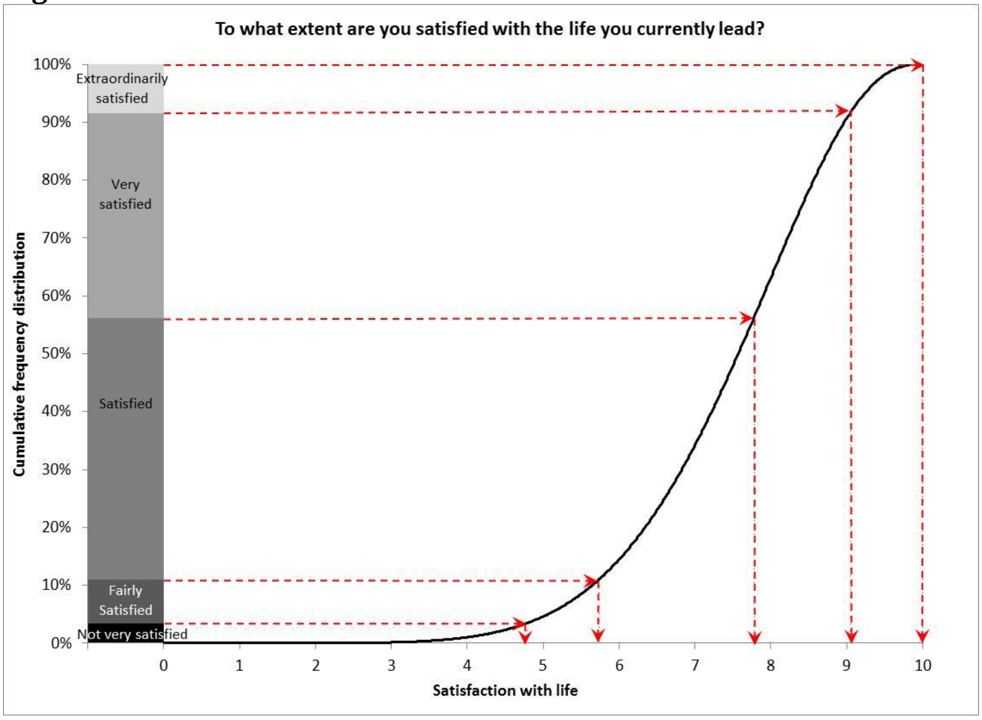
- Extraordinarily satisfied: 8.4%
- Very satisfied: 35.5%
- Satisfied: 45.1%
- Fairly satisfied: 7.6%
- Not very satisfied: 3.4%

see Fig. 2.

The corresponding cumulative frequency distribution is shown on the left side of Fig. 2. To the right side of this cumulative frequency distribution, the reference distribution derived from the ESS is depicted.

The procedure to determine the reference boundaries between the response options of the primary verbal scale on the continuum from 0 to 10 is as follows, see also Fig. 2. For each response option, a horizontal line is drawn from its cumulative frequency displayed for the verbal scale to the point where it touches the reference distribution. At this point the value of the reference distribution is equal to the cumulative distribution on the verbal scale. From this point down, a vertical line is drawn to the horizontal axis. The value at which the vertical line touches the horizontal axis is the position of the reference boundary of the corresponding response option. Following this procedure, the reference boundaries for the response options on the 0 to 10 continuum are, consecutively, 4.78, 5.73, 7.77, 9.04 and 10.00.

Fig. 2 Illustration of the Reference Distribution Method



[7] Permanent Survey on Living Conditions

The reference boundaries and the frequencies measured on the verbal scale can on their turn be used as input for the application of the Continuum Approach.

3.4 Application of the Reference Distribution Method to other surveys items fielded in 2008

For the research question addressed in this paper, we had three other survey items besides the POLS item for life satisfaction available, which were fielded in 2008. These were an item on life satisfaction from the Eurobarometer (European Commission 2013), an item on happiness from POLS[8] and an item on happiness from the Dutch Household Survey (DHS)[9]. In the same way as we did for the satisfaction with life item from POLS, we applied the Reference Distribution Method to the frequency distributions of these items in 2008. For the Eurobarometer we used the reference distribution derived from ESS data for 2008 on life satisfaction. For the two other items, we used the reference distribution derived from the ESS data for 2008 on happiness. The items, their frequency distribution in 2008 and the reference boundaries obtained by application of the Reference Distribution Method, are summarized in Tables 1 to 3.

Table 1 Eurobarometer life satisfaction 2008

	"On the whole how satisfied are you with the life you lead?"			
	Very unsatisfied	**Not very satisfied**	**Fairly satisfied**	**Very satisfied**
Frequency	0.6%	3.1%	44.8%	51.5%
Reference boundary	3.69	4.82	7.51	10.00

Table 2 POLS happiness 2008

	"To what extent do you consider yourself a happy person?"				
	Unhappy	**Not very happy**	**Neither happy nor unhappy**	**Happy**	**Very happy**
Frequency	3.4%	7.6%	45.1%	35.5%	8.4%
Reference boundary	4.26	5.13	6.05	8.46	10.00

Table 3 DHS happiness 2008

	"Taking all together, to what extent do you think of yourself as a happy person?"				
	Very unhappy	**Unhappy**	**Neither happy nor unhappy**	**Happy**	**Very happy**
Frequency	0.3%	1.6%	16.7%	61.6%	19.7%
Reference boundary	3.96	4.88	6.53	8.55	10.00

4 STABILITY OF THE BOUNDARIES OVER TIME

If the Reference Distribution Method is applied, the best fitting beta distribution in the reference year by definition coincides with the cumulative frequency distribution of the verbal response scale at the position of the reference boundaries. It is unlikely that this coincidence will also occur exactly for the beta distribution that fits best to these reference boundaries and the cumulative frequencies of a verbal scale item measured at different moments in time.

4.1 Approach for testing the stability of the boundaries

We recall from Sect. 3.3, that using the Reference Distribution Method forces the cumulative frequency of a verbal scale item in the reference year into the curve of a corresponding

[8] The frequency distributions of the two POLS items were obtained by personal communication from Statistics Netherlands

[9] CentERdata - Institute for data collection and research, www.dhsdata.nl

reference distribution and leaves us with a set of reference boundaries. As a result the mean of the transformed verbal scale in the reference year is equal to the mean of the reference distribution.

The main reason for determining the reference boundaries is that they are necessary for the transformation of time series of measurements using verbal scale items into mutually comparable means. To achieve this, the Continuum Approach is applied to estimate the best fitting beta distribution for each frequency distribution of the time series of a given item and the reference boundaries for this item derived from the reference distribution in the reference year. In this way we get a series of beta distributions for each item in which every beta distribution is based on the same reference boundaries but on a different frequency distribution. The reference boundaries are thus kept fixed over time, whereas the frequency distributions vary within each time series. In doing so, we implicitly assume that the boundaries between the response options are stable over time and that the differences in the means after transformation, can be attributed solely to changes in the frequency distributions on the same verbal scale. When we use the term ‘stability of the boundaries between response options over time’ we mean that if we apply the Continuum Approach to estimate a beta distribution which fits best to the cumulative frequencies positioned at the fixed reference boundaries for a survey item at different moments in time:

- the beta distribution that fits best to the frequency distribution of each wave may only slightly deviate from the observed cumulative frequencies at the positions of the reference boundaries
- if there is a deviation, its size should not be related to the length of the period between the time of measurement and the reference year

The horizontal and vertical deviation we mentioned in Sect. 3.2 can be formulated more formally as follows.

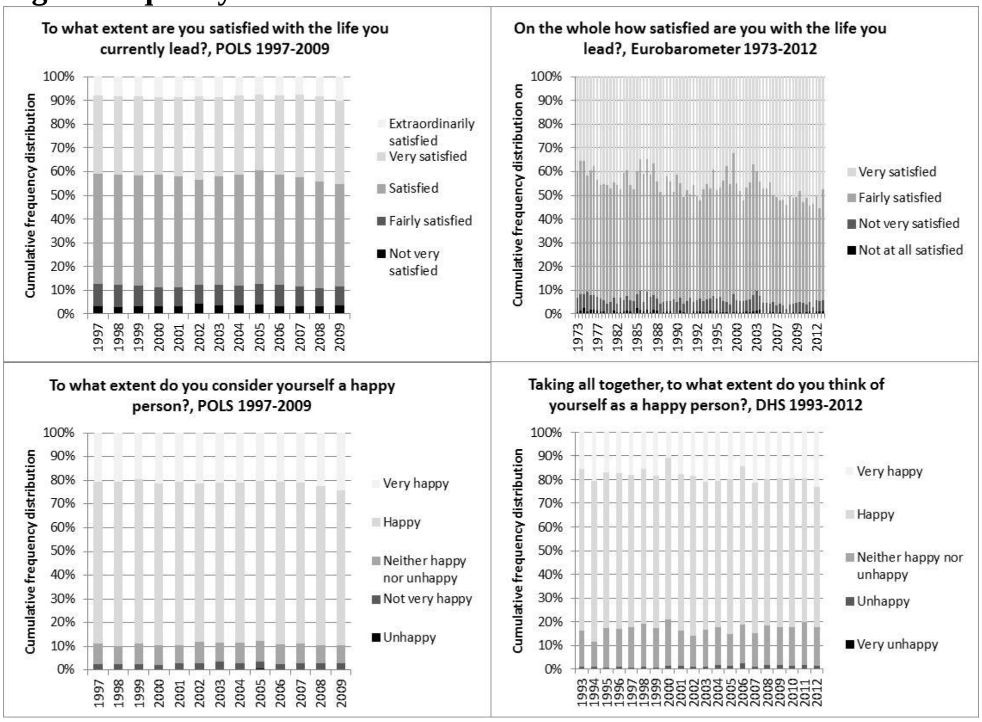
- ***The deviation in horizontal direction:*** for each response option *i* this is the difference between reference boundary *i* and the position on the continuum where the cumulative frequency of the response option is equal to the value of the best fitting cumulative beta distribution. We will go into this in Sect. 4.3.
- ***The deviation in vertical direction:*** for each response option *i* this is the difference between the cumulative frequency of the response option and the value of the best fitting cumulative beta distribution at the position of reference boundary *i*. We will go into this in Sect. 4.4.

If for a given measurement both the horizontal deviation and the vertical deviation of the estimated beta distribution to the cumulative frequencies of the primary scale when positioned on the reference boundaries are small, it means that the estimated beta distribution fits well to the measurement on the primary scale. What small in this context means, is a subjective judgment.

4.2 Available time series

For each of the survey items that we mentioned in Sect. 3 we had both the frequency distribution of 2008 available, and an entire time series. For the two items from POLS we had one frequency distribution for each year in the period 1997-2009. Frequency distributions for the DHS item were available for the period 1993-2012. The Eurobarometer item was fielded in The Netherlands almost every year for one to four times between 1973 and 2012 (Schmitt et al 2008, European Commission 2012a, 2012b and 2013). An overview of the frequency distributions for the various surveys is given in Fig. 3, in which the stack diagrams are projections of the cumulative frequency distributions on the vertical scale.

Fig. 3 Frequency distributions



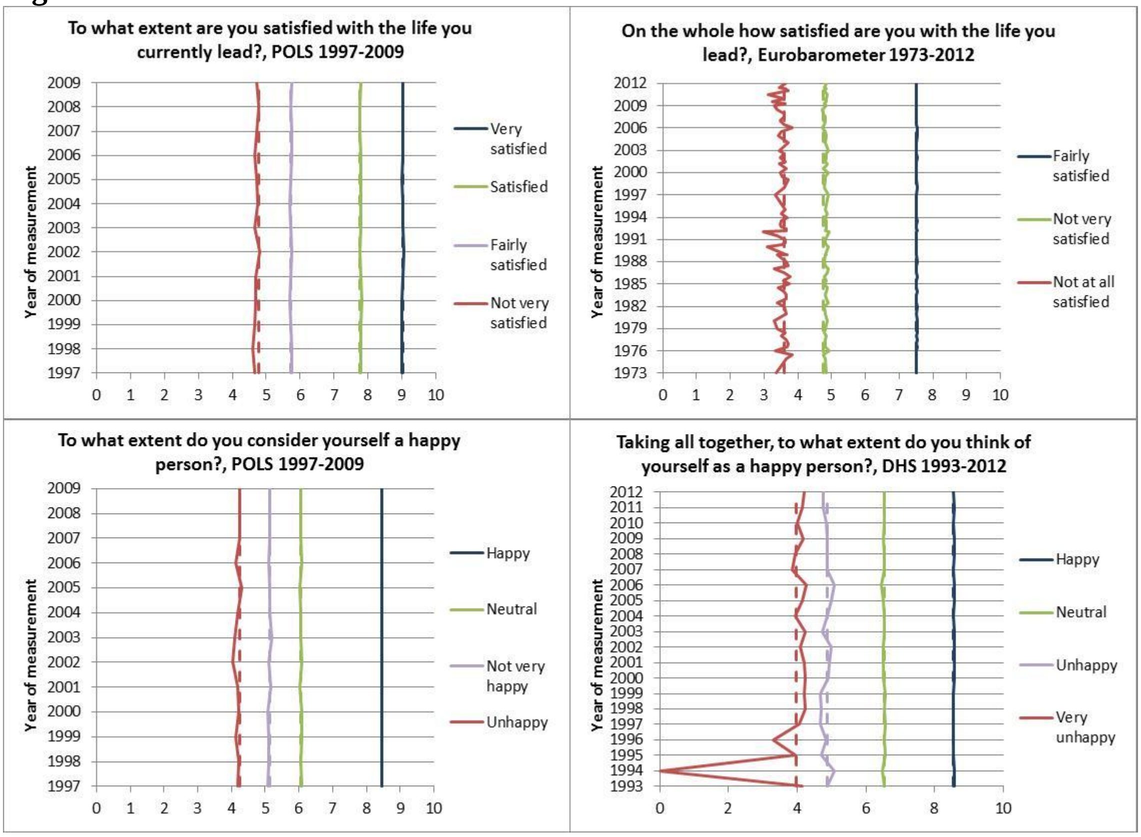
Of all the four items presented in Fig. 3, the frequency distribution of the responses to the Eurobarometer item had the most fluctuating pattern over time, by which we mean that the share of respondents that select a certain response option largely fluctuated over the time period of the survey. The options ‘Fairly satisfied’ and ‘Very satisfied’ were dominant in the ratings for each year and regularly changed places over the years with respect to representing the highest frequency. The two POLS items showed the least fluctuations over time. The cumulative distributions of all items were skewed to the left, which means that they had a relatively long tail on the left where there were relatively few observations. Furthermore it is worth noting that for the two items on happiness with the most negative formulated options, ‘Unhappy’ for the POLS item and ‘Very unhappy’ for the DHS item, were nearly never chosen by the respondents.

We applied the Continuum Approach to estimate a best fitting beta distribution to each frequency distribution and the corresponding reference boundaries for each item: for both the POLS item on life satisfaction and the POLS items on happiness we thus estimated thirteen beta distributions, for the Eurobarometer item which was fielded several times in a year, we estimated seventy five beta distributions and for the DHS item twenty. An overview of the cumulative frequencies on the primary scales and of the parameters of the best fitting beta distributions is given in appendix B. We determined the horizontal deviation and vertical deviation to the corresponding cumulative frequency distribution on the primary verbal scale for each of these beta distributions. The results are described in Sect. 4.3 and Sect. 4.4.

4.3 The deviation in horizontal direction

The deviation from the reference boundaries in the horizontal direction is an obvious choice of deviation from an intuitive point of view, since it gives insight into the distance between the reference boundary and the point on the continuum where the value of the best fitting cumulative beta distribution equals the cumulative frequency for a given response option. The fluctuations of the horizontal deviation over time for each response option are presented in Fig. 4 where the reference boundaries of each item are represented by straight dashed lines. Since the value for the reference boundary of the most positively labelled option of each item is, by definition, equal to 10, this trivial boundary is ignored in the analysis of the stability of the boundaries.

Fig. 4 Horizontal deviation to reference boundaries



The deviation from the reference boundaries in the horizontal direction is the largest for cumulative frequencies in the lower tail of the distribution. This has to be attributed to the small slope of the cumulative beta distribution in the tail and does not necessarily imply a large deviation in the vertical direction as we will show in Sect. 4.4. In line with the low fluctuations of the POLS items over time, the horizontal deviations from the reference boundaries for these items are most stable. For the Eurobarometer item, the point on the continuum where the value of the beta distribution is equal to the cumulative frequency for the option 'Not very satisfied' is the only one that is positioned to the right of the reference boundary for nearly all of the observations over the years. For the other response options of this item these points curl around the reference boundaries. Most eye-catching for the DHS item, is the horizontal deviation to the reference boundary of the response option 'Very unhappy' in 1994. This extremity is due to the fact that the response to this option was zero in 1994. Considering the low frequency at which this option was ticked over the course of time, it should be questioned whether it would not be better to combine this option with the option 'Unhappy' in the analysis. This would reduce the effective scale of the DHS item from five to four points, but given the low response to both options, it is not likely that this would affect the sample mean much.

The frequency distributions of the horizontal deviations from the reference boundaries over the years as presented in Fig. 4, characterized by their average value, and the standard deviation and the standard error from this average value are summarized in Tables 4 to 7. As a reference we have also included the values of the reference boundaries which we described in Sect. 3. Example: the horizontal deviation of the reference boundary to the cumulative frequency of the response option 'Not at all satisfied' of the Eurobarometer item (Table 5) varies with a standard deviation of 0.164 about an average horizontal deviation of 0.060 with a standard error of 0.02. The horizontal deviation is positive if the value on the 0-10 continuum where the beta distribution is equal to the cumulative frequency is higher than the value of the reference boundary of the corresponding response option.

Table 4 Distribution horizontal deviation POLS life satisfaction item 1997-2009 (13 waves)

Indicators	Not very satisfied	Fairly satisfied	Satisfied	Very satisfied
Reference boundary	*4.78*	*5.73*	*7.77*	*9.04*
Average horizontal deviation	0.076	-0.002	-0.018	0.016
Standard deviation	0.057	0.021	0.016	0.013
Standard error	0.02	0.01	< 0.01	< 0.01

Table 5 Distribution horizontal deviation Eurobarometer item 1973-2012 (75 waves)

Indicators	Not at all satisfied	Not very satisfied	Fairly satisfied
Reference boundary	*3.60*	*4.76*	*7.51*
Average horizontal deviation	0.060	-0.066	-0.003
Standard deviation	0.164	0.043	0.008
Standard error	0.02	< 0.01	< 0.01

Table 6 Distribution horizontal deviation POLS happiness item 1997-2009 (13 waves)

Indicators	Unhappy	Not very happy	Neither happy nor unhappy	Happy
Reference boundary	*4.26*	*5.13*	*6.05*	*8.46*
Average horizontal deviation	0.070	0.007	-0.007	0.001
Standard deviation	0.074	0.036	0.015	0.003
Standard error	0.02	0.01	< 0.01	< 0.01

Table 7 Distribution horizontal deviation DHS happiness item 1993-2012 (20 waves)

Indicators	Very unhappy	Unhappy	Neither happy nor unhappy	Happy
Reference boundary	*3.96*	*4.88*	*6.53*	*8.55*
Average horizontal deviation	0.091	0.031	0.011	-0.004
Standard deviation	0.934	0.126	0.026	0.008
Standard error	0.21	0.03	0.01	< 0.01

On average the horizontal deviation from the reference boundaries is small for all the response options of each item. The standard deviation is the largest, with a value of 0.934, for the option ‘Very Unhappy’ of the DHS item, which is mainly to be attributed to the zero response to this option in 1994. If the horizontal deviation in 1994 for this option is not taken into account, the standard deviation would reduce to 0.219. Leaving out the results for 1994, would reduce the standard error for the DHS item to 0.050. The relative high standard deviation for the horizontal deviation to the response option ‘Not at all satisfied’ of the Eurobarometer can be explained by the fact that the cumulative frequency for this option is situated in the lower tail of the life satisfaction distribution. In this part of the scale the number of respondents to this option is very small: in the Eurobarometer survey usually < 3% and often < 1%. Since the observed relative frequency acts as a weight of the contribution of the corresponding response option to the estimated parameters of the population distribution, it is acceptable to ignore its effect on the final conclusion.

4.4 The deviation in vertical direction

The deviation of the beta distribution from the primary frequency distribution at the reference boundaries in vertical direction gives insight into the extent to which the best fitting beta distribution under- or overestimates the cumulative frequency of a response option at the position of the corresponding reference boundary. We summarized the vertical deviation of the best fitting beta distributions from the cumulative frequencies of each response option of all items by their average, and the standard deviation and the standard error from this average over the years expressed in percentage points in Tables 8 to 11. Unlike for the horizontal deviation from the reference boundaries, there is no reference value to compare the vertical deviation of the beta distribution from the primary frequency distribution at the reference boundaries. By a positive vertical deviation we refer to an overestimation of the primary frequency distribution by the beta distribution and by a negative vertical deviation to an underestimation of the primary frequency distribution.

Table 8 Distribution vertical deviation POLS life satisfaction item 1997-2009 (13 waves)

Indicators	Not very satisfied	Fairly satisfied	Satisfied	Very satisfied
Average vertical deviation	0.38 %pts	-0.03 %pts	-0.54 %pts	0.31 %pts
Standard deviation	0.28 %pts	0.26 %pts	0.48 %pts	0.25 %pts
Standard error	0.08 %pts	0.07 %pts	0.13 %pts	0.07 %pts

Table 9 Distribution vertical deviation Eurobarometer item 1973-2012 (75 waves)

Indicators	Not at all satisfied	Not very satisfied	Fairly satisfied
Average vertical deviation	0.22 %pts	-0.04 %pts	-0.04 %pts
Standard deviation	0.26 %pts	0.32 %pts	0.22 %pts
Standard error	0.03 %pts	0.04 %pts	0.03 %pts

Table 10 Distribution vertical deviation POLS happiness item 1997-2009 (13 waves)

Indicators	Unhappy	Not very happy	Neither happy nor unhappy	Happy
Average vertical deviation	0.08 %pts	0.03 %pts	-0.10 %pts	0.04 %pts
Standard deviation	0.09 %pts	0.18 %pts	0.21 %pts	0.10 %pts
Standard error	0.02 %pts	0.05 %pts	0.06 %pts	0.03 %pts

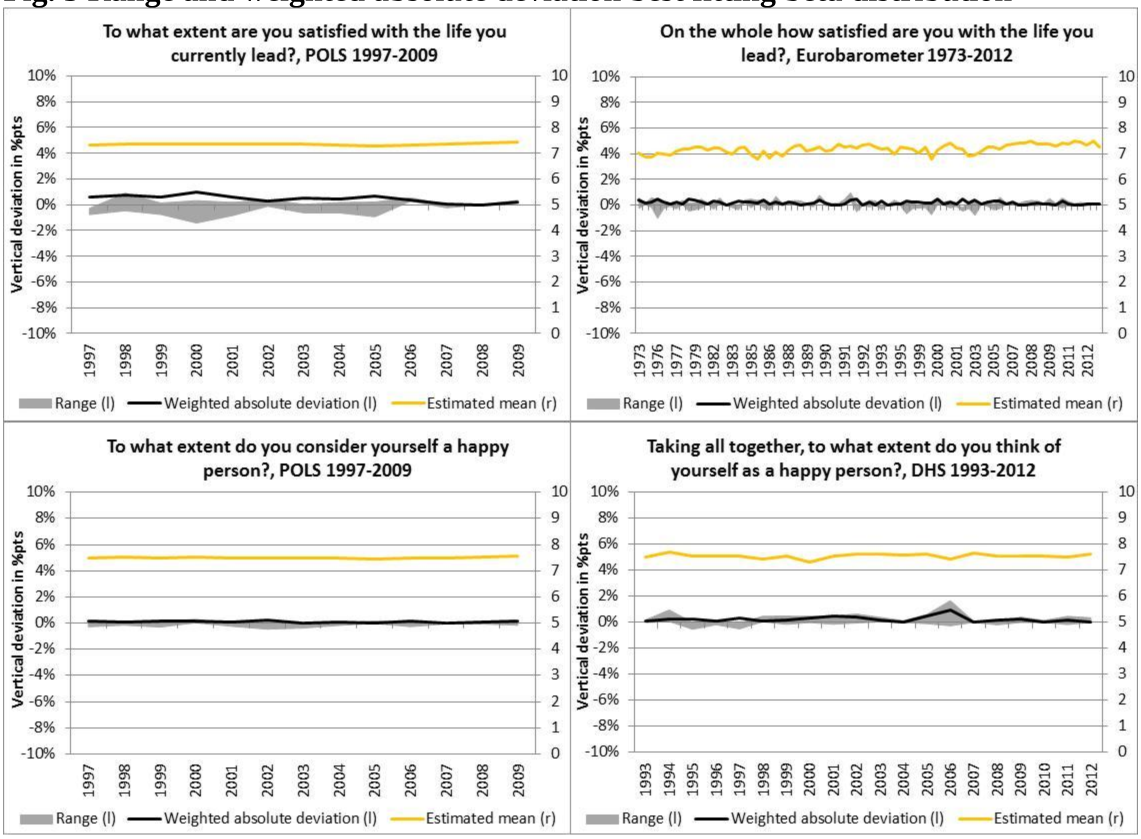
Table 11 Distribution vertical deviation DHS happiness item 1993-2012 (20 waves)

Indicators	Very unhappy	Unhappy	Neither happy nor unhappy	Happy
Average vertical deviation	-0.09 %pts	0.07 %pts	0.21 %pts	-0.13 %pts
Standard deviation	0.11 %pts	0.34 %pts	0.52 %pts	0.24 %pts
Standard error	0.03 %pts	0.08 %pts	0.12 %pts	0.05 %pts

The average vertical deviation of the reference distribution from the cumulative frequencies is small for all response options of each item, with a very small standard error. It is worth noting here, that when mutually comparing the average vertical deviations for two response options, one should keep in mind that these deviations are related to the cumulative frequencies. For example, the average vertical deviation for the response option ‘Very satisfied’ of the POLS item on life satisfaction (0.31 %pts) is not much smaller than that for the response option ‘Not very satisfied’ (0.38 %pts), but relatively speaking, the difference between the two average deviations is much larger: the 0.376 percentage points for the option ‘Not very satisfied’ corresponded to an on average cumulative frequency of less than 4%, whereas the 0.31 percentage points for the option ‘Very satisfied’ belonged to an on average cumulative frequency of over 90%. Keeping this in mind, the vertical deviations corresponding to the response options on the left side of the scale were relatively larger than those corresponding to the response options on the right side.

To finalize our analysis, we calculated two indicators for the goodness-of-fit of the beta distributions. The first of these indicators was the range of the vertical deviation which is defined as the absolute difference between the minimum vertical deviation and the maximum vertical deviation of the reference distribution from the cumulative frequencies, excluding the trivial deviation for the reference boundary at position 10, which, by definition, is equal to zero. The second indicator was the weighted absolute deviation, which is equal to the weighted average of the absolute vertical deviation for each reference boundary except the one at position 10, with the relative frequencies of the corresponding response options as weights. The use of these frequencies as weights was an arbitrary choice. Other possibilities would be the squares or roots of these frequencies and also the cumulative frequencies. The idea behind the weighted absolute deviation is that a large deviation that corresponds to a low frequency has a lower impact on the value of the estimated mean than a large deviation that corresponds to a high frequency. The range is an indicator that gives insight into whether the upper boundaries of all response options are overestimated or underestimated by the best fitting beta distribution or whether there is a mixture of over- and underestimations. The weighted absolute deviation provides guidance as to the extent to which the deviations affect the estimated population means. The range and the weighted absolute deviation of the vertical deviation are plotted on the left axis in Fig. 5. The underlying idea of the research question in this paper was to make responses to different survey items which aim at measuring the same item, here happiness, comparable. Therefore we also included the estimated means for all the transformed time series of measurements in Fig. 5, which are plotted on the right axis.

Fig. 5 Range and weighted absolute deviation best fitting beta distribution



On average the range over time was small for all four survey items. The average range over the years was largest for the POLS item on life satisfaction with a value of 0.72. For this item the standard deviation of the average range was also largest with 0.50 percentage points. The, in absolute sense, largest range occurred for the DHS item on happiness in 2006 when it was equal to 1.7. Clearly, the range for the reference measurement in 2008 was equal to zero for all items. The largest weighted absolute deviation could be observed for the POLS item on life satisfaction in 2000 when it was equal to one percentage point. The average weighted absolute deviation for this item was equal to 0.46 which was at least twice as large as the average for each of the other items. For each item neither the range nor the weighted absolute deviation showed a relationship between the size and the distance in time between the moment of measurement and the reference year.

5 DISCUSSION

The results we found were similar for all the survey items we considered in this paper; for each response option for all four items we considered, we found that both the average horizontal deviation and the average vertical of the estimated beta distributions to the cumulative distributions of the primary scales were small. From this we conclude that the beta distributions fit well to the primary distributions. In addition, the standard error of each of the deviations was very small. The latter means that the average deviations in both horizontal and vertical direction are stable over time. We conclude that these results confirm the implicit assumption we formulated in Sect. 4.1 that the boundaries between response options are stable over time and that the differences in transformed means can solely be attributed to changes in the frequency distributions on the primary scale.

We need to remark that we used the range of the vertical deviation and the weighted absolute deviation between the cumulative frequency of the primary scale and the value of the best fitting beta distribution at the position of the reference boundary as goodness-of-fit indicators. Future research is necessary to validate these indicators or to develop better ones.

We only studied results of survey items fielded in The Netherlands, where the average level of happiness has shown little change over time. To generalize our conclusion about the stability of the reference boundaries between response options, further research into the stability of the boundaries is required for other countries such as Greece, where the average level of happiness has recently undergone a large change.

When the Reference Distribution Method is applied, the estimated population mean of the reference distribution serves as a reference value for a comparison of the means estimated using the Continuum Approach to other survey items and other years of measurement. This reference value should not be considered to be the ‘true’ value of the perception of happiness on the continuum from 0 to 10. If another reference distribution is used, the reference value may be different. In other words, only population means that are estimated by using the Continuum Approach to survey items for which the reference boundaries are derived from the same reference distribution, can be compared.

6 CONCLUSION

The question we addressed in this paper is whether it is reasonable to assume that the positions of the reference boundaries between response options on the continuum from 0 to 10 are stable over time if the Continuum Approach is applied. We conclude that the answer is affirmative, at least in the case of The Netherlands.

REFERENCES

Bălţătescu, S. (2002).
Problems of transforming scales of life satisfaction.
Euromodule workshop. Berlin (DE).
http://worlddatabaseofhappiness.eur.nl/hap_bib/freetexts/baltatescu_sm_2002A.pdf

Cummins, R. A. (1997).
The Comprehensive Quality of Life Scale – Intellectual/Cognitive Disability (ComQol-I5), 5th edition, School of Psychology, Deakin University, Melbourne (AU)

Cummins, R.A. (2003).
Normative life satisfaction: measurement issues and homeostatic model.
Social Indicators Research, 64: 225-240.

DeJonge, T., Veenhoven, R. & Arends, L.R. (2014).
Homogenizing responses to different survey questions on the same topic. Proposal of a Scale Homogenization Method using a Reference Distribution
Social Indicators Research, **117**(1), 275-300, Springer, DOI: 10.1007/s11205-013-0335-6

European Commission (2012a).
European Opinion Research Group (EORG), Brussels. GESIS Data Archive, Cologne.
Eurobarometer 57.1 (Mar-May 2002), ZA3639 Data file Version 1.0.1, doi:10.4232/1.10949
Eurobarometer 58.1 (Oct-Nov 2002), ZA3693 Data file Version 1.0.1, doi:10.4232/1.10953
Eurobarometer 60.1 (Oct-Nov 2003), ZA3938 Data file Version 1.0.1, doi:10.4232/1.10958
Eurobarometer 62.0 (Oct-Nov 2004), ZA4229 Data file Version 1.1.0, doi:10.4232/1.10962

European Commission (2012b).
TNS Opinion & Social, Brussels [Producer]. GESIS Data Archive, Cologne.
Eurobarometer 63.4 (May-Jun 2005), ZA4411 Data file Version 1.1.0, doi:10.4232/1.10968
Eurobarometer 64.2 (Oct-Nov 2005), ZA4414 Data file Version 1.1.0, doi:10.4232/1.10970
Eurobarometer 65.2 (Mar-May 2006), ZA4506 Data file Version 1.0.1, doi:10.4232/1.10974
Eurobarometer 66.1 (Sep-Oct 2006), ZA4526 Data file Version 1.0.1, doi:10.4232/1.10980
Eurobarometer 67.2 (Apr-May 2007), ZA4530 Data file Version 2.1.0, doi:10.4232/1.10984
Eurobarometer 68.1 (Sep-Nov 2007), ZA4565 Data file Version 4.0.1, doi:10.4232/1.10988
Eurobarometer 70.1 (Oct-Nov 2008), ZA4819 Data file Version 3.0.2, doi:10.4232/1.10989
Eurobarometer 71.2 (May-Jun 2009), ZA4972 Data file Version 3.0.2, doi:10.4232/1.10990
Eurobarometer 72.4 (Oct-Nov 2009), ZA4994 Data file Version 3.0.0, doi:10.4232/1.11141
Eurobarometer 73.4 (May 2010), ZA5234 Data file Version 2.0.1, doi:10.4232/1.11479
Eurobarometer 76.3 (2011), ZA5567 Data file Version 1.0.0, doi:10.4232/1.11448

European Commission (2013).
TNS Opinion & Social, Brussels [Producer]. GESIS Data Archive, Cologne.
Eurobarometer 69.2 (Mar-May 2008), ZA4744 Data file Version 5.0.0, doi:10.4232/1.11755
Eurobarometer 71.1 (Jan-Feb 2009), ZA4971 Data file Version 4.0.0, doi:10.4232/1.11756
Eurobarometer 74.2 (2010), ZA5449 Data file Version 2.2.0, doi:10.4232/1.11626
Eurobarometer 75.3 (2011), ZA5481 Data file Version 2.0.0, doi:10.4232/1.11768
Eurobarometer 75.4 (2011), ZA5564 Data file Version 3.0.0, doi:10.4232/1.11769
Eurobarometer 77.3 (2012), ZA5612 Data file Version 1.0.0, doi:10.4232/1.11558
Eurobarometer 77.4 (2012), ZA5613 Data file Version 2.0.0, doi:10.4232/1.11697

Eurobarometer 78.1 (2012), ZA5685 Data file Version 1.0.0, doi:10.4232/1.11706

Frijters, F., Johnston, D.W. & Shields, M.A. (2008).
Happiness Dynamics with Quarterly Life Event Data
IZA Discussion Paper No. 3604

Guven, C., Senik, C. & Stichnoth, H. (2011).
You can't be happier than your wife. Happiness Gaps and Divorce
Paris School of Economics, Working Paper No. 2011-01, halshs-00555427

Hull, C.L. (1922).
The Conversion of Test Scores into Series Which Shall Have Any Assigned Mean and Degree of Dispersion
Journal of Applied Psychology 6(3), 298-300

Jones, L.V. & Thurstone, L.L. (1955).
The Psychophysics of Semantics. An Experimental Investigation
The Journal of Applied Psychology, 39, 31-36.

Kalmijn, W.M. (2010).
Quantification of Happiness Inequality
PhD-thesis, Erasmus University Rotterdam, The Netherlands: Ipskamp Drukkers, Enschede.
Available at http://repub.eur.nl/res/pub/21777/

Kalmijn, W.M., Arends, L.R. & Veenhoven, R. (2011).
Happiness Scale Interval Study, Methodological Considerations.
Social Indicators Research, 102(3), 497-515, DOI: 10.1007/s11205-010-9688-2

Kalmijn W.M. (2012).
Happiness is not Normally Distributed. A comment to Delhey and Kohler
Social Science Research 41 (1), 199-202, DOI 10.1016/j.ssresearch.2011.11.008

Kalmijn, W.M. (2013).
From Discrete 1 to 10 Towards Continuous 0 to 10: The Continuum Approach To Estimating the Distribution of Happiness in a Nation
Social Indicators Research, 110(2), 549-557, DOI: 10.1007/s11205-011-9943-1

Lee, H., Kim, K.D. & Shin, D.C. (1982).
Perceptions of Quality of Life in an Industrializing Country: The Case of the Republic of Korea
Social Indicators Research 10, 297 – 317, DOI: 10.1007/BF00301097

Lim, H.E. (2008)
The Use of Different Happiness Rating Scales: Bias and Comparison Problem?
Social Indicators Research 87, 259-267, Springer, DOI: 10.1007/s11205-007-971-x

Lodge, M. (1981).
Magnitude scaling : quantitative measurement of opinions
Beverly Hills, London: Sage Publications, Series Quantitative applications in the social sciences, ISSN 0149-192X ; 07-025, DOI: 10.4135/9781412984874

Saris, W.E. & Gallhofer, I.N. (2007).
Design, evaluation, and analysis of questionnaires for survey research
Publisher Hoboken, New York, USA, Wiley-Interscience, Wiley series in survey methodology, ISBN 978-0-470-11495-7, e-ISBN 978-0-470-16519-5

Schmitt, H., Scholz, E., Leim, I., Moschner, M. (2008).
The Mannheim Eurobarometer Trend File 1970-2002 (ed. 2.00).
European Commission [Principal investigator]. GESIS Data Archive, Cologne. ZA3521 Data file Version 2.0.1, doi:10.4232/1.10074

Veenhoven, R. (1984).
Databook of Happiness.
Publisher Reidel, Dordrecht, The Netherlands
http://www2.eur.nl/fsw/research/veenhoven/Pub1980s/84b-con.htm

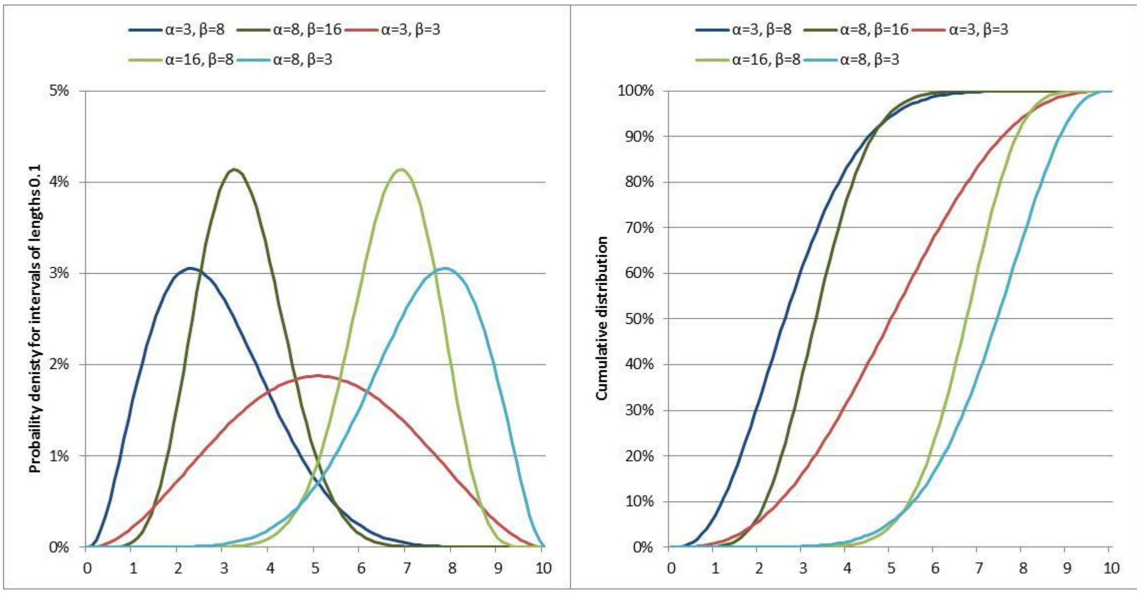
Veenhoven, R. (2008).
The International Scale Interval Study.
In V. Møller & D. Huschka (Eds*),* Quality of Life in the new millennium: 'Advances in quality-of-life studies, theory and research', Part 2: Refining concepts and measurement to assess cross-cultural quality-of-life (pp. 45-58). Social Indicator Research Series, vol. 35, Dordrecht, The Netherlands: Springer Press

Veenhoven, R. (2013a).
World Database of Happiness, Example of a focused 'Findings Archive',
RatSWD, Working Paper Series, Working Paper, no. 169,
http://www.ratswd.de/download/RatSWD_WP_2011/RatSWD_WP_169.pdf

Veenhoven, R. (2013b).
Measures of Happiness
World Database of Happiness, Erasmus University Rotterdam
Available at: http;//worlddatabaseofhappiness.eur.nl/hap_quer/hqi_fp.htm

Appendix A. Illustration of the beta distribution

Fig. 6 Examples of the beta probability density functions and cumulative beta distribution functions



If $\alpha < \beta$, the probability density function is skewed to the right, if $\alpha > \beta$ the function is skewed to the left and if both parameters are equal the function is symmetric about x=5, the abscissa x being the happiness value on a 0 to 10 continuum, and the larger the values of α and β, the more peaked the density curve and the steeper the cumulative distribution curve.

Appendix B Cumulative frequencies and parameters beta distributions

The tables given below contain the frequency distributions of the verbal scales depicted in Fig. 3 in Sect. 4.2. The parameters of the reference distribution and the frequency distribution for 2008 that has been used to derive the reference boundaries for the response options of the scale are given in bold in each table. These values of these fixed reference boundaries are given in Sect. 3.3 for the life satisfaction item from POLS and in table 1 to table 3 in Sect. 3.4 for the three other items.

Table 12 Cumulative frequencies life satisfaction and parameters beta distributions, POLS

	"To what extent are you satisfied with the life you currently lead?"					Parameters best fitting beta distribution	
Year	**Not very satisfied**	**Fairly satisfied**	**Satisfied**	**Very satisfied**	**Extraor-dinarily satisfied**	**α**	**β**
1997	4.1%	12.4%	58.7%	92.5%	100.0%	7.69	2.81
1998	3.8%	11.9%	58.1%	92.4%	100.0%	7.83	2.82
1999	4.0%	12.1%	57.9%	92.1%	100.0%	7.69	2.77
2000	3.8%	11.7%	57.4%	92.0%	100.0%	7.79	2.78
2001	3.7%	11.6%	57.2%	92.0%	100.0%	7.80	2.78
2002	4.1%	12.3%	57.2%	91.5%	100.0%	7.41	2.66
2003	4.2%	12.4%	57.6%	91.7%	100.0%	7.46	2.69
2004	4.0%	12.3%	58.2%	92.3%	100.0%	7.66	2.78
2005	4.4%	13.2%	59.7%	92.8%	100.0%	7.55	2.81
2006	3.9%	12.1%	58.4%	92.5%	100.0%	7.80	2.83
2007	3.7%	11.6%	57.8%	92.4%	100.0%	7.94	2.84
2008	**3.5%**	**11.0%**	**56.1%**	**91.6%**	**100.0%**	**7.92**	**2.76**
2009	3.9%	11.6%	54.7%	90.0%	100.0%	7.24	2.50

Table 13 Cumulative frequencies life satisfaction and parameters beta distributions, Eurobarometer

		"On the whole, how satisfied are you with the life you lead?"				Parameters best fitting beta distribution	
Year	**Version**	**Not at all satisfied**	**Not very satisfied**	**Fairly satisfied**	**Very satisfied**	**α**	**β**
1973	ECS73	1.2%	6.6%	61.0%	100.0%	7.52	3.22
1975	EB3	1.7%	8.3%	64.8%	100.0%	7.19	3.28
1975	EB4	2.0%	9.0%	64.5%	100.0%	6.76	3.10
1976	EB5	2.1%	8.5%	58.9%	100.0%	6.11	2.60
1976	EB6	1.8%	8.1%	60.5%	100.0%	6.61	2.86
1977	EB7	1.8%	8.1%	62.3%	100.0%	6.87	3.04
1977	EB8	1.7%	7.4%	56.4%	100.0%	6.33	2.57
1978	EB9	1.4%	6.5%	54.7%	100.0%	6.57	2.58
1978	EB10	1.3%	6.3%	54.6%	100.0%	6.74	2.64
1979	EB11	0.7%	4.5%	54.1%	100.0%	8.03	3.06
1980	EB13	0.9%	4.9%	53.0%	100.0%	7.49	2.82
1981	EB15	1.6%	7.1%	55.7%	100.0%	6.39	2.56
1982	EB17	0.8%	4.8%	54.4%	100.0%	7.79	2.99
1982	EB18	1.5%	6.6%	52.8%	100.0%	6.27	2.40
1983	EB19	1.0%	5.9%	59.5%	100.0%	7.79	3.24
1983	EB20	1.6%	7.6%	60.3%	100.0%	6.86	2.94
1984	EB21	1.2%	5.9%	54.2%	100.0%	6.94	2.69
1984	EB22	1.0%	5.3%	53.0%	100.0%	7.18	2.72
1985	EB23	2.3%	9.0%	60.2%	100.0%	6.08	2.65
1985	EB24	2.2%	9.7%	65.7%	100.0%	6.65	3.12

Table 13 (continued) Cumulative frequencies life satisfaction and parameters beta distributions, Eurobarometer

		On the whole how satisfied are you with the life you lead?				Parameters best fitting beta distribution	
Year	**Version**	**Not at all satisfied**	**Not very satisfied**	**Fairly satisfied**	**Very satisfied**	**α**	**β**
1986	EB25	0.9%	5.5%	58.8%	100.0%	7.99	3.28
1986	EB26	2.0%	9.2%	65.5%	100.0%	6.88	3.20
1987	EB27	1.4%	6.8%	58.9%	100.0%	7.09	2.96
1987	EB28	1.7%	8.1%	63.7%	100.0%	7.10	3.19
1988	EB29	1.6%	7.0%	55.8%	100.0%	6.48	2.60
1989	EB31	0.8%	4.7%	51.5%	100.0%	7.41	2.73
1989	EB31A	1.0%	5.2%	50.0%	100.0%	6.79	2.46
1989	EB32A	1.0%	5.7%	58.2%	100.0%	7.70	3.14
1989	EB32B	1.1%	5.8%	56.0%	100.0%	7.30	2.90
1990	EB33	1.2%	5.7%	52.1%	100.0%	6.74	2.53
1990	EB340	0.8%	5.2%	58.7%	100.0%	8.16	3.33
1990	EB341	1.6%	7.1%	55.2%	100.0%	6.32	2.52
1991	EB350	0.9%	4.7%	49.4%	100.0%	7.11	2.54
1991	EB36	1.0%	5.3%	52.6%	100.0%	7.07	2.66
1992	EB370	1.4%	6.0%	50.7%	100.0%	6.28	2.32
1992	EB371	1.1%	5.5%	53.9%	100.0%	7.17	2.76
1992	EB380	1.3%	5.8%	49.9%	100.0%	6.33	2.30
1992	EB381	1.7%	6.5%	48.1%	100.0%	5.61	2.00
1993	EB390	1.0%	5.3%	52.5%	100.0%	7.06	2.66
1993	EB40	1.3%	6.1%	54.5%	100.0%	6.84	2.67
1994	EB410	1.5%	6.5%	53.1%	100.0%	6.33	2.44
1994	EB42	1.5%	7.3%	60.9%	100.0%	7.10	3.06
1995	EB431	1.7%	6.9%	52.3%	100.0%	6.02	2.29
1997	EB471	1.5%	6.5%	53.7%	100.0%	6.43	2.49
1998	EB49	1.0%	5.6%	56.0%	100.0%	7.43	2.94
1999	EB520	0.8%	5.2%	62.3%	100.0%	8.83	3.76
1999	EB521	0.6%	4.0%	54.7%	100.0%	8.68	3.31
2000	EB530	1.4%	7.8%	68.0%	100.0%	8.09	3.81
2000	EB541	1.2%	6.2%	55.9%	100.0%	7.00	2.79
2001	EB551	1.0%	5.2%	52.1%	100.0%	7.09	2.65
2001	EB561	1.2%	5.3%	47.8%	100.0%	6.37	2.23
2001	EB562	1.2%	5.8%	53.2%	100.0%	6.80	2.60
2002	EB571	1.3%	6.2%	55.0%	100.0%	6.82	2.68
2002	EB581	1.5%	7.7%	63.6%	100.0%	7.35	3.28
2003	EB601	2.2%	9.0%	60.8%	100.0%	6.16	2.70
2004	EB620	1.9%	7.9%	56.2%	100.0%	6.05	2.46
2005	EB634	0.8%	4.7%	52.7%	100.0%	7.62	2.86
2005	EB642	0.8%	4.7%	52.9%	100.0%	7.60	2.86
2006	EB652	0.9%	5.2%	55.5%	100.0%	7.69	3.01
2006	EB661	1.2%	5.5%	50.1%	100.0%	6.57	2.39
2007	EB672	0.6%	3.8%	49.7%	100.0%	7.95	2.83
2007	EB681	0.8%	4.4%	48.1%	100.0%	7.11	2.49
2008	**EB692**	**0.7%**	**3.9%**	**48.5%**	**100.0%**	**7.92**	**2.76**
2008	EB701	0.4%	2.8%	46.2%	100.0%	8.64	2.89
2009	EB711	0.6%	3.9%	50.0%	100.0%	7.93	2.84
2009	EB712	0.8%	4.5%	49.0%	100.0%	7.17	2.54
2009	EB724	0.9%	4.7%	49.5%	100.0%	7.06	2.53
2010	EB734	1.0%	5.3%	52.0%	100.0%	7.03	2.63
2010	EB742	0.8%	4.4%	47.5%	100.0%	7.02	2.43
2011	EB753	0.8%	4.5%	49.1%	100.0%	7.18	2.55
2011	EB754	1.2%	5.2%	45.8%	100.0%	6.08	2.06
2011	EB763	0.5%	3.2%	46.7%	100.0%	8.15	2.76

Table 13 (continued) Cumulative frequencies life satisfaction and parameters beta distributions, Eurobarometer

		On the whole how satisfied are you with the life you lead?				Parameters best fitting beta distribution	
Year	**Version**	**Not at all satisfied**	**Not very satisfied**	**Fairly satisfied**	**Very satisfied**	**α**	**β**
2012	EB773	1.3%	5.8%	50.0%	100.0%	6.34	2.31
2012	EB774	1.3%	5.5%	44.8%	100.0%	5.76	1.92
2012	EB782	1.2%	5.7%	52.8%	100.0%	6.83	2.59

Table 14 Cumulative frequencies happiness and parameters beta distributions, POLS

	To what extent do you consider yourself a happy person?					Parameters best fitting beta distribution	
Year	**Unhappy**	**Not very happy**	**Neither happy nor unhappy**	**Happy**	**Very happy**	**α**	**β**
1997	0.6%	3.0%	11.2%	79.5%	100.0%	10.52	3.53
1998	0.5%	2.5%	10.2%	79.6%	100.0%	11.19	3.70
1999	0.5%	2.9%	11.1%	80.6%	100.0%	10.91	3.70
2000	0.5%	2.7%	10.5%	79.0%	100.0%	10.82	3.57
2001	0.5%	2.8%	10.7%	79.5%	100.0%	10.85	3.61
2002	0.7%	3.3%	11.7%	79.0%	100.0%	10.09	3.39
2003	0.7%	3.3%	11.7%	79.1%	100.0%	10.10	3.40
2004	0.7%	3.2%	11.5%	79.3%	100.0%	10.27	3.45
2005	0.8%	3.6%	12.5%	79.7%	100.0%	9.88	3.38
2006	0.5%	2.8%	10.7%	79.7%	100.0%	10.91	3.64
2007	0.6%	3.1%	11.4%	79.0%	100.0%	10.26	3.43
2008	**0.6%**	**3.0%**	**10.8%**	**77.5%**	**100.0%**	**10.20**	**3.33**
2009	0.7%	3.0%	10.7%	75.7%	100.0%	9.77	3.13

Table 15 Cumulative frequencies happiness and parameters beta distributions, DHS

	Taking all together, to what extent do you think of yourself as a happy person?					Parameters best fitting beta distribution	
Year	**Very unhappy**	**Unhappy**	**Neither happy nor unhappy**	**Happy**	**Very happy**	**α**	**β**
1993	0.1%	1.1%	16.8%	84.4%	100.0%	12.97	4.28
1994	0.1%	0.7%	12.8%	79.2%	100.0%	13.19	3.94
1995	0.1%	1.2%	17.0%	83.2%	100.0%	12.28	4.02
1996	0.2%	1.3%	17.1%	82.7%	100.0%	12.03	3.93
1997	0.2%	1.4%	17.3%	82.1%	100.0%	11.63	3.79
1998	0.2%	1.7%	19.5%	84.5%	100.0%	11.57	3.96
1999	0.2%	1.4%	17.3%	81.7%	100.0%	11.47	3.72
2000	0.2%	1.7%	21.6%	88.9%	100.0%	12.78	4.66
2001	0.2%	1.4%	17.0%	81.7%	100.0%	11.66	3.77
2002	0.1%	1.0%	15.0%	81.2%	100.0%	12.58	3.94
2003	0.2%	1.6%	16.9%	78.8%	100.0%	10.60	3.34
2004	0.3%	1.8%	17.9%	79.6%	100.0%	10.35	3.32
2005	0.2%	1.2%	15.8%	79.8%	100.0%	11.58	3.62
2006	0.3%	1.9%	20.5%	84.8%	100.0%	11.20	3.89
2007	0.2%	1.2%	15.4%	78.7%	100.0%	11.35	3.49
2008	**0.3%**	**2.0%**	**18.8%**	**80.1%**	**100.0%**	**10.20**	**3.33**
2009	0.3%	1.8%	18.2%	80.3%	100.0%	10.43	3.38
2010	0.3%	1.7%	17.9%	80.5%	100.0%	10.69	3.46
2011	0.4%	2.3%	19.8%	80.4%	100.0%	9.75	3.24
2012	0.4%	2.0%	17.7%	76.8%	100.0%	9.51	2.97